Leading Role or Bit Player? Main contractors, supply chain and sustainable construction.

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Abstract

Driven by increased urbanisation, construction of buildings and infrastructure continues to grow worldwide, further exacerbating the social and environmental impacts created by this sector. Large scale projects, requiring thousands of component parts and globally sourced materials, flow across supply networks to construct built assets. Embodied within these supply networks are minerals, energy, water, labour, waste, modern slavery and other human rights abuses. This thesis focuses on the UK construction industry and the ability of the main contractor, a key procurer of materials and manager of the build process, to affect the sustainability of the final asset. This research is case study based on unprecedented access to staff and key suppliers of a major UK main contractor, Carillion plc. The work is an holistic approach to sustainability, incorporating both social and environmental lifecycle thinking, sustainable supply chain theory, and the fields of stakeholder and collaborative working. Applying grounded theory methodology, four major themes emerge from this inductive research; fragmentation, the role of focal nodes, inter- and intra-company collaboration and knowledge of sustainability. Set within the context of a lifecycle perspective they define the ability of the main contractor to directly implement or influence sustainable build. The research develops theory uniting economic equity, network actor perspective and life stage impacts. The findings demonstrate that operating within current unsustainable business models the main contractor can only play a bit role. Additionally, it provides the basis for recommendations on business model, policy and process change.

Keywords: construction, sustainable supply network, holistic, fragmentation, collaboration, lifecycle

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Chapter 1. Introduction

This research, based on a single company case study and using a grounded theory approach, addresses a gap in knowledge; that of the apparent failure of main contractors to effectively leverage their focal position in the supply network to drive increased sustainability of buildings and infrastructure. In the UK construction sector, the management of components for large-scale projects has become dominated by major contractors, operating on behalf of clients to construct assets and manage project supply chains. Today, procured goods and services represent around 75% of a UK main contractor's annual turnover (Scholman, 1997, Carillion, 2017). Construction and the built environment have major impacts on multiple aspects of sustainability, as will be explored further in this introduction and discussed in much greater depth in Chapter 2, Indeed, the United Nations Environment Programme highlights the construction sector as a key area to address in terms of climate change (UNEP, 2009a), a position echoed by the recent IPCC report (UNEP, 2009a, IPCC, 2014). The industry also creates high levels of waste, with construction and demolition materials accounting for 59% of all UK waste in 2014 (DEFRA, 2018). There is also an increasing awareness of social issues embedded within construction supply chains and a greater focus on modern slavery has led to the construction sector being identified as a network where poor labour conditions and exploitation is likely to occur (Walk Free Foundation, 2016, ILO, 2017). Such issues are also being discovered in the UK and the government estimates that 3000 people currently exist in this illegal state, many of whom will be employed on construction sites or in the industry's UK supply base.

A recent report on the UK Carbon Budget identified that progress made in 'reducing emissions from homes over the first carbon budget period (2008-2012) had stalled and across public and commercial buildings has hardly begun' (Committee on Climate Change, 2017, p.69). The construction sector is seen to be falling behind the progress needed to ensure 80% carbon reduction in the built environment by 2050 (Ove Arup and Partners Ltd, The Climate Centre & WRAP, 2013). Repeated UK government reports (Latham, 1994, Egan, 1998) have recognised that meeting sustainability targets in the construction sector depends on sustainable supply chain networks (BIS, 2013a). Yet, there has been limited research on this topic within the UK (Adetunji, Price & and

Fleming, 2008, Dadhich et al., 2015). In particular, few studies have explored the ability of the secondary procurer, the main contractor, to utilise its focal role in the network to enhance the sustainability of UK built assets; in respect to both buildings and infrastructure (Green, S. D., Fernie & Weller, 2005, Fernie, Tennant, 2013).

To support the overarching enquiry into the apparent failure of UK main contractors to leverage their network position, highlighted at the start of this introduction, this work explores three research questions:

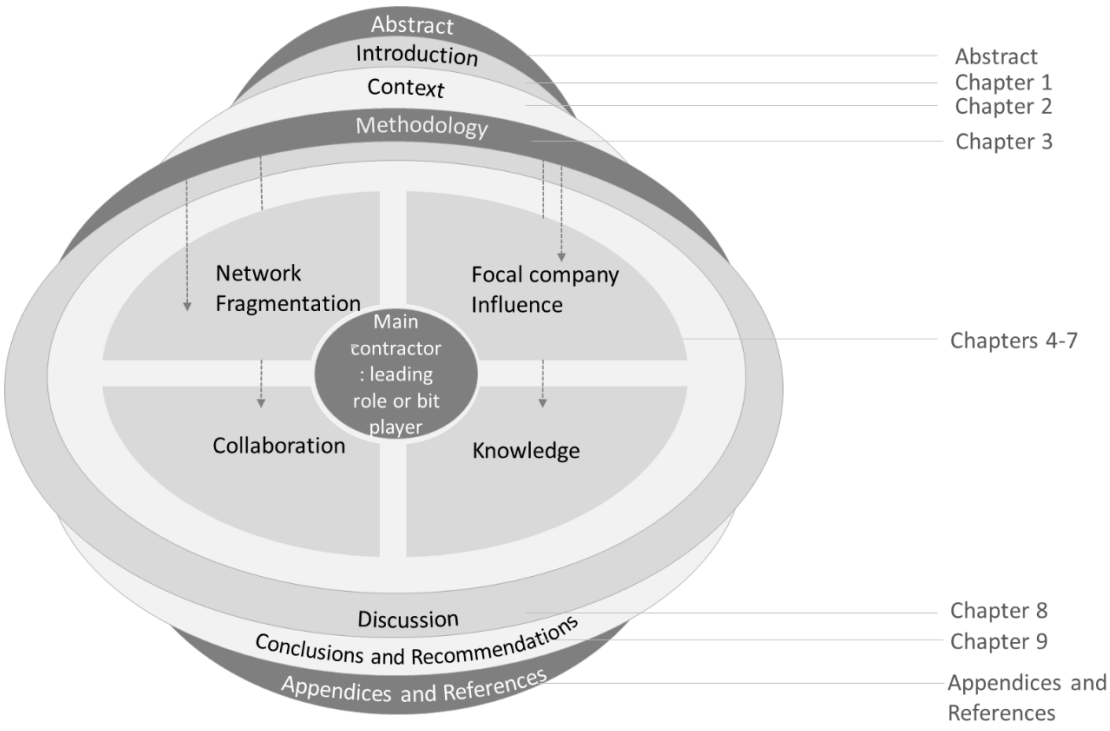
RQ1: What are the capabilities of the main contractor to manage the supply network?

RQ2: What is their ability to manage sustainability issues across the supply network?

RQ3: What is their capability to deliver sustainably built assets.

The structure of this thesis is shown in Figure 1. The research questions have guided the focus of the methodologies selected and the themes derived from the grounded theory research form the results chapters (chapters 4-7).

Figure 1: Thesis Structure



Findings relating to each theme are presented and compared to the existing literature, with new or corroborative observations discussed in chapter summaries. The context for these observations are provided in chapter 2 where literature, both academic and industrial, is critically assessed to offer an overview of the UK construction sector; and, the life stage impacts of construction and supply chains. Additionally, it reviews the terms and definitions associated with sustainability and procurement, identifying those adopted for this research. The methodology underpinning the research is presented in chapter 3, where coding, categories and themes are drawn from multiple sources of data. Within each 'theme' chapter links to the methodology are provided. A discussion, aligned with the research questions and related findings, occurs in chapter 8. The final chapter provides a conclusion and a reflection on the limitations and bias inherent in a single company case study. Additionally, it draws on issues discussed in chapter 8 to offer recommendations to industry, areas for future policy development and opportunities for further research.

The remainder of this introduction outlines, in greater depth, the context for this research and the sustainability challenges that are associated with the sector, and more specifically its supply networks. This will engage the reader with the primary topics covered in chapter 2 and provide an initial insight into the nature of the construction sector. A summary of the methodology adopted to support the investigation of the research question is provided and finally the introduction ends with an overview of the main research findings, as set out in chapters 4-7.

1.1 The construction sector

Globally, the value of construction output is estimated to grow by 85% to 15.5 trillion USD by 2030 (Oxford Economics, 2015), driven by increased building of housing stock and infrastructure (Lucintel, 2017). In 2012 buildings accounted for 18.4% of the world's direct and indirect energy-related CO_2 emissions (Edenhofer et al., 2014) and analysis of material flows, in 1995, identified that approximately 40-50% of the total annual flow of raw materials in the global economy were used in the manufacture of building products and components (Roodman, Lenssen & Peterson, 1995, Anink, 1996). To satisfy this

demand, globally sourced materials flow across supply networks[1] to form the constituent elements of built assets[2] and embodied within them are social and environmental impacts. The construction process consumes high levels of labour, land and materials such as aggregates, metals, plastics, cement, water and energy contained in the many thousands of products used for construction (UNEP, 2014). Extraction of raw materials frequently occurs in areas of high biodiversity and can adversely change habitats at a local and regional scale (Murguía, Bringezu & Schaldach, 2016). Mineral extraction also impacts local communities and at its most extreme can fuel violence and conflict (Maystad et al., 2014). As materials flow downstream through the supply network, transport to processing and construction sites consumes fuel and labour. Extensive extraction and processing of natural resources generates high levels of waste and is associated with many negative social impacts. These include damage to health caused by water pollution and air borne particles and the contamination of soils and watercourses affecting food production (ELAW, 2010). In the EU, construction materials form around 25% - 30% of waste by volume (European Commission, 2016); globally this is approximately 40% (UNEP, 2014). Research also highlights that inefficiencies within the UK construction supply network lead to 10–30% of resources being wasted as "unused product", including 800,000 tons of shaped and sawn timber (WRAP, 2007). Increasingly, these transient environmental inputs or wastes created during manufacture are described as being embodied within the asset. Research on embodied content is most highly developed for carbon emissions, with limited work on other environmental issues or social impacts.

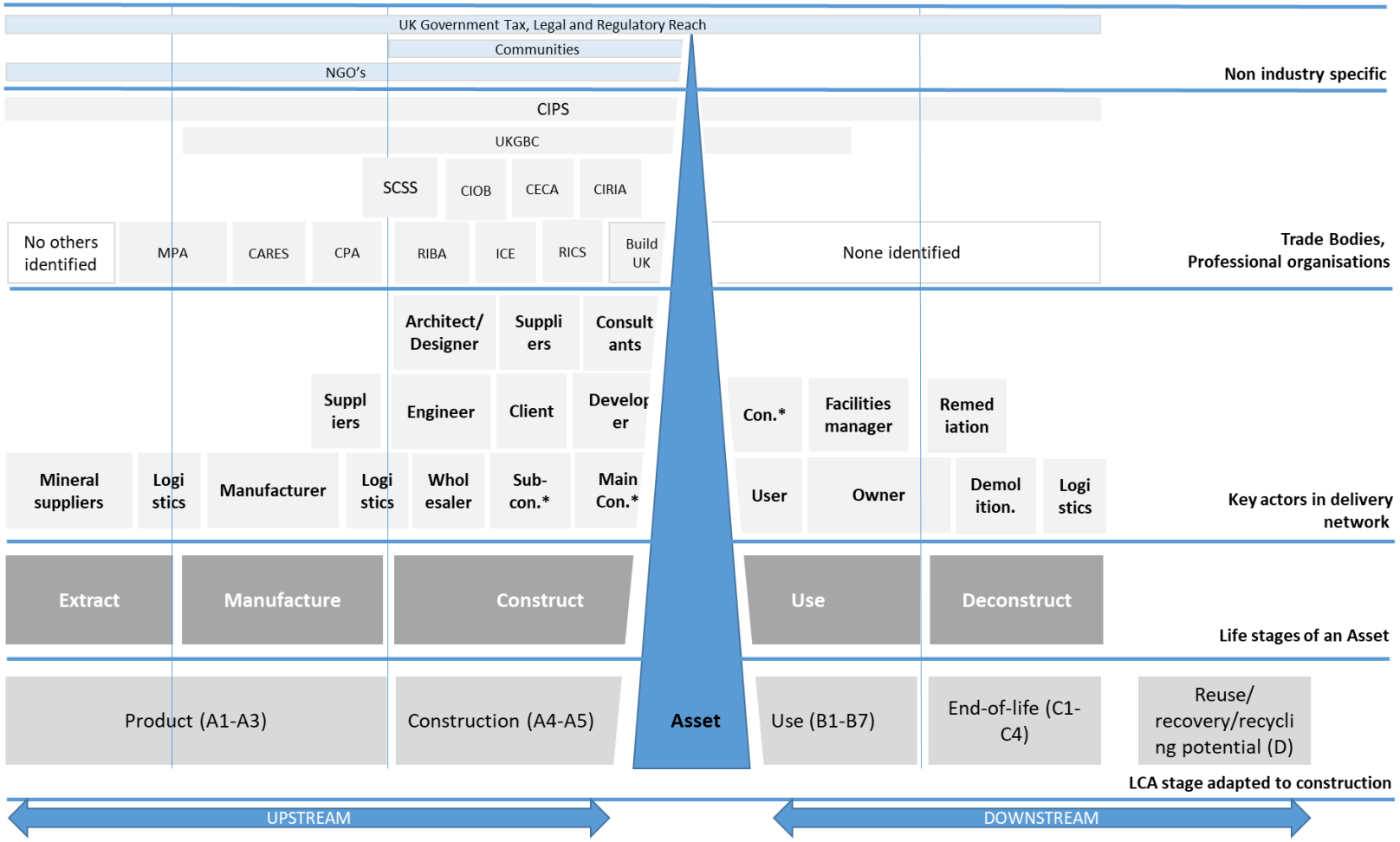
The UK construction industry has been dominated over the last 30 years by the development of subcontracting, driven by market forces and leading to work allocated primarily through competitive tendering. The resulting construction networks have

[1] The complex supplier base operating within the construction sector, across multiple products, has the characteristic of a network rather than a simple chain. This research concurs with this approach, although small projects may operate at a supply chain level. Network describes all organisations engaged in the construction of a built asset.

[2] This term is used throughout this thesis to describe the constructed asset such as a building and road, rail or other infrastructure

been characterised as ‘hollowed out conglomerates’ (Green, S., 2009, p.34) or ‘temporary multiple organisations’, created to respond to bespoke client requirements requiring the involvement of many value-adding organisations (Cherns, Bryant, 1984). As a result, the sector forms a complex supply structure: a ‘network of organisations that are involved, through upstream and downstream linkages’ (Christopher, M., 2011, p.13). Figure 2 identifies these network actors and places them within the life-stages of a built asset, visualised in this figure as a stylised image of a skyscraper, at the point they fulfil their primary function. Taking a broad network approach this representation also includes organisations which may not be directly involved with the supply process, but which have been identified as contributing participants, such as NGOs, Government bodies and trade organisations. Whilst useful, this figure has limitations, in that it presents a simplified linear representation of network actors, it also does not attempt to include repeated stages of refurbishment during the use life stage of the asset. This diagram and its constituent parts are examined in chapter 4.

Figure 2: Simplified representation of the Inter-company supply network identified by Carillion team members



*- Abbreviation 'con' in Figure 2 represents contractor

Operating at the centre of the network, main contractors ('Main Con.' in the figure above) act as project managers for clients, drawing together all the skills, services and materials required to create a physical asset. It is their role to procure goods and services, albeit to a pre-ordained plan, and with increased build complexity they become highly reliant on subcontractors. Client requirements for flexibility of supply has created a fragmented supply network in which relationships, especially between clients and main contractors, and main contractors and sub-contractors are highly competitive and frequently adversarial (Korczynski, 1996, Akintoye, McIntosh & Fitzgerald, 2000), as suppliers are driven by lowest price and legal disputes are common. This creates tensions between network actors, a position which conflicts with the general perception of academics (Fawcett, Magnum, 2002) and the UK government (UK Government, 2011) that the effective management of supply chains is largely synonymous with collaborative forms of working. Indeed, research into sustainable supply chain management (SSCM) identifies collaboration as a powerful tool for facilitating sustainability initiatives (Vurro, Russo & Perrrini, 2009).

Within the construction supply network Glass notes that contractors and designers are considered to have the most influence in the selection of products used in the construction of a built asset (Glass, Achour, Parry et al., 2011a) and to co-ordinate the construction process and network relationships (Pryke, 2012). On this basis there is an expectation that they should play a leading role in managing the supply chain management to achieve sustainable build, but this does not appear to be the case (Glass, Achour, Parry et al., 2011a). This research examines what prevents main contractors from taking on this leading role. It considers their ability and capacity to lead sustainability and what freedom they have to act within the constraints provided by the complex construction network. By taking a case study approach it focuses on the construction supply network and sustainable build[3] from the perspective of a main contractor.

[3] In the context of this thesis a sustainable build minimises negative impacts, or in some cases provides positive benefits, to environmental, social and economic issues at each stage of the built asset life cycle.

Carillion was recognised within the industry for its sustainability credentials, publishing its first environmental report in 1997 and winning Price Waterhouse-Cooper's Building Public Trust award for Sustainability reporting in three consecutive years (2013-2015). It was the second largest UK main contractor, with a turnover of £5.2bn in 2016 (Carillion plc, 2017a), and with an annual international procurement spend of 3.4 billion pounds sterling (Carillion, 2017). Carillion worked with over 8000 accredited first-tier suppliers and many thousands more in second and third tiers[4]. Thus, integration with Carillion offered an opportunity to directly observe how sustainability was incorporated into the operations of a commercial company.

Initial scoping discussions with senior Carillion sustainability team members identified a company that aspired to 'lead the way' on sustainability within the sector. At the time of the research, Carillion primarily implemented sustainability actions that were inwardly focused, on areas over which the company had direct control, i.e. the construction site, company estate and staff; a position reflected in Carillion's annual sustainability report (Carillion plc, 2016a). However, its role as a main contractor placed it at a focal procurement point within an extensive construction supply network, and it managed the thousands of materials and service suppliers required to construct buildings and infrastructure for multiple clients. Demand to expand sustainability approaches to the supply network were limited but they had been given increased impetus by the Modern Slavery Act, which set legislative requirements on supplier engagement, and a rising requirement within infrastructure to consider embodied carbon.

Within the company there appeared to be limited understanding about where sustainability impacts occurred across the life cycle of a built asset and little strategic focus on how the company could be most effective in supporting sustainability at a network level. This was exemplified by Carillion's long-standing commitment to Forest

[4] 'Tier' represents the position of a supplier in relation to the company being examined. In the context of this research a Tier 1 supplier represents a company that has a direct contract with the procuring company. A supplier who provide the Tier 1 company with goods or services relating to this contract would be described as Tier 2. Within the construction sector the project-based nature of industry leads to many companies consecutively operating at multiple tiers within a main contractor's supply network.

Stewardship Council (FSC) timber. However, this supply chain initiative remained isolated, failing to result in wider procurement development. In addition, there continued to be limited strategic engagement on sustainability with suppliers and more unexpectedly, with internal procurement teams. A perception of corporate impotence emerged, with sustainability practitioners feeling constrained by limited impetus within Carillion's supply chain teams to affect sustainability. Superficially this was surprising: research by Chegut et al (2011) identified that by 2008 6% of commercial new build in the UK was BREEAM[5] rated. Growth in built assets constructed to a green building standard has also been recorded globally (Holtermans, Kok, 2018) and a recent survey by the World Green Building Council noted that 47% of respondents anticipated that by 2021 60% of the construction they commissioned or managed would be 'green' (WGBC, 2018). This growth has been underpinned by legislation, which supported both environmental issues and social concerns, such as the Modern Slavery Act (UK Government, 2015b). Additionally, there was extensive information available on sustainable materials and sustainable procurement (CPA, 2012, CIPS, 2015d, Nicholson et al., 2017), all supported by a plethora of standards (BSI, 2017b, BREEAM, 2015, BSI, 2010) to help improve outcomes. This gap between corporate sustainability aspirations and implementation by Carillion's Supply Chain team, will be explored within the context of Carillion's focal network role. In the following paragraphs the research methodology adopted is outlined (a full justification and detailed presentation is provided in chapter 4).

The initial scoping observations identified above, indicated that analysis would require a social research approach. These observations provided, what Glaser and Strauss in their work on social research methods described as a partial framework of 'local' concepts which highlight some of the principal features for research (Glaser, Strauss, 2008). An analysis of social research methodologies was undertaken, to acquire an

[5] BREEAM is the world's leading sustainability assessment method for master planning projects, infrastructure and buildings. It recognises and reflects the value in higher performing assets across the built environment lifecycle, from new construction to in-use and refurbishment. BREEAM does this through third party certification of the assessment of an asset's environmental, social and economic sustainability performance, using standards developed by BRE (BRE, 2019).

understanding of the multiple approaches utilised (Gilbert, Stoneman, 2016), which then developed into more specific reading on grounded theory (Glaser, 1998, Strauss, Corbin, 1998, Charmaz, 2014). This led to the adoption of an inductive research methodology to support emerging 'grounded' theory (Glaser, Strauss, 2008). However, it should be noted that the embedded position of the doctoral practitioner within Carillion necessarily meant that the research approach is more reflective of Charmaz's interpretation of grounded theory, which 'recognizes mutual creation of knowledge by the viewer and the viewed' (Charmaz, 2003). Indeed, this research is most aligned with the epistemological stance of subjectivism, accepting that knowledge is always value-laden (Levers, 2013). Furthermore, it takes a pragmatist view, one in which Strauss was fully engaged, which considers that theories and concepts are best considered in terms of their usefulness rather than their truthfulness (Bryant, 2009). By focusing attention on the research problem pragmatism supports 'pluralistic approaches to derive knowledge' and 'opens the door to multiple methods, different worldviews, and different assumptions, as well as different forms of data collection and analysis' (Creswell, 2017). As a consequence, this research has adopted a mixed method approach using semi-structured interviews, observation, workshop outcomes, online surveys and systematic literature reviews of network actor publications.

Data was collected within the period May 2015 to June 2017. Information emerged from multiple teams within Carillion and external stakeholders, including suppliers, industry fora, company meetings and industry stakeholder groups. In keeping with a pragmatist approach, company, industry and academic literature providing context has itself also been considered as data, primarily that which indicates industry views, processes or sector knowledge. This has been followed by continued theoretical sampling, with data being analysed, new samples selected, further data collected and so on in an iterative process. All notes and transcriptions were coded, and reviewed using an online capture system, MAXQDA.

1.2 Overview of research themes

Through the systematic analysis of the coding noted above, abstract categories were created and continually re-appraised and amended until four key themes emerged;

network fragmentation, focal company influence, collaboration and knowledge. These themes, derived from the perceptions of Carillion supply chain practitioners, suppliers, supported by company procurement analysis and industry information offer new insights. All four themes contribute to the three research questions being considered by this work and thus underpin the discussion presented in chapter 8. The following sections (1.2.1 – 1.2.4) provide an overview of the research findings, which are explored in detail in chapters 4-7.

1.2.1 Fragmentation

The research findings presented in chapter 4 reaffirm the fragmented nature of this sector. However, emerging from this analysis is a greater understanding of the underlying characteristics of fragmentation that are shaping the industry's response to sustainability. The complexity of a non-continuous workload has led to a dynamic complex supply network rather than a sector operating through linear supply chains. Indeed, it appears as a continually shifting network of multiple sub-networks, supporting the hypothesis of Fernandez-Solis (2008) that the sector is potentially a meta-industry; a conglomerate of industries. Numerous Government reports (Latham, 1994, Egan, 1998, UK Government, 2018b) have highlighted the importance of industry collaboration in reducing industry fragmentation, which has been identified as a barrier to innovation and change. Yet, fragmentation is not a wholly negative position. It offers clients, including Government, a low cost and flexible supply network. Indeed, the flexibility required to operate multiple, contiguous yet short-term projects, each producing a unique built asset, has developed main contractor expertise in managing complex, time-pressured and high-risk operations. It has also shaped main contractor structure. The research identified that Carillion were operating not so much as a single company, but as an internal network of complex and often conflicted specialist teams, a microcosm of the wider construction supply network. For sustainability, in an environment where the client base, especially for buildings, is equally fragmented and primarily focused on short-term time horizons, there was little apparent client demand to view new developments through the lens of sustainability. Only infrastructure, operating within longer-term procurement frameworks and a stable public or regulated client base was beginning to consider the whole-life sustainability of a built asset.

Fragmentation was also reflected by a multiplicity of company sustainability goals and KPIs, which are identified in chapter 4, section 4.3. Driven by multiple drivers such as regulation, client demand, global reporting standards, marketing positioning and the position of the network actor within the supply network there appeared to be no strategic attempt to adopt a systems-based network-wide approach to sustainability. This fragmentation affects the main contractor's ability to manage or lead multiple complex networks. Only Government and a small number of NGOs, including the Supply Chain Sustainability School, had the breadth of vision to take a more holistic view. There is little support for this approach from traditional industry bodies, such as the Chartered Institute of Procurement and Supply who currently focus on generic procurement issues, and Build UK, the contractors trade body, who fail to provide any sustainability guidance. Technology to support knowledge development was also fragmented, with systems such as finance packages, site records and a supplier database, developing as stand-alone management tools. There was little capacity within the technology for flexible cross network sharing of information. Finally, the literature and industry practitioners identify sustainability itself as a complex and often fragmented issue, both in practice and within a narrow academic focus. Sustainable construction has developed its own language, data, experts and silos which have grown as new knowledge has emerged. This creates barriers to implementation and effective decision making, further complicated by competing, commercially focused standards organisations vying for market share in a growing reporting and implementation market.

1.2.2 Focal nodes

The literature identifies two focal nodes operating within the construction network, the main contractor and the client. Main contractors, positioned at a central point within the construction process, are highlighted in the literature (Glass, Achour, Parry et al., 2011b) as the most able to affect sustainable or responsible procurement. However, at the wider construction network level specifications for the built asset were initiated by the client and formalised in contracts and framework agreements which then flowed across the supplier network, primarily via the main contractor. The Carillion SC team did not believe there was a great demand from clients for green construction, with BREEAM identified as a box ticking exercise. They did identify a strong requirement for

construction to support social benefits but were sceptical that most clients were doing little more than meeting planning requirements. They felt only a tiny number of public sector clients were taking a more holistic approach to the built asset and beginning to implement whole life thinking or costing. Where this did exist within public sector clients Carillion Sustainability teams found that higher upfront costs for longer term future savings were unlikely to be adopted by them (see chapter 5, Section 5.2.3); LED lighting being one of the few exceptions (Carillion, 2015).

This research identifies that for Carillion procurement teams, the primacy of client specifications appears to outweigh the main contractor's own corporate sustainability objectives. In effect, if the client is not asking for product sustainability or a green building standard then it is not important. With such weak client demand the research suggests that the main contractor perceives few direct monetary benefits from sustainability actions, and this restricts the company's will or ability to be responsible for wider network sustainability goals. Sustainability is also frequently linked to innovation but with a strong focus by clients on low cost, perceived by the Carillion supply chain (SC) team as synonymous with 'best value', there was little impetus to try new products or processes, especially if this increased risk. This concern was exacerbated by the very low margins under which main contractors operate (Construction News, 2016).

1.2.3 Knowledge

The final theme, explored in chapter 7 of this thesis, is that of knowledge. This chapter considers existing sustainability knowledge within the SC team, how this was acquired and how it impacted on the contractor's ability to lead the sector. The analysis demonstrates that SC team knowledge acquisition was primarily experiential, driven by previous project experience. Whilst team members were aware of corporate sustainability goals, multiple personal perceptions of sustainable construction persisted. Professional bodies, who supported knowledge acquisition through professional development requirements, seemed to have little relevance to SC teams. Increased use of information technology had increased the gathering and transfer of information, although it was less clear that they supported the development of new knowledge.

Sustainability targets that the SC team incorporated within procurement processes did not support a more holistic understanding of the topic. They were based on disparate client demands for green building standards and the number of SMEs contracted, a long standing, embedded corporate commitment to FSC timber, and a practical need for suppliers to provide waste management. Rather than develop further SC team knowledge client requirements were sub contracted directly to contractors, product manufacturers and consultants. Sustainability was seen as complex, not core to delivery and required this engagement of experts, something the thesis argues created knowledge silos, primarily at a network actor level. Sub-contracting sustainability reduced the capacity of the main contractor to have the internal expertise necessary to initiate a leading position.

In the final chapters of the thesis the key research outcomes from chapters 4-7 are discussed within the context of the research question. Findings are considered taking a holistic approach, aligning the impact of a built asset with the supply network. In taking this approach, the researcher adopts a stance that performance of a supply network cannot be enhanced by focusing on isolated processes, rather it is contingent on interactions across the chain (Stevens, Johnson, 2016). Considered in the context of the whole supply network, in this study the main contractor demonstrated limited capacity to be a leading sustainability actor. Within the gap between corporate sustainability aspirations and implementation by the SC team, this grounded theory based research has identified several barriers previously unexplored in the literature.

- Supply Chain teams are driven by highly transactional client requirements. The client operates as the focal point within the network and has primacy over corporate sustainability goals.
- Main contractors do not know what they procure. Product variation and sub contacting of packages prevents the main contractor from having a strategic view of products purchased.
- Collaboration is transactional, identified as a supplier requirement, not a joint engagement.

- Failing to take a holistic view at a built asset level results in global sustainability targets that do not allow for multiple actor perspectives and impacts and may indeed divert network actors from focussing on issues they are most able to affect.
- Most environmental and social issues continue to be reviewed in isolation. There is no attempt to consider the trade-offs associated with product or construction decisions.

and several enablers of sustainability in the supply chain that have not included in the construction literature:

- When different actors within the network play complementary roles, as noted in FSC timber, sustainability can be increased.
- Product category management reduced direct commercial pressure in main contractor and supplier relationships and allowed experts to collaborate.
- Stakeholders traditionally seen outside the supply network, play an important role in facilitating cross network collaboration and supporting a whole-life perspective.

The final chapter reflects on the methodological approach undertaken during this research process and suggests further opportunities. The conclusion draws together the findings and makes recommendations, for both industry and policy makers, on the contribution this thesis offers to the implementation of supply network sustainability with the UK construction sector.

1.2.4 Collaboration

The role of collaboration, in supporting sustainability within the construction sector, has received little attention and in chapter 6 this research expands the understanding of how network actors perceive collaboration within this context. For Carillion supply chain staff, collaboration on sustainability issues primarily remained something that they demanded of suppliers and that might be required of them by clients. Whilst the literature suggests that sustainability is most effectively implemented through relational and non-contractual practices (chapter 6, Section 6.1.1) this sector's continued focus on

transaction led, risk-based contracting, limits the possibility of this occurring at a network scale. The research however did find examples of collaborative relationships beyond the boundaries of this case study firm. The most striking example of this was the FSC chain of custody approach which suggested collaboration was possible across multiple network actors when actors at the top and bottom of the 'chain' have agreed goals and complementary functions. Industry fora provided valuable knowledge development and exchange platforms, but only added value if the knowledge developed could be incorporated into operational practice. Examples of person-level collaboration were also observed where trust had been built and this also offered opportunities for collaboration to support local and often ad hoc sustainability interventions.

Of all the examples that emerged from the research only category management[6] offered the basis for a main contractor to lead collaborative working. Category managers, as industry experts, did not manage supplier's commercial contracts but did advise the Carillion SC team on 'preferred-supplier' status. This removed a major adversarial issue from supplier and client relationships. The category manager role was identified as an asset for some clients and their designers, as they could benefit from a relatively impartial view of the category sector and product selection. There was not, at the time of this research, any major strategic engagement by category managers with sustainability issues but the approach could be adapted to incorporate this function.

[6] Defined as a strategic approach which organises procurement resources to focus on specific areas of spends. This enables category managers to focus their time and conduct in depth market analysis to fully leverage their procurement decisions on behalf of the whole organisation (CIPS, 2018a).

Chapter 2. Context

This chapter identifies the current state of academic and industry knowledge on the environmental, social and economic impacts of construction, the role of the supply chain in supporting the sustainability of built assets and the structure of the UK construction industry. It is intended to provide background context to the research topic. Literature more specifically relevant to the inductively derived themes; fragmentation, focal nodes, collaboration and knowledge (presented in chapters 4-7), is considered within each chapter and compared to the research findings.

The UK Government, a key participant in the sector, which acts legislator, regulator, policy maker and key client, defines the construction sector as the

> 'production and supply of construction materials and products; building services manufacturers, providers and installers; contractors, subcontractors, professionals, advisors and construction clients; and organisations relevant to the design, build, operation and refurbishment of civil engineering works and buildings' (UK Government, 2006, p. 9)

In other words, the UK Government envisages the sector to be comprised of organisations directly involved, on a commercial basis, in the construction of a built asset. Globally, construction is identified with major environmental, social and economic impacts, and whilst the sector has increasingly demonstrated sustainable practices there is still a failure to undertake the construction of a built asset, and its subsequent operation and deconstruction, on a sustainable whole life basis. Considering an asset through the lens of life cycle thinking is complex, with each stage of an asset's construction reflecting a fragmented set of network actors, environmental and social standards and academic literature itself. Reports and strategies purporting to represent sustainable construction frequently have a major focus on environmental issues, with environmental impact categories and measurement being more developed and accepted; especially those relating to waste, climate change and CO_2 emissions. Categorising and presenting social impacts are less well defined. This is perhaps not surprising as the measurement of social impacts and their standardisation is at an early stage of development. Hence, many Social Life Cycle Assessment (sLCA) methodologies currently consider potential midpoint impacts such as fair wages or standard of

education, rather than the final endpoint, that of human wellbeing, which is recommended by Ciroth and Eisfeldt (2015). There is also a divide between technical experts, who work with Life Cycle Assessment impact categories that do not fit easily into the more prosaic and generic descriptions used by government and industry i.e. waste. How sustainability in the sector has been approached has also fluctuated with time, as exemplified by the UK Government's Strategy for Sustainable Construction Strategy (2008b), now superseded by the Construction 2025 Strategy (UK Government, 2013), part of the UK's Industrial Strategy (UK Government, 2017a). Sustainability remains as part of the vision statement but is primarily focused on low carbon and green construction (BIS, 2013a).

2.1. The importance of construction: the global impacts

The worldwide construction industry is a driver of economic growth. Growth is linked to economic development supported by rising middle classes, increasing populations and a move to greater urbanisation. The industry offers improved housing, provides infrastructure, creates buildings offering social good such as schools and hospitals and provides employment for many skilled, and unskilled workers (Oxford Economics, 2015). However, as noted in the introduction, the sector also creates negative social impacts with modern slavery, and poor labour conditions frequently found embedded within construction supply chains, (Walk Free Foundation, 2016, ILO, 2017). Continued building also demands the consumption of high levels of raw materials including water and energy which in turn generate high levels of waste. In the EU construction materials form around 25% - 30% of waste by volume (European Commission, 2016) and globally buildings account for 19% of the world's energy-related CO_2 emissions. The latter has led construction to be identified by the United Nations Environment Programme (UNEP) as a key area to address in terms of climate change, a position echoed by the most recent IPCC report (UNEP, 2009a, IPCC, 2014). Data on the impacts of construction on global biodiversity are limited however, although modelling of EU biodiversity levels suggests that urbanisation, disturbance from infrastructure created fragmentation of landscapes and logging of forest areas will contribute to a decline in diversity (Verboom et al., 2007).

The Green Construction Board notes that despite improvements, the sector is falling behind the progress needed to ensure 80% carbon reduction in the built environment by 2050. In-use, or operational carbon has declined, which in turn is putting greater focus on capital or embodied carbon (Steele, Hurst & Giesekam, 2015) generated through the supply chain.

2.2. Adopting a lifecycle approach to identify impacts associated with a UK built asset

Sustainability has been likened to wicked (Rittel, Webber, 1973) or messy problems (Rittel, Webber, 1973, Ackoff, 1974), characterised by multiple and conflicting stakeholder perspectives, system uncertainties, ill-defined goals and a lack of objectively correct solutions. It is within this context, that life cycle thinking offers an approach to the whole product system life cycle, from the cradle to the grave, therefore ensuring that all impacts are considered, rather than just those within a more limited operational boundary. Life cycle thinking can apply at an individual product or service level, company, sector or extend to a country analysis. These different boundary levels suggest the application of a number of methodologies from Life Cycle Assessment (LCA), associated with the environmental management of a product or service (Clift, Wright, 2000) to the environmentally extended input-output analysis more suitable for city scale investigations (Dias et al., 2014).

Academic attention has also turned to the application of LCA techniques for social issues and a methodology, Social Life Cycle Assessment (sLCA) (Ciroth, Eisfeldt, 2015, Benoit-Norris, Cavan & Norris, 2012) is currently emerging field of research. There is discussion between LCA experts as to the validity of combining LCA, sLCA and lifecycle costing (LCC) to create an overarching Life Cycle Sustainability Assessment (LCSA); which it is believed may overcome fragmented approaches and support improved decision making. The UN have championed this approach (Ciroth et al., 2011) but it remains contested due to challenges between indicators and weighting issues and the trade-off between validity and applicability. This in turn creates concerns about how to present such complex data in a format that is understandable to decision makers (Finkbeiner et al., 2010). Life cycle frameworks, such as those noted above, are not the only approaches available to practitioners. Environmental impact assessment, which considers the effects of

construction and as well as the post build phase is a requirement of UK planning legislation. However, it offers only a narrow view of the immediate site and fails to consider environmental resources and limits (Jay et al., 2007). Development of valuation approaches, ascribing monetary value to ecosystem services, has also provided another method for the analysis of environmental impacts. Natural capital accounting is being used by government (UK Government, 2018a) and increasingly the insurance sector, to highlight ecosystem value with decision making. It is noted in this review but has not been utilised within this research as its application is still evolving and there are continued ethical debates over putting a price on the environment.

In considering the life-cycle of a product or service several different life stages are reviewed. These have been codified within global standards such as EN15804:2012 (BSI, 2013), and Figure 3 presents the life stages in a format adapted by BRE to align with recognised construction phases (BRE, 2018). It also highlights the different Cradle to Gate and Cradle to Grave approaches utilised.

Figure 3: Product Category Rules for construction products EPD, an illustration of mandatory and optional elements and information modules adapted from EN 15804:2012+A1:2013(BRE, 2018)

	Life cycle stages	Product			Construction		Use stage							End-of-life				Benefits and loads beyond the system boundary
							Related to the building fabric					Related to the building operation						
	Modules	A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4	D
		Raw material supply	Transport	Manufacturing	Transport	Construction	Use	Maintenance	Repair	Replacement	Refurbishment	Operational energy use	Operational water use	Demolition	Transport	Waste processing	Disposal	Reuse/ Recovery/ Recycling potential
	Scenarios																	
Type of EPD	Gate[1]	M	M	M														
	Cradle to Gate with option(s)[2,4]	M	M	M	O	O	O	O	O	O	O	O	O	O	O	O	O	O
	Cradle to Grave[3,4]	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	O

Key M Mandatory O Optional

Notes [1] for a declared unit

[2] for a declared unit or functional unit

[3] for a functional unit

[4] Reference Service Life to be include only if all scenarios are included

Each life-cycle assessment provides information on a range of impacts but a wide variation in impact selection creates difficulty in both their comparative use and potential for decision making. To illustrate this point key approaches within the construction industry have been analysed and are presented in Figure 4. This offers a comparison between several relevant global publications, UK government strategies and LCA impact categories. The latter are represented by those utilised by BRE in the Product Category Rules (PCR) applied to their Environmental Product Declaration (EPD) format, a standardised LCA method use to quantify the environmental impact of a product, impacts utilised in environmental input-output analysis of the US construction sector (Kucukvar, Tatari, 2013) and social LCA impacts from one of the most developed approaches, PSICLA.

Figure 4: Analysis of public, academic and industry materials to illustrate the breadth of impacts utilised in reporting (UNEP, 2014, WBCSD, 2016, UK Government, 2006, UK Government, 2008b, Kucukvar, Tatari, 2013, BRE, 2018, Eisfeldt, 2016)

			Construction Specific							Generic
			Green	Sustainable	Sustainable	Sustainable	Generic	Sustainable	Green	Sustainable
Impact Type	Impact Description	Impact Category	European Publications		UK Government Strategy Documents			I-O and Hybrid LCA	eLCA	sLCA
			Greening the Building SC	The Business Case - LC Metrics	Review Sust. Con.	Strategy for Sust. Con. UK Gov 2008	Industrial Strategy: Con. 2025	Towards a triple bottom-line	BRE Global PCR's	Introducing PSILCA
			UNEP 2014	WBCSD 2016	UK Gov 2006	UK Gov 2008	UK Gov 2013	Kukavar 2013	BRE 2018	Eisfeldt 2016
Environmental Impacts	Biodiversity	Biodiversity				3				
	Land Use								3	
	eutrophication								3	
	CO2 emissions and Climate Change	CO2		3	3	3	3			
	Climate change and energy				3					
	CO2 emission									
	energy		3							
	carbon		3							
	greenhouse gas emissions			3						
	energy footprint							3		
	carbon footprint							3		
	Global warming								3	
	Raw Material Depletion	Materials							3	
	Minerals consumption									3
	Material use		3	3	3	3				
	ozone depletion								3	
	Biomass consumption									3
	ecological footprint							3		
	acidification	Pollution							3	
	emissions to air									
	photochemical oxidant creation								3	
	Toxicity								3	
	Pollution									3
	Waste	Waste	3		3	3	3		3	
	Water	Water	3	3	3	3				
	water footprint							3		
	Embodied water								3	
	Industrial water depletion									3
Economic Impacts	Corruption	Governance								3
	Anti-competitive behaviour/violation of anti-trust and monoply legislation									3
	Employment	Income			3					
	Reduced Cost						3			
	Income							3		
	Tax							3		
	Gross Operating Surplus (GOS)	National Wealth						3		
	Gross Domestic Product (GDP)							3		
	Increased Exports						3			
	Imports							3		
	Increased Productivity						3			
Social Impacts	Community	Community			3		3			
	Health and Safety	Health and Wellbeing			3					
	Wellbeing			3						
	Work Related injuries							3		
	Workers affected by natural disasters									3
	Health expenditure									3
	DALYs due to indoor and outdoor air and water pollution									3
	air quality - human health			3						
	Sanitation coverage									3
	Fair Salary	Human Rights								3
	Association and bargining rights									3
	Social security expenditures									3
	Indigenous rights									3
	International migrant workers (in the sector/site)	Modern Slavery								3
	trafficking in persons									3
	Skills	Skills			3		3			
	Illiteracy									3

The variation in impacts across different strategies, assessment methods and even within assessment method approaches restricts the ability of the construction sector to compare and benchmark best practise (Gervasio et al., 2018). Application within the industry is also made more complex as the impacts derived from eLCA's and sLCA's are perceived as 'technical' and require expert interpretation to support a decision-making process. This can create difficulties for practitioners who must apply the technical requirements of the process and yet be able to provide clients with a "scientific answer" that gives a "clear cut" result (Freidberg, 2015). Indeed, LCA practitioners may find themselves in a high trust role of 'quasi' decision maker when industry counterparts lack the time or knowledge to interpret results and want a simple answer. Indeed, this misalignment would suggest that Rex and Baumann's (2008, p. 428) proposal that practitioners should move from presenting a 'structural understanding to an interpretive perspective' is valid.

2.2.1 Environmental impacts in construction

2.2.1.1 Resource use

As noted in the introduction some 40-50% of annual raw material flow in the global economy is used in the manufacture of building products and components (Roodman, Lenssen & Peterson, 1995, Anink, 1996). Analysis of multiple construction material stocks (defined as an element in a system that can be measured e.g. built asset) and flows (the process of increasing or decreasing stocks) case studies, noted that most concurred that the accumulation of stocks was continuing, and that infrastructure was its major component (Augiseau, Barles, 2017). The UNEP Greening the Building Supply Chain report estimates that over 10,000 different materials are used in the construction and use phase of buildings (UNEP, 2014). Demand for construction minerals, such as rock, sand, gravel, clay, chalk/limestone, brick clay and gypsum, has expanded rapidly, increasing by 8.7Gt or 80% from 1980 to 2008. Growth has also been recorded in metals, wood and fossil energy and whilst the OECD does not allocate usage by sector they note the importance of aluminium, steel, iron and copper in the construction sector (OECD, 2013). Data for the volume and value of material use attributed to the UK construction sector in the UK is incomplete but two studies have suggested this was 330 million tonnes in 2008 and in 2012, it was 420 million tonnes, 62% of total UK materials usage

(EISC Ltd, 2012, DEFRA, 2015b). It is estimated that almost 90% of these construction materials, by weight, were aggregates and concrete products. By value, lighting products, plastic and timber are the most important material sectors. Furthermore, it is thought that around 6% of UK's energy is used in the production and transportation of construction materials (EISC Ltd, 2012)

Water, most often associated with the use phase of a building, is a major resource also consumed during the raw materials extraction, manufacturing and construction phases of buildings. There is extensive literature on water efficiency in buildings and data on operational use but far less on the full life-cycle of water use. Research has primarily been conducted into the embodied or pre-operational water for commercial and residential property and is much more limited in scope than that for energy and CO_2. Two studies of embodied water in Australia identified between 20.1 kl /m^2 of gross floor area (McCormack et al., 2007) and 54.1 kl/m^2 of constructed area in commercial properties, of which the greatest proportion (17%) was within the steel framework (Crawford, Treloar, 2005). Research in China and India, also on commercial properties, have found similar embodied usage of 20.83m^3 per m^2 of floor area (Meng et al., 2014) and 23.8895 kl/m^2 of floor area (Choudhuri, 2015).

Work by Crawford, using environmental input-output (EIO) analysis, on residential property found higher levels of pre-operational water and noted that this was equivalent to the entire operational use of water during an estimated lifetime of the property. Crawford estimates that only 0.7% of water associated with a building is used during its construction phase (Crawford, Treloar, 2005). An American triple bottom line EIO-LCA analysis identified that for the construction of non-residential and healthcare buildings only 1.7% of water was used in the construction phase whilst 28.8% was embodied in the Tier 1 suppliers and 69.5% in the Tier 2+ supply chain. They identified that nearly 80% of supply chain related water use was from sectors such as, electric power generation, transmission, and distribution, paint and coating manufacturing, grain farming, and stone mining and quarrying (Kucukvar, Tatari, 2013). In the UK, Balfour Beatty, using a tool based on a methodology created by the Water Footprint Network, assessed direct and indirect water usage during the Heathrow Terminal 2B

development. Their findings indicated that 2.7% of the water could be attributed to the construction phase and the balance was embodied in materials, most notably steel, quarried materials and cement (WRAP, 2012). This work highlights the importance of water embodied within the supply chain, an area that has received little industry attention.

2.2.1.2 Waste - physical materials

As noted above material additions to the built environment are considered as additions to the stock of the construction industry. The addition to the stocks in the UK in 2008 was calculated as 275 million tonnes, but to achieve this over 420 million tonnes of material resources were required, of which only 360 million were transformed into products, the balance becoming waste, mainly quarry waste (Smith, Kersey & Griffiths, 2003). In 2014 the UK generated 55.0 million tonnes of non-hazardous construction and demolition (C&D) waste, of which 49.4 million tonnes (89.9%) was reused, recycled or otherwise diverted from landfill. However, construction waste (including dredging) represents 59% of all UK hazardous waste produced (105700 Tonnes) in 2012 (DEFRA, 2015a).

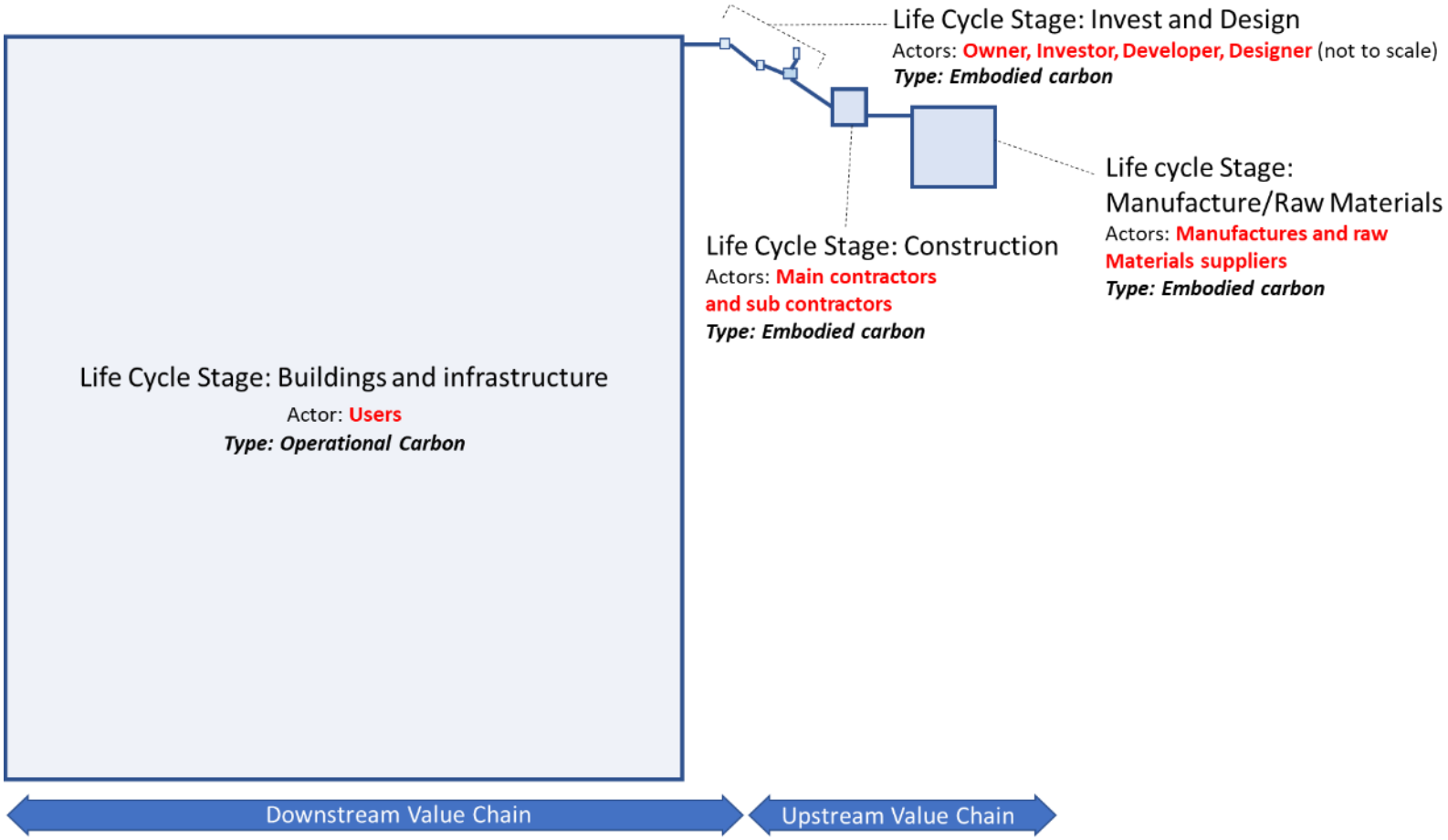
2.2.1.3 Waste - CO_2

In the recent Fifth Assessment Report of the Intergovernmental Panel on Climate Change it was noted that 117 Exajoules (EJ) or 32% of global final energy consumption and 19% of energy-related CO_2 emissions were generated from buildings. This equated to 51% of global electricity consumption being associated with buildings (IPCC, 2014). The direct emissions of CO_2 from the building sector (excluding the emissions from electricity use) has been estimated globally at about 3 $GtCO_2$, 0.4 $GtCO_2$-eq CH_4, 0.1 $GtCO_2$-eq N_2O and 1.5 $GtCO_2$-eq halocarbons (including CFCs and HCFCs) (Levine et al., 2007). The greatest use of energy in buildings is during their in-use phase, with Levine et al. (2007) estimating this to be around 80% of total life cycle energy whilst the construction operation itself consumes 15-20% of energy. As an EIO-LCA of the US construction sector noted, less than 40% of the total energy footprint could be attributed to direct or on-site construction activities. Furthermore, when assessing CO_2 emissions based on the Greenhouse Gas Protocol accounting standards scope 1-3

reporting (WRI, WBCSD, 2004), they identified that key scope 3 supply chain emissions were generated by electric power generation, transmission, and distribution, cement manufacturing, truck transportation, petroleum refineries, iron and steel mills and ferro alloy manufacturing, and oil and gas extraction (Kucukvar, Tatari, 2013).

Identifying the emissions from the different life stages for UK built assets continues to be difficult and highly specific to building type, use and life span selected. A report by the UK Government (BIS, 2010a) suggested that 80% of emissions were from the in-use phase, 15% embodied in the materials used and only 1% derived from the construction of the building. These figures were based on ONS Environmental Accounts, National Inventory or CRF, DECC data and industry sources. Acquaye and Duffy (2010) in their review of the Irish construction sector identified just 1% of CO_2 emissions were generated during construction, and of these sub sector: structural works emitted the highest proportion of CO_2. A further UK publication by the UK Innovation and Growth Team expanded this data and estimated 0.4% of CO_2 emissions were derived from the design phase, 15.1% from manufacturing, 0.9% transport of construction material, just 0.9% construction whilst 82.3% was from the operational or in-use phase, and only 0.4% are related to demolition (BIS, 2010b). A report by The Green Construction Board in 2013 produced similar findings with 18% CO_2 attributable to capital or embodied carbon of direct process emissions and indirect emissions from the manufacture and production of UK and imported construction materials and products, emissions from the transport of materials, emissions associated with professional services in support of construction, and all C&D work on site (Ove Arup and Partners Ltd, The Climate Centre & WRAP, 2013).

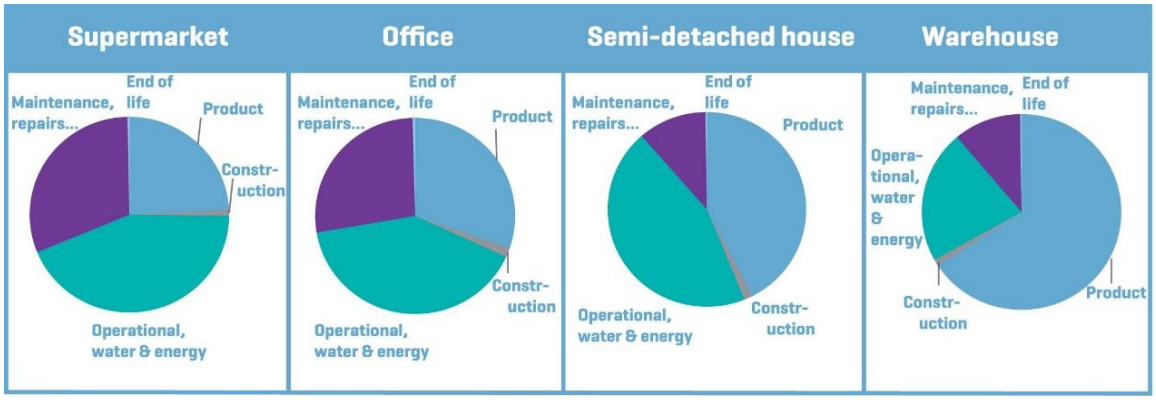
Figure 5: The percentage of carbon in UK built environment by lifecycle stage, 2010 (Diagram, to scale, from data provided by Green Construction Board 'Routemap', (Ove Arup and Partners Ltd, The Climate Centre & WRAP, 2013))



The analysis also identified that domestic and industrial operational activity generated 79.6% of CO_2 and the balance of 21.4% was derived from operational infrastructure. The latter included emissions from water/wastewater, outdoor lighting and construction and demolition (C&D) waste treatment but excluded emissions from use of infrastructure by vehicles. The baseline was developed from UK emissions data 1990-2010 (Arup, The Climate Centre and WRAP 2013) and is represented visually in Figure 5.

Whilst information at a sector level provides a general indication of emissions, industry is increasingly looking to understand this by building type. Studies using Life Cycle Analysis (LCA) and hybrid EIO-LCA are available but comparisons prove complex as there is not only variation in where boundaries are set, or the type of emissions measured, e.g. energy or CO_2, the quality of the data sets used, but also in the length of life attributed to buildings and the effect of country/site conditions. In his review of embodied carbon research, Ibn Mohammed noted that building life span ranged from 25-100 years, and that results showed significant variation between countries (Ibn-Mohammed et al., 2013). The difficulties this variation presents can be seen for example even where one type of building, an office block, is selected. Based on academic research a large office block in Thailand demonstrated 19% of energy was embodied (Kofoworola, Gheewala, 2009), another office block in Canada identified 14% (Cole, Kernan, 1996), whilst a smaller office unit in the UK had 25% embodied carbon (Eaton, Amato, 1998). More recent work by the Royal Institute of Chartered Surveyors (RICS) (Figure 6), using building regulation requirements, suggests that embodied carbon will continue to play an increasingly significant role in the whole life of the building. Whilst this may vary considerably by building type, they identify at least 50% of the carbon associated with buildings over a 30 year lifespan, is embodied (RICS, 2014).

Figure 6: Relative Impact of the consequent life cycle stages on the overall carbon footprint for different types of buildings, calculated over 30 years (the energy results have been based on the building regulations) (RICS, 2014).



Further granularity of emissions has been mapped by Aitkins, a global design, engineering and project management consultancy, by considering over 50 different building types. This has provided a benchmark which suggests the majority of major buildings constructed have between 500-1500 kg CO_2e/m^2 (RICS, 2014). This work, although associated with a high degree of uncertainty, has been derived from their commercial emissions database. Assumptions relating to different phases continue to be challenged as exemplified in a recent report by Innovate UK which notes that in a sample of 100 UK buildings CO_2 emissions were underestimated during the in-use phase by a magnitude of 3.6 (Innovate UK, 2015, Palmer, Armitage, 2014).

Due to climate change concerns most literature relating to the lifecycle impacts of buildings tends to focus on the main greenhouse gas emission: carbon dioxide. However, other embodied gases have also been assessed using an LCA approach, including studies which consider their impact on air quality. Of the three emissions most associated with air quality issues, PM_{10}, SO_2 and NOx, the latter two were primarily emitted at the operational phase of building (approximately 70-80%), whilst around 80% of PM_{10} was embodied in the built asset. However, the results for embodied PM_{10} may be lower as emissions during use phase were not included in the research (Bilec, Ries & Matthews, 2010). It was estimated that approximately 5kg of PM_{10} was emitted per m^2 of building whilst SO_2 was around $24kg/m^2$. Increasing the number of studies would provide more

accurate data and benchmarks and could support more effective targeting of air quality policies.

2.2.2. Social impacts of UK construction

Social LCA approaches have yet to be applied to the UK construction sector and indeed only one paper testing this approach in the construction industry was identified, by Hosseinijou, Mansour and Shirazi (2014). Their work focused on the Iranian building sector and identified the social impacts relating to material selection and evaluated the application of UNEP Guidelines for Social Life Cycle Assessment of Products (UNEP, 2009b). However, most of the data relating to the social impacts within construction are focused on impacts local to the construction site. This includes the industry's ability to provide UK employment and on-site health and safety. Engagement with social issues beyond UK regulatory borders or post construction user wellbeing have been minimal.

The UK construction sector provides positive social impact within the UK economy, employing around 2 million people, which represented approximately 6.2% of UK employment in 2015 (Rhodes, 2015). There are over 300,000 small and medium sized companies working directly in the sector (UKCG, 2009) and more benefit indirectly through products and services required to construct buildings and then in their operation, maintenance and demolition. In 2016 more people were working and more companies operating in the sector than prior to the recession of 2008. Indeed, increased demand for labour and an ageing workforce have resulted in greater employment opportunities than the market can supply. Skills shortages were identified by 62% of UK construction companies in Quarter three 2017 (RICS, 2017). The UK industry also offers high standards of health and safety for its workers, driven by the Health and Safety at Work etc Act (1974) and more specifically the Construction (Design and Management) Regulations (2015a), which are specific to construction activity. The UK consistently has one of the lowest rates of fatal injury across the EU with its standardised rate, at 0.51 per 100,000 employees in 2015, being one of the lowest of all European countries (HSE, 2018). Whilst main contractors are responsible for the health and safety of all staff on-site, including supplier labour, there remains an acknowledged tension between health and safety and productivity (Sherratt, 2016). For the first time, with the introduction of

the Modern Slavery Act (2015b), all UK construction firms became legally responsible for ensuring fair labour within their supply chains; beyond the limits of the construction site. They were required to demonstrate they were working to ensure forced labour did not exist within their global supply chains. Data on slavery is problematic, but in 2016 it was estimated that globally 45.8m people were working under conditions of modern slavery, of which 18% worked within construction (ILO, Walk Free Foundation, 2017). This includes the UK construction sector (UK Government, 2017b) with 12.5% of those reporting slavery issues to the Unseen charity helpline in 2017, being construction workers (Unseen UK, 2017). Whilst recent cases have highlighted forced labour of British born individuals, many slavery issues appear to be linked to migrant workers. Indeed, forced labour is most likely to be associated with greater informality of employment (Tutt et al., 2011), which in turn increases the likelihood of illegal migrant labour and enhances the potential for modern slavery.

2.2.3. Economic impacts of UK construction

Within the UK's industrial strategy, the construction industry is identified as major enabling sector; one highly susceptible to societal change and influenced by regulation. Globally construction, renovation, and maintenance of buildings is a major contributor to countries' Gross Domestic Product (GDP); between 10% to 40% and represents on average 10% of country-level employment (UNEP, 2009a). This is similar in the UK where the construction industry created £99.27 bn of value for the economy in 2016 and accounts for 6.5% of the country's gross value added (ONS, 2017). Spatially this value was reasonably evenly spread across the country, as growth in the sector tends to occur locally to the people it serves (UK Government, 2017a). However, the sector frequently goes through cycles of "boom and bust" and in 2016, the sector also saw one of the highest sector business failures (ONS, 2017). In 2018 the industry was hit by the collapse of the second largest main contractor Carillion plc, and with two large contractors going into administration in early 2019 (BBC News, 2019, Davies, 2019).

The industry annually procures over 380 million tonnes of resources (Hobbs, 2008) of which a high proportion of materials and services are derived from UK sources. These primarily include aggregates, machinery, real estate, architectural and technology

consultancies, plastic, wood, metal and mined products (UKCG, 2009). In 2007, calculated on purchase price, the value of UK procured construction products or services was estimated to be £27.8bn. However, many higher value items are globally sourced, leading to a UK trade deficit of £9.09bn in 2016 (ONS, 2017). In 2013 BIS (UK Government Department of Business, Innovation and Skills) estimated that the supply chain accounted for £124bn of intermediate consumption, almost all of which was sourced in the UK (BIS, 2013a). UKCG extend their estimate of construction value into the supply chain stating that for every £1 spent on construction a further £1.09 of indirect impact is created through greater output and income in the supply chain and £0.74 of induced impact results from increased household spending due to employment (UKCG, 2009).

However, there is history of large construction companies requiring extended credit terms and work by University College London (UCL) for BIS found that Tier 1 construction firms (main contractors) 'take much more trade credit[7] from their suppliers as a proportion of their balance sheet than do firms elsewhere in the economy'. Tier 1 firms were found to be net receivers of trade credit whereas Tier 2 firms (sub-contractors, manufacturers or other suppliers) were found to be large net providers of trade credit (Ive, Murray, 2013). It is also noted that the industry is highly wasteful, with UK government estimates suggesting that improved management of materials in the UK construction sector could save circa £3.0bn per annum (Oakdene Hollins, 2011).

2.3 The importance of construction supply chains in delivering sustainability

For most large-scale projects, main contractors purchase most of their products, services and labour requirements externally to their business. This equates to around 75% of their turnover and consequentially they are increasingly reliant on their supply chain to deliver a built asset (Scholman, 1997). It is for this reason that the research has focused on the supply chain as the medium through which sustainable built assets are delivered. The construction sector has a highly complex and multi-tiered supply base with the main contractor operating as the focal point for the construction of a built

[7] Trade credit is provided by suppliers when they allow purchasers to defer payment for goods and services.

asset. Companies in the construction sector operate in a highly fragmented supply network which creates major challenges in taking a whole life approach to construction, and in creating shared goals.

Academic research on sustainable construction supply chains is limited. An analysis of Scopus in 2016, using the search criteria 'sustainable supply chain construction, created a list of 283 entries, of which only 8 papers directly related to the topic with only 2 incorporating the words 'sustainable supply chains construction' in their titles. Additionally, there were several papers related to greening, or green construction supply chains and a more specific search using these terms elicited 113 entries of which 11 were directly focused on the topic of supply chains. Industry documents also highlighted a major UNEP report 'Greening the Building Supply Chain' (UNEP, 2014) and various publications relating to the Olympic Games 2012 and the Crossrail project. Another term that has only recently begun to appear in the literature is responsible sourcing which has greater affinity with ethical procurement and incorporates elements of the supply chain. It is represented in the UK by the BES6001 standard (BRE Global Ltd, 2008). Development of construction sustainable supply chains thinking appears to have drawn on existing research, much of which is derived from the retail and manufacture sectors, and for which there is considerable disagreement on the transferability of these models to construction (Green, S. D., Fernie & Weller, 2005). The demand for greater understanding of how supply chains can deliver sustainable structures is identified as a UK sector wide issue, and one that has been identified by government (E.C Harris LLP, 2013), academics (Adetunji I., Price A.D.F. & Fleming P., 2008a, Dallasega, Rauch, 2017) and industry organisations (Upstill-Goddard et al., 2015).

2.3.1 The development of supply chains; an overview

The concept of supply chains has been considered within scientific literature since the 19th century but as a field of study it has only recently become important. From 1981 to 1984 only 8 academic papers were published with 'supply chain' in their title, but by 2009-2012 this had increased to 16100 (Ullrich, 2014). There are many definitions of supply chain but two appear to encapsulate a broad approach. One, created in 1992, stated that it comprised of 'upstream and downstream linkages, in the different

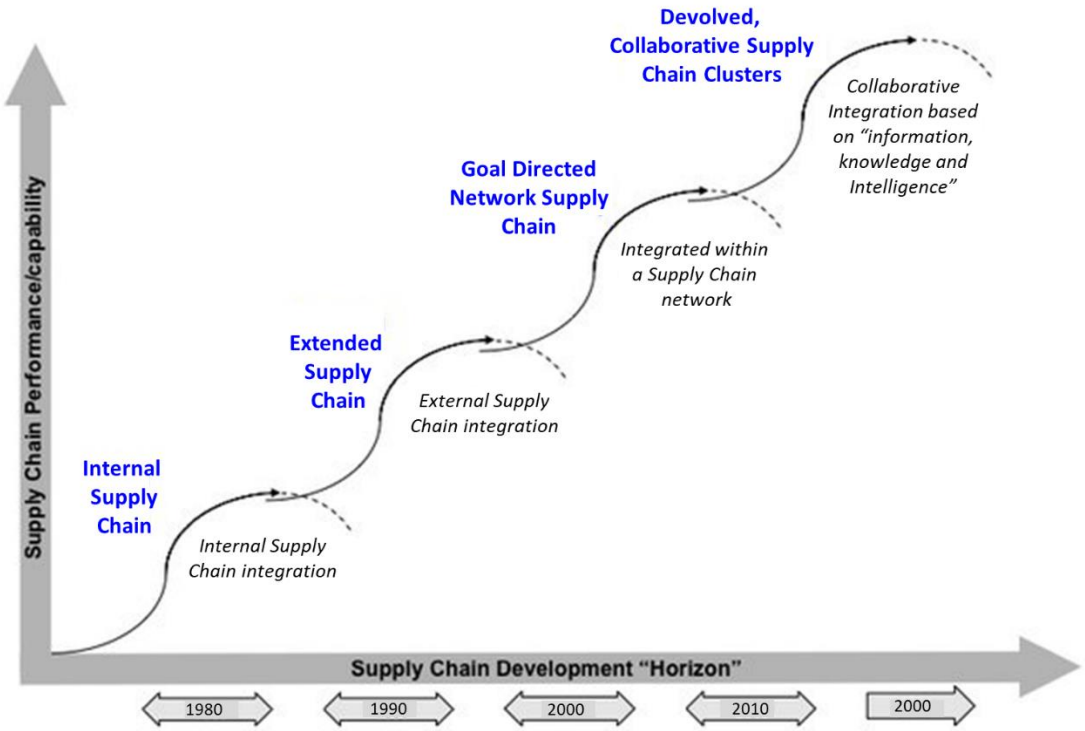
processes and activities that produce value in the form of products and services in the hands of the ultimate consumers' (Christopher, M., 1992, p. 17) and then further expanded by Chopra and Meindl (2013):

> 'A supply chain consists of all parties involved, directly or indirectly, in fulfilling a customer request. The supply chain includes not only the manufacturer and suppliers, but also transporters, warehouses, retailers and even customers themselves. Within each organization, such as a manufacturer, the supply chain includes all functions involved in receiving and filling a customer request. These functions include, but are not limited, new product development, marketing, operations, distribution, finance and customer service' (Chopra, Meindl, 2013, p. 13).

Much of the increased interest in this sphere of research has been due to the changing nature of business. Initially large corporates were operating at a national scale and competing with similarly structured businesses. However, the business profile has now changed with a greater move to competitive global supply chains generally comprised of specialist smaller operating units (Handfield, Nichols, 1999, Christopher, Martin, Ryals, 1999). This development has been driven by external forces such as greater access to new economies such as the Eastern Block in Europe, China, Brazil and India, and scientific and technological progress facilitated by cheap, rapid communication through the internet (Ullrich 2014). Researchers have also argued that changes within business also arose from a need for companies to be more flexible and adaptable. Two theories to account for these developments have been expounded. That of 'core competency' which envisages companies specialising in core business and outsourcing inefficient activities (Prahalad, Hamel, 1990), and 'transaction cost'. The latter assumes that bureaucracy grows with company size and at a certain point smaller collaborating specialists could become more competitive (Williamson, 1991, Williamson, 2008). Increasingly the term supply chain, indicating a linear sequence of physical flows between companies, has become a less relevant structure to define complex, global, independent companies operating in an inter-organisational grouping (Choi, Dooley & Rungthusanstham, 2001, Bastl et al., 2012). This structure is more effectively described as a supplier network. Procuring companies often dual or multiple source products or services, and suppliers may be operating at both Tier 1 and Tier 2/3 levels

simultaneously, functioning as a network rather than a linear supply chain. Stevens and Johnson developed this concept of a network further by stating that companies are undergoing a process of development with supply chains and networks continuing to evolve. They suggested that company's moved through four stages of growth, that of internal integration, externally focused extended supply chains, goal direct network supply chains and finally developed collaborative supply chain clusters (see Figure 7) (Stevens, Johnson, 2016).

Figure 7: Development of the supply chain network (Stevens, Johnson, 2016, p. 16)



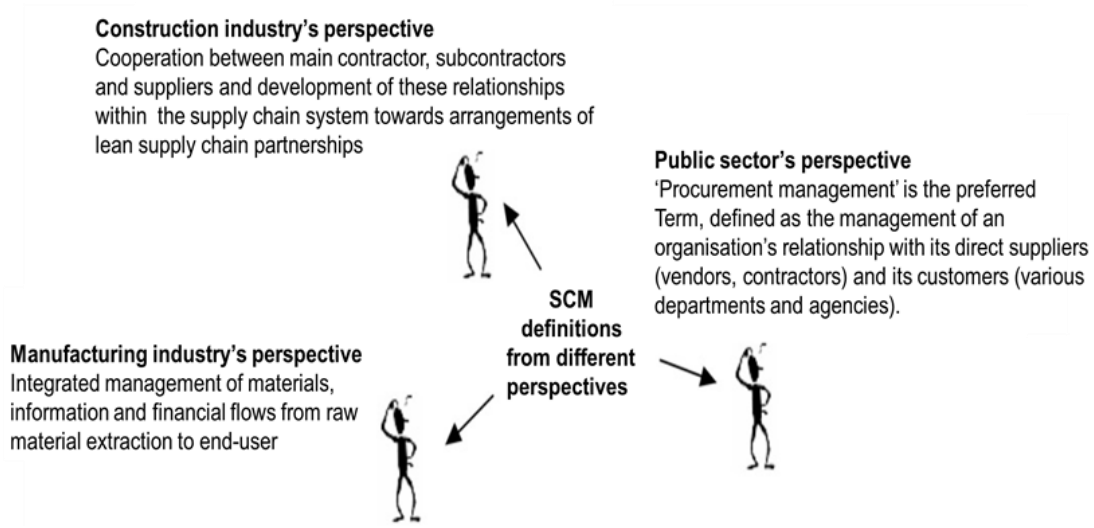
2.3.2. Supply chain management and sustainable supply chain management

Closely linked to the developing research on supply chains has been supply chain management (SCM). The term has been used to define the management of the intra-company supply chain, represented either by a dyadic relationship between two organisations; the inter-company supply chain from source to customer, or the management of a network of interconnected businesses (Harland, 1996). An early definition in this field is that of Mentzer et al who stated it was

> 'the systemic, strategic coordination of the traditional business functions and the tactics across these business functions within a particular company and across businesses within the supply chain, for the purposes of improving the long-term performance of the individual companies and the supply chain as a whole' (Mentzer et al., 2001, p. 16).

However, there are multiple definitions of supply chain management, with the term having different meaning to different people (Skitmore, Smyth, 2009). The concept of supply chain management began to develop in the early 1980s with manufacture and retailers being early adopters (Akintoye, McIntosh & Fitzgerald, 2000). As with definitions relating to the supply chain and sustainable procurement, the construction industry struggled to adopt that of supply chain management. It was observed by Adetunji, Price and Fleming (2008b) that different sectors of the supply chain appeared to have their own perceptions of the terms (see Figure 8) the client in this instance being represented by the public sector.

Figure 8: SCM definitions from 3 perspectives (Adetunji I., Price A.D.F. & Fleming P., 2008b, p. 164)



Fernie and Tennant (2013) have noted that whilst indeed supply chain terminology has been taken on by the industry, their research would indicate that this is disconnected from the holistic management of chains or networks. Rather, it has been adopted as a description of partnering or a collaborative relationship between two organisations. Tennant and Fernie (2011a) suggest, that based on the Lockamy III and McCormack

supply chain maturity model (Table 1), larger construction companies have moved beyond the ad hoc level and are operating with some structures in place but with little change in traditional working practice (level 2). They identified that a few larger organisations were beginning to work strategically, building collaboration and trust (Level3).

Table 1: Adapted from the Lockamy III and McCormack (2004, p. 275) supply chain maturity model by Tennant and Fernie (2011a)

Maturity Stage	Description
Stage 1 - Ad-hoc:	An unstructured and ill-defined approach to supply chain management. If the term supply chain management is employed, it is highly likely in response to management practice witnessed elsewhere and in this context represents mere tokenism.
Stage 2 - Defined:	Whilst the implementation supply chain management has structure and key supply chain facilitators are in place, working practices remain largely unchallenged and resolutely traditional.
Stage 3 - Linked:	Supply chain management takes on a strategic orientation, focusing on business objectives and customer satisfaction. Collaboration between supply chain stakeholders begins to cultivate an atmosphere of trust and 'budding' team spirit.
Stage 4 - Integrated:	Supply chain management principles become embedded in the commercial process, over-riding traditional practices in favour of greater inter-dependency and commercial solidarity. Corporate investment in supply chain management principles begin to benefit from increasing levels of efficiency and effectiveness.
Stage 5 - Extended:	Supply chains compete against other supply chains. Asset specificity is likely to be high and commercial interests are inextricably extended to the success of the collective supply chain participants.

They conclude from structured interviews with the construction companies that the translation of supply chain management theory and practise from other sectors has been 'problematic, patchy and largely unsuccessful' (Fernie, Tennant, 2013).

The theory underpinning supply chain theory is considered to be still developing, and currently has only limited engagement with organisation theory and a need for improved rigour in methodology (De Beuckelaer, Wagner, 2012). It is also suggested that there is a failure to relate theory development to the context of practice (Fernandez-Solis, 2008). Fernie and Tennant (2013) argue that within the construction sector the lack of theoretical underpinning, supply chain rhetoric and a 'disparity between stakeholders with institutional power to …….explore change and others who possess

the power to diffuse widespread sustainable change' (Fernie, Tennant, 2013, p. 1038) has resulted in limited clarity in the development of construction supply chain management (SCM). This failure to adopt an effective management of the construction supply chain is identified as a major barrier to adoption of more efficient practice (Egan, 1998).

Where government, customers or other stakeholder groups, and more recently industry peers, create the demand or pressure to incorporate sustainability issues into supply chains, companies have been required to respond (Sharfman, Ellington & Meo, 1997, Seuring, Müller, 2008, Hassini, Surti & Searcy, 2012, Xie, 2016) and an extension of SCM has arisen; that of sustainable supply chain management (SSCM). In attempting to define SSCM Hassini, Surti, et al (2012) draw on a wide literature review and from this attempt to unify SCM and sustainability stating it is

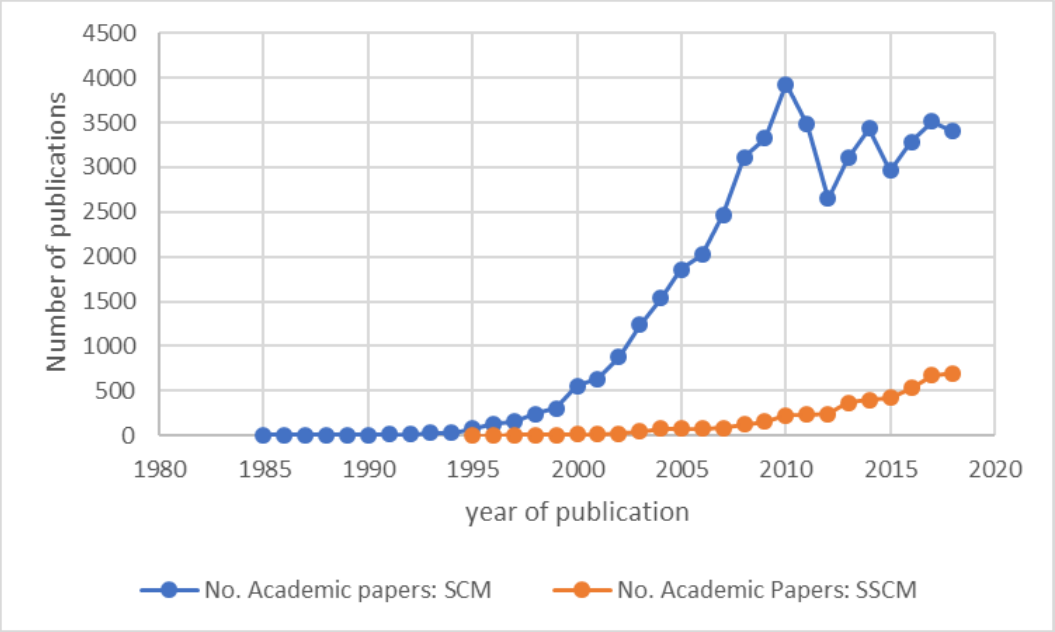
> 'the management of supply chain operations, resources, information, and funds in order to maximize the supply chain profitability while at the same time minimizing the environmental impacts and maximizing the social well-being' (Hassini, Surti & Searcy, 2012, p. 70).

Yet, as with SCM, the definition of SSCM remains contested and it has proven difficult, due to the complex nature of supply chains, to create a global definition that will apply to all sectors (Pullman, Maloni & Carter, 2009). It is also a field in which only limited theory exists (Sarkis, Zhu & Lai, 2011, Carter, Liane Easton, 2011). It is stated that holistic approaches to SSCM reflecting economic, environmental and social issues are relatively rare in the literature (Seuring, Muller, 2008a). They also note that SSCM focuses on a win-win approach rather than managing trade-offs. Initially it was envisaged that focal companies, and those managing sustainable supply chains, would 'cascade environmentalism through the industrial ecosystem' (Holt, 2004, p. 72), although this rarely appears to occur (Gold, Seuring & Beske, 2010a). Patel and Desai (2018) identify 29 barriers to implementation within the literature and according to Beske and Seuring (2014) the most critical are; a weak understanding of the process, poor training, failure to adapt 'borrowed' SSCM practice, traditional mindsets, and limited top management commitment. Despite more than a decade of work companies still appear to struggle to implement SSCM effectively (Hassini, Surti & Searcy, 2012). Several researchers also noted that there is evidence suggesting there is little benefit to the company from the

adoption of SCM, Green SCM or SSCM (Beske, Land & Seuring, 2014, Hassini, Surti & Searcy, 2012). Others suggested this was not particularly a failing of SSCM but the need for companies to more effectively monitor and manage barriers preventing the effective implementation of the process (Hassini, Surti & Searcy, 2012, Ahi, Searcy, 2015).

The academic development of the field has continued to expand with work on the role of inter-organisational resources (Gold, Seuring & Beske, 2010a), the identification of decision-support tools and performance measurement (Taticchi et al., 2015), and the development of a new field; that of world class sustainable supply chain management (WCSSCM) (Dubey et al., 2017). However, SSCM still remains a less well-developed area of research than SCM. To illustrate this a review of SCM and SSCM papers in Scopus was undertaken using each term (see Figure 9).

Figure 9: Comparative scale of academic research between SCM and SSCM (Scopus search Nov. 2018)



This included a systematic literature review of SSCM in 2018 which identified just four papers that included references to the construction sector (Patel, Desai, 2018).

Much of the research into supply chain management has focused on reaching optimal solutions or best practice, yet researchers suggest this failed to understand the effect of

people and their behaviour (Tokar, 2010, Schorsch, Wallenburg & Wieland, 2017). Traditionally, SCM had focused at the inter-organisational level (Gligor, Holcomb, 2013) rather than on the individual relationships that operate within multi-level systems (Carter, Meschnig & Kaufmann, 2015). Indeed, there is evidence that cultural differences have a significant impact on trust and business interactions within the context of a supply chain (Ribbink, Grimm, 2014). Schorsch et al (2017) note that individual perceptions, values and beliefs emerge from individuals into group culture at the team, firm and network levels; a not dissimilar depiction to organizational culture which is described as a pattern of 'shared values and beliefs' (Deshpande, Webster Jr, 1989). Encapsulated within a further field of supply chain research, behavioural supply chain management (BSCM) is also the important role of social bonds. These are defined as 'investments of time and energy that produce positive inter-personal relationships between actors' (Ramström, 2008) which support enhanced boundary spanning communication (Gligor, Autry, 2012). This approach, BSCM, is an area of developing research (Schorsch, Wallenburg & Wieland, 2017) and one which could address issues of construction industry fragmentation. A search of Scopus and Google Scholar databases in October 2018 identified no construction sector focused papers addressing BSCM.

2.3.3. Defining sustainability within the context of construction procurement

Industry uses a variety of definitions when addressing sustainability within a business context. Whilst in academic writing and at a governance or policy level many of these phrases have specific designations, those same phrases when used in industry often acquire more generic and interchangeable meanings. Supply chains are primarily referred to as 'sustainable' or 'green'. Sustainability in the construction sector is most strongly associated with corporate social responsibility (CSR) and social issues, rather than that of environment or economy. Green supply chains primarily, although not exclusively, look at environmental issues and have been particularly strongly associated with Climate Change strategies, energy efficiency and CO_2 reduction, a recent example being the "Greening the Building Supply Chain" (UNEP, 2014). Sitting within the supply chain framework are several additional phrases such as sustainable procurement, ethical procurement, responsible procurement or ethical sourcing and responsible

sourcing. Some practitioners also note that for smaller businesses “buying” is probably a more accurate description of the purchasing process. At a corporate level, corporate social responsibility (CSR), sustainability and sustainable development are used to supplement more traditional financial reporting structures.

To ensure clarity of purpose and to facilitate discussion during this research it was important to select the terms that would frame the research discussions and to agree a standard definition for each term selected. This research did not undertake an exhaustive search of all relevant supply chain and procurement terms but rather focused on those most applicable to the scope of the study. To achieve this, it was decided to review the terminology used by organisations that were identified by Carillion SC team and the corporate sustainability team as most relevant to the industry sector (Table 2). At a global level construction is a key research sector for the United Nations Environmental programme and Carillion became a signatory to the UN Global Compact in 2017. The UN is generally seen as high status, relatively impartial and provides a level of peer review in its materials. The European Union (EU) has an important role in terms of setting strategic goals and creating policy leading to legislation, research and innovation funding. Environmental and social issues are a key area of concern to EU members and guidance is offered on sustainable construction and procurement. The UK Government is also frequently quoted in UK construction literature, especially the work of the Sustainable Procurement Task Force and their report “Securing the Future”. The UK Government does not currently have a strategic focus on a broad range of sustainability issues but rather improved efficiency through the supply chain and a reduction in CO_2 emissions (BIS, 2013a). Its chairing role in the Green Construction Board and its importance as a client for Carillion warrant its inclusion in this review. Three major UK construction bodies were also considered for the review; CIRIA, BRE (formerly the Building Research Establishment) and the UK Green Building Council (UKGBC). Additionally, given the importance of green asset assessment methods such as LEED, BREEAM, or environmental and social standards such as ISO, and BSI these were also included. Following interviews with Carillion’s UK procurement teams it became clear that guidance from the Chartered Institute of Purchasing and Supply (CIPS) was important to the Carillion senior procurement team and thus was included in the review.

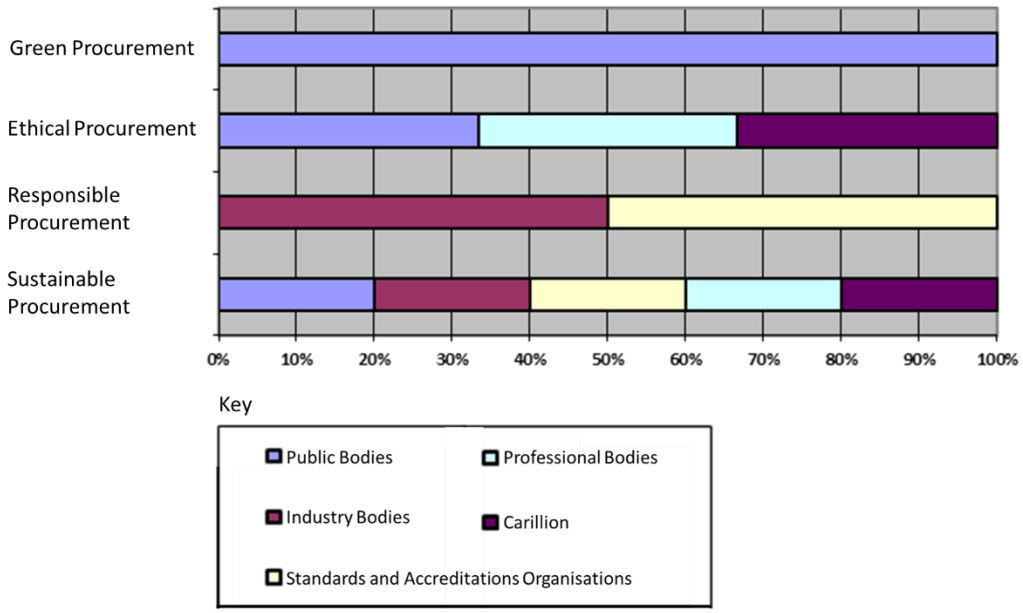
Finally, academic literature was considered, not to support the selection of the terms most relevant to the industry but to provide additional perspective when definitions were considered.

Table 2: Stakeholders selected for review of key terms and definitions

Public Bodies	Industry Bodies	Standards and Accreditation Organisations	Professional Body	Other
The United Nations (inc. Global Compact and Environment)	CIRIA	LEED	Institute of Packaging and Supply (CIPS)	Carillion
The European Commission (inc. DG Environment)	Building Research Establishment (BRE)	BREEAM		Academic Research
UK Government	Green Building Council (UKGBC)	British Standard		
		Global Reporting Initiative (GRI)		

Searches for terms and definitions were carried out on-line and the findings are based on website content or documents available via organisations websites. Not all terms were available from each organisation and this provided an interesting insight into the use and prevalence of the terms (Figure 10). Sustainable procurement was the most widely used terminology.

Figure 10: Procurement terms used by organisation type



In reviewing material relating to sustainable procurement it also became clear that multiple descriptions of the 'purchasing process' were being used. It would appear sensible to ensure that these different terms are also clearly defined. To achieve this, and mindful of the importance of professional body status of CIPS to the Carillion Supply Chain team, the definitions used by CIPS are utilised.

Procurement describes all those processes concerned with developing and implementing strategies to manage an organisation's spend portfolio in such a way as to contribute to the organisation's overall goals and to maximise the value released and/or minimise the total cost of ownership (CIPS, 2015a). Purchasing describes all those transactional processes concerned with acquiring goods and services, including payment of invoices. It is a narrower term than procurement, describing reactive, tactical processes (CIPS, 2015b). Sourcing describes all those activities within the procurement process concerned with identifying and evaluating potential suppliers, engaging with selected suppliers and selecting the best value supplier(s). The phrase 'strategic sourcing' may be used to describe the application of the sourcing process to significant acquisitions, or the team that manages the sourcing process on behalf of the organisation (CIPS, 2015c). For the purposes of the following definitions, procurement, purchasing and sourcing were accepted as having the same general purpose.

2.3.3.1 Definitions of sustainable procurement

Carillion provided two definitions for sustainable procurement; firstly, adapting a Forum for the Future definition they state it is 'the process of acquiring goods and services that: meet user's needs; deliver long term value for money, maximise social and economic benefits and minimise damage to the environment and health' (Carillion plc, 2014b). In internal sustainable procurement training materials they used an alternative framing: 'Using procurement to support wider social, economic and environmental objectives, in ways that offer real long-term benefits', a phrase adapted from a statement by a previous chairman Sir Neville Simms in his role as Chairman of the Sustainable Procurement Task Force (DEFRA, 2006, Carillion plc, 2014b). The first definition, and one most widely promoted, failed to acknowledge the importance of sustainable procurement in delivering benefits beyond the immediate supply network. The second places procurement at the heart of enhanced benefits but does not have a fully holistic approach. The UN Global compact developed this further noting

> 'Sustainable Procurement practices integrate requirements, specifications and criteria namely by seeking resource efficiency, improving the quality of products and services and ultimately optimizing costs' (United Nations, 2009).

This has been expanded by the United Nations Environmental Programme who define sustainable procurement as

> 'a process whereby organisations meet their needs for goods, services, works and utilities in a way that achieves value for money on a whole life basis in terms of generating benefits not only to the organisation, but also to society and the economy, whilst minimising damage to the environment' (UNEP, 2015).

The UN Global Compact would suggest that this needs to go further and suggest actions must be 'compatible and in favour of the protection of the environment, of social progress and in support of economic development'. They also note the importance of sustainable procurement in that

> 'Through the development of procurement criteria that support sustainability principles, requisitioners and procurers can send strong signals to the market in favour of goods and services that promote sustainability. The key international organizations already increasingly recognise public procurement as a means of changing the unsustainable patterns of consumption and production' (United Nations, 2009).

These types of approaches have been further adapted by professional bodies such as, the Chartered Institute of Packaging and Supply (CIPS), where they recommend that the impact of environmental, economic and social factors should be considered along with price and quality and they highlight the importance of the relationship with suppliers, including contract negotiation especially when sourcing globally with unfamiliar work cultures (CIPS, 2015a). Most recently, the International Organisations for Standards, has developed a Sustainable procurement standard, ISO 20400. Here, they use the simple definition:

> 'Procurement that has the most positive environmental, social and economic impacts possible over the entire lifecycle' (ISO, 2017)

For the purposes of this research, the UNEP definition of 2015, with its focus on whole life value, will be adopted. Further discussions of sustainable procurement within this thesis will reference this statement.

2.3.3.2 Definition of responsible procurement/sourcing

Carillion did not provide any written definition of this term but used it within their FSC Timber policy. The term has been gaining momentum since the middle of the last decade when the UK Government adopted the setting up of a responsible sourcing standard as a deliverable of their Strategy for Sustainable Construction. They noted that

> 'A Responsible Sourcing Scheme is a documented set of criteria setting out the obligations of an organization in managing the supply of construction products in accordance with a set of agreed principles of sustainability' (BIS, 2008, p. 12)

A new standard to support this government aim, BES6001 for Responsible Sourcing, was launched by BRE in 2008 (BRE Global Ltd, 2008). To date 88 companies have achieved BES6001, for multiple products, and in some sectors such as concrete are now able to offer certification for 92% of all UK sales by volume. Loughborough University have been closely involved with the development of responsible sourcing within the UK construction sector, working closely with BRE and other industry bodies and they suggest that responsible sourcing is 'the management of sustainability issues associated with materials in the construction supply-chain, often from an ethical perspective' (Glass, Achour, Parry et al., 2011a). During the research process this work adopted the Glass et al. definition of responsible sourcing. Glass (2014) also notes that key products

such as metals and concrete are now being incorporated into responsible sourcing frameworks by the Ethical Trading Initiative and the International Council on Mining and Metals. However, responsible sourcing terminology is not considered by all organisations to differ from existing frameworks, indeed CIRIA suggest that responsible sourcing or procurement is synonymous with sustainable procurement (Berry, McCarthy, 2011).

2.3.3.3 Definitions of ethical procurement/sourcing

Definitions of ethical procurement often appear synonymous or interchangeable with responsible sourcing. Internal guidance by Carillion to their supply chain team suggested that 'ethical sourcing' was synonymous with

> 'responsible sourcing; also referred to as supply chain responsibility. It is a voluntary commitment by companies to take into account social and environmental considerations when managing their relationships with suppliers' (Carillion plc, 2014b).

They also closely associated it with a code of ethics or Ethical Business Practices, highlighted in internal training as 'Ethics is about doing the right thing, complying with the law and our values, acting honestly and following the rules' (Carillion plc, 2014b). The most comprehensive definition provided by the stakeholders reviewed was that of CIPS. Their guidance suggested that

> 'Ethics involves distinguishing between what is right and wrong behaviour by an individual or organisation. Typical principles are that staff must perform their duties impartially, personal interest should not affect professional decisions, information should not be used to gain financial advantage for themselves and staff should maintain the highest standard of integrity in all business relationships' (CIPS, 2015d).

They also provide members with a Code of Ethics, an extensive document, that focused specifically on guidance to those in procurement (Alder, Gooch, 2013). It has a very strong bias towards social ethics and there is only a minor mention of any ethical consideration for environmental issues. The UN takes similar approach with its guidance to procurement teams (United Nations, 2017) whilst the ETI Base Code (ETI, 2014) and the UK government in their Ethical Procurement Policy Statement focus solely on social considerations (DEFRA, 2011) (see Table 3).

Table 3: Analysis of the ethical principles of the Global Compact, ETI Base Code and the Manifesto for Ethical Sourcing in Construction (Sisco et al., 2015), (ETI, 2014), (McClelland et al., 2015)

Global Compact - The Ten Principles Relationship to Supply Chain	ETI Base Code	Manifesto for Ethical Sourcing in Construction
Human Rights		
Principle 1: Businesses should support and respect the protection of internationally proclaimed human rights; and		
Principle 2: make sure that they are not complicit in human rights abuses.		
Labour		
Principle 3: Businesses should uphold the freedom of association and the effective recognition of the right to collective	2. Freedom of association and the right to collective bargaining are respected	
Principle 4: the elimination of all forms of forced and compulsory labour	1. Employment is freely chosen	
Principle 5: the effective abolition of child labour and	4. Child labour shall not be used	
Principle 6: the elimination of discrimination in respect of employment and occupation	7. No discrimination is practised	
	3. Working conditions are safe and hygienic	
	5. Living wages are paid	
	6. Working hours are not excessive	
	8. Regular employment is provided	
	9. No harsh or inhumane treatment is allowed	
Environment		
Principle 7: Businesses should support a precautionary approach to environmental challenges		
Principle 8: undertake initiatives to promote greater environmental responsibility		
Principle 9: encourage the development and diffusion of environmentally friendly		
Anti-Corruption		
Principle 10: Businesses should work against corruption in all its forms, including extortion and bribery		Procure Labour materials products and services only form orgnaisations demonstrating and implmemntoing zero tolerance to bribery and corruption
		General Principles
		Adopt the Ethical Trading Initiative Base Code and work collaboratively with all supply chain organisations on its implmentation
		Evaluate and address together the economic social and environal sustainablitiy challenges and impacts of sourcing labour materials products and services
		Demonstrate a traceable and transparent supply chain for labour materials, products and services
		Benefit the health safety and wellbeing of all stakeholders including the natural environment
		Demonstrate materials are of legal origin
		Optimise social, environmental, and economic impacts and opportunties of comples/manufactured products over their entrie lifecycle.
		Design, specify and procure materials products and services with the greatests circular economy benefits
		Design, specify and procure using credible and recognised resopnsbile sourcing and certification schemes where available
		Foster and communicate a business cultrue of openess, collaboration and accountability in order to achieve and demonstrate the principles of this manifesto

Additional to these three terms there are two further descriptions, most frequently found in public organisations, green public procurement and the less common, socially responsible public procurement. The former is defined by EU-DG Environment as

> 'means that public authorities seek to procure goods, services and works with a reduced environmental impact throughout their life-cycle compared to goods, services and works with the same primary function that would otherwise be procured' (EU-DG Environment, 2015).

Socially Responsible procurement places much greater emphasis on the social element of Sustainable Procurement and

> 'is about setting an example and influencing the market-place. By promoting SRPP, public authorities can give companies real incentives to develop socially responsible management. By purchasing wisely, public authorities can promote employment opportunities, decent work, social inclusion, accessibility, design for all, ethical trade, and seek to achieve wider compliance with social standards. For some products, works and services, the impact can be particularly significant, as public purchasers command a large share of the market (e.g. in construction, business services, IT and so on)' (EU Commission, 2010a).

For the purposes of this research the definition of ethical procurement that has been utilised was that of the Chartered Institute of Procurement and Supply. Assessing the definitions currently adopted by key stakeholders has highlighted considerable overlap between the different terms and variation in the approaches adopted by professional bodies and client organisations. This complexity would suggest a basis for confusion and frustration amongst procurement teams

2.4 UK construction supply networks for large scale, built assets and infrastructure

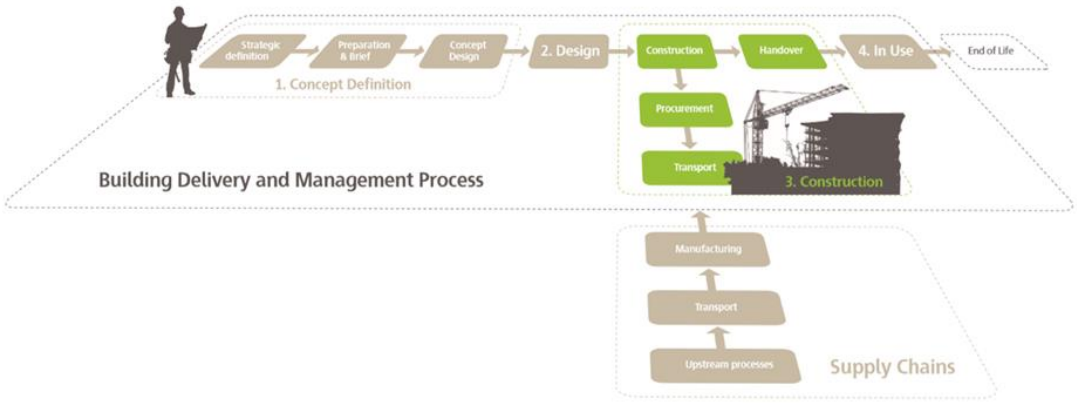
2.4.1. Supply network structure and actors

Dominated over the last 30 years by the development of subcontracting and driven by market forces the UK construction industry witnessed the emergence of 'hollowed out' firms (Green, S., 2009, p.34). It is postulated that the change has been driven by either or both uncertainty and complexity (Eccles, 1981) and has created a need to control costs, risk, relationships and organisations that cross industry boundaries (Usdiken, Szen & Enbiyaog˙lu, 1988). This approach is however not unique to the construction sector.

Similar network structures occur in sectors such as clothing and apparel. Companies focus on their core business, where they have differential advantage, and outsource everything else. Companies such as Nike no longer make components or even assemble them; they are now identified as 'virtual' organisations (Christopher, M., 2011).

As a result of market demands, fragmentation within the construction sector, has resulted in the formation of a complex supply network including investors, developers who fund new assets; clients who may act as owners or be developers; architects/designers, main contractors acting as project managers, controlling the building site; contractors delivering packages of work on site; manufacturers; raw materials suppliers; and at end of life, or indeed often start of a new project, demolition experts. These different operational stages are visually represented by UNEP in the Greening the Construction Supply Chain publication (2014) in Figure 11 below:

Figure 11: Construction Process (UNEP, 2014, p. 23)



Main contractors occupy a pivotal role at the centre of the network, acting as project managers for clients, 'ordinarily responsible for the planning, programming and scheduling of construction activities and, increasingly, design elements of a project' (ICE, 2015). The resulting fragmentation has created a supply network in which relationships are highly competitive and frequently adversarial (Korczynski, 1996, Akintoye, McIntosh & Fitzgerald, 2000), leading to narrow profit margins for main contractors. Relationships between network actors (or nodes) remain primarily dyadic, i.e. between the client and

main contractor or main contractor and Tier 1 supplier (King, Pitt, 2009). The structure provides a limited basis for the development of trust between network members or collaboration in a supply network that is rarely managed beyond the first tier (Saad, Jones & James, 2002, Briscoe, G., Dainty, 2005, Skitmore, Smyth, 2009).

In 1994 Sir Michael Latham reported that many of the severe issues facing the construction industry in the UK could be removed by engendering collaboration and fair dealing from clients through main contractors, designers, sub-contractors and specialist suppliers. He felt that joint working was required to overcome key industry issues and this approach was central to improving the then adversarial, low cost, highly litigious and dangerous sector. Whilst the report does not use the term supply chains, Latham included within his report the recommendation of a 'fair deal' contract, later developed as the New Engineering Contract (NEC). This enshrined the principle that there was a specific duty for all parties to deal fairly with each other, and with their subcontractors, specialists and suppliers, in an atmosphere of mutual cooperation' (Latham, 1994). In 1998 a further report was delivered by Sir John Egan, 'Rethinking Construction', which gave greater prominence to the role of the supply chain and improved sector performance. In his summary of actions required he noted:

> 'To achieve these targets the industry will need to make radical changes to the processes through which it delivers its projects. The industry should create an integrated project process around the four key elements of product development, project implementation, partnering the supply chain and production of components' (Egan, 1998, p. 6).

Egan also noted that long term relationships were important in building trust and shared goals, that all stakeholders needed share in the benefits of improved performance and that alliances were critical to modify the upstream demands of less experienced clients (Egan, 1998).

Whilst changes have been implemented, the construction industry continues to be typified by a 'market forces' driven by a lowest cost led approach. Tendering, with its financial costs to the industry and high scoring on "best price" is still the most common form of "work winning". This has led to an industry that is contractual rather than

relational in its supply chain structure (Thompson, Cox & Anderson, 1998). It is assumed by clients that supplier competition at each level is the best way of driving efficiency, but this frequently creates cost for the client as a new learning curve is required for each project (Cox, A., Thompson, 1997). It is also suggested that each project is unique, often due to the purchasing behaviour of primary contractors but Dubois and Gadde suggest in their findings that the focus on individual projects and competitive tendering make each project more unique than necessary (Dubois, Gadde, 2000). Others argue that in many instances it is a highly effective method of dealing with short term, individualised project-based work (Fernie, Tennant, 2013). A survey, focused on UK contractors, two years after the publication of the Egan report found that whilst there had been a limited increase in partnering there was still little understanding of the importance of supply chain management at board level. The industry remained highly focused on the downstream supply chain (the client), there was limited trust in the sector and a very limited understanding that supply chain theory required benefits to be accrued by all parties in the chain (Akintoye, McIntosh & Fitzgerald, 2000).

Where changes have occurred, such as the use of framework contracts and an increasing use of Pre-Qualification Questions (PQQs) that follow industry standard PAS 91 (BSI, 2017a), their effectiveness has been questioned. Whilst the latter incorporates social and environmental modules these remain optional and only need to be included in the PQQ 'when judged relevant' (BSI, 2017a). Fernie and Tennant (2013) believe environmental questions have little weight and lowest cost is still the key determinant. Framework contracts may have been intended to reduce the amount of tendering required for major developments but as noted by Wilmott Dixon, at an industry conference in 2019, they now have 700 client framework agreements, of which only a proportion will offer the opportunity to quote for work (Barrett, 2019).

The Governments most recent report "Construction 2025" was published in 2013. Whilst it identified a 'strong and resilient supply chain' (UK Government, 2013, p. 12) as a key driver for change it continued to observe an industry with low vertical integration in the supply chain and a high reliance on sub-contracting (UK Government, 2013). The report also noted that they were looking to achieve

> ‘an industry that has become dramatically more sustainable through its efficient approach to delivering low carbon assets more quickly and at a lower cost, underpinned by strong, integrated supply chains and productive long-term relationships’ (UK Government, 2013, p. 18).

The Government believes that repeat customers have a greater strategic ability to engage supply chains earlier in the process and engender better whole life value (UK Government, 2013).

2.4.2. The role of UK construction supply networks in delivering sustainable assets

As noted in section 2.1 of this chapter, construction has been identified by major inter-governmental organisations, governments, academics and NGOs as an industry with global environmental, economic and social impacts. Flowing from this is a wide body of work in the UK which considers sustainability within the construction industry including, government reports (HM Government, 2008), industry bodies, standard and certification bodies and academic publications. The view of sustainability is primarily presented through a global or national prism and is dominated by an ‘ethical imperative’, most often of that of climate change and social concerns.

Whilst the global economic benefits of limiting global warming have been articulated (Stern, 2006), it can be argued that the ‘business’ case for adopting sustainable measures is less articulated. Several researchers note that the economic argument for incorporating sustainability into the construction supply chain is well developed (Zhou, Lowe, 2003, Sweett, 2007, Mefford, 2011) and supported by marketing, finance, and production theories. These state that by engaging in socially responsible behaviour the firm will increase sales, decrease costs, reduce financial risk, and increase profits, which will ultimately increase returns to the firm's shareholders. Research based on empirical evidence to support these views appears to be surprisingly limited. Sustainability is also seen to offer competitive advantage (Porter, Kramer, 2006) and increased operational effectiveness through the supply chain, often based on a lean production theory (Koskela, 2000). Even if this is the case, as previously noted and demonstrated in recent studies, that in terms of being sustainability driven, the sector is lagging behind other industries (Glass, Achour, Parry et al., 2011a). This would appear to be further

corroborated by a survey of CIOB members where only 41% saw sustainability as a key issue, and this was primarily related to carbon reduction measures (CIOB, 2010).

The main driver of UK Government action has been environmental or green issues such as CO_2 emissions, waste or materials reduction supported by eco-efficiency. Reduction of operational emissions from buildings is one of the main drivers of UK regulation and strategy. The Government has set ambitious and legally binding targets to reduce national greenhouse gas emissions by at least 80% by 2050 (BIS, 2013a). In addition, the EU's Energy Performance of Buildings Directive (EPBD) requires all new buildings to be "nearly zero energy" by December 2020 (EU Commission, 2010b). Currently both commercial buildings and housing over a certain square meterage must display Energy Performance Certificates (EPCs) or Display Energy Certificates (DECs) and CO_2 emissions reduction is now included in Part L of the UK's Building Regulations. Government supports the uptake of renewable technologies and public procurers are encouraged to use sustainability criteria within their purchasing decisions.

The UK construction sector has a long history of providing social benefit, traditionally driven through the supply network through planning requirements, but most recently reinforced by two major pieces of UK legislation, the Modern Slavery Act (UK Government, 2015b) and the Public Services (Social Value) Act (UK Government, 2012a). The former obliges companies with turnovers greater than £36m to remove modern slavery from their supply chain and to set out an annual modern slavery statement. Due to this regulation all main contractors are now raising modern slavery with their Tier 1 suppliers. The Publics Services Act, 'requires public authorities to have regard to economic, social and environmental well-being in connection with public services contracts' (UK Government, 2012a). Research by Temple and Wigglesworth (2014) identified 66% of Local Authorities and Housing associations were now incorporating support for local social issues in their contracts. It is also argued that there are growing stakeholder expectations about accountability and transparency due to concerns about environmental impacts, labour and welfare conditions, bribery and corruption in the industry and this extends through the whole supply chain (Glass, Achour, Parry et al., 2011a). For major clients and contractors this has created an added driver to engage

with the sustainability agenda often focused on CSR and public reporting, something that is increasingly being considered by investors and procurers as a way to mitigate risk or demonstrate good governance.

As demand has grown to evidence environmental and social actions, standards such as ISO 14001, and more recently ISO 26000, have been developed. These provide a structured approach to managing sustainability at a company level and can offer competitive advantage within the supply chain (Curkovic, Sroufe, 2011). With the launch of the updated ISO 14001 (ISO, 2015) the life cycle approach recognises companies must have greater engagement with their supply chain, a similar position to that of the Sustainable Procurement ISO 20400 (ISO, 2017). The BES6001 framework for the responsible souring of construction products was launched in 2008 (Upstill-Goddard et al., 2012). There are now a multitude of certification schemes for low carbon or low impact buildings or infrastructure such as BREEAM, LEED, Green Globe and CEEQUAL, which support increased sustainability of products through the demands of building specification and are operated through a points-based system. Indeed, a standardised life cycle approach (ISO14025 or EN 15804 for construction products) is now available, which supports an Environmental Product Declaration (EPD). This provides purchasers with life cycle impact information; the basis for increased points in a Green Building standard (Murphy, B., 2015, EPD International, 2016). The importance of understanding the impacts of the materials procured was found by Thormork (2006) who demonstrated in his research that materials procured with an understanding of carbon showed a decrease of 17% in CO_2 emissions whilst incorrect selection resulted in a 6% increase.

When considering the management of sustainability through the construction supply chain it should be noted that no definition of sustainable supply chain, solely relating to construction, was identified. One that could be adopted by the sector was created by Ahi and Searcy following a review of over 180 papers on the topic:

> 'The creation of coordinated supply chains through the voluntary integration of economic, environmental, and social considerations with key inter-organizational business systems designed to efficiently and effectively manage the material,

> information, and capital flows associated with the procurement, production, and distribution of products or services in order to meet stakeholder requirements and improve the profitability, competitiveness, and resilience of the organization over the short- and long-term' (Ahi, Searcy, 2013, p. 339).

Despite limited industry engagement with the sustainability of their supply chains, the UK Government has identified that the achievement of UK sustainability targets in the construction sector depended on sustainable supply chain networks (BIS, 2013a). This creates a structural tension within the sector as the effective management of supply chains has become largely synonymous with collaborative forms of working (Fawcett et al., 2012), a position at odds with most construction contracts. For major construction projects, there has been an attempt to incorporate collaboration into the business model. This has seen contracts with main contractors develop from "build" to "design and build" and "design, build, operate", the last an increasing feature of public-private partnerships. However, there is evidence that collaboration does not always result in beneficial outcomes (Nystrom, 2007, Fernie, Tennant, 2013). It can also be difficult to achieve, as demonstrated in an industry-wide survey of 87 German firms by Brinkhoff and Thonemann which identified a 50% failure rate in collaborative supply chain relationships, the greatest issue being the difficulty of defining shared objectives (Brinkhoff, Thonemann, 2007).

2.4.3 The industry perspective on sustainability

It was important that this research engaged with a main contractor recognised for its sustainability credentials. The company sponsoring this doctoral thesis was Carillion plc. Carillion had a long history of environmental work with its first environmental report being published by the company to highlight its actions during 1997 (Carillion, 2000). In November 2016 the company's Chief Sustainability Officer presented Carillion's work on the Sustainable Development goals at the UN Conference on Trade and Development (Picton, 2016). The company had clearly articulated corporate values encompassing economic, environmental and social issues, 'we care; we achieve together; we improve, and we deliver' (Carillion plc, 2016b). Their Sustainability 2020 Strategy was published in 2011 and incorporated

a range of KPIs, based on their '6 Positive Outcomes' structure. These were reported by each business division and reviewed at board level. As noted earlier, they used GRI reporting and held ISO14001 and ISO9001 accreditation. Its position as a main contractor made it a focal node of the supply network. The company operated in the UK, Middle East and Canada, with an annual international procurement spend of £3.4bn (Carillion plc 2016), working with over 8000 accredited first-tier suppliers and many thousands more in second and third tiers. They were operating within the UK Government's Sustainable Procurement Task Force Flexible Framework for procurement and achieved a self-reported Level 5 in 2015 (Carillion plc, 2016a). Thus, involvement with Carillion offered an opportunity to examine how sustainability was being incorporated into the operations of a main contractor with long-term sustainability credentials.

The procurement function of the company operated within the descriptor of Supply Chain, which was revitalised in 2013 with the launch of the "Step Up" programme. It is referred to throughout the research as the SC team. The SC team was created to transform the existing structure and ensure 'robust strategies (were) in place to create value in the Supply Chain' (Carillion plc, 2013). The programme was built on the foundations of quality, team, service, and price and was budgeted to reduce costs by £145m between 2013- 2018. As well as cost savings, objectives included standardisation and simplification of processes, improving transactional activity and 'taking the complexity out of the supply chain'. To achieve the latter, Carillion set a target; their top 5000 suppliers would represent 97.4% of company spend by 2018 (Carillion plc, 2013). Additionally, the company instigated category management specialists to support the buying teams and provide opportunities for bundling contracts across projects (Carillion plc 2015). The company had a Supply Chain Policy (see Appendix 1, Figure 46) which confusingly provided guidance on both health, safety and environmental issues as well as sustainability requirements. This division appears to align with internal corporate structures. Health, safety and environment (HSE) requirements were focused on operational needs at a project or tender level. They were defined by Carillion operations team or the health safety and sustainability team (HS&S team) and primarily managed compliance with legislation

and the management of the associated risks. Sustainability stipulations were more strategic and formed the basis of public reporting. They were based on Carillion's 2020 Strategy, the requirements of the Flexible Framework, and the guidelines within Carillion's Sustainable Procurement Charter (renamed the Sustainable Supplier Charter – see Appendix 1, Figure 47). The Sustainable Supplier Charter was updated in October 2017 and was endorsed by the Chief Executive, Group Finance Director and Chief Sustainability Officer. The document outlined how Carillion would behave and how they expected suppliers to behave in terms of health and safety, sustainability, ethical working, values, continuous improvement and innovation. Created in 2012 the document initially had an internal use, presented to suppliers when they commenced working with Carillion. It was only made available to potential suppliers, through the corporate website, in 2017.

To understand how Carillion's approach to sustainability aligned with industry peers a textual analysis of annual sustainability reports was undertaken. The methodology is presented in chapter 3, Section 3.4.2.2. and the full analysis, including the sustainability practices identified, is available in Appendix 2. It was not the intention that this review was an exhaustive assessment of industry action but rather an overview of the approaches to sustainability, reporting and future concerns currently being undertaken. The companies selected are presented in Table 4. This provides additional information on country of origin, turnover and number of employees. Based on the assumption that approximately 70% of main contractor turnover is spent with the supply chain this analysis allows us to deduce that the UK based company sample accounts for £17.2bn of goods and services in 2014.

Table 4: Companies selected for annual sustainability report analysis 2015 (Balfour Beatty plc, 2014, Carillion plc, 2016a, Skanska, 2016, Keir Group Plc, 2016, Laing O'Rourke, 2014, Interserve Plc, 2014, Arcadis BV, 2014, Peab AB, 2014, Patigonia, 2014, Unilever, 2014)

Source	Company	Country	Turnover 2014 £m	No. employees 2014	Note
	Carillion	UK	4000	40000	
UK main contractor peer group					
Carillion identified	Balfour Beatty	UK	8800	36000	
	Interserve	UK	2913	80000	
	Kier	UK	3000	15000	
	Laing O'Rouke	UK	3577	15351	
	Lend Lease	Australia	7190	13200	
	Sir Robert McAlpine	UK	1064		
	Skanska (Sales: UK)	Sweden	1200	5000	
	Skanska (Sales: Workdwide inc. UK)	Sweden	7575	57000	
Other European construction sector companies					
Acquisti & Sostenibilità 2014	Arcadis	Netherlands	2,100.00	2,800.00	
	Groupo ACS	Spain	24,417.00	210,345.00	74,000 in Construction Division,
	Hochtief	German			inc. in Groupo ACS results
	Peab	Sweden	3,225.00	13,000.00	
	Royal BAM	Netherlands	4,900.00	23,000.00	
	Wilmott Dixon	UK	1,259.00		
Global sustainability leaders					
Globescan's 2015 Sustainability Leaders Survey	Interface	US	700.00	3,425.00	
	M&S	UK	10,300.00	83,069.00	
	Patigonia	US	462.00	2,000.00	
	Unilever	Netherlands	33,880.00	172,000.00	

Carillion, like many of those in the construction sector, used existing global reporting methods to drive their programmes. Eight of the fourteen construction companies reviewed were using the Global Reporting Index (GRI), four companies had signed the UN Global compact, one company was listed on the Dow Jones Sustainability Index. The Footsie4Good, FTSE350 and the Climate Disclosure Leadership Index were also referenced. This created a compartmentalised approach to reporting, with each aspect of sustainability being reviewed and considered separately; arguably a checklist rather than a vision for the future. Indeed, it has been suggested that this failure to take a holistic approach may reduce the ability of companies to integrate their effects properly into corporate decisions and procedures (Lozano, Huisingh, 2011). Interestingly the four companies selected as 'world leaders' did not promote a standard approach and indeed Patagonia specifically stated that the costs and structure of formal data reporting were not appropriate for a smaller company.

Stakeholder analysis and customer perceptions are given increasing visibility in the reporting and were often linked to the requirement to report 'Materiality', or as a response to standards and reporting guidelines such as ISO 26000 and BSI. Increasingly many of the companies were using a combination of the formal annual sustainability or CSR report, website content, and shareholder updates to promote their work. Several identified their limited sustainability communications with stakeholders as a weakness. The majority of the UK major contractors used 'Industry Awards' to highlight and endorse their sustainability work. Only eight of the construction sustainability reports featured their capacity/expertise to work to Green Building standards, whilst two of the 'World Leaders Group' noted they were involved with, or used, LEED. This was surprising as a much greater proportion of buildings are now being built to green standards (if not always accredited), with US Green Building Council reporting in 2015 that 41% of all non-residential new builds in the US were working to LEED accreditation, compared to 2% in 2005 (USGBC, 2015).

All construction companies demonstrated a strong emphasis on environmental activity and highlighted well developed community programmes. There was less focus on health and safety, a separate function within many of the companies. Most of the environmental and social impacts reported, focused on issues under the direct control of the company. Whilst it was difficult to extrapolate from the environmental data the level of engagement with the supply chain, there are clear signs that activity is occurring. Arcadis, Hochtief, Groupo ACS and Wilmot Dixon all reported Scope 3 carbon emissions (primarily derived from their supply network). In 2014 Interserve piloted a new method to measure supply chain emissions, working with an inventory of top 20 suppliers and an analysis of supply chain spend. Laing O'Rourke had taken a different approach and were reviewing carbon as part of their offsite construction work. They had tested traditional methodologies against their 'Design for Manufacture and Assembly' (DfMA) and found a 35% reduction in lifetime carbon emissions (Laing O'Rourke, 2014). Skanska were working on product transparency from suppliers as one of their goals whilst Keir was looking to understand their water footprint (Keir Group Plc, 2014). Interserve were

working closely with procurement teams as they had identified that the majority of their water use lay within their supply network (Interserve Plc, 2014). Carillion did not report scope 3 carbon emission within their supply network.

Social issues are less well represented except for community engagement, much of which is local to projects; often a reflection of the requirement by public sector clients. It is frequently measured in the value of the days of staff time volunteered along with direct donations. Carillion was identified as one of the most engaged in this area, offering staff annually, six paid volunteering days. Ethics were strongly represented in seven of the company reports, with several noting they had a code of conduct which was used to express their ethical position to staff and suppliers.

The term "sustainable supply chain" was included in many of the reports, primarily referring to the interaction by the company with their Tier 1 suppliers and operating to targets that met regulatory, contractual (e.g. SME or local purchasing) or UK Government requirements (e.g. improved payment terms). Several companies noted supplier Pre-Qualification Questions (PQQ's) now incorporated sustainability, and sustainability criteria were also included in some contracts. This would suggest that many in the construction industry are at relatively early stage of sustainable supply chain management. There is however evidence of focal companies influencing change within the supply chain. Groupo ACS noted their H&S programme, Project One, included working with contractors and sub-contractors (ACS Group, 2014) whilst Skanska ran a training week for 29 of its top suppliers (Skanska AB, 2014). There is some evidence of support for supply chain innovation such as Keir's work with the Manufacturing and Advisory service and the British Constructional Steelwork Association (BCSA) to help 100 members of their supply chain to meet steel regulations. There would also appear to be a widespread use of external agencies to deliver sustainability requirements such as Achilles, the Supply Chain Sustainability School (SCSS) and Constructionline. Achilles collects and validate supplier data on behalf of client companies, Constructionline provides a similar service for public sector procurers but is solely focused on the construction sector. The Supply Chain Sustainability School is funded by major contractors and

clients and offers free online sustainable procurement guidance to the construction supply network.

Innovations in sustainable business thinking were represented in the reports. Several companies were testing and learning from new processes, such as trialling climate change adaptation measures on UK buildings (Interserve Plc, 2014), Wilmot Dixon were undergoing experiential learning through the building of a Passivhaus Centre for Medicine and Arcadis had worked with Imperial College and EC Harris using whole life value analysis to develop plans for an estate in Kensington. Companies were also testing new business models, such as incentivising sub-contractors to cut waste (Willmott Dixon, 2014) and developing Energy Performance Contracts which underwrote clients future energy savings (Skanska AB, 2014). There was also evidence of at least two companies setting up joint ventures or directly investing in new companies that were developing sustainable solutions to industry problems. Two construction firms, one of which was Carillion, allocated sustainability actions with a monetary value, something more prevalent in the non-construction group.

This chapter provides the context and background for the doctoral research. The economic impact of the sector and its effect on climate change alone, make sustainable construction of major importance to a wide range of stakeholders from policy makers, industry bodies and companies to individuals using built assets or living in the urban environments created. The review of construction impacts, both social and environmental, highlights the effects of the building process, the long-term use of a built asset and its final demolition. Understanding assets in terms of a life cycle approach offers a framework through which to analyse the supply network. Yet the evaluation of current literature indicates that whilst there has been an increase in industry and academic life cycle research, especially at the product level, it is less well understood in terms of the built asset. Methodologies to support an understanding of social impacts across an asset lifetime are limited, with sLCA, a nascent approach, offering only one construction sector example. Failure to understand where impacts occur within the life cycle of an asset limits the ability of network actors to respond to the issues which they

can most effectively manage. This chapter identifies the main contractor as a key focal point within a highly complex supply network and that sustainable procurement and sustainable supply chain management appear to be at the early stages of development. It is clear that in the construction sector sustainability remains a developing field of research and practice. This view was supported by the review of sustainable procurement where definitions are not fixed and are continuing to evolve, with different ideas and terms competing for industry acceptance. An analysis of key construction industry corporations indicated a variety of approaches, with some companies undoubtedly more advanced in their implementation of sustainability practices, yet there appeared to be only limited engagement of upstream actors. This would suggest that this inquiry considering the ability of a main contractor to lead the supply network, whilst based on one case study, would have applicability beyond the single company level.

Chapter 3: Methodology

3.1 Summary

To explore the three research questions postulated, this research takes an inductive grounded theory approach based on a pragmatic epistemological stance. This methodology was selected to ensure that findings were drawn from the actors engaged in construction practices rather than be framed by pre-conceived concepts. To address gaps in knowledge about the barriers and enablers of supply network sustainability a single case study approach was undertaken, allowing much greater depth of insight from within a main contractor. In selecting a single case study, albeit a company identified as one of the UK contractors leading on sustainability, it was accepted that there was the potential that findings may not be fully applicable or appropriate to a wider audience. This was overcome by triangulating findings with other network actors and the literature. The research uses mixed methods, including primary data drawn from online surveys, semi-structured interviews, notes drawn from meeting attendance and the secondary sources such as industry and academic literature. Textual analysis has been undertaken using MAXQDA software.

3.2 Introduction

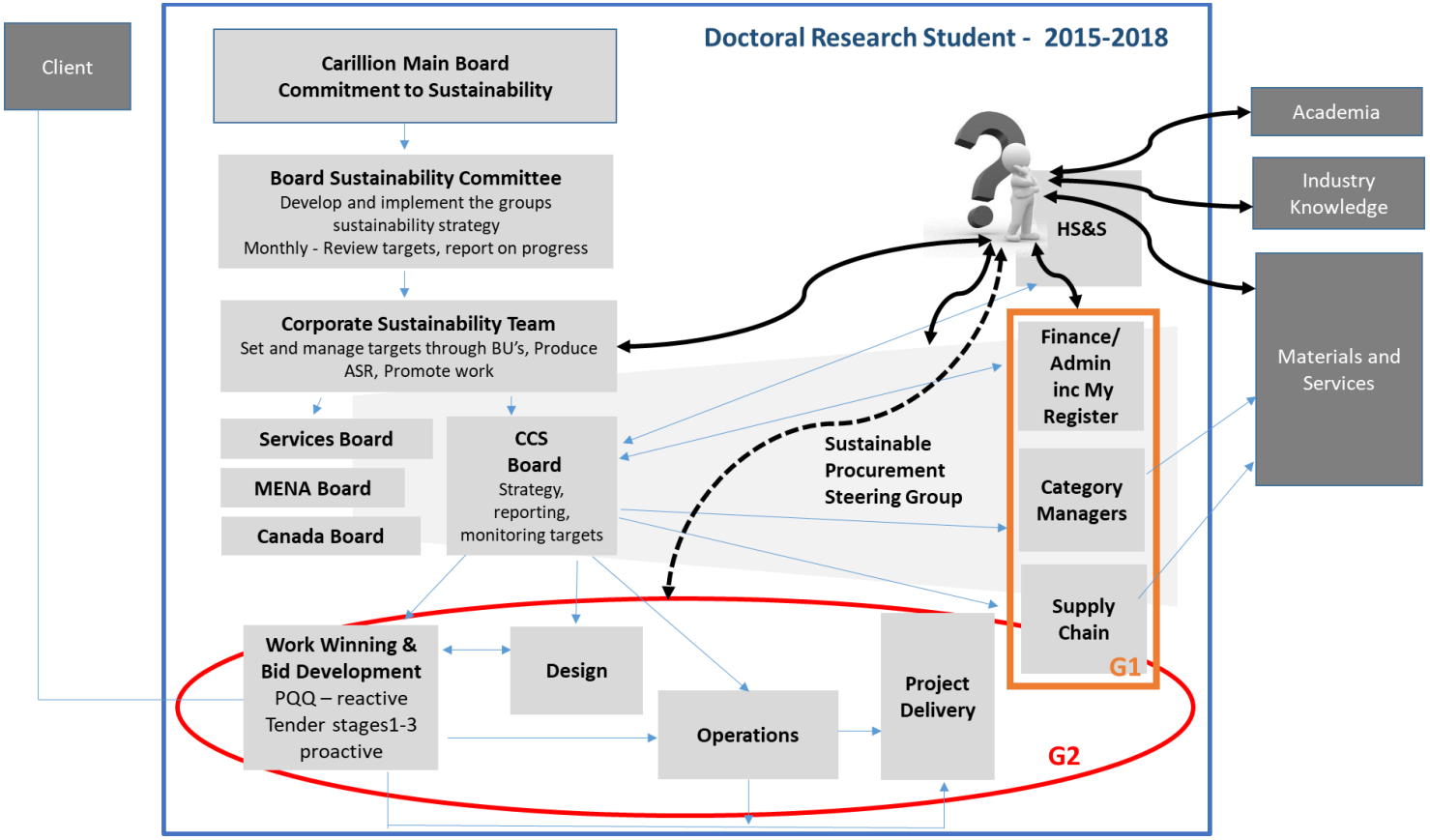
This PhD has been completed as part of a Doctoral Practitioner programme which undertakes research into industry challenges. The research was jointly funded by the Engineering & Physical Sciences Research Council (EPRSC) and Carillion plc. Carillion provided the student with a 'real world' problem that they wished to engage with and open access to company data and staff. This included unrestricted access to internal procurement information, sustainability and supply chain team staff and other relevant personnel within Carillion Construction Services (CCS), a business unit within the company. Members of these teams also provided introductions to industry peers, industry forums and suppliers (Figure 12). This offered a level of practise-based insight into a main contractor rarely visible to University-based research students. To ensure a level of 'impartiality', whilst the researcher was provided with a Carillion email address and phone, they were clearly identified as a University research student to both Carillion staff and to external organisations. This was achieved by use of the Doctoral Practitioner

title in email signatures, joint use of Carillion plc and the University of Surrey logos on all presentations, and the introduction of the 'University of Surrey researcher' to internal teams at the start of the project.

Carillion plc required a confidentiality contract between themselves, the University, and the student to cover the process of researching but they noted, at project outset, that they wanted the PhD thesis to be publishable without commercial restriction. This did not affect the research path followed by the student, with confidentiality of interviewee materials and supplier anonymity automatically undertaken as part of the research process. The balance between a fully publishable thesis and one with embargoed content or a time embargo was to have been discussed once all results were confirmed. However, the demise of Carillion in January 2018 removed the need for this requirement as the contract became invalid and the company no longer had an interest in the research work. Thus, whilst the research focus and materials were shaped by the company's initial brief and staff engagement this thesis has been written without any restrictions on structure or content.

Carillion plc operated three divisions: Carillion Services, providing UK facilities management; Construction Services (CCS), which managed the construction of UK buildings and infrastructure with all overseas facilities and construction management operated through MENA. The Carillion plc main board was responsible for the operation of the company, with divisional chief executives managing operational delivery and reporting to the corporate board. The Carillion plc board were supported by a Sustainability Committee, which acted in an advisory capacity. The researcher, illustrated as the figure in the diagram below (Figure 12), was embedded in the CCS Division, within their Health, safety and sustainability (HS&S) team. Boundary Code G1 in Figure 12 bounds groups where a strong connections existed between the HS&S team and other teams, in this case the supply chain (SC) team, category management team and CCS finance. This provided the researcher with open and relatively straightforward access to this group.

Figure 12: Position of Doctoral student within Carillion plc and access to intra and intercompany groups



Key

G1 represents teams with which the HS&S team had frequent contact and collaborative relationships

G2 represents teams with which the HS&S team had less frequent contact and less collaborative, more antagonistic relationships

A close connection was established with the corporate sustainability team, initiated by the industrial supervisor and utilising his relationship with corporate team members. This rapport had developed from his long service with the company and from his role within internal corporate-level working groups. The researcher was invited by the Group Sustainability Manager (S-CM) to join the Carillion plc sustainable procurement steering group (SPSG). This met via skype calls six times per annum, or more regularly as required, and all Carillion divisions were represented. Its primary function was to provide oversight of corporate sustainable procurement goals and to advise on future corporate action. The researcher had limited access to the other company teams illustrated in the figure above and coded G2. This was predominately due to weaker internal relationships between G1 and these business division teams. Groups operating externally to Carillion plc were identified as important and were incorporated into the research plan. They primarily comprised of Universities currently engaged in construction sector research such as the Universities of Loughborough, Nottingham, Leeds, Cambridge, Bath and Reading or industry forums both membership-led or initiated by professional bodies, conferences, workshops and suppliers. Additionally, the researcher requested access to Carillion clients, but commercial sensitivities made this difficult and no interviews occurred.

The topic area for research had been identified by the Head of Sustainability at CCS, who initially agreed the doctorate sponsorship. He believed that the Carillion supply chain was an area warranting investigation and within the preliminary written research brief he highlighted multiple areas of interest within this topic. Broadly, these incorporated the role of effective supply chain metrics for both social and environmental issues, the importance of “sustainability” skills and knowledge of sustainability within supply chain actors and the identification of Carillion’s network operating boundaries within which it accepted responsibility for sustainability impacts. The brief also required that doctoral insights must be available to support internal sustainability action, communications and future sustainability and supply chain strategies during the programme. Thus, the research needed to be structured to allow ongoing feedback of findings to the company. Retirement of the Head of Sustainability, prior to the student appointment, meant that he was unable to develop the research outline further. The briefing stage was, instead,

undertaken by the CCS Sustainability Manager (S-BM), Michael Winhall, who acted as the industrial supervisor for this Doctorate. Whilst both individuals had been with the company for more than fifteen years and had oversight of, and engagement in, operational activity, their perspective was of sustainability professionals rather than supply chain experts. S-BM identified a company that wanted to 'lead the way' in sustainable procurement but as an organisation was unclear what this entailed and how it could be implemented. This scoping suggested several concepts related to the challenge they wished to address; lack of clarity in defining the 'problem', a gap between 'desire to do the right thing' and implementation, and intra and inter-company team disconnects. These features indicated that the research would require exploration of individual and team knowledge, perceptions of barriers to implementation and stakeholder responsibilities, set within the context of sustainable build; it would have a strong social research requirement.

3.3 Methodological framework

This thesis has adopted an inductive approach to support the emergence of grounded theory. This methodological stance was derived from a review of methods, a critical assessment of approaches and the relevance of their underlying epistemological in relation not only to the problem being addressed, but the role of the researcher in this process. The starting point for this work was Gilbert and Stoneman and their introductory text to social methods research (Gilbert, Stoneman, 2016). The company embedded context of the research, relatively small numbers of participants and a focus on qualitative data suggested, an inductive research approach to theory building rather than a deductive, hypothesis testing stance. Inductive approaches supporting emerging 'grounded' theory were first developed by Glaser and Strauss in 1967. Their book offered a systematic guide for collecting and iteratively analysing qualitative data to create a theory 'grounded' in the data (Glaser, Strauss, 2008). They avoided any epistemological framing to their methodology claiming that researchers should come new to the subject, without considering existing literature and that theory should emerge from the data itself. Failure to engage with issues around data, induction and the role of the researcher however led to criticism from those undertaking more traditional, qualitatively-orientated approaches. This has since led to several grounded

theory variants (Bryant, 2009). The epistemological position, has been considered from differing perspectives, with Charmez taking a constructivist stance, whilst Levers proposed grounded theory derived from subjectivism; accepting that knowledge is always value laden (Levers, 2013, Charmaz, 2014). Bryant has taken this further and argues that it is set within a pragmatist view. Here all knowledge is provisional and has to be judged in terms of its usefulness within some confines (Bryant, 2009). Charmaz's interpretation of grounded theory which 'recognizes mutual creation of knowledge by the viewer and the viewed' (Charmaz, 2003, p. 250) and Bryant's acceptance that all research has to take account of the researcher or observer is closer to the embedded position of the practitioner doctorate within Carillion (Bryant, 2009, Charmaz, 2014). Indeed, Bryant goes further and states that 'it is often precisely people's prejudices that enable them to produce innovative insights and alternative models' (Bryant, 2009, p. 21). Glaser and Strauss' position on literature has also been challenged and today many researchers combine inductive categorisation with ongoing evaluation of the literature (Bryant, 2009, Gilbert, Stoneman, 2016). This research is based on the Charmez grounded theory variant with additional insight more consistent with the approaches of Charmez and Bryant. Theoretical sampling has been used to create an initial analysis, which has then been developed to enhance the concepts identified in the earlier stages of information gathering (Bryant, 2009). This research applies mixed methods, adopting both qualitative and quantitative approaches, accepting that this offers greater insight than either method alone (Creswell, 2017).

Over a period of thirty months this inductive process, using semi-formal interview notes, observations, surveys and text analysis has provided a rich source of material. Information was derived from multiple teams within Carillion and external stakeholders, such as suppliers, industry events, company meetings and industry stakeholder groups. In keeping with the Pragmatist approach literature, itself has also been considered as data, primarily that which indicates industry views, processes or sector knowledge. Commencing in 2015 the researcher identified a sample group for interview based on a set of criteria, also described as purposeful sampling (Sandelowski, 1995). This has been followed by continued theoretical sampling, with data being analysed in an iterative process. All notes have been coded, and reviewed using an online capture system,

MAXQDA. Through systematic analysis of the coding, abstract categories have been created and continually reappraised and amended until key themes have emerged.

Ethical considerations, often a major issue within social research, were reviewed with the supervisory team in the context of this industry focused programme. To meet the requirement of a thesis publishable in full, without restrictions due to commercial concerns, all internal staff members are only referred to by a code reference and external bid and tender documents are noted with minimal generic references such as public-sector building. Both the Academic and the Industrial Supervisors were comfortable that discussions with Carillion staff would not require Ethics panel approval. However, as the research developed, a need was identified to gain knowledge through in-depth interviews with external stakeholders. Thus, it was considered prudent, for this element of the analysis, to apply for approval from the University of Surrey Ethics Panel. This was undertaken, and approval was granted in 2017 (See Appendix 9).

3.4 Data management

Management of data, both qualitative and quantitative was an important part of the research process. Over the research period an extensive number of notes, memos, documents, papers and other materials would be created which would require a structured approach to allow for the retrieval and review of information. Additionally, grounded theory approaches require extensive coding of notes and documents and, whilst this can be managed manually, increasingly researchers have used Computer Assisted Quality Data Analysis (CAQDAS) tools to facilitate their work. These have been shown to offer increased levels of project organisation and the ability to sort, retrieve and search the data (Richards, Richards, 1987). This research has adopted a CAQDAS tool to support data management. Multiple CAQDAS tools are available and several were selected for review. These were identified through social research guidance (Gilbert, Stoneman, 2016), recommendations from the University of Surrey Department of Sociology and expert opinion within the Centre for Environment and Sustainability. From this information a review was carried out, initially using information available on the providers websites, online taster sessions and supported by journal-based opinion.

Two different approaches to data analysis were identified; that of researcher led coding through Nvivo (QSR International, 2015) and MAXQDA (VERBI Software, 2015), with the bias this may engender, and Leximancer's automatic text analysis. Leximancer (Leximancer, 2016) offered researchers a rapid assessment of large volumes of data and produced a visually attractive display of the key themes and concepts but was 'tedious' to try and develop a 'storyline' (Sotiriadou, Brouwers & Andrew, 2014, p. 21). Researcher generated coding can engender bias but the process of coding and re-examination of data by the researcher allows thoughts to form and enhances appreciation of the material being studied (Sotiriadou, Brouwers & Andrew, 2014). MAXQDA and Nvivo appeared to offer a more critical analysis and interpretation through coding, which was more appropriate for a grounded theory approach (Bringer, Johnston & Brackenridge, 2006). Expanding on the work of Sotiriadou, Browers and Andrew (2014) the different attributes of the CAQDAS programmes were identified and the results are presented in Table 5.

Table 5: Comparison of 3 CAQDAS tools: Nvivo, MAXQDA and Leximancer (adapted from Sotiriadou, Brouwers et al. 2014, (Gilbert, Stoneman, 2016)

CAQDAS Tool	Organising data	Volume of materials	Types of materials	Mixed Methods	ease of coding and recoding	audit trail	analytic memos	Comparative analysis Tools	mapping & visualisation	Easy data extraction
Nvivo	straightforward, Microsoft word-like hierarchical filing system	most effective for small to medium levels of material	text, pdf, images, video and speech	able to handle both	researcher led manual coding and option automated coding, text analysis	yes	yes: easy to use and attach	yes	multiple visualisation tools	yes
MAXQDA	straightforward, Microsoft word-like hierarchical filing system	most effective for small to medium levels of material	Microsoft word, excel pdf, images, video and speech	specifically designed to integrate both	researcher led manual coding and option automated coding, text analysis	yes	yes: easy to use and attach	yes	multiple visualisation tools	yes
Leximancer	straightforward, Microsoft word-like hierarchical filing system	effective for large volumes of data	Plain Text, CSV, Microsoft word, Pdf or HTML	qualitative data only but can incorporate quant data	Automated text analysis inc. coding	not clear	not clear	yes	Conceptual map is a major feature of the tool	yes

Based on the assessment above, the researcher undertook two training courses. The first in February 2017 was for Nvivo and comprised of a two-day workshop provided by the Sociology Department at the University of Surrey. This was taught in a computer lab at the University, with a group of students and was a combination of teaching and practical exploration of the tool. The training for MAXQDA was provided as an online webinar, with student questions answered by the presenter during the session, the use of online tutorials offering guidance on specific elements of the tool and self-learning through a test research project. This allowed for much greater engagement with the tools and an opportunity for more effective analysis. The courses confirmed the initial observations that both CAQDAS tools provided support for ground-up coding, mixed methods, and were relatively simple to use, once basic principles were understood. MAXQDA did appear to offer more effective quantitative analysis than the Nvivo tool and it had a higher standard of visualisation. Cost was also a considered, with Nvivo being available free to University of Surrey students, whilst MAXQDA would require a purchased license. MAXQDA felt instinctively more comfortable and usable. This was by no means a rational basis for selection but something that would be important to the researcher as coding and comparison developed.

A project folder was created in MAXQDA to file all materials. Notes and interview transcripts created during this research, along with relevant Carillion materials were uploaded to MAXQDA. All coding was done manually and begun in the early stages of the data collection process and continued to expand as further materials were added to the files. Memos were added to specific sections of coded text where the researcher could offer additional insight associated with a point, linkages with other comments or documents or a query for further investigation. Coding continued to develop with codes being moved into groups as themes began to emerge. At the end of the research process 3089 sections of text had been coded. The MAXQDA code book developed for this thesis is available in Appendix 4.

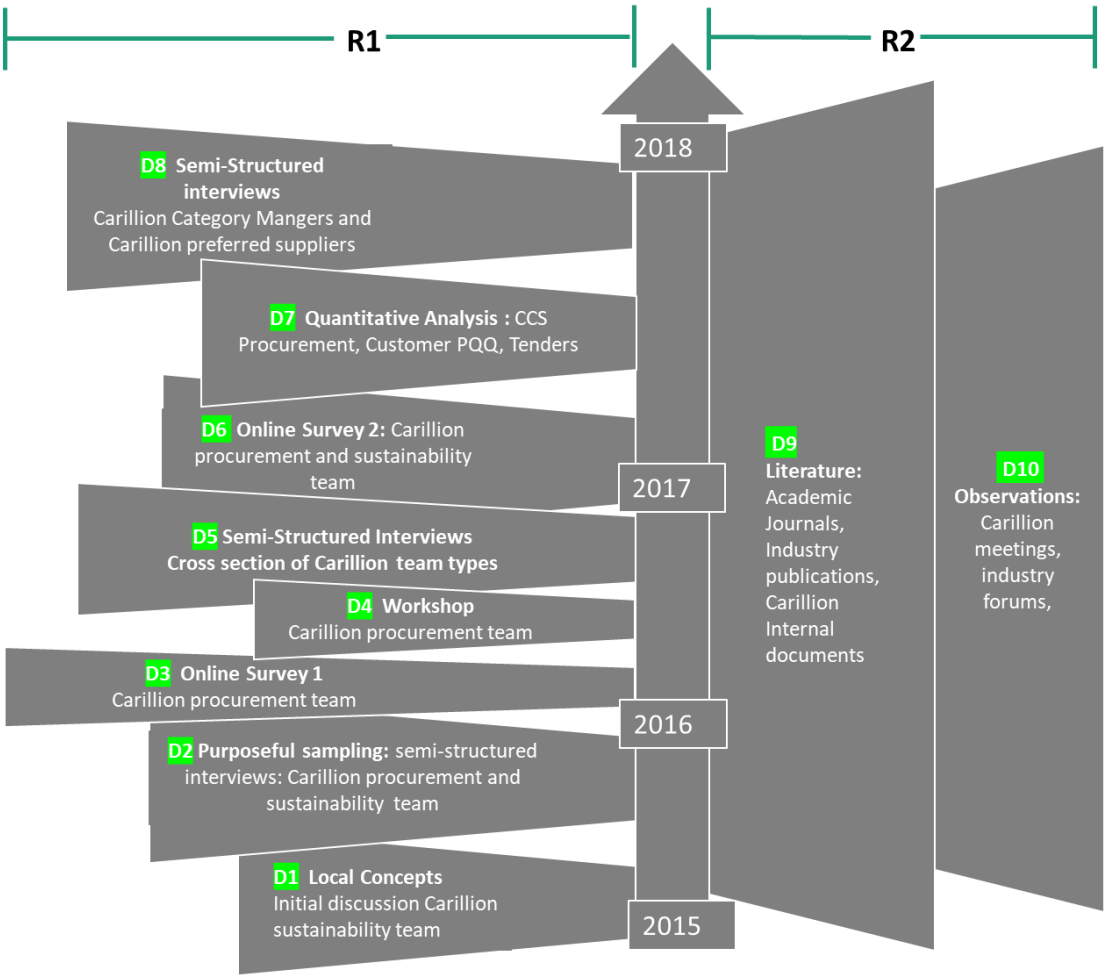
3.5 The data acquisition process

This research has adopted an iterative approach to the selection of mixed methods for the collection of data. This has been led by the development of different research

themes identified during the inductive research process. This is consistent with the approach adapted by Charmaz that in building rich data fieldnotes, observations, interviews and information from reports and records are utilised. Charmaz is clear that data collection methods should flow from the research question and can include quantitative data if this is relevant; grounded theory is not just a method for interview studies (Charmaz, 2014).

The research was comprised of two distinct types of data gathering; that of data creation illustrated in Figure 13 as discrete activities under research type 1 (R1); and, that of data mining from existing industry and academic materials, identified as research type 2 (R2).

Figure 13: Mixed methods undertaken, and data sources utilised in this research 2015-2018



Data emerging from each step within R1 was coded and a process of reflection was undertaken to consider the ideas or those emerging. These formed the basis of the next research action, each step flowing from the findings of earlier work. The materials

considered in R2, academic and industry literature (D9), observation at Carillion meetings, and ad hoc discussions with Carillion staff and industry forums (D10) did not occur at discrete research points but supported emerging themes and formed part of an ongoing data capture process. A summary of the research undertaken is presented in Table 6.

Table 6: Summary of research activity

Code	Research Question	Title	Sample base	Sample Size	Purpose	Primary Method of Analysis
D1	**RQ1, RQ2,RQ3**	Local Concepts	Initial Discussion Carillion Sustainability Team	4 people	Developing focus of research	Initial coding of text
D2	**RQ1, RQ2,RQ3**	Purposeful Sampling	Semi-structured interviews: senior SC/ sustainability team members	9 people (2 teams)	Testing potential research questions	Coding text, systematic analysis
D3	**RQ2**	Online Survey 1	Carillion Procurement and Sustainability Teams	70 people	Expanding research questions to multiple decision makers	SPSS/ Coding text, systematic analysis
D4	**RQ2,RQ3**	Workshop	SC team	74 people	probing SC team knowledge, drawing out barriers and enablers further	Excel, Coding text, systematic analysis
D5	**RQ1, RQ2**	Semi-structured interviews	Carillion teams	11 people (6 teams)	probing intra-organisational siloes, knowledge and fragmentation	Coding text, systematic analysis
D6	**RQ1, RQ2**	Online Survey 2	Procurement and Sustainability Teams	68 people	further development and refining of emerging themes	SPSS/ Coding text, systematic analysis

Code	Research Question	Title	Sample base	Sample Size	Purpose	Primary Method of Analysis
D7	**RQ2, RQ3**	Quantitative Analysis	CCS procurement, customer PQQs, Tenders	35 PQQs and 3 tenders	probing process and supplier sustainability knowledge	Excel
D8	**RQ2**	Semi-structured interviews	Category Managers, Carillion preferred suppliers	6 Cat Mans, 9 Suppliers	further development and refining of emerging themes	Coding text, systematic analysis
D9	**RQ1, RQ2, RQ3**	Literature	Academic Literature, Industry Publications, Carillion documents	476 documents referenced	understanding from literature the importance of the emerging themes	Reading, notes, coding
D10	**RQ1, RQ2, RQ3**	Observations	Carillion meetings, industry forums	37 meetings, 20 conferences	understanding from current debate the importance of the emerging themes	Coding text, systematic analysis

Key

D1-D10 are outlined in detail in sections 3.5.1 and 3.5.2 and presented in figure 13
RQ1: the capability of the main contractor to manage the supply network
RQ2: the ability of the main contractor to manage sustainability issues across the supply network
RQ3: the capability of the main contractor to deliver sustainable built assets

The following two sections of this chapter outline the methods utilised and highlight some of the issues arising from the approaches adopted. The reader may find it useful to have a separate copy of this diagram available when reading this thesis. The coding of research actions will be used throughout chapters 4-7 to identify the process by which the data presented has been acquired.

3.5.1 Research type 1 (R1)

In the following section the different steps identified in R1, Figure 13 will be discussed.

3.5.1.1 Local concepts (D1)

The briefing document, created by Carillion, formed the basis for the first outline of potential areas of research. From this the researcher, supported by both the industrial and academic supervisors, explored these in greater depth and further refined the potential areas of enquiry that would meet the requirement for doctoral research and provide a valuable insight for Carillion. These ideas were presented to Carillion and observations from the CCS sustainability team (D1) narrowed the research focus further. Indeed, their comments created a partial framework of 'local' concepts and highlighted some of the principal features for research (Glaser, Strauss 2008). These were to develop a greater understanding of the role that the main contractor could, and should play in sustainable procurement, and how this impacted on the company's ability to affect sustainable construction. Carillion plc wanted to be seen as leading sustainability in their sector.

3.5.1.2. Semi structured interviews (D2, D5, D8)

Having identified the key area of research the next stage was to test how Carillion's role was viewed by informed internal sustainability and procurement team members. This process described by Sandelowski (1995) as "purposeful sampling", was undertaken in May-June 2015 to draw on the shared knowledge and experience of sustainable procurement within the company (D2). Discussion with Carillion's Supply Chain Director and Sustainability Manager identified seven members of the supply chain team and two of the sustainability team likely to provide relevant insights (see Table 7). This initial

review included both high and medium-level decision makers (as defined by Carillion) which provided a strategic overview of current procurement and sustainability within the company and the wider industry. Interviewees were also selected to offer a mix of job roles, from strategic to joint venture procurement, key project management, supplier accreditation and on-site sustainability monitoring. All interviewees engaged with this doctoral research are identified in the text by code descriptions to preserve anonymity. A master code list, identifying all participants is held separately to all research files and is held on an encrypted hard drive. This is available only to the researcher. All codes used within this research are presented in Appendix 5 for ease of reference. The reader may find it useful to have these available when reading chapters 4-7.

Table 7: Team and job role of orientation interview participants (D2)

Team	Code	Role	Length of Interview
Supply Chain	SC-A1	Supplier Accreditation and Monitoring	1hr
Supply Chain	SC-A2	Supplier Accreditation and Management	1hr
Supply Chain	SC-D1	Managing Regional Strategy, supply chain procurement - multiple projects, client liaison	1hr
Supply Chain	SC-RM1	Managing Regional Supply Chain Team- multiple projects, client liaison	1hr
Supply Chain	SC-RM2	Managing Regional Supply Chain Team- multiple projects, client liason	1hr
Supply Chain	SC-JV	Managing Procurement - Joint Venture	1.15hr
Supply Chain	SC-P1	Leading team for large public sector project, delivery, client liaison	1hr
Sustainability	S-CM	Corporate Sustainability - policy, strategy and reporting	45mins
Sustainability	S-BM	Business Unit Sustainability Strategy - monitoring, reporting, leading project sustainability	1hr

At this initial stage of enquiry, where the key research questions had been established, but where the researcher had only a limited understanding of how Carillion teams understood and perceived sustainability a semi-structured format was selected. This format was adopted during these orientation interviews to allow major questions to be asked in the most appropriate sequence and for the researcher to 'probe for more information' (Gilbert, Stoneman, 2016). This also allowed the interviewer to explore themes or comments in more depth. To review the structure of the interview prompt questions, see Appendix 3 Interview, workshop and survey questions

Appendix: 3a Semi-structured orientation interview questions (D2).

A further two interview programmes, in each case using a semi-structured interview format, were undertaken to

a) deepen the understanding of the Carillion intra-company team perspectives of the main contractor's role within the construction network. Interviews were undertaken with a range of internal team members. They were specifically targeted at discovering their perspectives on the network actor values across the supply chain, the importance of longer-term relationships with the client and their approaches to sustainability action (for interview structure see Annex 3c).
b) to explore the depth of knowledge across the supply network. This involved working with the category management team and preferred suppliers. A standardised semi structured format interview format (Annex 3c) was created. It was based around a topical issue: recycled content.

a) Cross company teams: theme-led interviews (D5)

To investigate specific issues that were emerging a series of topic-based interviews were undertaken with staff members, many of whom were outside the supply chain or sustainability team. Unless noted in Table 8, interviews were conducted face to face.

Table 8: Carillion teams: topic-based interviews (D5)

Carillion Team	Code	Role	Topic	Length of Interview
Operations	O- AD0	Account Director - Building project	Client drivers/role of long term relationships	45min (tel con)
Work Winning	WW-PM	Proposals Manager	Client drivers	1 hour (tel con)
	WW – PC	Proposals Co-ordinator	Client drivers	(included in above)
Operations	O-BIM	BIM Implementation Manager	Technology	1 hour
Design	D-HD	Head of Design	Impotence	2 hours
Category Management	CM-D	Director	Values and relationships in supply chain	1.5 hours
Supply Chain	SC-D1	National Director	Values in supply chain	40 mins (tel con)
Supply Chain	SC-RM1	Regional Director (Building)	Values in supply chain	40mins (tel con)
Supply Chain	SC-RM3	Regional Director (Infrastructure)	Knowledge transfer	40 mins x 2 (skype)
Sustainability	S-SA	Sustainability Advisor CCS	Long term relationships	1hr (tel con)
Sustainability	S-BM	Sustainability Manager CCS	Long term relationships	1hr (tel con) & written response

Members of teams were based across the UK and it was not possible for all interviews to be face to face. Contacts within the Carillion teams were identified by the industrial supervisor, following discussion with the researcher. The researcher had a topic they wished to probe in greater depth, but the interviews were allowed to flow, drawing from the interviewee issues they felt were important. All notes taken during the interviews were logged on MAXQDA and coded.

b) Carillion category management team and preferred supplier interviews (D8)

Following attendance at several category management team meetings and ad hoc conversations, it became clear that this team held a pivotal role, linking procurement, operations, bid winning teams, and for some projects, the client. To explore this network spanning role in greater depth a more formal set of discussion-based interviews were undertaken during March-May 2017 (Table 9). The interviews were held at sites most convenient for the staff; the Midland Metropolitan hospital construction site in

Birmingham, Carillion Euston, London offices and the Kings Cross, London construction site. The interviews were undertaken as semi structured discussions, with two Heads of Category being present at two of the sessions and a Head of Category and Category manager at the third interview. The S-CM and S-BM were also present, primarily by skype, with the S-BM attending the meeting in Birmingham. The discussions were led by the researcher, and the feedback appeared open and frank. In addition, the sustainability team helped clarify questions that emerged. Having multiple participants engendered a dynamic and animated discussion with observations sparking comment and, in some cases, alternative perspectives and insightful disagreement.

Table 9: Category manager team interviews (D8)

Carillion Team	Code	Role	Length of Interview
Category Management	CM-1	Head of Category – MEP	2hrs
Category Management	CM-2	Category Manager – MEP	(included in above)
Category Management	CM-3	Head of Category – Prelims.	1.5 hours (joint interview with CM-4)
Category	CM-4	Head of Category -	1.5 hours (joint
Category Management	CM-5	Head of Category - Building Envelope	2 hours (joint interview with CM-6)
Category Management	CM-6	Head of Category – Finishes (Construction)	2 hours (joint interview with CM-5)

The results from the category manager interviews and online survey responses (D3, D6) highlighted the important relationship between procurement teams and suppliers, especially preferred suppliers. Supply chain teams were looking to suppliers to support and even drive sustainability. Category managers were sector experts, with considerable experience in specific manufacturing areas rather than expertise in procurement. Their relationship with preferred suppliers seemed especially close and the final phase of the research was developed to understand the dynamics of the relationship between category teams and preferred suppliers. It also examined the approaches and understanding of these suppliers to sustainability across the construction network.

To explore the supply network from the supplier perspective (R1), and their view of the ability of the main contractor to manage sustainability in the supply network and of the

final built asset (R2, R3) further semi-structured interviews were planned. As noted in section 3.4.1.2 this format allowed consistency between each interview but also provided the researcher with opportunity to probe and explore specific points more deeply. Each category manager was asked to identify several suppliers that they closely worked with, and whom they perceived to be sustainable. The researcher did not offer any guidance on how to define sustainability in this context. Based on their experience working on 'Prelims'; products and services required prior to construction, CM-3 did not feel that any of his suppliers or their products would be relevant. Shortly after requesting supplier contact details the Grenfell Tower fire occurred and as a consequence CM-5 came pressure to respond to numerous technical questions. The researcher did not engage further with CM-5 for contacts and no envelope (glazing and cladding) suppliers were interviewed. The remaining category managers put forward several suppliers which are listed in Table 10. Interviews were carried out face to face, by skype or telephone, primarily with only the researcher present. However, two of the interviews were incorporated into part of a category manager review meeting, which provided an immensely rich insight into the relationship dynamics. Whilst these sessions appeared to be open and collaborative the researcher accepted that the presence of the category manager may have repressed some areas of discussion. This was not however, apparent from interview responses. Notes were taken during all interviews and were uploaded to MAXQDA and incorporated into the ongoing reviewing and refining of codes and theme development.

Table 10: Carillion Suppliers, Tier 1-3: Semi Structured Interviews (D8).

Supplier Type	Supplier Code	Interview Format	Length of Interview
Tier 2/3: Manufacturer - Ceramics	SUP- 1	Face to face, in group including CM-2, SUP-1 Sustainability Manager, 2x SUP-1 Sales team	1.25 hours
Tier 2&3: Manufacturer - Ceramics	SUP-2	Face to face, in group including CM-2, SUP-1 Sales team	1 hour
	SUP-2	Tel con researcher & SUP-2 Director of Sustainability	
Tier 3: Manufacturer - Plastics	SUP-3	Face to Face – SUP 3 Head of Sustainability + SUP-3 Key Account Manager	1.5 hours
Tier 1&2: Wholesaler	SUP-4	Tel Con, Researcher, SUP-4 Sustainability Manager and SUP-4 Key Account Manager	1 hour
	SUP-4	Follow up tel Con, Researcher and SUP-4 Sustainability Manager	0.5 hour
Tier 2&3: Manufacturer – Cables	SUP-5	No interview possible – limited written feedback to interview prompt questions	N/A
Tier 2&3: Manufacturer – Cables	SUP-6	No interview possible – written feedback to interview prompt questions	N/A
Tier 1&2: Manufacturer - Cement/Aggregates	SUP-7	Tel Con Researcher and SUP-7 Sustainability Manager	1hour
	SUP-7	Face to Face site visit: Researcher and SUP-7 Sustainability Manager	2 hours
Tier 1&2: Manufacturer - Cement/Aggregates	SUP-8	Face to Face Meeting: Researcher, UK Head of sustainability and Sustainable Construction Engineer	2 hours
Tier 1&2&3: Manufacturer -Paving and Stone	SUP-10	Tel con Researcher and SUP-10 Head of Sustainability	1 hour
Tier 1&2&3: Manufacturer - Plasterboard	SUP-11	Tel con Researcher and SP-11 Head of Sustainability	1 hour
Tier 1&2: Manufacturer Assoc. -Steel	SUP-12	Face to Face: Researcher. SUP-12 General Manager and SUP-12 Technical Manager	2 hours

3.5.1.3. Online surveys (D3 & D6)

Whilst initial interviews had provided the perspective of several Carillion high and medium-level decision makers on Carillion's role within the supply network they gave

only limited insight into the ability of the whole procurement team to manage sustainability across the network (R2). Therefore, it was important to understand how these views translated across SC team operational levels. The Carillion Supply Chain 'family' comprised of more than 90 staff, and whilst hour long semi structured interviews would have offered enormously rich data this approach was not feasible. Carillion would not have approved such a high loss of staff working time or researcher travel costs. To reach this breadth of staff an online survey was created. Whilst several different online survey templates are available the researcher did not review these programmes for suitability. Instead, SurveyMonkey (SurveyMonkey, 2016), for which Carillion had an annual subscription was utilised. This was the preferred Carillion format for internal surveys and staff were sensitised to its operation and format.

The orientation interviews and further insight from academic research were used to shape the first draft survey (Appendix 3d: Survey 1 questions (D3)). Its aim was to explore the knowledge and approaches taken by members of the Carillion supply chain team to sustainable procurement. This included an understanding of the perceptions of SC team responsibilities, that of other relevant groups, and their perception of the effectiveness of sustainability delivery. The survey looked to further explore barriers to sustainable procurement, the issues they encountered, and how they felt this could be improved. Survey questions incorporated closed questions, where respondents were asked to select from a prepared list, interval-level questions and open text responses. In most questions, respondents were also offered the choice of 'other' or to provide a comment if they wished to offer a different perspective. Questions were prepared and reviewed by academic and industrial supervisors. Several senior members of the Carillion supply chain team tested the survey prior to publishing; reviewing use of language, structure and usability. Several changes to the language used and usability were suggested, and these were implemented. The survey was sent to participants by the Carillion Supply Chain Director, with an email prepared by the PhD researcher and was followed up a week later with a 'chasing' email. Ninety members of the supply chain team within the construction business unit were contacted and of these 81 responded but of these 11 only answered the first two 'generic' questions and were excluded from the results analysis. All respondees provided information on their job role and this was

used to generate a hierarchy of responsibility for decision making, with those most senior being classified as “high”, middle management roles as “medium” and more junior roles as “limited”. The numbers of respondents represented by each decision-making level were then defined (Table 11).

Table 11: Identifying a decision-making hierarchy based on respondent’s job role

Job role of respondents	Decision making level ‘High’	Decision making level ‘Medium’	Decision making level ‘Limited’
Supply Chain Director	1		
Head of Supply Chain	9		
Head of Category	1		
Head of Health Safety and Sustainability	1		
Finance		1	
Category Manager		5	
Supply Chain Analyst		1	
Sustainability Manager		1	
Supply Chain Manager		26	
Senior Buyer		3	
Area Buyer			1
Buyer			7
Admin/Supply Chain			1
Assistant Buyer			1
Graduate			4
In House solicitor			1*
TOTALS	**12**	**37**	**15**

*Note: Although the solicitor operated within a senior position in Carillion they were coded as a limited level decision maker in the context of sustainable procurement.

These classifications were reviewed and confirmed as a fair representation of role responsibly levels by Carillion’s Supply Chain Director. Data from the survey D3, including these decision-making levels, was prepared for analysis using the statistical analysis software SPSS. The University of Surrey provides students with access to this software package and the doctoral student underwent a short SPSS training session with a member of the CES teaching staff. Data was downloaded from Survey Monkey in an excel format and uploaded to SPSS version 24 (IBM Corp., 2016), and the initial analysis

of Survey 1 was undertaken. Data for Survey 2 was available in 2017 by which time SPSS had been updated to version 25 (IBM Corp., 2017). This updated package was used for all final analysis. All text notes were input and coded in MAXQDA.

The SC-D permitted a second survey to be run in 2017 but requested a shortened format to minimise staff response time. In addition to the two standard role and team questions, three questions on responsibility, effectiveness and sources of knowledge were repeated to provide longitudinal data. Three new questions, based on topics arising from interviews were added; on modern slavery, the importance of FSC operational and the prevalence of sustainable building standards requests. One final, open ended question on air quality was included to support an issue identified by the Carillion corporate team (see Appendix: 3f Survey 2 questions (D6). Again, the industrial supervisor and several supply chain members reviewed and tested the survey.

The survey was sent out prior to the April 2017 Carillion supply chain conference, in the same online format as 2016, and with a covering email from the SC-D (Appendix: 3g Survey 2 covering email (D6). All supply chain team staff were invited to attend the conference, with the additional invitees from finance, sustainability, and legal teams. In addition, CCS Head of Design (D-HD) also attended. A follow up email was sent to all conference participants encouraging them to respond. A response rate of 72% yielded 68 completed surveys. Data, generated through survey monkey, was downloaded in excel and analysed using SPSS version 25. Where relevant, respondees answers were compared to the results of 2016 questions. However, this was undertaken with the knowledge that there was a small variation in respondees between the two surveys and, although offering an indication of change, the findings were not directly comparable. All written responses were uploaded to MAXQDA, coded and memos created. Decision making levels of staff responding were coded as per the categories defined in 2016 (see Table 11).

Only limited statistical analysis was undertaken on the survey data as the maximum sample size was 69 in 2016 and 72 in 2017 (as illustrated in Figure 20). For some questions only 33 respondents answered (Table 19). The response rate of 72% was close to, but below the point required to achieve a 95% confidence level.

3.5.1.4. Workshop (D4)

The Carillion Supply Chain Conference 2016 was themed, by the SC-D, to 'focus on the challenges faced in sustainable and ethical procurement'. It was a Carillion SC team conference and not open to suppliers or other external groups. Issues that had relevance for procurement teams were covered by internal presentations from Carillion staff; topics such as Forest Stewardship (FSC) timber, the Carillion 2020 Sustainability Strategy, environmental incidents and fines, modern slavery and by an external speaker from the Supply Chain School, of which Carillion was a board member. The SC-D offered the researcher the opportunity to engage directly with the supply chain team. Whilst this had not been envisaged as part of the original research plan this additional engagement would allow the researcher to explore in greater depth, topics examined in the online survey. The methods selected for the workshop had to meet criteria set by SC-D; that research must be through interactive participation and that the workshop had to increase staff knowledge. All findings were to be collated and produced as a short briefing note for circulation to participants following the event. The design and research objectives, however, were to be defined by the researcher.

The conference was attended by 74 participants of whom the majority were supply chain team members. This included Infrastructure, Building and Sky Blue (a group who supported staff requirements across the company), and those working on Joint Ventures. It also incorporated category management staff, who were considered part of the 'procurement job family'. Additional participants were:

a) Carillion CCS finance: 1 person
b) Carillion HS&S: 2 people
c) Corporate admin support: 1 person
d) Carillion legal team: 2 people

There were 49 male participants (70%), 21 females (30%). No age data was collected but visual analysis suggested the majority of attendees were 45-64.

The interactive workshop was designed to illuminate a research category that had been highlighted during semi structured interviews, Carillion documentation and the pre-conference survey. This was to understand the knowledge of the supply chain team about the social and environment impacts associated their work. The interactive element of the group working was created by the researcher, following a brief discussion with a member of the CES academic team. All materials were produced by the researcher and were reviewed by the conference organising group to ensure they met the conference requirements. No changes were made

Workshop Structure:

a) Introduction to Lifecycle thinking
b) Action 1: The sustainability impacts of procured materials and supply chain comprehension: small groups working together (8 tables of 6-9 people per table)
a) Action 2: Embodied Carbon Exercise: individual contribution

a) Introduction

The researcher provided a three-minute visual presentation "The Lifecycle of a Pencil", to ensure all participants were engaged with lifecycle thinking prior to the start of the exercises. The presentation considered the components of a pencil, the life stages it underwent and the environmental and social impacts at different life stages (See Appendix 3h, Figure 57).

b) Action 1: The sustainability impacts of procured materials and supply chain comprehension.

Table groups were self- selected and at the start of the workshop an ice breaker exercise was carried out. Cards had been prepared that highlighted a construction material and a simple impact related to it (see Appendix 1, Appendix: 3h Workshop materials (D4)

Figure 54).

Participants needed to link the product with the impact. This engendered interaction between team members and was quick to complete. The researcher walked between groups and it was clear that the cards generated discussion.

Immediately following these lively debates each table was provided with a sample of one of the following products which they would be 'buying':

1. A high-density concrete block
2. A miniature example of a plywood form (structure into which concrete is poured)
3. A solar powered light
4. Cordless drill with carbide dust extracting bit
5. A cordless, telescopic LED work light

Products had been selected to offer complex multi-component items and simpler mono or minimal component goods. The S-BU requested samples from manufacturers, explaining the way in which they would be used and additionally requesting product information sheets. Any data sheets provided were available to the teams during the exercise.

Each table was provided with an A2 printed feedback sheet (Appendix 3h, Figure 55) and a set of issue cards (Appendix 3h,
Figure 56). Both sets of materials had been developed and designed by the researcher. Sustainability 'issues' had been selected through analysis of academic and industry literature, client KPIs, and Carillion sustainability targets. Teams were asked to consider the product they were 'purchasing' and to rank the sustainability issues in order of impact. They were asked to note their ranking on the feedback sheet. For the top three issues selected, each team then discussed how this related to the product they were 'buying' and its supply chain, the opportunities and the barriers to be addressed. Teams were given 40 minutes to complete these tasks. The level of engagement with the task was high, it generated debate and several teams felt that it had finished 'too early'. All Feedback sheets were completed, many with extensive notes and comments.

Notes were also taken by the researcher who visited tables as the exercise was being undertaken.

c) Action 2: Embodied Carbon Exercise

Following this work all attendees at the conference completed one further task. They were asked to consider the carbon embodied in three simplified life stages (pre-operation, construction, in use) of a building and a bridge (Appendix 3h, Figure 58). For the purposes of this exercise demolition was highlighted, but not included due to the minimal impact noted in the academic literature. Participants were provided with the expected length of life of each structure. They were asked to write on sticky labels the percentage of CO_2 emissions they believed occurred at each of the three life stages and to place these on the relevant sections of the life cycle sheets provided. Most people did this exercise without discussion, but a few small groups formed in front of the life cycle sheets and debated the outcomes: thirty two participants completed this exercise. All worksheets and lifecycle sheets were collected at the end of the conference. Text was transcribed and uploaded to MAXQDA for analysis. Data from the lifecycle sheets was collated and compared to existing life cycle literature.

3.5.1.5 Analysis of PQQ and tender documents (D7)

It was evident from interviews and meeting notes that communication of requirements between network actors was highly transactional in nature. The primary materials that signalled the procurers demand for sustainability prior to contracting were Pre-qualification questionnaires (PQQs) and tender documents. To establish the procurer's level of engagement with sustainability, sources of material were examined:

1. Sustainability requirements in client tenders and PQQs: A list created by the Carillion corporate sustainability from information provided by the Carillion bid development team (2017)
2. Responses to Carillion pilot infrastructure PQQs and tenders (2016-17)

The data was provided in excel spreadsheet format by S-I, and the analysis was undertaken using excel, as the information presented a straightforward review of PQQ and tender outcomes.

By engaging with these sources of material it firstly allowed the researcher to examine how clients were approaching sustainability issues with the main contractor. In the pilot study the information provided insight not only into Carillion's approach to sustainability, but also enabled the researcher to appreciate the capacity and capability of suppliers to respond to PQQ and tender demands.

1. Client PQQs and tender documents

The Carillion corporate sustainability team had reviewed 81 bids, of which 41 bids elicited sustainability content providing 233 individual sustainability questions. The corporate team had coded the questions by category, such as waste, resource use, fair labour, and by the three Carillion corporate sustainability themes, 'Better Business, Better Environments and Better Communities'. Bid questions with sustainability content were uploaded and coded in MAXQDA. Additionally, the researcher made notes on the way in which the Corporate Sustainability team had categorised the questions, and observations on the importance of the supply chain.

2. Infrastructure PQQ and tender pilot

The second set of data analysed was derived from scoring sheets created through the procurement of four product categories by Carillion's infrastructure team. This work was being carried out as part of a pilot to trial a new procurement format requiring greater emphasis on total value, rather than just awarding for lowest cost. The project was led by SC-RM3 and S-I had been heavily involved in developing both environmental and social sustainability questions. Due to issues of confidentiality the written responses from suppliers to PQQ and then tender documents were not made available to the researcher. Instead the scores from both PQQ and tender questions were supplied. These had been set by the sustainability team and were scored by an experienced internal sustainability professional (S-I). This data allowed a quantitative analysis of the outcomes of the tender process, the role of sustainability, and the procurement process

to be observed. Memos were made by the researcher which were recorded in MAXQDA. The findings are explored in chapter 7, Section 7.1.2.1.

3.5.2 Research type 2 (R2)

3.5.2.1 Literature review (D9)

The use of literature in grounded theory is seen as problematic. Glaser highlighted that researchers should immerse themselves in related subjects but should shy away from that most relevant to their topic, until most of the data had been collected and analysed (Glaser, 1998). However, confusingly, Strauss and Corbin expected most professionals to be aware of the literature in their field when undertaking research (Strauss, Corbin, 1998). Nonetheless, this position has been rejected by many scholars working within this field (Charmaz, 2014) and Thornburg recommends that understanding existing literature is an essential element of theory development (Thornburg, 2012). Bryant emphasises that literature has a role to play in grounded theory and indeed a Pragmatic approach takes account of this, where insights can come from anywhere (Bryant, 2009). This research work has adopted a stance that attempts to be sensitive to these views and underlying concerns. From a pragmatic perspective it is a key requirement for doctoral students to be able to demonstrate their work is contributing to 'gaps in existing knowledge'. In this research the topic being studied is not one the researcher has a detailed knowledge of professional and academic thinking; a not unusual position. To attempt to achieve these competing objectives the literature has been assessed and presented in three formats;

1. A review of approaches, tools and methodologies to support the development and undertaking of the research process. This is presented in this chapter, sections 3.2 and 3.3 (D9).
2. An initial, critical and reflective review (presented in chapter 2) was carried out to identify the potential scale of impact the research could generate, the existing work on construction supply chains and sustainable procurement within the sector. Literature was identified through word search functions in academic listings, Scopus and Google Scholar and repeating these key word searches in google for industry publications. Industry materials were supplemented by recommendations from Carillion staff and industry experts. As categories began

to emerge from the analysis specific topics were further considered, including collaboration and knowledge within the supply chain context. This offers the reader context to the findings drawn from the inductive research and presented in chapters 4-7 (D9).

3. In line with Glaser's approach (Glaser, 1998) specific literature related to the themes was reviewed only after the research themes had been established. This material forms the basis of the comparative analysis between existing knowledge and the research findings that are presented within each main section summary (chapters 4-7) (D9).

In addition to the planned review of formal academic papers or industry reports and documents, observations at meetings, industry forums, conferences and online presentations were 'opportunistic' and occurred throughout the research period. This provided a rich, informal, assessment of many key industry issues which were recorded as typed notes. All notes were input to MAXQDA and coded.

3.5.2.2 Content Analysis of Annual Sustainability Reports (D9)

To gain insight into how companies within the construction sector were approaching sustainability and sustainable procurement an initial analysis of the Annual Sustainability reports (2014-2015) of Carillion and four of its UK peers was undertaken. The selection of a content analysis approach enabled the researcher to review large amounts of text which was coded and presented in a format to allow comparison. Peer selection was made following discussions with the Carillion sustainability team. All occupied the same Construction phase position within the supply network and had a relatively similar client base. Each Annual Sustainability report (ASR) was read in detail and, the corporate aspirations, issues and actions undertaken were recorded in an excel spreadsheet. To provide further context for this peer review approach the same exercise was carried out with four global companies identified as sustainability leaders. It was not the intention that this review was an exhaustive assessment but rather to provide the researcher with an appreciation of the sustainability practices, reporting and future concerns being undertaken by Carillion in comparison to its peers. This first stage of analysis was

completed but after reviewing the data it was felt that a broader base was required to enhance the comparison. This was achieved by expanding the peer base to European companies. To support this further selection the Sustainable Supply Chain Review 2014 (Acquisti & Sostenibilità, 2014) was used to identify companies that had been selected specifically on the sustainability quality of their supply chains, as evidenced in their reporting. This was further narrowed to consider only those that were directly comparable to Carillion, and of these Balfour Beatty and Skanska had already been selected within the 'Peer Group'. Globescan's 2015 Sustainability Leaders Report (Globescan, 2015) was used to identify corporates that were rated most highly in terms of their sustainability. Globescan acquired this data through a global, online survey. This was sent to 816 qualified sustainability experts of whom 69% had more than ten years of experience working on sustainability issues. The survey was completed in Spring 2015 and respondents, spanning 82 countries, were drawn from corporate, government, non-governmental, academic/research or other commercial backgrounds. The companies selected for the review, including country of origin, are presented in Table 12.

Table 12: Companies included in the Sustainable Reporting Review

Source	Company	Country
	Carillion	UK
	Main Contractor Peers in UK sector	
Carillion identified	Balfour Beatty	UK
	Interserve	UK
	Kier	UK
	Laing O'Rourke	UK
	Lend Lease	Australia
	Sir Rober McAlpine	UK
	Skanska (Sales: UK)	Sweden
	Skanska (Sales: World inc UK)	Sweden
	European Companies in Construction Sector	
Acquisti & Sostenibilità 2014	Arcadis	Netherlands
	Groupo ACS	Spain
	Hochtief	German
	Peab	Sweden
	Royal BAM	Netherlands
	Wilmott Dixon	UK
	Global Sustainability Leaders	
Globescan's 2015 Sustainability Leaders Survey	Interface	US
	M&S	UK
	Patigonia	US
	Unilever	Netherlands

All reports assessed were based on 2014 reporting and were predominately titled 'Sustainability Report'. This was either issued as separate document or included as a discrete section within Annual Reports. There was no evidence of integrated reporting. The analysis did not include interrogation of corporate websites or other company material. For the full review see Appendix 2.

3.4.2.3 An analysis of construction sector key performance indicators (KPIs), (D9)

Having identified diversity and different sustainability approaches amongst Carillion peers (Section 3.4.2.3) the researcher wanted to identify if this fragmentation was reflected across the wider supply network. To achieve this the researcher needed to select a measure that was accessible through published materials, reported in the same time period, would provide insight into the sustainability practices of network actors

and was a metric with a level of accepted uniformity thus allowing differences between actor approaches to be illustrated. Business or industry sector KPIs met these criteria and were selected. To enable a cross network perspective, organisations that represented each phase of the build process, or if not feasible the main suppliers in the phase were analysed. To represent the investor sector the Global ESG Benchmark for real estate (GRESB) was utilised. In 2016 they represented over 750 global investors and encouraged members to report on the KPIs that had been developed by the organisation (GRESB 2016). Developers and key clients were represented by seven major UK organisations that managed construction, of which three were private and four were either public or quasi-public clients (e.g. Network Rail, Highways England). Main contractors were represented by Carillion, Keir and Skanska. To ensure a more general peer group contractor perspective was included, Build UK, the industry body representing all UK contractors, was also reviewed. Raw material suppliers and product manufacturers were represented by two trade bodies, the Mineral Products Association (MPA) for cement and concrete and UK CARES; steel. These two groups were selected as representative of most of the UK product sector providers and both were supplying high impact, high volume materials within a build. . It should be noted that trade bodies and other representative organisations were counted as single units. Using an excel spreadsheet to record information all KPIs identified in online corporate reports, or online corporate pages for the organisations noted above were described and logged. They were grouped into the following sub sectors: Environmental, Economic, Social and Sustainable Development. KPIs which were worded in slightly different ways but clearly were had the same aim were grouped together. Finally, the total numbers of indicators were averaged by the number of contributor organisations to ensure they were comparable across network actor type. At this point the sub sector 'Sustainable Development' was eliminated as it contained few KPIs, and this grouping did not appear to provide any additional insights. KPIs were re allocated to Environment, Social or Economic, where most appropriate. The outcomes of this analysis are presented in chapter 4, section 4.3.

3.5.2.4 Meeting Notes, Observations, industry forums and ad hoc conversations (D10)

Throughout the period of doctoral research value was given to information derived from ad-hoc discussions, Carillion meetings attended (Table 13), industry forums and conference notes (Table 14). In addition, the researcher recognised online webinars being offered by companies working in the sustainability arena such as Ethical corporation, Globescan and Ecovardis as an additional valuable source of information. Key global industry speakers provided their perspectives on aspects of sustainable supply chain management. For all interactions, notes were taken, usually manually and then typed. This process supported the review and thought process of the researcher and elicited additional memos from the material.

Table 13: Carillion meeting notes and ad hoc conversations

Date	Meeting/Conversation
15.5.15	Meeting with S-BM
19.5.15	Notes from Carillion IMS team meeting
24.6.15	Notes: Carillion Heads of Supply Chain meeting, S-BM and researcher
Sept 2015	SPSG Meeting – led by S-CM
October 2015	SPSG Meeting – led by S-CM
Nov 2015	SPSG Meeting – led by S-CM
2.11.15	Meeting: senior Supply Chain team Directors (SC-DB, SC-D1) S-BM and researcher
Dec 2015	SPSG Meeting – led by S-CM
January 2016	SPSG Meeting – led by S-CM
February 2016	SPSG Meeting – led by S-CM
4.3.16	Notes: Health and Safety meeting – Present: HSS-HO, H&S team, S-BM and researcher
March 2016	SPSG Meeting – led by S-CM
5.4.16	Online Meeting: SPSG – full team
21.4.16	Meeting: category management team, S-BM and researcher
1.5.16	Meeting: embodied carbon monitoring – present SC-RM2, D-HD, S-BM and researcher
5.5.16	Notes from HS&S meeting launching the Carillion ASR 2016. All HS&S team members present
May 2016	Meeting: SPSG update, present S-CM, SC-PM and researcher
26.7.16	Meeting sustainability content on Carillion website: S-CM, S-BM, intern and researcher
29.7.16	Notes: presentation of EPD research by UoS Masters student to CM-D
Sept 2016	SPSG Meeting – led by S-CM
12.8.16	Research update and discussion: SC-DB, S-BM and researcher
October 2016	SPSG Meeting – led by S-CM

Date	Meeting/Conversation
21.11.16	Meeting: Corporate sustainability team, present S-CM, S-BM, corporate sustainability team member and researcher
January 2016	SPSG Meeting – led by S-CM
8.2.17	Meeting: S-CM, S-BM recycled product content
8.3.17	CCS Sustainability Forum: Present CCS Sustainability team
21.3.17	Meeting: category management team, S-BM and researcher
March 2017	SPSG Meeting – led by S-CM
3.4.17	Meeting: Sustainable procurement strategy - led by S-CM - attendance from sustainability, SC, operations and bid winning teams
5.4.17	CCS Sustainability Forum: Present CCS Sustainability team
19.4.17	Research update and discussion: SC-DB, S-BM and researcher
10.5.17	CCS Sustainability Forum: Present CCS Sustainability team
25.5.17	Meeting: Corporate Sustainable Procurement strategy – led by S-CM - attendance from sustainability, SC, operations and bid winning teams
14.6.17	CCS Sustainability Forum: Present CCS Sustainability team
10.7.17	CCS Sustainability Forum: Present CCS Sustainability team
10.7.17	CCS Infrastructure (Rail) team meeting
Sept 2017	BIM Tie Talks: presented by Carillion operations team

Table 14: Industry Forums and conferences attended

Date	Event provider	Industry Forums and conferences
July 2015	University of Surrey	8th Biennial Conference of the International Society for Industrial Ecology
17th June 2016	Ecovardis	Webinar: Interview with David Spacey: Director Heineken -Global Procurement
19th October 2015	Ethical Corporation	Webinar: Enabling Responsible Procurement strategy for business resilience
November 2015	IEMA	Webinar – multiple presentations on the introduction of updated ISO 14001
November 2015	University of Loughborough	5th APRES Conference: Managing risk and enhancing reputation
January 2016	IEMA	Webinar: Climate Adaptation
February 2016	Data Leaders	Webinar: Changing approaches to procurement: industry views on the impact of increased data and interconnectivity
February 2016	IEMA	Webinar: Natural Capital Protocol
March 2016	Ecobuild	Attendance at Ecobuild exhibition and conference
March 2016	Supply Chain School	Completed on-line learning module: BIM
June 2016	University of Surrey	SEES conference
16-17th June 2016	United Nations	UNEP Hotspot Analysis Prototyping Workshop, Paris
November 2016	BRE	6th APRES Annual Conference on 'Responsible and ethical sourcing – a professional approach for materials, products and people',
January 2017	Action Sustainability	Webinar – online presentation for Carillion staff only: the introduction of ISO20400
March 2017	Ecobuild	Attendance at Ecobuild exhibition and conference

Date	Event provider	Industry Forums and conferences
May 2017	Royal Holloway University	Conference: SDGs and sustainable supply chains in the post-global economy
30th May 2017	IEMA	Webinar: Capital, Social and Environmental
13th July 2017	Ecovardis	Webinar: Ethical supply chains
July 2017	University of Surrey	PDS Conference
July 2017	NBS	Workshop: embodied carbon

The documents and memos were logged in MAXQDA.

3.6 Limitations of the research methods

This research was conceived as a single case study analysis, a method that, whilst providing a richness of insight, is associated with a number of criticisms. Foremost amongst these are the concerns that case study results cannot be generalised to a wider population; indeed, that they are not replicable. Whilst the outcomes of this supply network approach are indeed drawn primarily from network actors within one company, the researcher has attempted to overcome this issue by incorporating interviews with inter-company actors, notes from industry meetings and conference materials, thus testing a wider level of industry applicability. There is also debate within the academic community regarding the relatively limited guidance on methodological techniques (Bennett, Elman, 2006) for case study implementation, which can result in the absence of systematic procedures (Yin, 2009, p. 14-15). Finally, there are concerns with single case studies that they may be affected by researcher subjectivity. This is a valid point but one which is equally present in other methodological approaches and indeed, within grounded theory, researcher engagement with the subject is acknowledged as part of the research process (Bryant, 2009).

The selection of a grounded theory methodology initially created difficulty for the researcher in establishing how to undertake a process which continues to have several contested approaches. Following extensive reading of key academics working in this field, such as Glaser, Strauss, Corbin, Charmaz and Bryant a position between the approaches of Chamaz and Bryant was adopted. However, this pragmatic, epistemological stance, would be seen as problematical by other researchers working with the model proposed by Glaser and Strauss (2008), where no prior knowledge or

epistemology position should be taken. As a researcher new to the process of coding, the use of coding programmes and continued development of coding it must be accepted that some subtlety or nuance offered by participants in interviews and meetings may have been lost. It is also accepted by researchers using grounded theory that the mere process of having to consolidate data into emerging categories becomes difficult and may be constraining, a point noted by Ellis (1986, p. 91) in her work on communities.

The grounded theory methodology was supported by mixed methods. Use of qualitative and quantitative material is considered wholly consistent with a grounded theory approach (Charmaz, 2014) but, as with all combined approaches there remains the frequent difficulty of integrating these methods. Whilst this research has attempted to draw findings from both elements there are obvious issues in how to incorporate quantitative findings into the qualitatively driven coding and category development. Where text has been coded, the original material is always available for review, enabling re-assessment and even re-coding as greater or different meanings are ascribed to it as the research process develops. This is unlike quantitative coding which is precise, and the information provided by each code is single dimensional and has to totally represent the category concept it stands for (Sivesind, 1999). This has created some limitations in interpretation across datasets but the researcher believes that the mixed methods has created a greater illumination of the research problems. (put into thesis at this point).

The ability to construct coding that can function across datasets may also be a function of researcher experience and skill. This highlights one of the other major research dilemmas when using mixed methods. To achieve effective mixed methods research it requires the PhD researcher to have acquired a good working knowledge of the multiple methods being used. This includes their limitations, the procedures that need to be undertaken, the types of tools and their use and an ability to not only analyse but also interpret the findings. their assumptions, analysis procedures and tools, and an ability to understand and interpret results derived from those different methods. Despite engaging with the literature and undertaking training a PhD researcher, operating at an early stage in their research career, cannot have the same tacit knowledge that comes

with many years of experience with a particular type of methodology. However, it could be argued that this research has benefited from an open minded approach to different techniques, looking to work with those that best support the research questions, rather than being burdened by methodological prejudice (Cook, Reichardt, 1979).

Chapter 4. Network fragmentation

4.1 Introduction

The fragmentated nature of the construction sector has emerged from participant comment, and observation, as an issue which effects the main contractor's ability to lead sustainable build. It is a structural issue repeatedly cited in the literature as affecting industry productivity, innovation and wastefulness (Latham, 1994, Egan, 1998, Morledge, Knight & Grada, 2009). It has emerged as a barrier within the context of sustainable build, as it is a major structural feature of the 'hollowed out conglomerate' (Green, S., 2009, p. 34) or temporary multiple organisations (TMO) (Cherns, Bryant, 1984) that dominate the UK construction sector. A main contractor, such as Carillion, operated at a key central node within the supply network, acting as the client's primary project manager, and operating where multiple stakeholders converged; the project site. Here, elements of the supply network co-operated for an intensive 2-3-year period, working together at a relational level to problem solve and adapt (Dubois, Gadde, 2000). However, beyond this, the wider, permeant network appears to operate at a transactional level with negligible relational engagement (Thompson, Cox & Anderson, 1998, Dubois, Gadde, 2000). Multiple aspects of fragmentation have emerged from the research and all impact the ability of the main contractor to lead supply network sustainability. These aspects are:

1. Non-alignment: Each network actor selects sustainability goals, KPIs and metrics relevant to their supply network function and commercial aspirations
2. Inequality of sustainability benefit and margin across the supply network influences actions
3. Segregation of roles restricts integration of sustainability: sustainability knowledge is trapped in network silos.
4. Everyone is responsible for sustainability, but uncertainty on what this means

These aspects are considered in detail within this chapter, commencing with a review of the of network actors identified by the SC team and the functions they undertake within the construction of an asset. The analysis of non-alignment, inequality, segregation and responsibly are considered, both in relation to the operation of these actors and the

supply network, but also how this affects the ability to embed sustainability across the network. This chapter offers new perspectives on existing gaps in knowledge and challenges some of the assertions associated with fragmentation and their uniqueness within this sector. Based on the network actor review and an evaluation of the four aspects, the final section offers a more nuanced assessment of the characteristics of construction fragmentation. It identifies a complex and dynamic network in flux, with a numerous but occasional client base and project focused working. The chapter concludes with a short summary of key findings and the impact these have on the role of the main contractor.

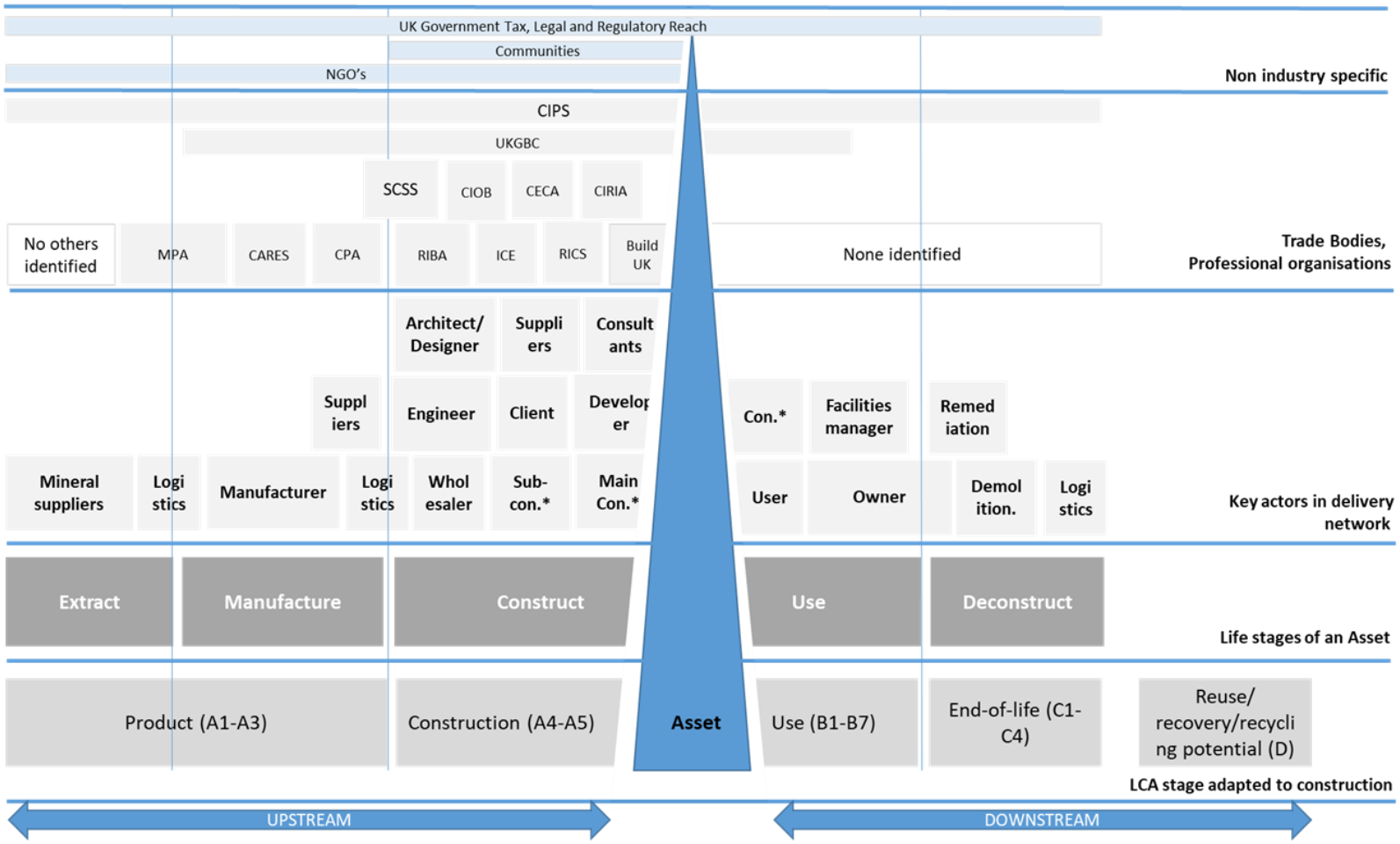
4.2 A review of actor types

The most obvious effect of supply network fragmentation, observed during the initial purposeful sampling (D2) and continually expanded during the course of the research, was the high number of different actor types identified. Carillion supply chain staff were asked to identify network actors that were relevant to their roles and affected sustainable build. They noted individuals, teams and organisations, both internal and external to Carillion, with whom they were either directly or indirectly connected. The description of sustainability was self-defined by the participants and encapsulated a range of descriptors. These included generic terms ethical, sustainable, responsible environmental, green, social and more specific issues such as community, BREEAM, ISO14001, the (Carillion) 2020 strategy and waste. It covered a multitude of aspects such as product offers, guidance, CPD, reporting, design, administration, legislation, planning. It appeared that fragmentation was not confined to network actors but extended into descriptive terms and phrases that were used by different team members to identify sustainability. The issue of definitions, language and knowledge is explored further in chapter 7.

In total 59 actor types were identified, with 41% (24), being intra-company: mirroring the complex inter-company network was an equally complex internal set of actors. The inter-company actor types were mapped onto a schematic representation of the standard phases of construction and the lifecycle stages, adapted for construction (BSI,

2013). To enhance ease of reading Figure 2, which is first presented in Chapter 2 is repeated at this point in the discourse and is noted as Figure 14.

Figure 14 (repeat of Figure 2): Simplified representation of the Inter-company supply network identified by Carillion team members (D1, D2, D3, D4, D5, D6, D8, D9, D10)



*** Abbreviation 'con' in Figure 14 represents contractor**

This helped visualise where in the life stage of a building the network actors operated and their function within the construction process. Frequently the supply chain is represented solely by organisations that directly contribute or gain from the asset (commercial actors). However, it was clear from discussions with the SC team that they engaged with a much wider group of non-commercial actors. It was thus important to represent the supply network in its widest form.

4.21 A whole life perspective

As seen in Figure 14, it is immediately clear only two network actors have the potential to actively engage across the entire supply network; the UK Government and the Chartered Institute of Procurement and Supply (CIPS). Neither of these operate directly within the commercial supply network. Government, representing the multiple roles of client, policy maker, legislator, and regulator intervene directly with sustainable build across the network. They can operate across the asset lifecycle from extraction of raw materials, to asset use and demolition. Until recently their interventions were primarily focused within UK boundaries. However, with the passing of the Modern Slavery Act (UK Government, 2015b), the legal responsibility of network actors for issues beyond their corporate boundaries and Tier 1 supplier base, was established. CIPS operates globally across all business sectors; with professional practitioners based in 150 countries. They have worked with international bodies such as UNEP to develop best practise for the developing world and supporting donor funded training in sustainable supply chains (CIPS, 2012). Their primary function is to provide members with ethical standards, guidance and skills development. Carillion supply chain team members noted CIPS as their main professional body (D2, D5). All members of the Carillion SC team had undergone CIPS ethics training in 2015 and the associated guidance had been incorporated into Carillion's corporate supplier charter (Carillion plc, 2017b). Although no analysis has been undertaken, industry comments (D8, D10) indicate that CIPS members operate at all levels of the UK construction supply network, and it is likely that they are represented in major non-UK based product supplier procurement teams. They do not provide a focal or co-ordinating role across the multiple procurement stages of an asset build.

Three other non-commercial stakeholders were identified who offered more limited but specifically construction cross-network engagement (See Table 15). The Worldwide Fund for Nature (WWF) and the UK Green Building Council (UKGBC), both NGOs, had an aspiration to collaborate across the construction supply network. Closely linked to WWF, FSC timber chain of custody was identified during the research as a major element of the Carillion sustainable procurement strategy. Carillion's SC team high-level decision makers worked closely with WWF who supported them in working the FSC chain of custody (a bottom up approach to sustainable product), undertook Carillion process audits and provided guidance. In this role WWF worked directly with a range of network actors from the raw material suppliers, manufacturers, UK wholesalers and contractors, including a few operating at the demolition stage. The UKGBC has strong industry partnerships and works with many different network actors to develop a holistic vision of construction. They identified their function as one that would 'unite the UK building industry using sustainability as a catalyst to positively transform the places people use every day' (UKGBC, 2018b). This pan sector approach is reflected in their current membership which incorporates investors, clients, architects, contractors, higher education, product manufacturers and charities. The final group that emerged as a cross-industry actor was the Supply Chain Sustainability School (SCSS). This had been founded, primarily by main contractors, to support increased sustainability knowledge amongst SMEs. It has increasingly moved away from its original main contractor base to engage with others in the pre-operational, construction and use phases. Its vision is to create 'a world class collaboration to enable a sustainable built environment' (SCSS, 2018b). The three organisations primarily address sustainability through network influence and knowledge development, although WWF, in its support of FSC engaged directly with the provision of responsibly sourced products.

Table 15: Primary NGO and construction sector organisations identified by Carillion SC team operating at multiple life stages of an asset build

Organisation	Knowledge	Accessed by	Knowledge used to:
WWF (NGO)	FSC, nature conservation, ecological footprinting	1-2 Senior Supply Chain Managers	Support discussion with some suppliers. Production of internal communication materials for SC team
UK Green Building Council (UKGBC) (NGO)	Environmental aspects of buildings including carbon, water, materials and waste	Corporate Sustainability team	Corporate support for client guidance – external stakeholders
Supply Chain School (Industry body)	Sustainability information for SMEs, Key industry topic working groups, engagement with Universities	SC- CSO on board, Senior SC team on working groups and sub boards	1000 Carillion suppliers registered, suppliers engaged in workshops, reported in ASR.

Other actors, whilst not operating across the whole network, did have expertise in lifecycle thinking. SC teams identified RICS, several of the major consulting engineers and the Building Research Establishment (BRE) as experienced in considering the whole life perspective of an asset. Additionally, many manufacturers had undertaken EPDs, although they remained poorly understood and appeared to be a sales tool rather than a methodology to engage with the lifecycle implications of their own products (D8).

4.22 Sources of information and skills

Other organisations mentioned, such as professional bodies the Royal Institute of British Architects (RIBA), the Royal Institute of Chartered Surveyors (RICS), the Institute of Civil Engineers (ICE), the Chartered Institute of Building (CIOB), and trade bodies the Mineral Products Association (MPA), UKCares, the Construction Products Association (CPA), and the Civil Engineering Contractors Association (CECA) offered varying levels of guidance, and skills development on sustainability issues. Professional bodies incorporated sustainability into their CPD programmes and several high-level decision makers in the supply chain team had seen construction bodies such as ICE and RICS operating as platforms for cross network collaboration on sustainability issues (D9). The supply chain team recognised the work being carried out by these groups and identified them as source of information on sustainability. Surprisingly, BuildUK, the UK contractor's

industry trade body (recently formed by the amalgamation of a main contractor and other building contractor groups) offered no support or information on sustainability (BuildUK, 2017). Supply chain teams also identified industry research/standards groups BRE and CIRIA as offering knowledge and tools to support sustainable build. This was especially the case with BRE who operated the BREEAM and CEEQUAL standards, the main mechanism for operationalising sustainable build across the network. However, engagement with BRE was limited primarily it appeared due to a perception they were 'too expensive', possibly due to their change from UK Government funded body to a commercial enterprise.

4.23 Direct suppliers

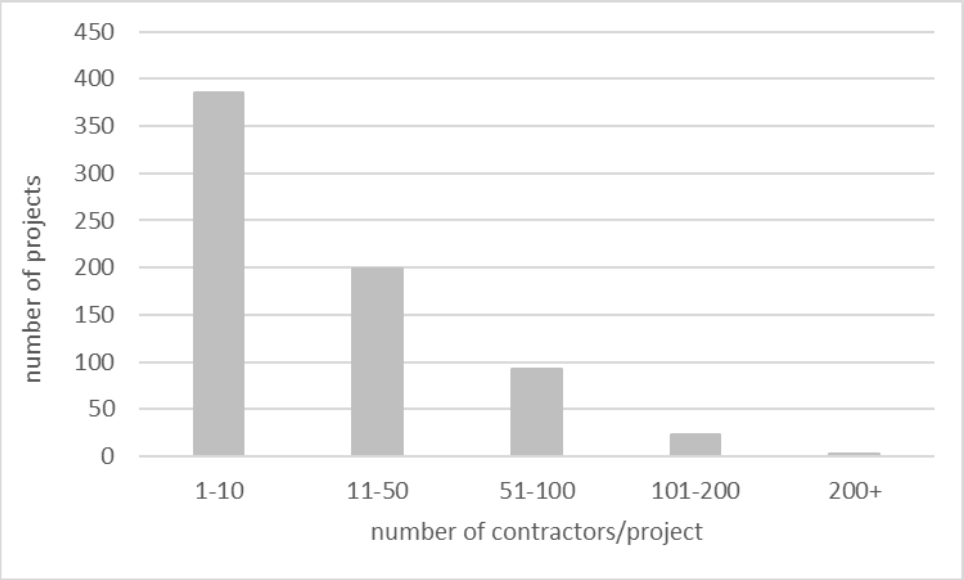
Upstream, within the supply network, there was a strong cluster of organisations closely linked to the construction process and site, with suppliers, wholesalers, consultants and sub-contractors featuring strongly in discussions with all decision-making levels of the team. At the pre-operational stage senior decision makers in the SC team worked directly with major raw material (primarily aggregates) and product manufacturers for key products such as concrete and steel. Such collaboration, however, appeared to be dependent on contract type and package structure. The final life stage of a built asset, demolition, was for many major inner-city building projects, the starting point of a new build for the main contractor. Carillion's SC team frequently worked with demolition companies, land remediation and asbestos removal firms, identifying them as part of their upstream supply chain. There were no examples of engagement with demolition actors as part of building development to ensure more sustainable deconstruction. What was most apparent in the direct supplier structure was a reliance on sub-contractors to deliver packages of work. Analysis of Carillion's CCS 2015 and 2016 annual procurement spend identified that 81.9% of spend was with just 181 companies and that of the top 80% of spend 60% was procured directly with sub-contractors. This resulted in the SC team being disconnected from many product and service suppliers operating below Tier 1, a source of SC team frustration. One category manager noted 'even when we ask (the subcontractor) they won't say who they're working with' (CM-4). The primary form of engagement with these suppliers was through tendered

contracts and contractually binding specifications, with risk passed to the main contractor by clients, and then transferred by them to sub-contractors.

Despite this strong focus on sub-contracted packages, fragmentation, driven by asset variation and the need for flexibility, was reflected within Carillion's Tier 1 supplier base. Data extracted from the Carillion supplier database in September 2016 identified 16599 suppliers on their internal "My Register"[8] database, of whom 5790 were 'active', i.e. approved for procurement. The balance of suppliers was either unaccredited or suspended due to lapsed insurance or accreditation. This was primarily due to the requirement that all revisions to supplier information had to be, by the Carillion supplier team, before their details were amended on "My Register". Carillion had not selected a database structure that was directly editable by their supply network and due to the scale of the database supplier data was therefore only updated every two years. Carillion coded suppliers by construction phase, specialism, locality and size. This suggested that the company needed to be able to select from a wide range of function specific suppliers that were required to meet varied, often short term (episodic) and place based, project specific demands. This position was supported by an analysis of projects undertaken by CCS during 2015 (Figure 15). Here 702 separate projects (as defined by Carillion) were noted, ranging from small schools to infrastructure and major hospital developments. The projects were at all stages of construction, from start up to post completion, and included a number providing post build services. There was no direct relationship between the number of contractors and the value of the project, although as expected, multi-million-pound flagship projects were operating with a high numbers of suppliers on a site.

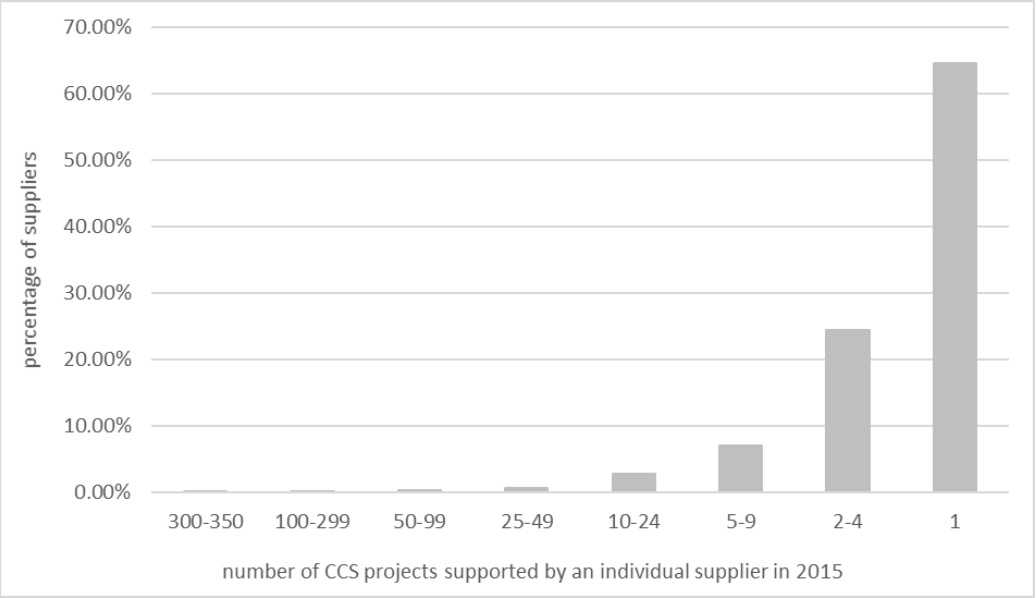
[8] "My Register" was Carillion's bespoke, but externally provided supplier record management system. It held financial information, regulatory and sustainability data. Each supplier uploaded their data and was required to review their information every two years. All procurement team members could access My Register to review supplier data. SPI supplier ratings created by project managers could be viewed by the Carillion SC Team.

Figure 15: Number of suppliers per Carillion project 2015 (Carillion procurement data CCS Jan-Dec 2015)



To understand the scale of the procurement process Carillion purchasing data was analysed using Carillion's spend cube software. This provided information on spend by project and by supplier. The analysis identified that between January-December 2015, 23,146 direct payments were made by Carillion CCS to 7,929 suppliers. Further analysis of this material using a pivot table, based on an excel extract of project specific procurement data, highlighted that 66.6% of suppliers Carillion procured during 2015 only worked on a single site, i.e. they were highly project specific, with just 1.21% of suppliers working across 25 or more sites (Figure 16). Those who operated across the widest numbers of projects, i.e. 100-350, were primarily service providers, such as site equipment suppliers, office stationary providers, food retailers or construction wholesalers. This scale of project delivery, number of suppliers and the siloing of suppliers limited most engagement on sustainability issues to a transactional level and provided little basis for collaboration.

Figure 16: Percentage of Carillion CCS suppliers servicing multiple projects 2015 (Carillion procurement data CCS Jan-Dec 2015)



The Carillion procurement data was not available over a longer time period due to a change in software and data capture processes. It is however not an unlikely assumption that whilst further analysis would have demonstrated a greater number of suppliers operating across more projects over time, it would remain a highly fragmented, site specific, supplier base.

The review of the procurement process also highlighted that whilst Carillion did record spend at a category level, detailed procurement requirements were held at a project level. Carillion had no companywide database of products procured for the assets it constructed; this was identified as being 'too complex' (CM-5) and the value of having this data was questioned (D10). It was also difficult to manage, as a high proportion of spend was through packages, delivered by sub-contractors. Discussions with the SC team confirmed that there was 'currently no real contact below Tier 2 (note: Carillion Tier 1)' (SC-P1). Details of Tier 2 and Tier 3 suppliers, including those suppliers whose products embodied a high proportion of the environmental and social impacts within an asset, were not held on the company database (SC-D). Only Category Managers, who were operating across project boundaries, and multiple supply tiers had their own, more detailed records of key Tier 2/3 companies; 'to keep track of products and suppliers'

(CM-5). Consequently, at a strategic level, the Carillion SC team did not have access to product procurement data.

4.24 Designers and clients

Downstream connections between the SC team and stakeholders were limited. The main contractor did not appear to have any direct connection to the built asset user, especially in the case of speculatively built assets. The range of engagements included examples such as Carillion mechanical and electrical engineering (M&E) staff working with facilities management teams at hand over phase. Others downstream collaborations were identified on major contracts, especially those linked to PFI or other assets where Carillion was managing the site post build. On these projects there appeared to be wider team involvement with clients, supporting build and facilities management decisions. Only SC team high level decision makers and one category manger had regular client (developer or quasi Government) engagement. Medium-level and high-level decision makers also cited engagement with designers and engineers. They also engaged with more specialised services such as legal organisations (D2, D5, D10).

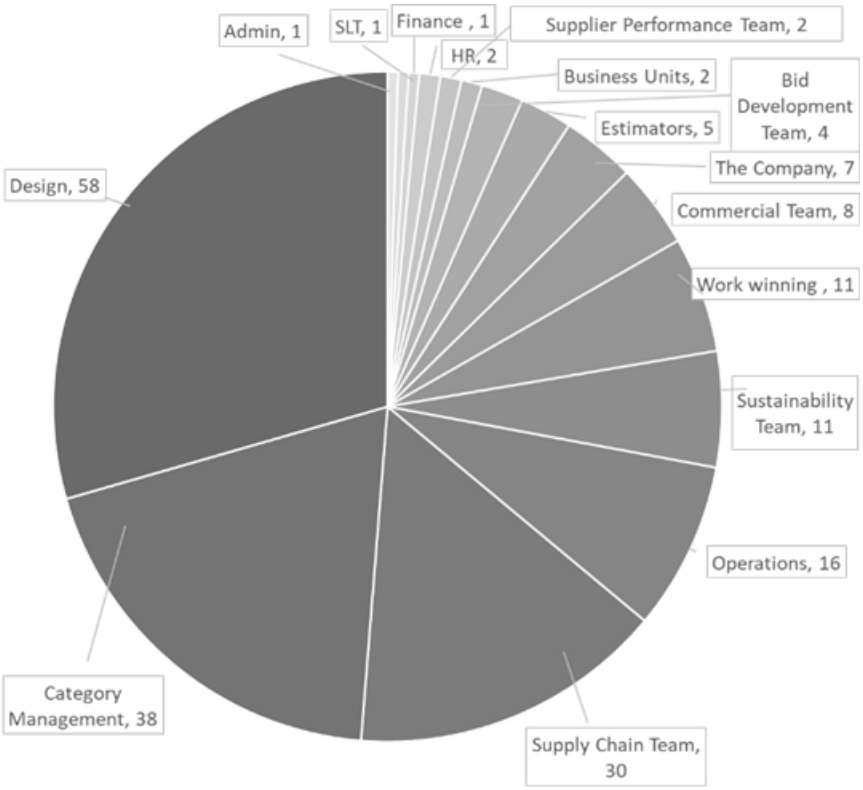
In summary. a broad supplier base, with limited multiple engagements is necessary to satisfy multiple, local project delivery. It is clear from the data, that supplier engagement was primarily a formal or transactional process, managed through contracts and specifications. However, the results of interviews and discussions would indicate that relationships did exist between different individuals or companies within the network and that these transcended project boundaries. These relational connections included individuals who had previously worked together, had developed buying relationships over many years, or met on pan-industry working groups. This type of connection appeared to present an opportunity for overcoming fragmentation and engendering increased collaboration. This is explored further in chapter 6.

4.25 The Intra-company networks

From these discussions with Carillion teams it was clear that underlying this large, complex, external network was an equally complex intra-company network: that of the

intra-company actors. During interviews, open responses in surveys, meeting notes and observations a wide range of intra company groups were identified as having a function within sustainable build and procurement. All these sources were coded in MAXQDA and in Figure 17 this data has been represented in a pie chart. The chart illustrates the sixteen groups, noted by participants.

Figure 17: Number of times a Carillion intra-company team was mentioned in connection with sustainable procurement (source: interviews, surveys and observations 2015-2017)



Key: Labels indicate the intra company group and the number of mentions recorded in interviews, open responses in surveys, meeting notes and observations.

Whilst the number of times a group has been referred has been presented in the figure above there are two flaws in the data. Firstly, the term “design” is a very general term used by Carillion to denote architects, structural and mechanical engineers and other designers. Whilst coded as intra-company actors, it is in fact difficult to allocate between intra and inter-company organisations. Supply chain teams used the term indiscriminately to define anyone with that role. Within Carillion the function responsible for the ‘transfer of the client vision to operational delivery were described as design’ (SC-RM2). It must also be accepted that the number of times designers are

referred to will have been impacted by the direction of interviews and further narrowing of research focus. However, the data does still offer several points of interest, some of which are explored in more detail within this chapter. Firstly, that the design team has such a dominant position, even allowing for allocation issues. Design is repeatedly identified by the supply chain team as a point where Carillion should have the greatest impact on sustainable build. Internal design teams are frustrated because at 'at the tender and construction phase very little can be changed' (D-HD). Category management was also flagged as key to sustainability. The team is comprised of experts in a variety of build elements and they work directly with manufacturers to support the supply chain team with supplier and product selection.

Major suppliers are seen by the SC team as strongly advanced in their work on sustainable processes and products but often invisible, as they operate through sub-contracted packages. Category management were unusual in operating as a cross-company team, working across business units and project boundaries. They have also occasionally worked with clients directly to support building design, especially in areas such as building cladding (HCM-D). The role of category management, in supporting collaboration, is important and considered in greater depth in chapter 6. Both corporate and CCS business unit sustainability teams had relatively low level of mentions, which is surprising in the context of the discussions. They appear to be primarily viewed in connection with corporate KPIs, primarily FSC timber and SMEs. Finally, in an industry where information flows are complex and risk laden it is notable that the supplier management team receives only a small mention, especially as the "My Register" system they manage is the primary data capture method for supplier sustainability details. Building information management (BIM) was highlighted during discussions as a developing methodology for data management.

4.2.6 A comparison to existing literature

In the UK construction sector fragmentation is identified as the basis for poor productivity, limited innovation, wastefulness and inefficiency (Latham, 1994, London, Kenley, 2001, E.C Harris LLP, 2013). This statement, or similar, appears uncritically questioned in the opening literature reviews of most papers written about the sector

and this structural facet has become regarded as a major problem in the development of the industry (Fernandez-Solis, 2008, Morledge, Knight & Grada, 2009). Fragmentation is also considered a feature created by the unique sectoral context of construction; a position questioned by Green et al (2005). Indeed, examination of literature beyond this industry suggests that fragmentation of a supply network is not unique to the construction sector but is seen to reflect a general change in 'business profile' with a greater move to competitive global supply chains, generally comprised of specialist smaller operating units (Christopher, Martin, Ryals, 1999, Handfield, Nichols, 1999). Indeed, Cox and Wartenbe (2018) note that most Fortune 500 corporations have transformed their production over the last thirty years, moving away from producing a product, from start to finish, to subcontracting production to multiple firms. Much of the research considering fragmentation in the construction sector, has focused on understanding the deficiencies and identifying solutions that enhance the coordination of both contractors and suppliers, and designers and main contractors, in the supply chain (Dubois, Gadde, 2000, Vrijhoef, Koskela, 2000, Segerstedt, Olofsson, 2010). The research, whilst it has addressed many perspectives such as logistics, purchasing, transportation, operations management, marketing and R&D (Arlbjørn, Freytag & de Haas, 2011) has not focused specifically on sustainability.

Whilst economic benefits are derived from this highly flexible operating model, adopted by the construction sector as a response to market demand (Usdiken, Szen & Enbiyaog˙lu, 1988, Dubois, Gadde, 2002), fragmentation does create conflict when addressing major sustainability issues. One example of this is the issues of climate change, which can only be addressed at a systems level (Pinkse, Kolke, 2010, Seuring, 2013). It is surmised that individual companies, reliant on their supply network for goods and services cannot tackle sustainability on their own (Krause, Vachon & Klassen, 2009) and that they must meet the challenge through joint efforts (Seuring, 2013). Consistent with this position the literature identifies collaboration and governance as powerful tools for facilitating sustainability initiatives (Vurro, Russo & Perrrini, 2009) and effective supply chain strategies (Fawcett et al., 2012) (See chapter 2 for further context).

Considering the importance of fragmentation in construction there appears to be limited research on the sectoral structure of fragmentation. Using search terms fragmentation, construction and supply chains, and fragmentation, building and supply chains only twenty papers were identified using the Scopus search engine. Of these, none specifically addressed the topic. The majority of these papers focus on potential solutions to the problem of fragmentation, such as the use of BIM, or Industrialised Building Systems (IBS) or they provide further analysis of the barriers that limit collaboration and integration. The findings of the research presented here contribute to a more nuanced understanding of the sector-specific nature of fragmentation and its impact on sustainable build. Emerging from the analysis are the characteristics of construction fragmentation;

1. A supply network in constant flux
2. A numerous, changing, and occasional client base
3. Episodic and unique product creation at a project level

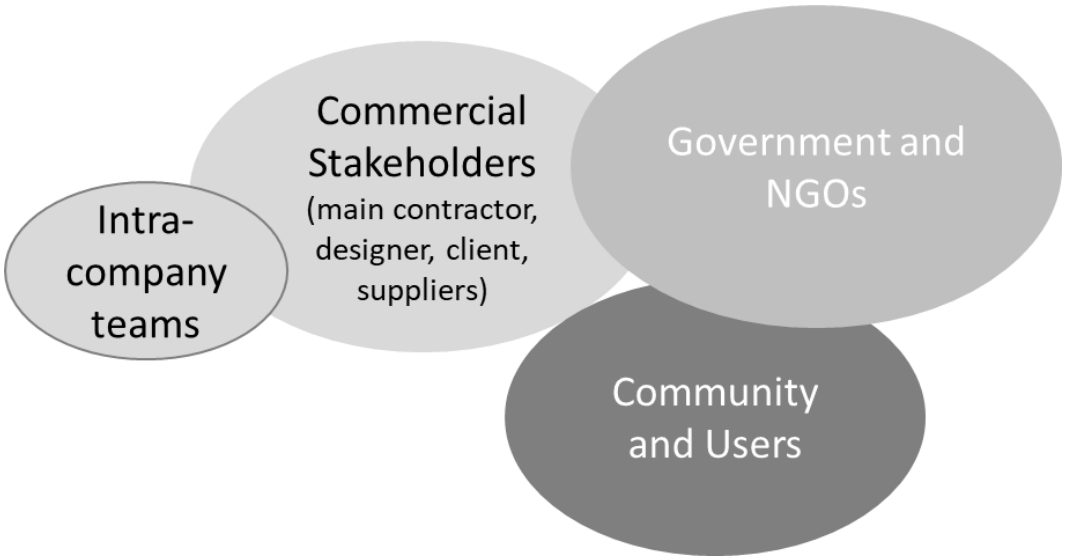
4.2.6.1 Complex and fluid networks

Construction literature has previously, primarily, focused on linear supply chains but it is clear from the analysis of engaged stakeholders that the main contractor is operating amongst a highly complex, interconnected, network of actors. In considering networks from a global production perspective, Coe et al (2008) identify that networks are affected by space and time and are highly variable and that this contingent nature is integral to their operation. This research would concur with this perspective, and that construction networks also conform to the definition by Carter et al (2015) that the supply network operates as a dynamic system which is difficult to predict and control. They identify that these systems operate in a constant state of change and with multiple interconnections, both across tiers, and upstream and downstream. The research supports the assertions of Dubois (2000), confirming that suppliers shift tier position between projects, and boundaries are blurred, as companies flex their offers to meet project demands. For example, in some projects a supplier may incorporate logistics in the procured service, for others they provide just product and in others they may offer product and specialist installation labour. It is not surprising that supply chain

management has only poorly been implemented in the construction sector when faced with operating in such a dynamic network of networks.

The complexity of actors within the construction supply network is frequently noted but analysis has primarily focused on two groups of project stakeholders: those that are primary participants and directly involved in the project e.g. designers, main contractor (inside), and secondary stakeholders, identified as communities and users (outside) (Newcombe, 2003). Emerging from SC team comments is the identification of not only commercial companies interacting to create a built asset, the insiders of Newcombe's definition, and those directly affected (the outsiders) but also two further key stakeholder groups; influential non-governmental and governmental organisations and those of intra-company actors, specifically in the context of this research, those of the main contractor. These groups are represented in Figure 18.

Figure 18: The four construction stakeholder groups derived from Carilion team perspectives



The SC teams position the intra-company network, which constantly re-forms around project demands, as a key element of the supply network. They recognise the importance of the company's own multi-functional internal structure, as a reflection of the industries wider differentiation of expertise. They accepted that functional departments of a firm must differ from one another because they differ in their tasks, goals and periods of operational focus. Lawrence and Lorsch (1967) conceptualised an

organization's structure in terms of both differentiation and integration believing there was a need for the intra-company actors to cooperate to achieve the organisation's goal. However, within Carillion, tensions were observed between the need to meet corporate goals and those required to achieve project delivery. This misalignment extended to sustainability where corporate strategy and project implementation frequently failed to align. The internal complexity of focal firms, and their multiple internal stakeholders is also recognised in the context of sustainable supply chain management (Andersson, Sweet 2002, de Bakker, Nijhof 2002). Government was also identified in this research as directly influencing network fragmentation. As a major construction client public procurement targets required 25% of public spend to be with SMEs, either directly or through supply chains (UK Government, 2018c). This affected supplier selection at both main contractor and Tier 1 levels and increased operational costs; requiring greater engagement, monitoring and reporting. The final non-commercial group identified by Carillion staff was the local community and the eventual asset user. Community was fragmented by time and place, often being associated with the project site and delivery of client requirements. It was most frequently managed by site specific engagement or at a corporate level, through organisations such as Business in the Community (BITC) and Hospice UK. These NGO's provided a focus for staff volunteering activity; a large element of the Carillion's social sustainability work. Whilst this wider network was identified as a critical feature, in supply chain management literature, for the empowering sustainability action (Seuring, Muller, 2008b, Hassini, Surti & Searcy, 2012) it should be noted that the end user of the built asset or infrastructure was invisible to Carillion teams and more generally disconnected from the supply network.

Despite operating within a network, the relationships between network actors continued to remain primarily dyadic, i.e., between the client and main contractor (Akintoye, McIntosh & Fitzgerald, 2000) or main contractor and Tier 1 supplier (King, Pitt, 2009). This would concur with Carillion's primary supply chain engagement structure. The term SCM was recognised by Carillion, they operated a supply chain management policy, but there was little evidence of this resulting in wider management of the construction supply network. As highlighted in previous studies, managing this complex network through the application of supply chain management (SCM)

techniques has made only limited progress in improving strategic co-ordination and long-term network performance (Vrijhoef, Koskela, 2000). This research suggests that the strategic positioning of the category management team enabled expertise to be utilised to develop cross network engagement. Applying SSCM as a methodology to manage the supply network to achieve sustainable outcomes was not mentioned during any interview, survey or conversation. Management of upstream and downstream suppliers was primarily limited to Tier 1 suppliers, and designers. Strategic management of the network to support sustainability, by Carillion, was minimal.

4.2.6.2 Numerous and occasional clients

Whilst networks operate through inter-connected relationships between all engaged actors (Hoejmose, Brammer & Millington, 2012) they are frequently identified in academic literature as being 'driven' by major corporations, acting as the primary focal point (Segerstedt, Olofsson, 2010). Unlike a manufacturing sector, such as aerospace, where a small number of large, technically skilled, mature focal companies drive market requirements, the construction sector has more numerous and occasional clients (Green, S. D., Fernie & Weller, 2005). Clients may be highly knowledgeable, operating over long time scales or act as short term, speculators with little knowledge of the build process. This creates variability within the sector and is a source of further fragmentation (Cherns, Bryant, 1984, Pries et al., 2004). In construction supply chains or networks the customer operates as the focal company, in preparing the design and specifications of a built asset. They appoint the main contractor and provide funding for the built asset. Indeed, there is strong evidence that meeting customer demands is prioritised over the many other stakeholder needs (Green, S. D., Fernie & Weller, 2005). Clients managing infrastructure developments appear to provide greater stability for the supply network in which they operate. They are primarily Government funded and operate on framework contracts or work on long term national programmes e.g. Crossrail. These projects offer suppliers the time to develop relationships and engage in greater collaborative working. Carillion teams contrasted the relative stability of public contracts with the short termism of private developers, where continuous competitive tendering limited long term corporate collaborative relationships. For the latter each project operated in isolation and, project learning remained confined to the experience

of individuals rather than shared across the network; a point also highlighted by Thompson (1998). Where short term or infrequent relationships occurred there appeared to be limited trust, high risk and a strong focus on lowest cost. This restricts, both the client and main contractor appetite for change to tested processes and approaches (Dubois, Gadde, 2000).

4.2.6.3 Episodic supply

There has been limited research on time fragmented or episodic construction work on the composition of main contractor supply networks. This is despite considerable literature considering the role of the construction project and its relationship to a supply chain structure (Cherns, Bryant, 1984, Dubois, Gadde, 2000). However, considering this episodic or time fragmented structure over multiple contiguous projects has received less attention. Main contractors rely on an ongoing flow of projects to generate income and this has led to multiple project-based supply networks, overlaid with longer term transactional networks. Each project demands a short-term supply network, created specifically to meet a unique client product. The analysis of Carillion's procurement during 2015 (Figure 16) reinforces the view that that only a tiny proportion of suppliers operate across multiple contiguous projects. However, in the longitudinal evaluation of suppliers noted in Section 4.2.3, analysis of procurement data suggests that longer term relationships may exist and at a more strategic level. The supplier base may not be as fragmented as first assumed, when considered by key product or service. Access to procurement data at this level of granularity is highly unusual and offers an insight not seen within the existing literature.

Another effect of fragmentation, or sector specialisation, has been the acceptance that a firm does not require to have all the knowledge necessary to undertake a task, but it may need to draw on stakeholder expertise (Grant, Baden-Fuller, 1995). Historically the supply network literature has focused on long-term relationships (Zacharia, Nix & Lusch, 2011). Such longer-term collaboration is seen as a precursor to both effective supply chain management and more recently sustainable supply chain management (Gold, Seuring & Beske, 2010b). In construction episodic networks, all actors in the project are focused on the delivery of the built asset. This appears to create powerful, short term

relationships where problem solving is a key element of site activity. Based on a sample of 473 companies in construction, manufacturing, transportation, communication, wholesale and retail trade industries Zacharia, Nix et al (2011) identifies that collaboration did occur in episodic networks but this required companies to both absorptive capacity and collaborative process competence.

4.3 Non–Alignment: multiple goals within a fragmented supply network

Each organisation, each main actor type and even each professional body represented within the supply network appears to have their own sustainability goals and aspirations. Even within peers, operating at the same point within the network, different business drivers and market differentiators engender a range of sustainability focused actions. This proliferation of goals and associated metrics was raised as an issue by suppliers and featured in industry discussion. Main contractors, such as Carillion, were being forced to consider issues such as embodied carbon reporting for infrastructure clients and for many major Government led contracts provide data on SMEs and social value. To understand the level of fragmentation an initial analysis of the Annual Sustainability reports (2014-2015) of Carillion and four of its peers was undertaken. (This work, and other comparative ASR analysis is available in full in Appendix 2 and the methodology is presented in chapter 3, Section 3.4.2.2.). The analysis identified multiple different actions and processes but for the purposes of clarity it was further simplified (see Table 16) to present the most common areas of sustainability engagement and reporting.

Table 16: Analysis of annual sustainability reports 2014/15 (Balfour Beatty plc 2014, Carillion plc 2016, Skanska 2016, Keir Group Plc 2016, Laing O'Rourke 2014)

	Reporting and Standards			Primary areas of sustainability reporting						Areas of developing interest				
Company	GRI Reporting used	Signed up to UN Global Compact	Promote buiding to Environmental standards	H&S	Health	Ethics	Community support	Environmental	Staff and Skills	Indentifying value of sustainability to the business	Materiality	Scarcity of resources	Sustainable supply chain	Natural capital
Balfour Beatty			yes		yes	yes		yes	Limited				yes	
Carillion	yes		yes	yes	yes	Limited	yes	yes	yes	yes	yes	yes	yes	
Skanska		yes	yes	yes	yes	yes	yes	yes	yes			yes	yes	yes
Keir			yes	yes		yes	yes	yes	yes	yes	yes		yes	
Laing O'Rouke		yes	yes	yes	yes		yes	yes	yes				yes	

Reporting is particularly strong for environmental issues, particularly those related to the construction site process and company operation. These issues include waste, carbon (scope 1 and 2 emissions) and to a lesser extent water. Skills and staff development also feature strongly. From a wider network perspective all organisations confirm that they are able to create structures to 'Green Building standards' such as BREEAM, CEEQUAL and all actively promote this to clients. However, the researcher also looked at the reports for issues which were of increasing concern to industry commentators and sustainability experts. Here a smaller number of main contractors were focusing on issues impacting beyond corporate boundaries, such as scarcity of resources, and natural capital as well as the economic value of sustainability to the company.

Interestingly, in a sector which is noted in academic literature to be lagging on sustainable supply chain management all organisations offered commentary on their support for sustainable supply chains. At its most basic this was little more than an extension of their Health and Safety programme to suppliers but more frequently it was identified as increased communication with Tier 1 suppliers. Three of the five organisations mentioned working with local businesses and SMEs (a requirement of Government contracts), others had sustainability charters and were offering meet-the-buyer events, workshops and toolbox talks. One contractor was working with cloud-based suppliers Achilles and Constructionline to map and support their Tier 1 procurement. Achilles construction database has 180 buyers and 8000 construction suppliers listed across North and West Europe (Achilles, 2018). It, and similar companies offered cloud-based software to reduce repetitive questions and improve information flows across networks. This was seen by their clients as 'helping create transparency through the supply base' (Heineken 2016). Carillion had elected to use an internal system, "My Register" which relied on supplier self-declaration and where sustainability data was unaudited.

Analysis of the main contractor peer group suggested that whilst there was developing work with the supply chain and with clients, main contractors were primarily focused on sustainability issues directly under their control; within their corporate boundaries.

Extension of their influence on sustainability issues beyond this controlled boundary comprised of limited upstream supply chain engagement, primarily through a sub-contracted supplier audit function. They also offered some supplier upskilling, carried out limited mapping and minimal scope 3 carbon reporting. Downstream contractors were working with stakeholders (primarily customers) to understand their sustainability aspirations and ensure they were reflected back in bids and tenders. Skanska had taken a stronger stance and created a rating system for all projects, "Deep Green", which allowed them to present their performance and that of the client designed structures they created (Skanska, 2016). The variety of approaches, illustrated here at just one level of the supply network, is identified by Government as a barrier to more effective working across the supply network. At a meeting of industry main contractors and key suppliers, sustainability measurement requirements were discussed. It quickly became clear from the group that everyone was using slightly different descriptors when talking about outputs, goals, indicators, and targets. This was confusing to those discussing the topic, all of whom had considerable expertise on sustainability reporting, but they agreed it was 'even more confusing for the suppliers that are being asked for such different information' (D10). One major supplier summed this up succinctly during an interview:

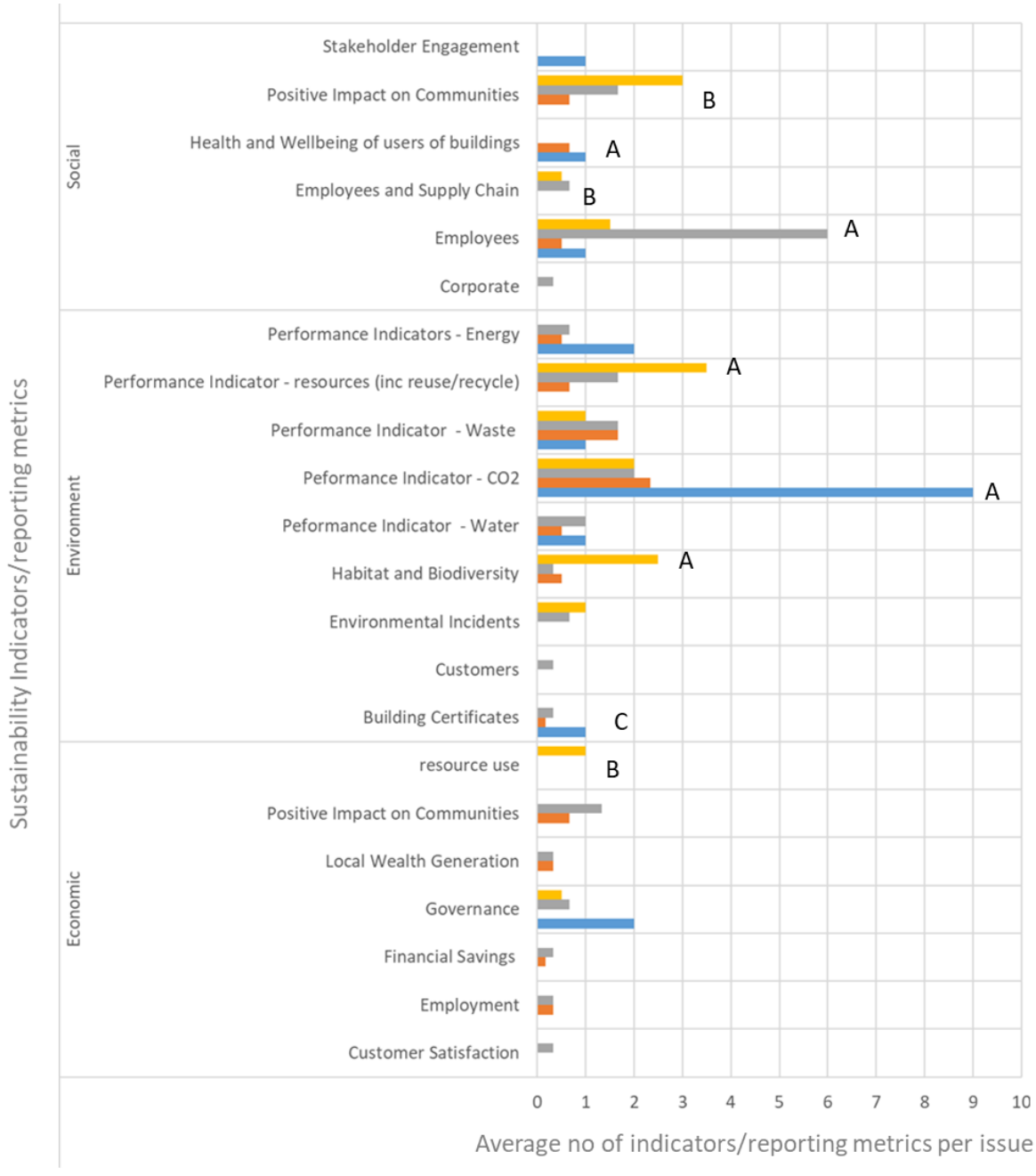
> 'The issue of getting data is the problem I think – so how do we collect it? how do others collect it? Are the boundaries the same? etc etc. So therefore, can you add them all up directly or are them some issues and then once you get around to looking the supply chain, the merchants, the contractors. Unless everyone is doing it the same way then it's very difficult to add these up.' (SUP-10)

He also pointed out that even if these problems could be overcome by the manufacturers, 'every project has a different client. Every client has a different wish list' (SUP-10).

The analysis of the main contractor peer group highlighted multiple approaches to sustainability, albeit those that they selected to present to their stakeholders, but it failed to offer an insight into the KPIs operating across the whole supply network. To achieve this more holistic view, organisations were selected from across different life phases of a built asset within the UK. The rational for the selection of the organisations

presented in Figure 19, and the methodology, are considered in chapter 3, Section 3.4.2.3.

Figure 19: KPIs supported by Investors, Developers/Clients, Main Contractors and Product Manufacturers (GRESB, 2016, M&S, 2015, Argent llp, 2016, Highways England, 2016, MOD, 2013, Network Rail, 2015, SDU, 2016, Carillion plc, 2016a, Keir Group Plc, 2014, Skanska, 2016, MPA, 2015, UK CARES, 2016)



Key:

Product Association Main Contractor Developer Investor

A: indicators perceived by network actors as most relevant
B: potential gaps in reporting
C: unexpected indicator values

Whilst this analysis cannot provide evidence of action and impact it does indicate that organisations have created key performance indicators (KPIs) and targets on a wide range of sustainability issues. This exercise, with a relatively small but representative sample of the network identified ninety-nine different indicators and sub indicators. It confirms that complexity and fragmentation of reporting increases across the supply network sector when upstream and downstream organisations are considered.

Environmental issues are well represented, with waste, energy, CO_2 and water KPIs being addressed by most of the supply network actors. It was relatively straightforward to group these indicators although metrics such as customers (measuring the number achieving sustainable builds) and building certificates, did not easily combine with more standard measures. Fewer social issues were identified and only employee wellbeing, fair treatment and skills were common across the network. The economic aspects of sustainability proved to be the most challenging to both identify and allocate. A separation by most organisations of financial and sustainability reporting appears to reduce, or most frequently fail, to offer sustainability indicators that link to economic issues. This is an interesting insight when one of the most common questions sustainability practitioners are asked is 'does it mean more expense' (SC-D).

This analysis would suggest that network actors focus on indicators that they perceived were most relevant to their position in the network or were required by clients or regulators. There are several examples which appear to validate this view, and these have been marked A in Figure 19. Developers and Investors consider the health and wellbeing of those in the buildings they commission or fund; Main contractors have a large number of indicators linked to employees and skills. This makes sense as they provide a service that is primarily skills and expertise based. Product Associations, in this case directly linked to extractive industries, have multiple indicators for resource use and biodiversity impacts. The growing number of investors that subscribe to GRESB are reporting on a sophisticated range of key and sub indicators around CO_2 emissions; both sending out a buying signal across the supply network, but potentially reflecting a longer-term concern about asset values. There was however, less emphasis on the use building standards (marked C in the diagram above) within their indicator portfolio. This

was surprising as there is a strong focus by green building NGOs, UK planning regulation and standards bodies on the benefits of green building standards. The indicators marked B on Figure 19 highlight where there appear to be gaps in reporting. Developers and Investors see their impact on local communities primarily in terms of health and wellbeing of completed buildings but not in terms of the construction of assets and product manufacturing. They also fail to have metrics to measure social issues across the supply network, it appears that this responsibility falls to main contractors and product manufacturers. Surprisingly only product manufacturers are measuring the economic impacts of resource use and scarcity. At the time of this analysis it is notable that no network actors were testing Circular economy indicators other than those associated with traditional waste recycling.

If the sectors self-developed indicators lead to multiple measurements, different emphasis and assumed responsibility by actors it was interesting to consider if an increased focus on standardised reporting was able to enhance cross-network goals. A small number of industry organisations were using global reporting frameworks such as the GRI index or the Carbon Disclosure Project (CDP) and social indices, for example, the UN Global Compact. There was also an increase in major UK construction companies committing to support the Sustainable Development Goals (SDGs), which had been agreed by the United Nations in 2015 (UNSD, 2017). Carillion's corporate sustainability team had identified the SDGs as 'the world's development roadmap for the next 14 years' and saw the global goals as a framework that that recognised the relevance of a whole system approach (Picton, 2016). The adoption of the goals, a survey carried out by the company with key stakeholders in 2016 and their long-term commitment to FSC chain of custody, provided a case study to examine if the SDGs could unify the construction network.

The analysis, represented in Table 17, considers how stakeholders in the FSC chain of custody perceive the importance of different SDGs based on their different perspectives with the supply network. These were derived from three sources, a materiality survey, Carillion's Annual Sustainability Report and an FSC publication on SDGs. Carillion undertook a major materiality survey in 2016, asking staff, clients and other

stakeholders to identify the goals they felt Carillion could effectively support. Stakeholders identified five goals, all of which focused on social equality or business innovation. In 2017, Carillion published its Annual Sustainability Report identifying the companies support for nine SDGs. Additional goals had been incorporated by Carillion, recognizing that the board and corporate sustainability team identified additional goals addressing their supply network (SDG12) and environmental issues (especially SDG 15: Life on Land) (Carillion 2017). The Forest Stewardship Council carried out a similar assessment and identified that, for those within the supply network, FSC accreditation supports 11 SDG goals and 35 targets (FSC 2016). For FSC, Sustainable Consumption and Production, is one of the goals to which they aspire, closely aligned with the timber value chain, but, they do not see it as a primary focus. FSC believes that another goal, SDG 15—Life on Land—is most relevant to their work, specifically target 15.2: progress towards sustainable forest management. The goals selected by each stakeholder are highlighted in Table 17.

Table 17 Analysis of SDGs across an FSC supply network (2016), (FSC 2016, Carillion 2017)

Sustainable Development Goals 2015	Forest Stewardship Council	Carillion plc	Carillion Stakeholders
1. No Poverty	*FSC Additional Goals*		
2. Zero Hunger	*FSC Additional Goals*		
3. Good Health and Wellbeing			
4. Quality Education			
5. Gender Equality	*FSC Additional Goals*		
6. Clean water and sanitation	*FSC Additional Goals*		
7. Affordable and clean energy	*FSC Additional Goals*		
8. Decent work and economic growth	*FSC Additional Goals*		
9. Industry, Innovation and Infrastructure			
11. Sustainable Cities and Communities			
12. Responsible Consumption and Production	*FSC Additional Goals*		
13.Climate Action	*FSC Additional Goals*		
15. Life on Land	***FSC Primary Goal***		
16. Peace, Justice and Strong Institutions	*FSC Additional Goals*		
17. Partnerships for the Goals	*FSC Additional Goals*		

Key: Dark panels represented SDGs selected by the groups

This analysis offers a fascinating insight into how different network actors perceive roles and responsibilities within the network. Despite the SDGs offering a clearly defined set of goals and targets, and despite Carillion's twenty year relationship with FSC chain of custody, only two SDGs are common between all network partners, those of Gender Equality (SDG 5) and Decent Work and Economic Growth (SDG 8). Such variation in goal alignment would suggest that the position and role of an organisation within the supply network influences its view of how it can effect change and thus which goals are most relevant. It also questions the benefit of apply top down goals across the network.

4.31 A comparison with existing literature

UK construction sector actors do not appear to have a holistic vision of sustainability that spans the whole life cycle of a built asset. At an industry level the UK Government has set high level environmental and social strategic goals for the sector, primarily focused on CO_2 reduction, minimisation of waste to landfill and skills development (UK Government, 2013). The targets for CO_2 are most developed, linked to the UK's carbon budget (UK Government, 2016a), and are implemented through legislation and policy tools. They focus on key emissions areas across the life of an asset; improved energy efficiency in buildings, greening of energy sources and reduction in carbon emissions from major product suppliers e.g. cement and steel. At the level of individual supply chain actors, a proliferation of independent goals, targets, KPIs and metrics was identified by the research. In the context of project delivery Love et al (1999) noted that companies appeared to develop their own goals and value systems without considering the impact on others or on overall project performance. These may be driven by legislation (Hillman, Keim, 2001), peer pressure, client demands, moral or ethical considerations, improved financial performance (Paulrai, Chenc & Blome, 2017) or a perceived competitive advantage (Porter, Kramer, 2006) identified by the network actor. Whilst not unique to this sector, many companies have also had to deal with a proliferation of sustainability standards which are increasingly required by clients to demonstrate good performance, (Henson, Humphrey, 2008). Carillion, and other actors within the network, set targets based on annual reductions in environmental impacts, and for social issues, incremental annual gains. There does not yet appear to be an attempt to consider targets that support the planetary boundary approach as advocated by Clift, Sims et al (2017). SSCM literature focuses on the role of the company as the goal setter, aiming to achieve economic, environmental and social sustainability by integrating flows of products and services, information, capital and decisions, to provide maximum value to multiple stakeholder groups (Wolf, J., 2011). Whilst each company may consider a wide range of stakeholder views, as evidenced by Carillion's sustainability materiality survey (Carillion plc, 2016a), they appear to respond to stakeholder demands from their own corporate perspective. Schmidt et al. (2017) however note that, whilst stakeholders may advocate monolithic outcomes across the supply chain, very different issues are salient for different companies, which therefore

set different goals depending on their position within the supply network (Gualandris, Klassen et al. 2015). The findings of the research would support this latter view and it is especially demonstrated by the example of weak alignment of SDGs across the FSC value network; even where strong, long term relationships already exist.

4.4 Inequality: value creation across the network

Observations at meetings and topic specific discussion identified that Carillion operated on very low margins, which were under constant pressure from highly competitive tendering and post-award risks. This put enormous strain on the supply chain team to look at material prices and seek cost reduction. As a senior supply chain manager stated 'you have to understand that the system is like a giant pressure cooker…..and everyone is judged by money' (SC-RH2). A review of company literature highlighted that Carillion operated on a maximum profit margin of approximately 2.5%, something that Carillion staff noted was not uncommon across their main contractor peers. In addition to the construction process major clients, especially public sector, were frequently looking for suppliers who would deliver additional social benefit; more SME suppliers, excellent local community engagement and local upskilling but as noted by a member of the sustainability team 'these targets are a real drain on resources' (S-SA). This puts pressure on members of the supply network especially those on narrow margins, such as the main contractor. To explore the financial ability of network actors to manage these demands industry data was utilised to undertake a supply network profit analysis (see Table 18). This was a small sample and for some categories, such as Architects, it was difficult to gather direct profit data and more industry generic research was used (RIBAJ, 2014). There was a strong perception that developers achieved much higher margins than the main contractors, exemplified by SC-JV who said that 'where contracts were more transparent I have seen clients achieving much higher profit levels than the main contractor……..(we had an) open book approach with the client and asked them on the five million pound job how much they were making – one million (pounds, they said)'. This analysis indicates that those operating within the centre of the network, primarily engaged in the construction process, achieve least margin. Within this central low margin zone most actors are selling labour, skills, knowledge and risk mitigation. The

Carillion SC-D reviewed the profit margin analysis and agreed that this was a fair reflection, in his experience, of margins achieved by each actor.

Table 18: Analysis of the net profit margin, after tax, within the UK construction supply network, 2016 (D8)

Company	Reporting Year	Source	% margin based on net profit after tax/turnover (unless otherwise noted)	Raw Materials	Manufactueres	Wholesaler	Consulting Engineers - Design	Main Cons	Architects	Developer	Owner
Lafarge	2016	https://www.lafargeholcim.com/Q4-full-year-results-2016		10.50%							
Breedon Group (Aggregate Industries)	2016	https://www.breedongroup.com/images/uploads/articles/FULL-YEAR_2016_RESULTS_FINAL.pdf		8%							
SIG	2016	http://www.sigplc.com/investor-relations/financial-performance/				4.20%					
Travis Perkins	2016	https://www.travisperkinsplc.co.uk/investor-relations/results-				4.25%					
Mott MacDonald	2016	www.mottmac.com/article/3430/report-and-accounts					3.60%				
Atkins	2016	Corporate/group/financial-news/2017/2017-06-15-results-for-the-year-ended-31-march-2017.pdf					6.20%				
Top 100 UK contractors 2016	2016	CN100 Construction News	pre tax profit					1.50%			
Carillion	2016							2.40%			
Keir	2016	http://www.kier.co.uk/~/media/Files/K/Kier/documents/investor-relation/reports-and-presentaions/prelims-statement-2016.pdf						0.16%			
Laing O'Rourke	2016	file:///C:/Users/User/Downloads/LOR%20Corporation%20Stats%202016.pdf						-8.75%			
RIBAJ	2014	https://www.ribaj.com/intelligence/success-begins-at-home	unknown						+20%		
Derwent	2016	https://webcasts.derwentlondon.com/derwent038/files/Derwent-London-Annual-Results-2016-Prelim-Announcement.pdf								27.60%	
Argent	2016		unknown							unknown	
Land Securities	2016	https://landsec.com/sites/default/files/2017-06/AR_2016_Landsec_2.pdf	net profit after tax/turnover (note excludes capital gains from revaluation of property)							48.60%	
Network Rail	2016	https://cdn.networkrail.co.uk/wp-content/uploads/2016/11/Network-Rail-Annual-report-and-accounts-2016.pdf									11.80%
Highways England	2016										Fixed by Government

Despite operating on low margins Carillion had a strong and long-standing commitment to the integration of sustainability into its business strategy. Yet, Carillion staff had mixed views on this position. They felt that clients often got a 'Rolls Royce (sustainability) job' (S-BM) regardless of client spend. Whilst many environmental costs were built into contracts, primarily to meet legislative requirements, other sustainability spend was funded from business overheads as part of the company's corporate sustainability commitment. Carillion operated a small corporate team, funded an external annual audit of its sustainability data, and published an annual sustainability report. Other corporate commitments included a company spent of 1% of pre-tax profits on community issues and staff time to support industry innovations such as mapping and reducing embodied carbon, enhanced biodiversity management, and participation in industry bodies (Carillion plc, 2016a). Whilst community engagement, often referred to internally as "the social side" was a long-standing element of corporate values it also supported client tender requirements. There was some disquiet at the balance between CSR and work winning activities:

> 'Communities are a different team to sustainability…..they are a business overhead. Clients are gaining these benefits often as part of Carillion's CSR offer ……we have really used the social side to get the job – or that's what it feels like. Targets are higher on % local spend and local investment– really elevated compared to NHS Project (A). I spoke to one of the guys up at NHS Project (B) and when he saw the targets he said - who would agree those – it was one-up-man-ship- to build up the bid……. sustainability inflation' (S-SA).

There was a concern that clients expected some major project costs to be absorbed by Carillion as part of their CSR programme. One senior decision maker commented 'there is still the big question - say for local spend – how much of a premium will the company pay for this….. 3%? 5%?' (SC-D). There were few benefits for Carillion for this work whilst at 'least when it is 'BREEAM or CEEQUAL, it's much longer term thinking and built into the price……and the sustainability of projects is elevated'(S-SA).

Low profit margin impacted strongly on the attitudes of the SC team members. Within each project the SC team were clear that there was a drive to cut all non-essential costs; 'what clients don't see is that in the background it's not uncommon for the company to

put targets on the supply chain, say 7% reduction. We have to meet that challenge and sustainability is not that important' (SC-Anon). This approach frequently affected the selection of sustainable products (D2, D8, D10), either due to the time or cost of innovation, increased risk affecting costs on site or post build, or where smaller volumes offered less opportunity for bulk discount. The latter was seen as important in an industry where buyers were frequently procuring from a small range of standardised products which were combined to form non-standard structures (Stinchcombe, 1959). Cost cutting also included the costs associated with monitoring and reporting. Where possible this was passed down the supply chain (D5, D8).

Elsewhere in the supply chain costs of managing sustainability information and performance were equally problematical, especially where major energy or process wins were limited. A major wholesaler, who managed 90,000 products, noted

> 'For someone like Carillion; they are probably drawing off 5000-6000 different stock lines. We just couldn't audit all these products with sustainability information too…….or we could but the cost would be huge, we would have to bring a whole team to do it – and we would have to see a big value in it' (D8: SUP-7).

The position on sustainability was different within high energy using manufacturers. Here two drivers operated to improve their sustainability performance; efficiency programmes, and legislated targets such as those set by CRC (SUP-7, SUP-8, SUP-10)). Legislation created a "level playing field" and forced companies to innovate. Monitoring and reporting was a key element of meeting legislation and improving efficiency and was supported by cost benefits to the organisation. The inequality across the supply network was neatly summed up by a comment from one of Carillion's sustainability team,

> 'There are little pockets of people who see the bigger picture. Stuff happens the closer you get to the money. The further away you are it just starts to become tick boxes – sustainability is part of the badge of operation: do the measurements' (D10: S-SA).

4.41 A comparison with existing literature

The findings indicate that actors within the network operate across a range of profit margins and that those operating downstream appear to gain the greatest profit from

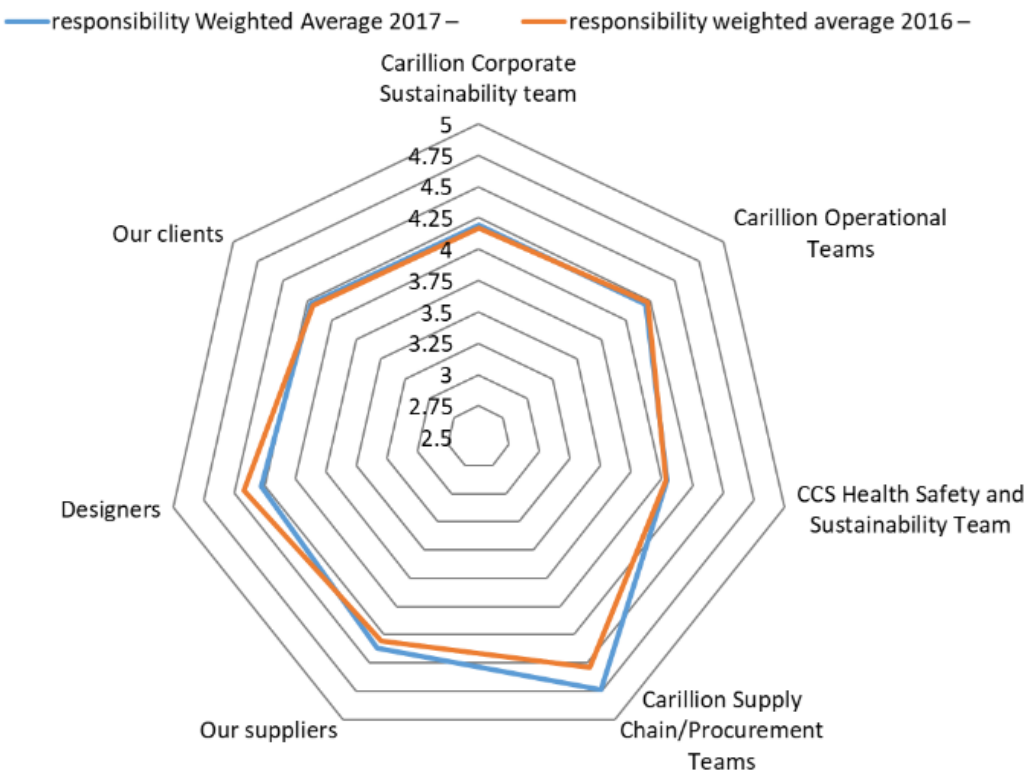
the construction of assets. Whilst this research has not considered added value or GDP along the asset chain, due to data limitations, the profit positions of the different actors would suggest a similarity with the findings of Clift (2004). Using an Overall Business Impact Assessment (OBIA) he identified that for environmental and social issues impacts and benefit are were not distributed fairly across the supply chain. Indeed, those closest to the resource extraction incurred the highest environmental impacts but received the low economic gain. In the Carillion case study, the downstream actors, i.e. those who design, develop and invest in the asset appear to generate the greatest profits but, in most cases, do not incur the impacts linked to long term asset use. In a cross-sector study Schmidt et al (2017) identified that where firms located downstream invested more in Green Supply Chain Management practices, they gained decreasing performance benefits. However, they found that companies upstream gained more performance benefits, with lower investment. They describe this as the Supply Chain Position Paradox. Reporting on sustainability issues are also seen by the SC team and several suppliers, as an additional expense which offers no direct economic benefit. The transaction costs of monitoring primarily fall on the upstream supply chain and clients appear reluctant to pay for sustainability attributes when an asset's sustainability rating, is expected to make virtually no contribution to achieving target returns or to risk mitigation (RICS, 2018). These additional costs, have been identified as barriers to the implementation of sustainable supply chain management (Carter, Rogers, 2008b, Connelly et al., 2011, Connelly, Ketchen. D.J. Slater, 2011). In their work on green supply chains Kersten et al (2010)and Mollenkopf et al (2010) suggest that long lasting competitive advantage for supply chains can only occur if there is a stable and fair distribution of burdens and benefits, something that is not evident in the construction sector. Such economic inequality makes meaningful change, where change in a dynamic, fragmented network is a difficult resource-intensive process, problematic without some form of collaboration (Choi, Dooley & Rungthusanstham, 2001, Carter, Rogers & Choi, 2015). Mapping the relationship between economic benefit and sustainability criteria across the construction network is poorly represented in the literature and a major gap in knowledge.

4.5 Everyone's responsibility, but who takes action?

One impact of fragmentation, explored in section 4.4 above, indicates that actors within the network see the issue of sustainable build in terms of their own position, margin and competencies. This raises a question of responsibility. Do those within the supply chain only see themselves responsible for the impacts they create locally, or do they recognise they have wider responsibility across the supply network? To understand this, within the context of the main contractor node, the Carillion supply chain teams were asked to consider their own colleagues and key actors within the industry and to identify those actors responsible for sustainable procurement (D3, D6). They were asked to rate several intra and inter-company actors on a scale of 1-5 in terms of their responsibility levels. The ranking listed 1 as being 'not at all' and 5 being 'high'. The responses for each actor was weighted by multiplying each point on the scale by the number of responses per point. The total of these results was then divided by the total number of responses to provide a weighted average. In their response to this question, tested in both 2016 and 2017, the supply chain team perceived their responsibility for sustainable procurement as high, greater than any of the other intra and inter network actors they were asked to rate (See Figure 20).

Figure 20 illustrates that responsibility for sustainable procurement was shared by several intra and inter-company actors. The SC team identified they had the greatest responsibility. Whilst the main contractor had a leading role, they were reliant on others

Figure 20: In your opinion where does the responsibility for sustainable procurement lie (Surveys 23.6.16, 69 responses and 24.6.17, 72 responses)



in the network also taking responsibility. Analysis of the 2017 survey data by level of decision maker suggested that different points of consensus occurred at decision making level. High level decision makers (sample size 12) showed greatest consensus in selecting Carillion SC procurement teams and Carillion operational teams (both with a mean of 4.75 and a standard deviation (sd) of 0.433, with slightly weaker consensus on the role of designers (mean 4.58, sd 0.493). Medium level decision makers (sample size 36) only showed similar consensus levels on the role of the Carillion SC team (mean 4.72, sd 0.448). Variability across responses existed in all other categories and in limited level decision makers (sample size 24). Whilst this appears to offer interesting insight into differences between decision making levels it should be noted that sample sizes are small and limit interpretation. Separate analysis of category managers was considered but with a sample size of 4 was seen as too small for valid statistical analysis. Small variations between years are likely to have occurred due to some variation in the respondents rather than changed perceptions. Participants were also asked to identify any other intra-company groups that had responsibility for sustainable procurement.

This was an open-ended question and received 33 comments. As Table 19 indicates many of the participants considered that 'everyone should have responsibility for Sustainability' (Survey 2016, respondent-anon). For many participants this was unequivocal, but others wanted greater clarity, a more nuanced approach that would maximise their impact. As one survey participant noted 'It is everyone's responsibility providing the guidelines and targets are clear (Survey 2016, respondent-anon). Another articulated the concern that this required greater understanding of individual roles; 'Everyone needs to understand our commitments as a business and take direct ownership within their roles where they can influence the correct business drivers & objectives' (Survey 2016, respondent-anon).

Table 19: Additional teams, identified by Carillion SC team, responsible for sustainability within the company (Supply Chain Survey 2016, 33 responses).

Carillion team mentioned	No of mentions	%
All teams – everybody	15	39.5%
Commercial	8	21.1%
Estimating	3	7.9%
Design	2	5.3%
HR	2	5.3%
Regional senior leadership team (SLT)	2	5.3%
Work winning	2	5.3%
Environmental	1	2.6%
Finance	1	2.6%
Legal	1	2.6%
Planning	1	2.6%
Total	38	

SC-teams, when asked a further question about the effectiveness of delivering sustainable procurement, saw a major gap between responsibility of teams and their current impact. This is illustrated in Figure 21, where the SC team rated all actors with low scores (based on a 1-6 ranking, with 6 being highest). They were particularly negative about inter-company network actors, especially designers and clients. A similar analysis to that undertaken to assess any differences in views between high, medium

and limited level decision making and indeed intra decision level variation was undertaken. This identified that only high level decision makers (sample size 12) reached a level of consensus on the effectiveness of network actors, and then only for two groups, those of suppliers (mean 2.78, sd 0.552) and the Carillion SC team (mean 3.75, sd 0.595). High levels of variation existed within all other network groups across all levels of decision makers. It would appear that all levels of decision maker struggled not only to identify effective practices but also to have consensus as to who these actors were.

Figure 21: Where does the responsibility lie for sustainable procurement and how effective are they in delivering this? (Carillion Supply Chain Survey 2017, 72 responses (D6))

This suggests a level of frustration between client, designer and the main contractors which affected their ability to procure sustainably. This theme continued to surface in multiple meetings and interviews. 'Carillion can have almost no impact if the design brief and spec are really tight. Should it be our responsibility?' noted SC-D1. This was reinforced by D-HD who stated that '(we) are generally involved at RIBA stage 3; and at

this point design changes are minimal – mainly a case of value engineering only'. He noted that in his experience 80% of the contracts Carillion take on are at this design stage. Being able to influence at an early stage also offered commercial benefits. D-HD commented 'being involved earlier in the design stage did have advantages for the main contractor. It allowed us more control over the materials and design which often gave us a better opportunity to have higher margins.' Time pressure within contracts also made sustainability improvements difficult. One sustainability team member felt that they were impotent to affect change; sustainability needed to be built in at the start of contract. He was clear that this had to be very early 'when negotiations go on; ……..but is there enough time for it to be done right? For contract X we have seen that we can just tinker about at the edges. It's all been done, we are just tinkering.' (S-SA). Making changes without being involved early enough in the process was hard to achieve but the category management team felt there was little that could be done if the designer and client were against environmental alternatives (D10).

Inter-company actors also identified frustrations with other parts of the supply network. Several suppliers picked up on the theme of earlier engagement: "What people don't realise is you can make real innovative changes…… But what we've found is to get this message across you have to collaborate and discuss much earlier' (SUP-3). Another noted 'At the point we get involved……by the time it gets to us it has already been decided. Only when we can look the spec stage (can we change this) ……..we're very much at the end of the supply chain' (SUP-4). However, there was evidence that external designers saw the contractor and suppliers as a barrier to driving sustainability downstream. Presenting at the 6th APRES conference in 2016 architect Rory Bergin considered the professions ability to influence 'ethical' build. He considered in his experience that they had high influence over conception and design, medium to low influence over procurement and construction and low to none over materials sourcing and raw material extraction. He noted during his commentary that 'the designers work is often lost because of the procurement team. Cost is the key driver' (Bergin, 2016).

4.51 A comparison with existing literature

The Carillion sustainability team accepted a high level of responsibility for sustainable procurement but identified this within the context of other network actors and collective responsibility. At first sight this suggests a positive basis for sustainability across the network, where a top down approach, based on a power position, has been found to be insufficient to drive meaningful change (Touboulic, Matthews & Marques, 2018). However, it is important to question what different actors perceive sustainability to entail. For example, the sustainability requirement in Carillion's internal project procurement plan was limited to: on-site reduction of materials to landfill and the use of FSC timber (Carillion plc, 2017c). Carillion SC team members personally identified sustainability with a whole life approach (Carillion Survey 2016) but this was not observed in client contracts, corporate targets or Carillion business unit processes. Whilst this is explored in greater depth in chapter 7 it would suggest that how individuals and companies perceive their responsibilities changes with time, the influence of stakeholders, personal values and company position and role within the network. Most crucially fragmentation affects the nexus between client, main contractor and designer where a circularity of passed responsibility occurs. The main contractor must work to client specifications, the designer is unable to take responsibility for sustainability as main contractors change plans due to cost pressure and clients frequently select main contractors on lowest cost basis. None of the network actors were identified by the SC team as being highly effective in implementing sustainable procurement practices.

Frostenson et al (2015) highlighted that within networks the focal node is accountable for expanding the network boundaries that sustainability implies. From the analysis of main contractor sustainability reports and the interaction with Carillion teams it would suggest that the sustainability boundaries of main contractor responsibility is largely focused on the construction project site. Indeed, both the main contractor, and many clients demonstrated a reluctance to take responsibility, for example, for greenhouse gas emissions outside their direct influence. This was despite US research that suggested about 75% of US carbon emissions were found within upstream supply chains (Matthews, Hendrickson & Weber, 2008). In the most recent report by the Carbon

Disclosure project (CDP, 2018), 34% of suppliers within major global client supply chains are now reporting scope 3 carbon emissions.

The final area worth highlighting is the ease with which misunderstanding of roles and functions could occur, even within an intra-company network. The example illustrated in the research is the expectation of the medium and limited-level decision makers within the Carillion SC teams that supplier accreditation by the Carillion supplier management system, "My Register", confirmed that sustainability credentials had been met. In fact, sustainability details for most suppliers were incomplete, many were out of date and they were not checked for validity by the administrative team. The administrative team primarily saw the site as one which monitored suppliers for valid insurance and financial stability. The two teams had quite different understanding of what the system was supplying and who was responsible.

4.6 Segregation: sustainability knowledge silos

Interviews, survey outcomes and observations identified a third area where network fragmentation affected the role of the main contractor; that of "trapped" sustainability information and knowledge. Different aspects of sustainability knowledge and its role within the main contractor procurement process is explored in greater detail in chapter 7. In this section we consider how fragmentation appears to restrict knowledge sharing within the supply network and how this affects the role of the main contractor. Through interviews with SC team members, sustainability team members and industry meeting notes, inter and intra company sustainability knowledge was mapped. To present this in a manner to aid discussion, a simplified construction supply network was visualised, over which sustainability knowledge data has been overlaid. As the main contractor, Carillion is positioned at the centre of the network and the figure includes intra-company teams within the company. Knowledge silos identified are illustrated. This material is presented in Figure 22. Three main sustainability knowledge silos were identified:

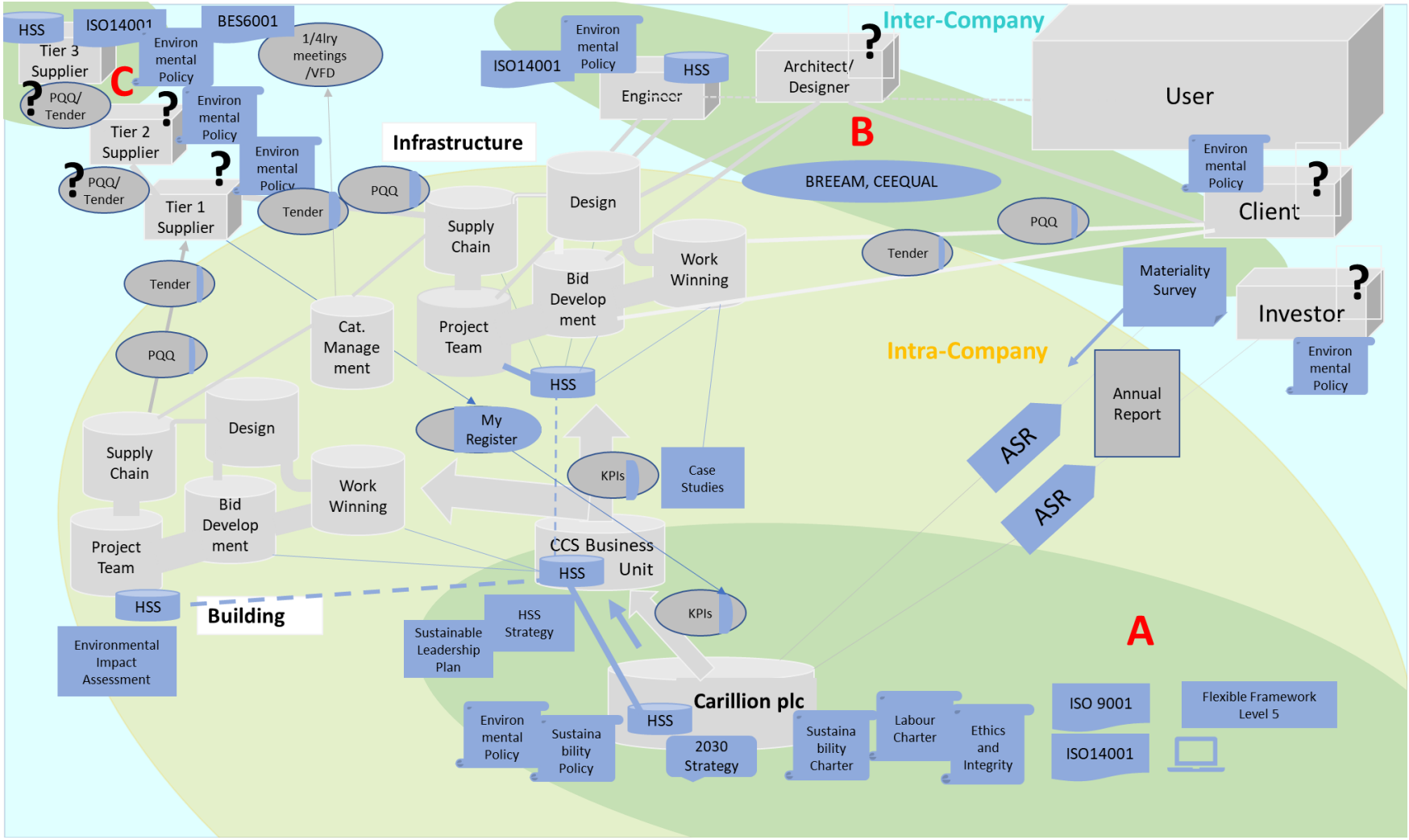
Silo A: Carillion corporate sustainability team

Silo B: Structural Engineers/Design

Silo C: Manufacturers

These are indicated on the figure below.

Figure 22: Mapping knowledge and Information flows across the supply network from a main contractor perspective



Silo A

A small corporate sustainability team developed the companies long term Sustainability Strategy with engagement from senior business unit Directors, guidance from the corporate Sustainability board, feedback from stakeholders via a materiality survey and by reviewing KPI performance. There was board support for the Chief Sustainability Officer (CS- CSO) and the company had approved a 10-year plan, the 2020 Sustainability strategy. From the strategy, policies and charters were produced, which included the Sustainable Supplier Charter (Appendix 1, Figure 47) and Labour Charter (Appendix 1, Figure 50). Policies were available on the company intranet and on the company website. The corporate sustainability team were seen by intra-company actors as the people who 'led' company sustainability (Carillion Survey, 2016) and were responsible for company sustainability KPIs. Sustainability was a complex agenda and S-CSO had been 'accused of being the only person in the company who understood it'. The corporate team had the expertise and responsibility to monitor corporate KPIs, reporting GRI and CDP performance data, and for preparing and promoting the Annual Sustainability report; one of the main forms of communication with investors, customers and other stakeholders. They also led the management of all group-wide sustainability standards such as ISO14001, and ISO9001. However, the corporate team acknowledged that 'at a sustainability level (we) don't tend to have the technical expertise or man hours in house to work on very complex issues'(S-CM). The corporate sustainability team relied on business units to fund and deliver the strategy. Specialist development work, such as 'net positive biodiversity' pilots, could only be undertaken if they could be incorporated into project costs. This limited their ability to drive actions. To translate corporate aims into action they were supported by the Business Uni S-BM who produced a Business Unit sustainability strategy and a leadership plan with activity needed to ensure they met the KPIs. The first 1-2 actions in the plan were mandatory but using his knowledge and experience the S-BM offered multiple further actions that would enhance the delivery of the goals but 'no one ever did them' (S-BM). With intense time and cost pressures Carillion business units were focused on delivering targets that were commercially important and which frequently entailed major cost penalties if not met.

In summary, within the corporate sustainability team resided the greatest level of intra company sustainability knowledge. Supported by a small number of business unit sustainability practitioners they used this knowledge to direct strategy and reporting requirements. To be effective they had to transmit the importance of sustainability issues through training and internal communications routes to drive local action. However, the good intentions of 'top down' sustainability KPIs issues appeared to have limited integration into operational practise, a position endorsed by the comment 'There is a real disconnect between policy and operational level' (D10:S-SA). The exceptions to this was where they were linked to a commercial driver such as a customer requirement or legal demands e.g. site waste management or where they had become embedded in business standard practise e.g. community engagement and FSC chain of custody. Sustainability practitioners operating within the company project teams were fragmented by expertise, job role and levels of responsibility and who 'often struggled to get teams to achieve even legal environmental requirements' (S-BM).

Silo B

Engineering consultancies such as Aitkins, ARUP, Mott McDonald and Walsh have built up expertise in the management of embodied carbon, with Aitkin's having developed a carbon database (RICS 2014), Mott McDonald a suite of carbon tools (Mott MacDonald 2018) and Walsh noting, during the development of a UKGBC publication (UKGBC 2017), over fifty case studies providing carbon benchmarks. They are also working to incorporate carbon metrics into Building Information Systems (BIM) to support sustainable design, especially in the infrastructure sector (S-I), as well as other materials and waste concerns. BIM has been identified by the UK Government as a technology which could improve information flow and greater collaboration (UK Government, 2013). The expertise of the consultant engineers was understood by Carillion sustainability teams working on infrastructure projects, especially in 'rail, the key areas of knowledge and expertise lie with consultants e.g.- Atkins, Arup' (S-I). However, those working in other teams did not appear to be aware of this work. An excellent example of this knowledge gap between experts was witnessed during an intra-company conversation on the potential to use BIM to assess embodied carbon data during design.

Carillion's internal expert, O-BIM, stated that the most effective way to hold CO_2 data would be in offline files; it would be too difficult to use directly in BIM project files. He flicked the screen to a live project and used an example of the concrete pad to illustrate his point. Looking at the information he saw CO_2 data linked to the concrete and commented;

> 'who put the data in on carbon?..... structural engineers? ……We didn't ask for that. It must come from the manufacturer's website – it's a BIM object from their website. We don't know who did it or how it got there'.

Consulting engineers viewed embodied carbon as a commercial opportunity, had invested heavily in developing skills and impact databases, and charged for access. This understandably created a barrier to knowledge flows and as few Carillion clients requested information on embodied environmental or social impacts at design stage there was little internal demand. For Carillion embodied carbon data was primarily a retrospective excel spreadsheet exercise for infrastructure clients, although the corporate sustainability team were considering Scope 3 carbon GRI reporting.

Silo C

Major manufacturers have gained sustainability knowledge through cost reduction programmes, emissions trading schemes (SUP-7), product development initiatives (SUP-1, SUP-3, SUP-7, SUP-8) and resource constraints (SUP-1,3,7,8). They frequently had well informed sustainability or environmental teams (SUP-1,2, 3, 4, 7,8,10,11), were engaged with at least one industry body (SUP-1,7,8,10) and in many cases were owned by large parent companies with global perspectives that impacted on UK product specifications (SUP-1,2,6, 7,8, 11). Many of the larger companies offered lifecycle based environmental data for their main products through environmental performance declarations (EPDs), something poorly known or understood by Carillion SC team (Q14: Survey 2016). There was a sense of frustration, from manufacturers that this knowledge, developed over time, was not being used to support decision making, or as one manufacturer noted 'a lot of the product people have been collecting a lot of this data for a long time. We've got stuff that can be shared…….. if people want it' (SUP-DM). At a Carillion Director level, the siloing of this knowledge was also recognised 'the major manufactures and trade associations are already working on some of these areas (sustainability impacts) but

Carillion is just not asking or capturing their work' (SC-DB). Internally supplier sustainability data captured through Carillion's "My Register" system was often difficult to access and 'the (Carillion) supply chain team don't really look at the more detailed information' (category managers, D8). They identified this as being because of lack of demand (see chapter 5) and the high cost of developing specific reports from a third-party data manager. The BIM team also saw this as a problem of information transfer 'vital in future ….. Opensource (software) is available…. otherwise manufactures operating systems will stop everything talking effectively to each other' (O-BIM). However, he felt that knowledge also became institutionally trapped in manufacturer silos due to procurement legislation;

> 'Carillion work to EU procurement guidelines so working closely with a manufacturer is also an issue at the design stage. At present designers tend to include a "generic" door in their specs as they're concerned about being anti-competitive if they named a supplier' (O-BIM).

In summary this analysis highlights four major points. Firstly, that in nearly all cases studied the end user of the building had no relationship or engagement with those who were involved in the construction of the asset, and thus no influence on its sustainability. Sustainability knowledge was siloed within Carilion corporate team boundaries and failed to extend effectively into operational teams. Consulting engineers had increasing knowledge, supported by data analysis but this was identified as a commercial product and only available if the client was willing to pay for the service. Finally, manufacturers, who had products or services providing improved sustainability, were increasingly frustrated that they could not communicate this with decision makes in the supply network. For those suppliers who were solely responding to main contractor direction they had little awareness of the company's corporate sustainability aims.

4.61 A comparison with existing literature

Knowledge is one of the most decisive factors capable of offering competitive advantages for supply chain partners (Crone, Roper, 2001, Cheng, J. H., Yeh & Tu, 2008), however, extensive outsourcing of non-core competencies has led to a fragmentation of knowledge across networks (Zacharia, Nix & Lusch, 2011). A review of supply chain

maturity in construction identified poor communications, due to internal and external (primarily contractor) compartmentalisation. Suppliers also suggest that main contractors lacked the specialist knowledge to fulfil a linking role (Broft, Badi & Pryke, 2016). Whilst this appears to resonate with the findings of this research this has not been previously been tested in terms of sustainability knowledge and outcomes. The findings from the network mapping indicates that outsourcing expertise has exacerbated the situation of multiple, highly competent sources of knowledge trapped in siloes. Many manufacturers have knowledge and innovative potential to improve whole life sustainability, but they remain frustrated that they are unable to influence design. The Carillion sustainability team struggled to implement sustainability practices beyond corporate managed projects and major engineering firms are leading on many new, sophisticated commercially focused sustainability tools such as embodied carbon estimating. However, it appears that sustainability knowledge is not able to overcome primary barriers such as increased real or perceived cost, benefits to profit margins and the risk of introducing new products or processes. In considering the management of the construction supply chain, Green et al (Green, S. D., Fernie & Weller, 2005), argue that construction practitioners are not 'uninformed or deficient' but are human actors able to think and take action. If, assuming this is correct, which would appear to be the case for Carillion high-level decision makers, it may suggest that knowledge also remains siloed and fragmented as it is not identified as a primary client need.

4.2 Conclusions

This more nuanced analysis of fragmentation supports the observations that the construction sector operates as a dynamic complex network rather than as a linear supply chain. Indeed, it is a continually shifting network of multiple sub-networks or as hypothesised by Fernando-Solis (2008) potentially a meta-industry; a conglomerate of industries. The flexibility required to manage short term projects, initiated by multiple clients and requiring unique end products creates an environment in which the main contractor has developed expertise in managing intensive, time pressured, high risk, operations. Whilst, at a corporate level, time horizons are longer, developing the capacity for a whole-life or the systems thinking necessary for sustainability across the supply network is highly challenging. This is exacerbated by the fragmented and

occasional nature of the client base where sustainability remains a relatively low specification requirement rather than the lens through which to view development. Only infrastructure, with its public funding sits outside of this norm. Unlike many construction developments it could be considered to have a branded identity, a clear requirement to meet a public good and it is contractually obliged to take note of Government policy aims. Whilst these pressures have provided the basis for many sustainability initiatives it is not clear if, major infrastructure projects on their own, can create the platform to develop industry consensus.

There are major societal and intergenerational gains with greater sustainability of build such as reduced CO_2 emissions, improved working conditions, and less waste of resources. However, these benefits are frequently identified as increased costs to the providers of a product or service, and where financial benefits do arise they are not equally distributed across the network. Main contractors operate at a central node within the network, but very low margins and few direct monetary benefits from sustainability actions, restrict the company's will or ability to be responsible for wider network sustainability goals. Carillion operated minimal management of the supply network beyond Tier 1 and where engagement did occur it was driven primarily by legislation, such as the Modern Slavery Act or by monetary benefits from major manufacturer discounts. Despite multiple Government reports, strategies and working groups there does not appear to be a clear vision of sustainability across the sector and certainly not one that offers operational guidance at a network level and made relevant to individual actors. The concept that everyone is responsible comes clearly from the research, but it remains unclear what this means to each actor within the supply network, a position highlighted by the multiplicity of goals and KPIs, each driven by self-interest and supply chain position, rather than a systems-based approach to sustainability.

Fragmentation has a major impact on the sector, affecting the main contractor's ability to manage or lead multiple complex networks. But fragmentation is not unique to construction; food, textiles and other major global supply networks experience similar issues. Inequality of benefits across the network, unclear boundaries of responsibility,

weak client demand where consumer pressure is limited, are identified as issues within many sectors. However, the construction industry does differ in its multiplicity of short-term networks, which continually disperse and reform around each asset build. It is argued that this fragmentation of supply prevents the collaboration necessary to implement sustainable build. Yet, in this chapter as well as transactional, contract led, interactions we also observe relational engagement, indicating, at least at the site level, collaborative working. We also see, beyond thousands of site-specific suppliers a core of longer-term suppliers, primarily subcontractors and major manufacturers. This suggests greater pan-project stability than first suggested. These findings will be reviewed in greater depth in chapter 6, which focuses on the role of the main contractor in network collaboration.

Sustainability is a complex issue; it has developed its own language, data, experts and silo's. Whilst many aspects of sustainability are being implemented by network actors a constantly shifting, constantly fragmenting and reforming network, appears to limit more effective network wide action. However, it could also be suggested that the construction industries very ability to manage complexity and constant change, although imperfectly, could provide the expertise needed to adapt sustainability as the lens through which building occurs.

Chapter 5: Focal company influence in the supply network

5.1 Introduction

Operating within a highly fragmented supply network, two network actors are identified as playing focal roles in a project supply network; the client and the main contractor (Tennant, Fernie, 2011b). Both actors operate through detailed contracts, specifications and project KPIs which in turn drive similar transactions with other network actors. Their dyadic relationship is focused on the construction process, with risk passed from client to contractor. Legal challenges are common practise in the construction sector and the most frequent parties involved in litigation are clients and main contractors (Häkkinen, Belloni, 2011). Whilst there are examples of informal social interactions across the network, something that will be explored further in chapter 6, they do not have the reach or authority to activate whole network change. To manage network interactions effectively the industry operates control and reporting systems through which they structure their interactions with others (Formentini, Taticchi, 2016). Within this highly transactional and adversarial network, the role of the focal company in setting and driving effective sustainability goals is important.

For the construction sector this raises an interesting question. Which supply network actor operates as the focal firm? Main contractors, positioned at this focal node, are highlighted in the literature as the most able to affect sustainable or responsible procurement, but who consistently fail to do so (Glass, Achour et al. 2011). However, at the wider construction network level the role of the client is seen as critical in defining the nature of the built asset. This chapter considers these two actors and the roles they play in leading sustainability across the supply network. In the following sections several major industry clients are examined to understand what is driving them to adopt sustainable practices and approaches. The role of client is examined in conjunction with legislative drivers and the position of the main contractor within the network is evaluated.

5.2 The client: focal company and sustainability

As observed in chapter 2, an extensive literature on the drivers for sustainable products and services notes the importance of consumer pressure and risk to brand reputation in initiating changes to practises in a supply network. In the construction sector the end user or consumer is rarely engaged in the structure design and clients, except for public bodies, operate as unbranded entities. Academic construction supply chain literature focuses on the importance of the role played by the client, primarily public-sector clients in driving forward sustainability. UK construction supply network actors, in a survey, agreed with this position where 53% thought 'clients should take the lead' in specifying responsibly sourced product, followed by architects (12%), and selecting contractors (6%) (Glass, Achour, Parry et al., 2011a). To understand what drove clients to undertake sustainable build, in the absence of drivers more commonly associated with consumer products, five major Carillion clients were selected for assessment: The Ministry of Defence, Highways England, Network Rail, Argent llp and BT Openreach. They represented public and private sector contracts, and infrastructure and buildings. They also offered a mix of procurement formats; long term framework agreements and shorter project-based contracts. The assessment utilised a range of published materials which was reasonably straightforward to access for the public-sector organisations, or those wholly funded by public money, as strategy documents, performance data and evaluations were freely available online. Argent llp (Private Client A) and BT Openreach (Private Client B) did not publish an annual sustainability report, and the only information available was that published in annual reports, website content and online case studies.

For each client their ownership structure and drivers were identified and tabulated to allow effective comparison between organisation types (Table 20). The construction type and procurement format the clients operated with Carillion were also incorporated into the information. Whilst the published 'aims' of each organisation were not guarantees of implementation they did provide insight into the clients motivations to act sustainably. The issues of policy and regulation, cost and risk identified in this table are reviewed as part of the discussion section, 5.2.1, below.

Table 20: Analysis of Client Sustainability Drivers 2015 (HM Government, 2015, Argent llp, 2015, BT Openreach, 2015, Office of Road and Rail, 2015, DfT, 2014, MOD, 2011, ORR, 2014, MOD, 2015, Highways England, 2015, UKGBC, 2015)

Line No.		Implementation	MOD	Highways England	Network Rail	Private Client A	Private Client B
1	Construction Type		Infrastructure + Building	Infrastructure	Infrastructure	Building	Infrastructure
2	Ownership		UK Government Department	As a Government owned company the HE is required to work to the UK Governments Sourcing Strategies.	Not-for-dividend owner and operator of Britain's railway infrastructure. They are an arm's-length central Government body created in 2014.	Owned by Private Pension Fund	Private (includes major Government contracts)
3	Procurement format with Carillion		Contract	Framework Agreement	Contract	Contract	Contract
	Driver						
4	Policy	Directly supporting Governmen t Targets	MOD are covered by the UK Governments 'Greening Government' Commitments which are reported on annually and scrutinised by Parliamentary committee. (HM Government 2015)	It is also likely that suppliers will be expected to contribute to the 25% Gov Target for SME spend, biodiversity plans, and efficiency savings. Highways England support PAS91 to help simplify SME engagement.	Not Applicable – See KPIs	Not applicable	Not applicable
5	Policy	Policy Governance - KPIs	Report on 16 KPI's	Highways England reports publicly on a set of 15 KPIs and performance measures on a six monthly basis.	The Secretary of State's High Level Output Specification: 'industry should also set out plans for embedding the rail	Use BRE SMARTWASTE Tool utilised to manage waste- 7 KPIs reported (Argent	CSR (Environment and Social): they support the key BT Plc KPIs (BT Openreach 2015).

Line No.		Implementation	MOD	Highways England	Network Rail	Private Client A	Private Client B
					industry's Sustainable Development Principles and measuring and reducing the carbon embedded in new infrastructure, throughout the lifecycle of programmes and projects. (DfT, 2014, Office of Road and Rail, 2015). NR report on 41 KPIs	llp 2015). Additional KPIs are available for individual projects e.g. Kings Cross (20 KPIs)	No unaggregated data available.
6	Regulation	Planning Requirement	Not identified as a major strategic driver	National Planning Policy Framework (NPPF) clear presumption in favour of sustainable development but does not cover specific infrastructure policies	National Planning Policy Framework (NPPF) clear presumption in favour of sustainable development but does not cover specific infrastructure policies	Consideration of environmental performance is undertaken as a matter of course in our industry today thanks to regulations and industry benchmarks such as BREEAM (Argent llp 2015)	No comment
7	Regulation	Other Legal requirements			Natural Environment and Rural Committees Act 2006,		
8	Cost / Value for money		The MOD also focus on the benefits derived from cost saving and provide a value for this.	Quality and cost will continue to be assessed but most significant differentiators in	• Improved whole life cost analysis, particularly for new infrastructure, to		

Line No.		Implementation	MOD	Highways England	Network Rail	Private Client A	Private Client B
			The financial benefits of SD are seen as an important element of future procurement decisions. (MOD 2011) •developing a revised whole life costs policy	determining best value are defined as •exemplar in Health and Safety Performance •excellence in Customer Service Delivery •performance that is based on whole-life value •affordability ¬ innovation	optimise option selection for investment decisions; • improved early estimating and improved analysis of changes in scheme costs through their lifecycle (ORR 2014)		
9	Whole-life Considerations	Impact on long term Asset Management	Key focus areas for the MOD are risks affecting its supply chain, such as resource scarcity and climate change, and to develop the scope for mitigation and adaptation strategies. (MOD 2015c)	Strategic long-term position is to require suppliers to take much greater control of activity across the life of an asset (Highways England 2015b).	Vital that railway infrastructure is resilient to climate change and extreme weather (DfT 2014)	Guiding Principles: We think long term …….. Ongoing, high quality stewardship of buildings …. delivering value over the long-term. …. long-term commitments to our projects… an involvement that often stretches more than 10 years. (Argent llp 2015) case study of sustainability at Kings Cross in 2015 (UKGBC 2015)	

5.2.1 Why clients build sustainably

5.2.2.1 Policy and Regulation

From the key client assessment (Table 20) Government policy emerges as a strong driver for public sector organisations and through its translation into regulatory interventions, the private sector. “Greening Government” reporting requirements and other sector specific Government targets are incorporated in public sector planning and procurement and are transferred to wholly owned Government subsidiaries and arms-length organisations through organisation targets (Highways England 2016) and contractual obligations (DFT 2014). For major infrastructure projects there is evidence that sustainability is being cascaded across the network, as noted by SC-P1 ‘Network Rail…..they are getting much stronger at pushing sustainability’. Main contractors are witnessing particularly strong requirements to support infrastructure clients with embodied carbon reduction and to support communities and meet SME targets. However, even where clients are more engaged in sustainability issues, and are attempting to drive this through the supply chain, the SC team identified a lack of client knowledge as a major barrier to change. As one Carillion Account Director noted ‘often clients don’t have the knowledge to challenge architects or designer specs……especially the smaller clients’ (SC-RM2).

Publicly funded organisations operate within clear governance structures and their contribution to policy goals are reviewed through several mechanisms; Parliamentary Committees, independent reviews and public reporting. Private companies appear to be driven largely by compliance with regulations. Large private sector organisations are only required by law to report details of greenhouse gas emissions and more recently on their response to the UK Modern Slavery Act, although many choose to expand this reporting set, frequently using the Global Reporting Initiative. In addition to meeting general environmental and social legislation such as waste management, pollution control, and diversity and equality the private sector clients reviewed appear to respond to more specific sustainable build requirements demanded by planning regulation. This was most frequently identified as a requirement to meet BREEAM standards. This position was supported by Carillion interviewees;

> ‘For the private clients, sustainability is not as high up on their agenda, but they need it to deliver against planning conditions – often they have had to make these kind of commitments when they were bidding to develop the site – part of how they beat of the competition to win it’ (BD-D).

Similar views on the impact of planning were expressed such as ‘(the client is) big on communities because they’re pushed by planning’, and ‘driven by planning’ (BD-B: SC-D: D-HD). High-level decision makers clearly differentiated companies forced to act because of planning or regulation from those led by ethical or even resource and risk concerns. There was a sense from informed high-level decision makers that such companies weren’t prepared to spend the money to do it ‘properly’ or they weren’t fully engaged in the concept or as one operations director noted ‘Client A just don’t do it like Google’ (C-AD). Private Client B appeared to have limited sustainability aspirations and provided little pressure on their joint venture supplier (of which Carillion was a partner) which in turn was reflected in the main contractor approach across the supply network: ‘There is no real discussion with suppliers about sustainability – it is not something that Client B are pushing either’ (SC-JV). Carillion attempted to implement their corporate position on FSC standards within the contract, but this was rejected by the client due to existing framework agreements with timber suppliers.

As noted above clients were required to comply with regulation and this requirement was transmitted to main contractors and other direct suppliers within the network. The importance of this driver was flagged by clients within PQQ documentation where information on previous environmental prosecutions was frequently set as a pass-fail position. From a main contractor perspective, the client would ‘just pass down to us the handling of hazardous waste and pollution control, which we had to meet by law anyway’ (O-AD). It was also accepted that legal compliance was the baseline for waste and pollution management where ‘we aim for compliance, the successes of sustainability depends on what is specified, which we do not always lead on’ (medium-level decision maker, Anon, Carillion Survey 2017).

5.2.2.2 Cost

As noted in the analysis of key clients and identified during multiple interviews, surveys and conversations (D2, D3, D5, D8, D10) it was clear that "low price" and "cost minimisation" were a major focus for the supply chain team. Most clients signalled lowest cost as a major buying criterion, within their PQQ and Tender documents, with price most frequently given a weighting of between 40-80% (Carillion plc 2017b). The latter was especially the case for 'single stage tendering, where 20% is technical and 80% commercial (price). Here there is no collaboration (with the client), it's all about best price' (SC-H2). Sustainability weighting at PQQ stage ranged from 1% to 15% with a median range of 5-8% (Carillion plc 2017b). Increasingly clients, especially those in the public sector have framed cost as part of a "value for money" requirement, which increasingly include sustainability measures (see Table 20, Line 8). Carillion supply chain teams regard the descriptor "value for money", even when used by the public sector, as synonymous with lowest price. Carillion SC team viewed clients as the primary focal point, where their requirements were the main guide to action, and for most contracts this meant achieving low costs whilst meeting time and quality demands. For the Carillion sustainability team there was only one lever to deliver change…….'How do we get supply chain to buy sustainability? – ultimately it comes down to money' (S-SA).

The perception that lowest cost, at point of purchase, was the primary procurement priority, pervaded the supply network and was considered by Carillion, key manufacturers and designers, to have a major impact on sustainability. Whilst the supply chain team acknowledged that some clients had a more collaborative position on costs linked to innovation and sustainability, they were few. A high-level decision maker in the SC team identified most clients as 'wanting to build a dream but they don't want to pay'. As noted in chapter 4 public sector clients did incorporate environmental and social sustainability into contract requirements whilst the private sector clients tended to focus on "commercial competitiveness" and frequently saw sustainability as a lower priority, and that much of it would be lost as it passed through design, operations and then into the Carillion procurement teams. Others working on bid development were even less convinced about private client interest: 'The private sector is not that bothered about sustainability, they are happy if you do it, but they won't pay any more for it'

(WW-PM). This view was corroborated by SC-D, S-BM and O-ADO in separate in-depth interviews (D1, D5).

As the contract requirements continue to flow through the network, they undergo multi-stage "lowest cost" procurements, initially with Carillion's sub-contractors (Carillion Survey 2016), who comprised around 60% of the company's annual procurement by value, and then with wholesalers and manufacturers. Upstream perceptions of cost as the dominant supply network driver are corroborated in interviews with Carillion suppliers. One wholesaler interviewed (SUP-4) confirmed that sub-contractors just do what the main contractor tells them to do and that this is completely cost led. Companies wanting to approach their suppliers with different criteria find the focus on cost so ingrained in the sector that they struggle to discuss other issues. This was exemplified by comment from SUP-10: 'In our sector, as we lead on this (sustainability), whenever we go into a new supply chain, they have a glazed look. First of all, it's usually about the price – 'you want to buy from me, I've given you the right price, you will get the right quality so what do you want now? You want what?' The main issue is that you have to find people that are going to share or understand where you are coming from'.

Both Highways England and Network rail are incorporating whole life costing into their procurement process (Table 20), although feedback from Carillion teams would suggest that this is not yet standard practise. More generally it was noted that clients with a whole life interest in built assets are primarily public service focused: utility companies, hospital trusts, infrastructure providers and Government. They have responsibility for build, operational and refurbishment costs and eventually decommissioning and typically the assets have long operational lives: 60-100+ years. From publicly presented materials and Carillion SC team perceptions it is clear that the public sector, primarily infrastructure, have a more holistic view of their long-term asset resilience to climate change and scarce material. On this basis it would be reasonable to assume that whole life costing would be integral to the design phase but discussions with Carillion design, supply chain and sustainability teams suggested this was only rarely occurring in practise. Whilst some whole life costing examples did exist within the organisation, such

as the use of LED lights calculated to save 625t of CO_2 and £37,000 for Network Rail over 25 years (Carillion 2015) most projects, where whole life costing was considered, still appeared to be struggling to overcome initial higher costs. As noted by the S-I;

> "We've worked with the client to look at new product and had it independently evaluated against the current option. It shows huge whole life cost savings…… less manpower to install - which also means less risk to people. But, it's more expensive to buy. I know what's going to happen – they'll be asked to find ways to bring down product cost……and they probably can't because of low volumes…. so nothing will happen' (S-I).

A similar issue was identified by the category management team 'One job wasn't going to pay more even if the longer-term benefit came to the company. How do we get around this? They just couldn't see or weren't structured to look at the whole life costs' (D8). Internally the SC team faced a similar problem, CM-3 tried to offer more sustainable temporary accommodation on site. It was more expensive but could be used multi – times. It failed to be utilised as each project operated as a separate cost centre.

With private sector clients, especially speculative developers, there was little interest in how the building performed over the longer term. As S-BM noted 'we're just in and out…… lowest cost'. The SC team recognised that for current business models the importance of sustainability is 'all about who owns the long-term asset' (SC-DB). The SC-DB took the example of a developer;

> 'they will have spent most of their money on buying the site, and they just want it built as quickly and cheaply as possible. They will fill it with tenants and sell it on to a pension company as soon as possible" (SC-DB).

CM-5 felt that speculative building was the worst case of unstainable build. 'You created something not knowing what the user wanted and probably had to then make many changes to suit the new owners'.

5.2.2.3 Risk

Risk flowing upstream across the network creates a major barrier to the implementation of 'innovation', including sustainability, that is increasingly being demanded in public and private sector contracts. The tensions created by a need for new methods of work or materials to meet sustainability criteria and risk was neatly summarised by SUP-10

'clients want innovation but not if its new'. This was also acknowledged in a presentation at the APRES conference where a project manager for Turner and Townsend queried if it was possible to be too sustainable for a client. He felt it was all based on the client's appetite for risk (Healy, 2015).

High Decision makers within the Carillion SC team had a negative perception of construction procurement across the supply network: 'It's just a huge risk transfer…….contractors get minimum time to review, have to deal with poor design and take all then take all the risk '(SC-D). They are fully conscious of savings that can be made with better product or design, but they see a 'risk aversion with designers' (BIM). In turn manufacturers find the same constraints with downstream supply actors. A major UK supplier highlighted this 'We are constantly looking at new materials – an example is the new permeable concrete. It is really hard getting this through the design process and then into procurement. Everyone is worried about risk……(they) want proven evidence that this will work. ……we're in an industry where most people just do what they have always done'. SUP-8. This is echoed by SUP-7 'one of the biggest barriers is that standards aren't performance led…… if they just use standard specifications you can't develop…..but if they are very set and not varied there is no risk element'.

5.3 Clients are less important than legislation in driving sustainability

High-level decision makers within the Carillion supply chain team recognised that the sector had improved its appreciation of sustainability issues, 'with more clients, and especially suppliers, being much more aware of the topic……. very different to 10 years ago' (SC-D). However, it was not the client but legislation that the Carillion supply chain team identified as the primary motivation for Carillion to undertake sustainable practices (see Figure 23). High-level decision makers were quite clear that legislation was the only strong driver and indeed, when linked to costs it had been successful mechanism. As SC-D noted

> 'I guess the one that has really worked is landfill tax – 20 years ago we just dumped everything. The tax really had an effect – it was punitive but applied to everyone. Now if you go on site we are working incredibly hard to reuse all the topsoil and crushed demolition waste. Every scrap of metal is recovered; we now pull a site apart. And, of

course, it helped fund more research like WRAP to look at waste and reuse of aggregates. Good use of tax'.

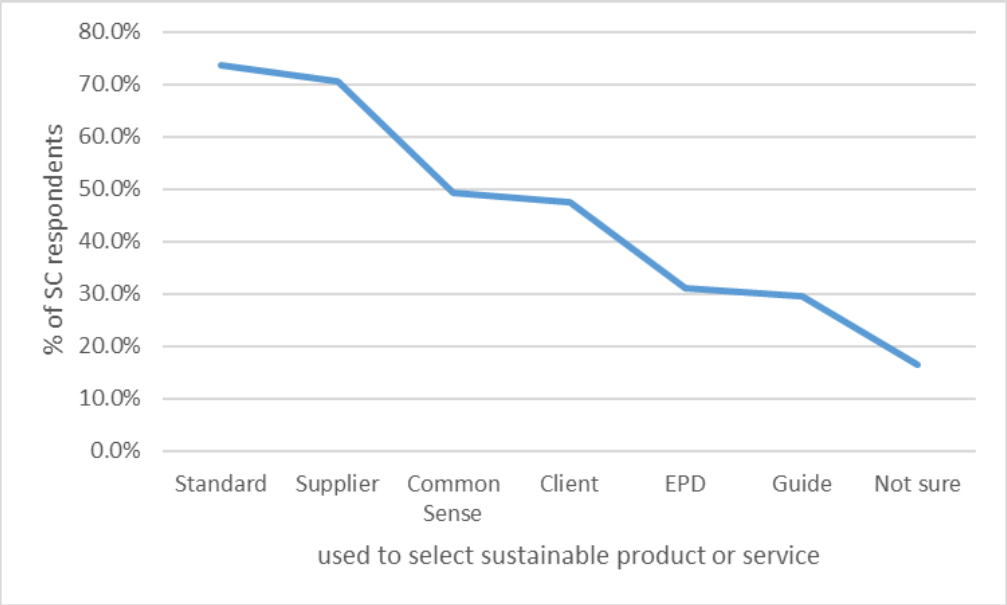
Legislation also operated across the network and engaged multiple stakeholders. Carillion's Chief Sustainability officer (S-CSO) noted after the 2016 Annual General Meeting, 'for the first time there were more questions about sustainability than any other topic……including questions on ethical sourcing'. This was driven primarily by increased operational and supply chain governance concerns from investors due to the newly passed UK Modern Slavery Act (UK Government, 2015b). Legal compliance was expensive but a cost that had to be met by all competitors and therefore incorporated into contracts. However, the failure to comply could result in large fines, a major concern amongst main contractors working on very low profit margins.

The SC team believed that the Carillion were implementing sustainable procurement because there was a legal requirement to do so and that it was a response to client demands (Figure 23). In an industry which has a strong operational focus on meeting multiple legal demands, such as health and safety laws and planning regulation this does not appear to be an unsurprising finding. It does however suggest conflict with the corporate position of social responsibility, where the organisation aims to operationalise sustainability beyond legal requirements.

Figure 23: Why do you think sustainable procurement matters to Carillion (Q4: Survey, 69 responses)

When the supply chain team were asked to identify how they would judge sustainable products or services only 49.1% stated they would rely on client specifications, not dissimilar to those who would rely on common sense and well below the primary reference source; standards (73.8%). Further analysis based on decision making levels within the Carillion team (Figure 24) identified a different approach between the high-level decision makers and medium/limited-level decision makers. The former thought it less likely they would work to a client specification or client guidance.

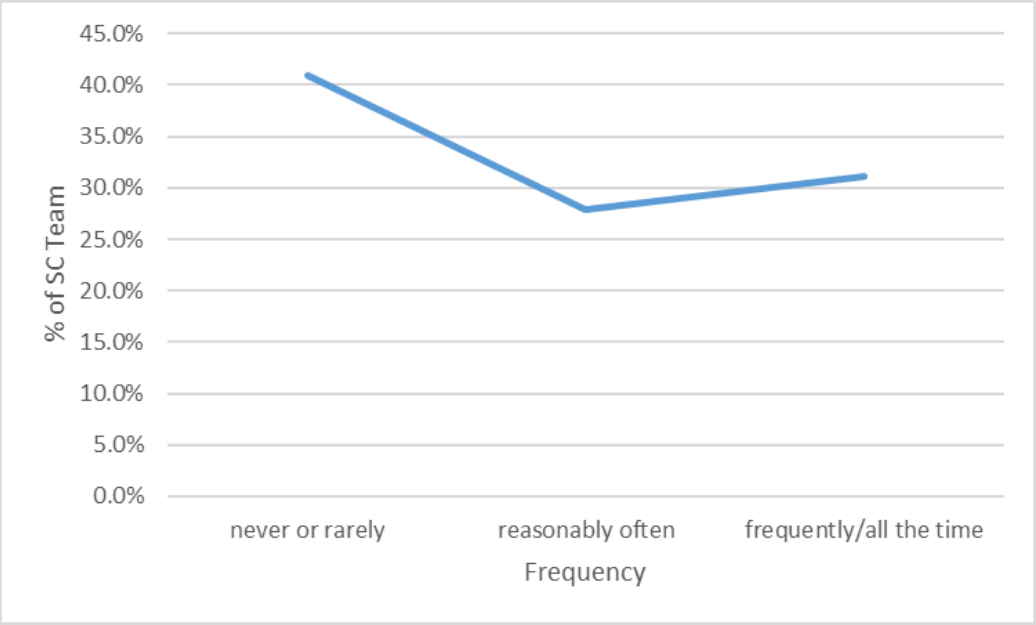
Figure 24: How do you normally judge how sustainable a product or service is? Select all that apply (Q14: Survey, 61 responses)



As indicated by the responses in Figure 24, members of the SC team were most likely to use a standard, or request information from a supplier when they needed to judge the sustainability of a product or service. Just under half of the team (47.9%) would expect clients to provide information which could support sustainable procurement. These findings are interesting and, in several cases, highly illuminating. Firstly, the role of the client in driving sustainability is not strong, and for senior SC team members weak. The SC team rely on standards as a simple method of verifying product sustainability but there is an unexpectedly low use of EPDs to support their decisions. Also, unexpectedly high in this set of responses is the importance of common sense, perhaps also better described as knowledge gained through experience, something that is explored further in chapter 7.

When the SC team were asked how often clients required them to buy sustainable materials, 41% noted this never occurred or only rarely (Figure 25).

Figure 25: With the exception of responsibly sourced timber how often are you asked, as part of the client requirements, to make sure the products you buy have sustainable credentials? (Q17: Survey 2016, 61 responses)



Whilst it appears encouraging that 31% of SC team members note that clients are 'frequently or all the time' requiring them to procure products that are sustainable, this was interrogated further considering some of the more negative positions taken on client sustainability. To cross check this response SC team members were asked to provide information on their engagement with BREEAM or CEEQUAL accreditation. This is the primary format for clients to signal the environmental standard required for the built asset. This also created a clear measure to respond to, rather than the more generic actions which could be standard site practise such as waste management. Responses were received from 66 participants to this survey question and just over a third of the team (35.4%) stated their clients were increasingly requesting the standard or that there had been no change since 2016. However, 36.9% felt that fewer clients were now including it in contracts. Somewhat surprisingly this left 27.7% who had never been asked to work with the standards. The data was checked for the impact of decision-making level and with a standard deviation of 1.115 for high level decision makers,

similar for limited level decision makers and 1.135 for medium level decision makers, similar variation from the norm occurred across all levels of decision making. This suggests that level of decision maker was not in itself significant in terms of their exposure to BREEAM or CEEQUAL. As discussed further in chapter 7 the industry has multiple definitions, encompassed within the sphere of sustainability, which may also affect response rates. For example, there is evidence that supply chain team members working with a client on ethical sourcing may view this as entirely separate from the concept of sustainability.

The SC team agreed that clients had a responsibility for sustainable procurement, but this was equally the case for suppliers and even their own operations team (see Figure 20, page 116). However, they believed that the client's stance would impact on the main contractor's ability to procure sustainably; as SC-RH1 noted 'generally it depends very much on the client how much influence Carillion can have on the materials and design/operation'. Whist there were positive examples of client engagement 'we're trying out a new local SME format on the Client C hospital project as it has been a key client criterion…….and they (the client) are testing out a new method of reviewing this' not all clients were interested in the outcomes. 'On some jobs it's in the specs but the clients are not so bothered once it has been agreed and may not monitor' (SC-RM1). Some of the supply chain team were highly sceptical 'a lot of key clients I believe just pay it lip service' (Survey 2016) and others that saw the client as a blocker to sustainability 'Why are we buying rubbish?! The disconnect is with designers and planners and client – waste is "baked in" before we get to it on a contract'. There were also examples where clients had specifically requested highly unsustainable materials. A Carillion category manager talked about 'a job where the designer decided that some panels had to be finished in stingray skin'. He had gone back to the client and said that he was not comfortable buying stingray but had been able to source a very good substitute. The client and designer said 'no – it had to be the real thing'. And in the end, they had to get it because that was what was being demanded' (D10). High-level decision makers recognised that one of their roles was to completely align client aims with 'what we are asking from suppliers' (SC-P1). Manufacturers, or their representative groups, were much clearer in their views; 'When people ask me who is the most

influential person in the supply chain you always have to say the client' (SUP-10) or 'only when the client is demanding sustainability does it happen – we really like working with a client like that. We know we can get up to a 30% reduction in carbon and ideally want to look at things from a whole life perspective - we know we can reuse and recycle' (SUP-8). SUP-12 confirmed the clients' role in driving sustainability in their business but also acknowledged the importance of legal requirements and 'a level of USP generated which offered them differentiation (for their members)'.

Only a few clients were identified as leaders in sustainability by both Carillion sustainability and SC teams. The clients were characterised as organisations who operated long term infrastructure procurement frameworks or were Government/quasi-Government organisations, where longer-term client-main contractor relationships existed. Major examples of this type of leadership organisation were Highways England and Network Rail. They were developing methodologies for the implementation and measurement of embodied carbon, net biodiversity and leading research on social value (SC-P1, SC-I, S-I, S-BM). Sustainability goals are incorporated into their business strategy and all supply network actors are required to meet targets as part of contractual agreements. New initiatives moved down into the supply network through working groups, commissioned tools and reporting requirements. Government has acknowledged its role as the UK's single biggest client to leverage its position to drive collaboration and develop 'informed client leadership' (UK Government,2016). Except for these leaders, the SC team view of other clients was much more ambivalent.

Whilst Carillion teams had generally limited confidence in the role of the client as a sustainability leader, they did reiterate the primacy of client demands. Several members of the team voiced this in connection with sustainability objectives: 'Quite frankly if something is in the contract the teams will do their utmost to deliver this – if it is in the 2020 strategy, they would not make much effort'. This view was supported by a comment within the Survey (2016) 'When a client stipulates ……our people pay much more attention to it than if it is a Carillion policy'. This suggests that failure by a client to incorporate sustainability in the build requirement does not automatically result in a

default to the Carillion sustainability goals. In fact, it seems likely that procurement teams will have only minor engagement as it is not seen as a client interest.

5.4 Is the main contractor operating as a focal company for sustainable build?

Carillion, in their Annual Sustainability Report, provided stakeholders with examples of the positive role their sustainable approach played on both social and environmental issues. Attempting to align company and client requirements for cost reduction with sustainability, they also identified that sustainability generated cost benefits. Supported by case studies and audited data they demonstrated that the main contractor could make multi-million-pound sustainability led savings. An analysis of fifteen case studies collected in 2017 by the CCS sustainability team (Table 21) highlighted that most of the cost benefits came from reuse of materials on site, primarily during the groundworks phase. Savings were identified as reductions in cost based on the initial project plan.

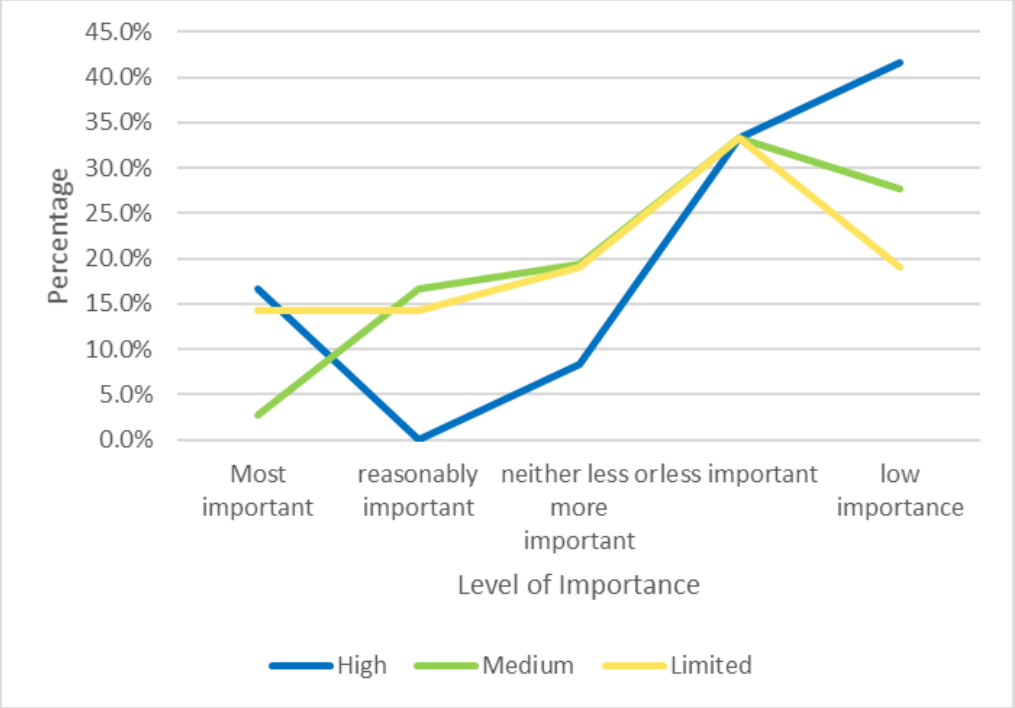
Table 21: 'Sustainability related' cost savings identified in 15 Carillion case studies (Carillion 2017)

	Carillion Design team led savings (£K)		Carillion Supply Chain team (including Category Management) led savings (£K)						Carillion Operations team led savings (£K)	Total
reuse of materials/products			£200	£63	£190	£600	£6	£200	£3	£1,262
reduce materials	£550									£550
producing less waste	£30	£200	£20						£300	£550
eco products	£67		£200							£267
Offsite testing			£200							£200
Total	£847		£1,679						£303	£2,829

Rather than being the outcome of planned sustainability activity most of the savings generated were a bi-product of 'standard' cost saving measures. These were primarily in response to legislative drivers such as waste charges for landfill or the minimisation of costs as part of the client/main contractor contract process. Whilst we could question the validity of base lines and valuation, Carillion was the only major contractor within the sector attempting to offer an economic evaluation of sustainability (Carillion, 2017). This was critical in a sector where main contractor margins were extremely low and cost and risk minimisation, were the paramount business drivers. Carillion's 'Better Business' programme was a strong offer to clients and a differentiator in the market (S-CSO).

Considering the importance of this measure to the corporate sustainability team and its potential unique selling point (USP) with clients and other industry stakeholders, it was assumed that the supply chain team would have an aligned position. In the 2016 survey the SC team were asked to consider why sustainable procurement mattered to Carillion. To help frame their answers they were provided with several options (see Appendix: 3d Survey 1 Questions Q4 (D3)) of which 'reducing cost' was included. The respondents were asked to score each option using a 1-5 scale, identifying them from most important to low importance. As shown in Figure 26 the majority of respondents did not see cost reduction as a major reason for Carillion to undertake sustainable procurement. High and medium-level decision makers were least convinced, with both ranking cost reduction as being of 'limited to low importance', with the total of these two descriptors comprising 83.3% and 80.6% of respondent scores respectively. Many of the supply chain team were unaware that their actions supported a high-profile corporate sustainability KPI (D3). Whilst this finding is derived from the Carillion SC team, a high proportion of the high and medium-level decision makers had worked within other construction companies. It is unlikely that their views had been solely informed by Carillion and that this finding would be similar with other main contractor teams.

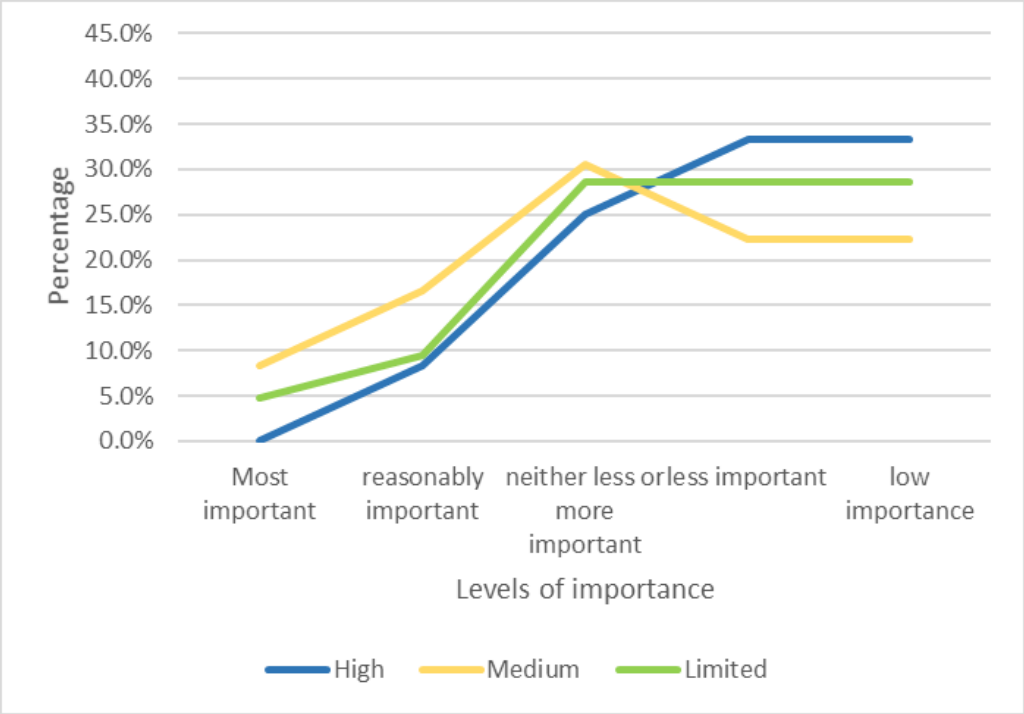
Figure 26: Why do you think sustainable procurement matters to Carillion? Reduces Costs (ranked 1-5) (Survey 2016, responses 69 (D3))



When asked if sustainable procurement mattered to Carillion because it offered value for money the SC team were even more sceptical (

Figure 27). The majority of the team rated this as 'neither less or more important to low importance'. The high-level decision makers were least convinced by this argument with 91.3% of them concurring with this statement.

Figure 27: Why do you think sustainable procurement matters to Carillion? Offers Value for Money (ranked 1-5) (Survey 2016, responses 69 (D3))



The prevailing view amongst the SC team was that sustainability costs more. This perception was both at a local level, (i.e. related to Carillion procurement) and at an industry level (i.e. a BREEAM 'Outstanding' building costs much more than a similar non BREEAM asset (Lockie et al., 2004, BAM, 2014)). Companies are highly sensitive to additional costs placed upon products or services not required by or funded by the client. Some of these arose as part of work winning commitments, others to meet corporate aims. Supply chain teams were 'under huge pressure to deliver, often at less than the estimated cost' (SC-RM2) and this pressure limited the role they played in sustainable procurement. The company faced demands on some projects to support community engagement, apprentices, and SME engagement but when extended to

corporate KPI's this created tensions between the company and its procurement teams; for Carillion local spend targets a senior SC team member asked '… how much of a premium will the company pay for this – 3%-5%?' (SC-D).

It was also clear that demanding more data, and increasingly detailed environmental and social reporting, increased costs across the network. There was also concern that burgeoning numbers of sustainability standards or certifications was placing a burden on suppliers. Many accreditations were expensive or assumed to be expensive; a concern especially for smaller SME suppliers. One member of the team had been at a new accreditation launch and was 'uncomfortable that suppliers had to pay for the service and members £1000 per day for auditing' (SC-PM). Accreditation/certification and standards, if mandatory, could limit Carillion's supplier base. Except for ISO14001, there was little client demand for sustainability certification (S-BM). The SC team noted that products labelled environmental or sustainable frequently came at a higher cost with some suppliers asking premium prices for sustainable products. The SC-RM2 had found he was being quoted a much higher price for FSC timber from Eastern Europe than the prices they were offering for PEFC. Whilst he accepted FSC, committed to chain of custody, incurred higher administrative costs than PEFC he found that the timber was coming from the same forest and the same sawmill. Where cost seemed disproportionate to benefit it generated negative perceptions that extended beyond the specific procurement. One of the most striking examples of this was the observation 'One site had had a major issue with newts. In end they found 4. The work cost £800,000: £200,000 per newt!' (SC-DB). This type of short, pithy comment was highly memorable and enhanced the 'sustainability costs more' story.

Whilst the Corporate Sustainability team presented sustainability as an opportunity for cost savings, the Carillion supply chain team identified sustainability with higher costs. Sourcing new and innovative products was time consuming, it conflicted with highly time and cost pressured roles and appeared to offer the company little short-term benefit. Taking on a focal role within the network was not seen as benefit by the SC team, and could indeed increase risk.

5.5 Comparison to literature

Theoretical approaches to global supply chains, global value chain analysis (GVC) and Supply Chain Management (SCM), and Global Production Networks (GPN) all acknowledge the importance of the focal company within a supply chain. The company centric approach of GVC identifies leading companies as the core actors in global economic governance (Gibbon, Bair & Ponte, 2008). They are supported by firm relationships and institutional mechanisms to co-ordinate non-market activity. This is achieved across the network through the setting and enforcement of product and process parameters (Humphrey, Schmitz, 2001). Buyer-led global commodity chains, where the focal company could leverage greater power over suppliers, led to the rise of the 'mighty buyer' concept. To drive non-market led activity, it was suggested, that appropriate regulation or pressure on a specific focal actor, could effectively drive change (Kogg, Mont, 2012). However, this has been challenged by Gibbon and Ponte (2008, p.385) who state that political actors have grossly overestimated the validity of the 'mighty buyer story'. This supports the view that whilst focal companies indeed exert influence over the chain, change is not driven by a strategic push down the chain but rather through the co-ordination between companies at certain lifecycle stages and by addressing structural barriers encountered (Gereffi, Humphrey & Sturgeon, 2005). The field of SCM, also supports the importance of increased collaboration, usually with a limited number of key suppliers with whom long term relationships are developed. It is also concerned with the ability of firms to exercise influence over actors in their supply chain (Kogg, Mont, 2012). GPN theory acknowledges the role of transnational corporates in driving complex networks of actors but they identify a much more relational set of linkages. Networks operate as dynamic interconnected systems in which functions, operations and transactions occur and where multiple focal points may exist (Scott, 2008).

Whilst multiple studies have demonstrated the role of clients, Government and other stakeholders in SCM (Nawrocka 2008, Seuring, Muller 2008) this research has highlighted the importance of Government acting as both major client and policy-setter in driving sustainability issues into the construction supply chain. In GVC frameworks non-market bodies are external to the 'supply chain' but within GPN theory these

organisations are incorporated into the network as key actors. This increases complexity and potentially undermines the concept of the purposeful management of a supply chain by a “mighty buyer” but it accepts that actions by one party in the system may have significant impacts throughout the supply chain (Kogg, Mont, 2012). The supply model observed within the Carillion case study supports the position that construction projects are most aligned to the concept of global value chain with highly dominant client’s organisations. However, the findings suggest that when sustainability is considered there is greater alignment with global production networks where the importance of ‘non-market’ actors are acknowledged and incorporated into the network. This would appear to be especially relevant for Government policy and regulation where market forces driving sustainable behaviour are weak.

The client focal role, in the UK construction sector, is noted by several researchers, with Briscoe et al. (2004) viewing the client as the most significant actor in achieving integration in the supply chain. The client can wield control over the process from physical structure to logistics. This may include the selection of designers, contractors and frequently material suppliers, which can lead to the disruption of established supply chains (Kornelius, Wamelink, 1998). The findings of this research concur with the importance of the client in appointing suppliers downstream, including the main contractor. However, whilst there are examples of materials procurement by the client, most frequently in the infrastructure sector, the majority of this responsibly is deferred to the main contractor. Both the client and the main contractor primarily engaged with Tier 1 suppliers, creating two major procurement points within the network. One bought design, project management and risk mitigation, the second materials, and services required to construct a built structure. London and Kenley (2001) also observed inter-company structural dominance within the client-contractor relationship and identified a similar position within the contractor’s network of subcontractors and suppliers’ relationships. Within the generic supply chain, the construction firm plays the major 'integrating' role for all upstream supply chains (Cox, A., Ireland, 2002). This concurred with the premise that two distinct supply chains are operating within construction, client-led and contractor led (Tennant, Fernie, 2011b). It is worth noting that when Vachon and Klassen (2008) examined environmental issues from the perspective of both

the supplier and buyer perspectives, collaboration with suppliers contributed to a relatively broad range of competitive benefits for the buyer, whilst supplier collaboration with the client offered a comparably narrower set.

This structure identified conflicts with arguments made by Preuss (2005) who argues that 'seen from a life-cycle perspective, environmental initiatives are impossible without involvement of the supply chain management function'. Several contributors to the field of environmental supply chain management have also noted that this requires closer collaboration and integration between actors in the supply chain (Bowen, Cousins, Lamming & Farukt, 2001, Seuring, Muller, 2008b, Vachon, Klassen, 2008, Gold, Seuring & Beske, 2010a). Within the construction sector clients are certainly understood to be leading the formalising alliances through frameworks, but Tennant and Fernie (2011b) could find no significant emphasis on the same approach to the management of a 'chain' of organizations. This contrasts with the suggestion that an effective supplier management strategy is critical in maximising the business value of procured products and services (Healy, 2015). The Carillion case study confirms that clients primarily only managed Tier 1 relationships and that there was no evidence of the widespread adoption of supply chain management. Only large public sector led infrastructure projects offered any evidence of structured multi-relational network management. Here the findings suggest that lowest cost price, at each stage of procurement, remains the primary value defining process in this sector. Indeed, demonstrating competitive market prices remains a dominant legitimizing institution within framework agreements (Scott, 2008). As noted in section 4, main contractors are expected to meet social targets even though issues such as SME procurement will add costs that may not be recovered. Client transfer of risk, linked to potential increases in cost and liability, were highlighted by Carillion as major limiters on product and process innovation. Similar findings were highlighted by Adetunji (2008) where industry interviewees noted a low-risk culture where clients are unwilling to take or share risks and opt for tried and tested materials and construction processes. Even where longer term benefits, including sustainability issues, would be accrued to the client, public sector organisations were found to struggle with higher capital costs due to restrictions on funding; a finding substantiated by this research. This issue was exacerbated if sustainability-oriented procurement strategies

required more investment without bringing financial benefits to the client. Similarly, a contractor who did not benefit from implementing sustainable solutions would be reluctant to invest in these solutions (Sourani, Sohail, 2011). Both points were reinforced by survey and interview data where the supply chain team associated sustainability with increased cost, a position endorsed in the literature, especially if seen as an add-on (Kats et al., 2003, Yates, 2003, Parker, 2012) and where developers, especially speculative developers, derived no financial benefit from taking a whole life perspective of building operations. Only where the client was prepared to directly engage with and fund more sustainable alternatives was this overcome, and in the PFI example provided this was supplemented by publicly funded research. Financial incentives were found to operate as drivers for sustainable build Hakkinen et al. 2011).

Briscoe et al. (2004) noted that without the client's willingness to develop supply chain relationships integration could not occur in the construction industry, a view supported by Sourani (2011) and Upstill-Goddard et al (2012) who identified a passive culture where no change was initiated unless required by the client. Within the Carillion case-study a leadership role in sustainability was most strongly developed in public sector clients, especially infrastructure projects, where longer term client-main contractor relationships existed. The SC team witnessed increased supply chain integration and non-regulatory sustainability led KPIs that required them to co-operate with Tier 1 suppliers to deliver (primarily community and no. of SMEs). However, for other clients' lack of sustainability demand stimulated minimal sustainable procurement from the SC team, despite Carillion Corporate sustainability team targets. The only exception, where Carillion procurement had primacy over client demand, was in the use of FSC timber, a position explored further in chapter 6.

5.6 Conclusions

The role of the client, as the focal point, within the UK construction supply network has been extensively covered in the supply chain and SCM literature. The findings of this research concur that for major projects clients remain the primary lead and that their requirements are formalised in contracts and framework agreements which then flow across the supplier network. The research suggests that this primacy has two major

effects on sustainable procurement processes within the main contractor studied. Firstly, weak signalling of sustainability by the client through contracts limits the potential for sustainable build especially when it is not supported by client funding. Secondly, and more surprisingly, the primacy of the client specifications appears to outweigh the main contractor corporate sustainability objectives; in effect if the client is not asking for it then 'it's not important'. When the client is considered through the lens of sustainable build their leadership role is weak. Instead the role of Government, as both policy maker and client become more prominent. Policy objectives drive non-market conditions into public contracts which require management, in collaboration with the main contractor, to at least two upstream tiers. In the research findings this was exemplified by the requirement to ensure a percentage of work was achieved by SMEs within the public-sector supply chain. Legislation created the basis for network collaboration with the main contractor identifying client demand for BREEAM and CEEQUAL standards, primarily a requirement of planning legislation. Whilst still new to industry, the UK Modern Slavery Act also required multiple-tier supplier engagement to meet corporate reporting requirements.

Supply chain teams were quite clear that procuring sustainable product and service cost more. Whilst we could argue that suppliers have sustainable products that are not being utilised and potentially could be offered at the same price it does not account for issues of enhanced risk, increased time to develop and potentially new supplier engagement. Sustainable build may offer long term cost benefits and other non-financial value, but it is difficult to understand how the main contractor could commercially justify increased cost with little economic or sustainability return under existing client procurement demands. The company had supported sustainability issues for many years but with extremely low profit margins was unlikely to be able to fund major sustainability projects. Only Carillion's public-sector clients, with long term responsibility for built assets, were more aligned with the whole life of the structure. They were considering whole life costing, but still faced barriers related to best value in implementing change.

Chapter 6: Collaboration

6.1 Introduction

Chapters 4 and 5 illustrated the nature and effects of a fragmented construction market in the UK. Sustainability operates at a systems level and Bankvall et al (2010) suggest that to achieve a more holistic approach construction requires some form of management or co-ordination between different elements of the network. Indeed, this is seen as requiring a the management of the supply chain base on a systemwide perspective (Turban, McLean & Wetherbe, 2005, Bankvall et al., 2010). For this to occur, collaboration, standardisation of information and an element of trust are seen as fundamental to successful outcomes (Bankvall et al., 2010). In response to this challenge supply chain management (SCM) theory and practise has developed. In construction this has primarily been adapted, with limited success, from the approaches used within the manufacturing and aerospace industries. The concept has been further developed to encompass sustainable supply chain management (SSCM). The latter requires supply chain co-ordination, integration of sustainability information across industry business systems to manage material capital, and information flows to meet stakeholder requirements over the short and long term (Ahi, Searcy, 2013). Fearne and Fowler (2006) argue that in order to improve the efficiency and effectiveness of construction supply chains, a fundamental change in the management of relationships between clients, contractors and sub-contractors is required; a point generally accepted in supply chain integration literature.

This research has identified relational ties that extend beyond projects and beyond directly linked network actors. This Chapter builds on these findings and considers the current approach to collaboration by the main contractor. It examines how they co-operate with upstream and downstream network actors to which they are directly linked, and with those more remotely connected. Collaboration was rarely referred to by the Carillion SC team and examples relating to sustainability issues are minimal. It was, however, a major element in the development of industry-wide sustainability knowledge and peer networking. This research has also highlighted two different types of collaborative forms operating within the sector; collaboration based on personal relationships (relational), which often transcend project or even corporate boundaries,

and corporate or industry initiatives, which are primarily transactional. The chapter initially considers the value of collaboration from the perspective of the main contractor and other network actors. Both the nature of transactional approaches and relational perspectives, such as values, trust, influence and control are examined and concerns about the capacity of network actors to undertake collaboration are explored. Drawing these elements together, the last part of the chapter presents three case studies that illustrate general network collaboration and sustainability initiatives undertaken by Carillion:

a) Category managed
b) Goal setting
c) Industry led

6.2 The nature of collaboration

Network actors do not appear to have an agreed definition of collaboration and indeed, like sustainability, the research suggests it is a term adapted to meet the need of the actor or participant. Whilst collaboration was used at Carillion to indicate "working together" this could represent a wide spectrum of engagement. Most frequently this remained at a transactional, contractual level, where it was used to ensure main contractor's requirements were met, rather than a truly collaborative dialogue with shared benefit. An example of this type of meaning can be seen by the language used within Carillion's Sustainable Supplier Charter (Appendix 1, Figure 47). Created by the corporate sustainability team, together with the supply chain team, the company offered an operational approach to assist suppliers meet the company's sustainability aspirations. It attempted to demonstrate collective responsibility, making it clear that Carillion, as well as suppliers need to commit to actions. Three actions in the document specifically noted the need to collaborate and these are considered in Table 22.

Table 22 An analysis of the use of the term collaboration within the Carillion Sustainable Supplier Charter (2014)

Item	Topic	Carillion Commits to:	Researcher Note
1	Health and Safety	Engage and collaborate with our supply chain to provide a safe environment and a safe supply chain	No reciprocal requirement of suppliers.
2	Sustainability	Collaborate with our suppliers on the development of enhanced sustainable products and services	Ask suppliers to buy ethically, FSC timber, and reduce own resource use
3	Sustainability	Collaborate with our supply chain to develop inclusive community engagement strategies that involve their employees working on our projects	Helping to meet Carillion CSR and customer targets

There was no supplier led action that incorporated the term "collaborate". This omission and the language and framing of the actions highlighted offers an insight into the perception of collaboration held by the main contractor. In Item 1 the suppliers are informed that Carillion will collaborate with them. No action is placed upon suppliers to engage in a reciprocal dialogue or delivery. For Item 2, suppliers offering wood products were mandated to supply FSC timber with full chain of custody. Even where suppliers were asked to meet collaborative commitment through ethical procurement and resource efficiency, it was unclear how much collaboration the SC team had with suppliers, other than offering guidance from the Supply Chain School. Item 3 required suppliers to support Carillion's CSR strategies. Whilst this may appear to be a collective process it should be noted that this type of community engagement was frequently part of a client contract, as they in turn had to meet planning requirements driven by the Social Value Act (UK Government, 2012b). An example of this was highlighted in chapter 4 where an offer of social benefits was used to support a major NHS PFI bid. Many of the targets agreed required supplier delivery and formed part of the tender process.

Collaboration was represented at an even more formal and transactional level by the company's achievement of BS11000 certification, Collaborative Business Relationships, in 2013 (Carillion plc, 2016b). Carillion Business Units and projects, where appropriate, had to complete a Relationship Management Plan which defined the basic Collaborative Business Relationship Management System. Sustainability and CSR could be included in

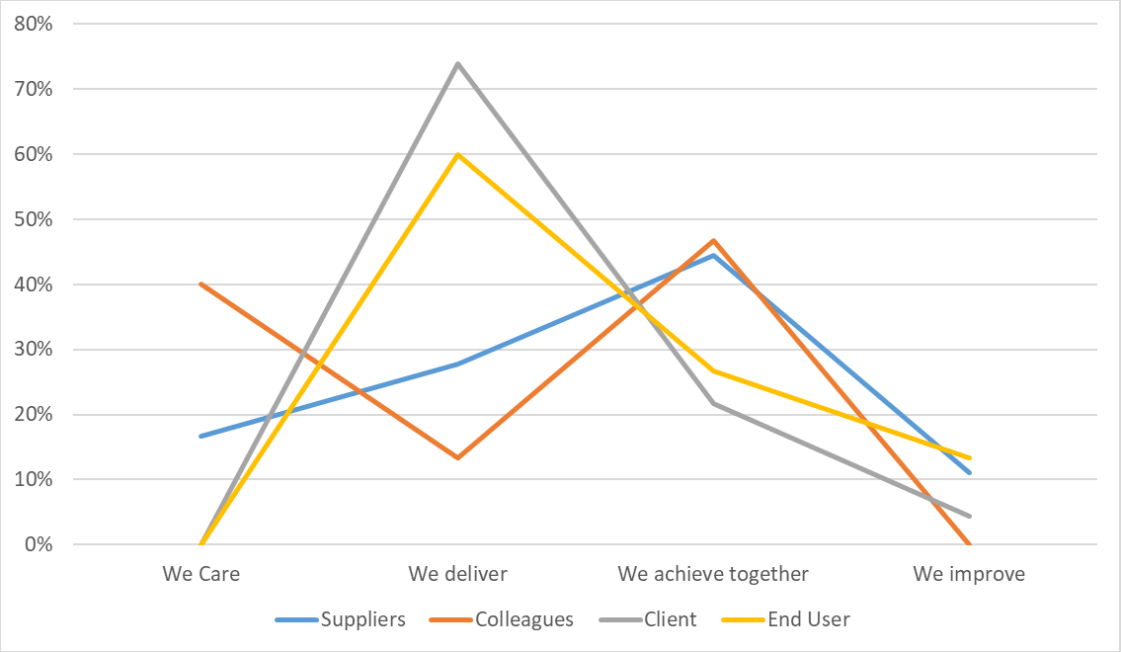
the plan if they supported Carillion business objectives but only where 'collaboration could be used to benefit the business' (Carillion plc, 2014a). In 2017 the company formalised its interpretation of collaboration through a new policy (Appendix 1, Figure 48) available to stakeholders. They identified collaboration as

> 'In meeting our corporate strategy, our collaborative objective is the implementation of a collaborative approach with our clients, supply chain partners and other stakeholders that will encourage greater levels of innovation and through our commitment to continuous improvement will deliver better value. It is through collaborative working methods that sound, cost efficient solutions will be found. Working together with our clients and supply chain partners from the early stages, will enable us to apportion and coordinate our efforts to better manage risk'.

Whilst this sees collaboration as offering network wide innovation and highlights the importance of early engagement in a project, in this main contractor vision, it is ambiguous for whom better value and reduced costs, or improved risk will offer benefits. As noted in chapter 5 better value was seen as synonymous by SC team members with lower cost, and the concept of collaborative working to reduce price would be an attractive, positive message for many clients.

The supply chain team, who sought to operationalise these views were clear that collaborative working was synonymous with 'closer working relationships, with fewer trusted suppliers' (SC-D). At this level collaboration, whilst often set within the confines of contractual processes, appeared to be driven by relationships which required trust and shared values. This understanding was tested with the supply chain team in 2017, when team members were required to consider four key groups of stakeholders across the supply network; Carillion colleagues, suppliers, clients and end users. For each category of stakeholder, they were asked to identify what they believed these actors valued. Responses were made on post-it notes and participants were asked place these on four different stakeholder boards. Final responses were not attributable to any one individual and multiple responses were encouraged. The comments were collated for each stakeholder and categorised by Carillion core values (Carillion plc, 2016c), see Figure 28.

Figure 28 Question: What do our stakeholders' value? Total of supply chain team responses analysed by Carillion values: Carillion Supply Chain conference 27th April 2017 (42 participants, 183 comments)

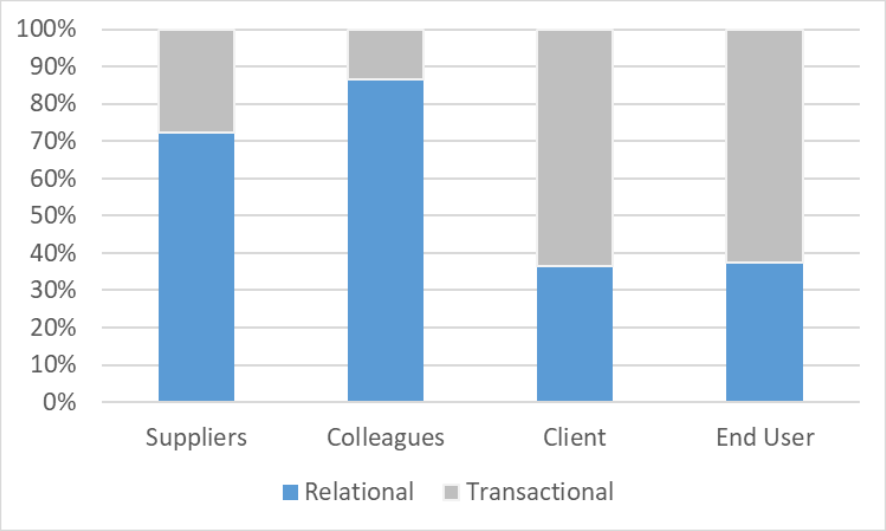


The results indicate two distinct groups. There is a clear alignment of Carillion suppliers and colleagues (group 1) core values and a similar link between clients and end users (group2). The SC team perceive that Group 1 are most strongly correlated in the attributes we care, and we achieve together. Group 2 however are extremely weak in 'we care' and very strong in values relating to 'we deliver'. The core value, 'we improve' is not identified by the SC team as a strong feature of any one stakeholder but is seen as weakest amongst colleagues and clients. Whilst this is a simple representation of stakeholder values it does suggest that the supply chain team view colleagues and suppliers as being more engaged with values linked to more relational positions, such as working together and caring about people, product or service. It is not surprising that clients and users were primarily seen as only valuing delivery, as the delivery of an asset is the essence of the main-contractors project role. This group of actors, especially users are also more remote from the SC team. Only the most senior members of the supply chain team were engaged with clients and then only on a very few contracts, such as a PFI building, was there any contact with the final asset user.

Using the same set of responses (Appendix 6) the SC team value comments were then reviewed to consider if they identified a relational or transactional position. Relational

positions are associated with personal values such as trust, openness and opportunity. Transactional values related to practical aspects of project delivery e.g. cost, timely payment and quality. Whilst open to researcher bias, allocation, for the majority of comments, was relatively straightforward. However, two client attributes, innovation and defining brand design and two colleague comments, brand and image were problematic. After some deliberation the former were allocated to transactional positions as they were practical actions and the latter to relational attributes; whilst business focused, they encompassed personal attributes. The analysis, presented in Figure 29, reinforces the perceived division between Group 1 and Group 2.

Figure 29 Relational vs transactional values: Carillion Supply Chain Conference 2017 (42 respondents)



The values allocated to suppliers and colleagues by the supply chain team have a much stronger relational basis whilst the client and end user are seen to be driven by much more transactional values. Engagement with clients elicited a high number of transactional responses relating to cost and price, whilst relational values include openness and trust. For end users cost and quality matter but the SC team felt they also value engagement and trust.

This analysis suggests that the main contractor's procurement team have very different relationships with upstream and downstream suppliers. They consider upstream and intra-company engagement to be with organisations aligned with more relational

values, whilst downstream they see network actors operating with a greater transactional value set. Trust, an important element in collaboration, was valued by all stakeholder groups and it features as a comment in several interviews and meeting notes. Interestingly, for the supply chain team, this links closely to a position of 'greater control' (CM-1, CM-2). An example of this was highlighted where category managers were increasing collaboration with preferred suppliers. This was identified by CM-1 as;

> 'My role is to build relationships and to do deals with the suppliers, such as getting manufactures who work with Carillion to provide volume discounts. In return Carillion work to specify their materials. This give the company more control.'

Whilst this statement has a major price and transactional element it does indicate that Carillion was offering a benefit back to the supplier; the opportunity for ongoing work. The result of this collaboration was reinforced by a comment at one of the category managers' meeting;

> 'We're asking Tier 3 manufacturers to understand where they are supplying Tier 1 sub-contractors, so we can have much greater visibility of the materials and product quality being used. Tier 3 are gradually co-operating as they are finding that Carillion are nominating them to sub-contractors.' (D10)

Here, greater levels of trust are beginning to develop as the category manager provides the basis for longer term and ongoing relationships with the manufacturer.

There appeared to be a very different level of trust with Tier 1 contractors. When discussing their relationship with sub-contractors and how they could support sustainability a category manager commented that 'many tier 1 suppliers (sub-contractors) do not want to engage with Carillion on what materials they are buying or who from – they'll only do this if specified, and not always then' (CM-4). Many sub-contractors did not trust Carillion and Carillion did not feel in control of the procurement process.

More surprisingly there was a high level of mistrust between internal colleagues, a point raised during several interviews and discussions. One supply chain team member commented that 'in my opinion the current status provides too much power for the (Carillion) operations team to change agreed strategy at critical points' (Anon: Carillion Supply Chain Survey 2016). Issues of transparency also resulted in frustration and

lowered trust between colleagues. This was demonstrated when the researcher probed further into specifications and the D-HD confirmed that all designers work with a bill of materials commenting;

> 'Usually this is produced by the client but where it isn't they (the Carillion estimators) will create one. They are created in an excel format. It is where the profit is really made – there might be twelve windows costed but if you walked round the final build you would only see eleven. The estimators don't release this sort of information'.

It was clear that whilst the company might put collaborative policies in place, personal relationships between individuals within the network were important. Multiple project working allowed Carillion team members to build up an informal personal network of colleagues in different teams. Similarly, it was clear from interviews, meeting notes and internal biographies that two thirds of SC team members had experience working for other construction network actors. Of these nearly 15% had worked for other main contractors and had personal relationships with people working in competitor companies. The category management team appeared to be more unique as many of them had key manufacturer or supplier backgrounds. The relationships mattered as a comment from SC-RM3 indicated 'we have a close relationship because we want to work with them. You need to have honesty between the two companies …….you have to do that face to face'. Supply chain team members accepted that it's difficult to build relationships (with suppliers) but these are key to bringing in new materials and ways of working' (SC-RM2).

6.2.1 Comparison to literature

In chapter 2 research materials on collaboration within construction supply networks were reviewed. This identified only a limited number of academic and industry publications which either looked to assess collaboration practices in the sector, identify barriers to application or consider the application of collaborative tools, such as supply chain management. As with industry more broadly, the definition of collaboration varies by situation. It could be described as the involvement and joint effort of clients, contractors and subcontractors to efficiently complete a shared object (Bishop, Felstead et al. 2009), or as a description of partnerships, joint ventures or even networking (Hughes, Williams & Ren, 2012). It could also be applied as a more generic term; Carillion

identified collaboration within their supply network as “working together”, a similar definition to that used by Hibbert et al (2008). Hughes et al (2012) also suggested that collaboration may have different meanings, dependent on the position of the actor within the construction network, and that the meaning of collaboration changed over time. Lambert et al (1999) also noted that collaboration is an evolving process rather just occupying a position between adversarial relationships and joint ventures. There may also be different shades of collaboration (Hall, 2000; Matopoulos et al., 2007). The findings of this research suggest that the definition of collaboration differs not only at a network level between inter-company actors but also between intra-company teams, individuals within teams and even between projects.

Collaboration was identified as a means of ensuring greater integration within construction supply chains, thus a key means to solve the problems caused by fragmentation (Latham, 1994, Egan, 1998, Dainty, Briscoe & Millett, 2001). Research by Murray, Langford et al (1999) suggested that long-term strategic partnerships held the key to integration and that these relationships could overcome the temporary nature of one-off projects and so provide a measure of continuity in the supply chain. Industry research suggested collaborative relationships could help firms share risks (Kogut, 1988), enhance profit performance over time (Mentzer, Foggin & Golicic, 2000), reduce transaction costs and enhance productivity (Kalwani, Narayandas, 1995), and access complementary resources (Park, Mezias & Song, 2004). Collaboration was also identified as building and maintaining SC relationships in order to create competitive advantages (Simatupang, Sridharan, 2002, Brockhaus, Kersten & Knemeyer, 2013, CIPS, 2018b). However, Akintoye, McIntosh & Fitzgerald (2000) stated that the objective of the collaborating and managed supply chain was to create value for the whole supply network, not just one specific company. There was no evidence that this was an aspiration for Carillion, although shared cost savings between the client, Carillion and a manufacturer had occurred on some projects. This type of collaborative behaviour is often described as informal interactions or embedded relationships (Pusha, Mathew, 2010) and is associated with a commitment to win-win outcomes (Eriksson, 2008). In the construction sector collaborative behaviour has been described as primarily unstructured and occurring in both inter-company and intra-company relationships

(Dike, Kapogiannis, 2014). However, Dainty et al (2001) note, collaboration assumes that those involved in the construction process have an inherent preference to be integrated within the supply chain. Developing closer relationships and achieving integration of processes were seen to be difficult to realise in practice, (Briscoe, G., Dainty, 2005, Green, S. D., Fernie & Weller, 2005). Indeed, it appeared that most firms within the construction sector were 'locked in a mindset of mutual competition' (Green, S. D., Fernie & Weller, 2005).

Whilst the construction sector has been highlighted as slow to adopt collaborative practices (Latham 1994, Egan 1998), exploration of the literature beyond the sector finds similar issues and concerns arising. For example, Fawcett et al (Fawcett, McCarter et al. 2015) working with retailers, finished-goods assemblers, direct materials suppliers, and service providers, identified that decision-makers struggled to reap the performance benefits of developing collaborative relationships with supply chain partners, and few firms had succeeded in collaborating to achieve a distinctive competitive advantage (Fawcett et al., 2015). Indeed, research suggested that only two out of ten collaboration efforts delivered significant results (Benavides et al., 2012). Within the construction sector, even in the absence of a conflict of goals and objectives, 'real' collaboration and integration between network actors within the construction sector required significant effort (Udom, 2013). Akintan (2013) found a general lack of enthusiasm about the idea of adopting collaborative principles within traditional construction procurement environment. There was also evidence that the rhetoric surrounding collaborative approaches in construction hid a slightly less favourable reality (Bishop et al., 2009).

The concept of supply chain collaboration was extended further by Vachon and Klassen (2006) from just considering a supply chain's core operations to its environmental performance. Indeed, Kruase et al (2009) argued that an organisation is no more sustainable that it's supply base. Further research has developed this position suggesting that environmental or sustainability issues can only be addressed with buy-in across the entire supply chain (Paulraj, 2011). This demands direct involvement of an organisation with its suppliers and customers to jointly develop solutions; to collaborate

across organisational boundaries (Rao, 2002, Seuring, Muller, 2008a, Gold, Seuring & Beske, 2010a). To achieve effective management of sustainability issues (Power, 2005) argues that it requires taking a holistic and systemic view of the supply chain. This requires a strategic approach; one where inter-firm collaboration takes on strategic importance (Sharfman, Shaft & Anex Jr, 2009, Luzzini et al., 2015). Carillion had not undertaken a strategic or holistic consideration of their supply network; they did not have formal sustainable supply chain or sustainable procurement strategies.

Several papers highlight the importance of relational capital such as trust and a shared history in creating commitment across the network to support collaborative efforts for sustainability (Simpson, Power, 2005, Sharfman, Shaft & Anex Jr, 2009, Touboulic, Walker, 2015). Simpson and Power (2005) show that a relational approach is more powerful than coercion when considering environmental performance and collaborative relationships are more effective when not contractually defined (Briscoe, G., Dainty, 2005). However, sector literature on collaboration suggests that relationships upstream are highly transaction driven by the main contractor, who creates a list of preferred sub-contractors and suppliers (Tennant, Fernie, 2011a). Carillion primarily worked with Tier 1 suppliers on sustainability issues, which resonates with Tennant and Fernie (2011a) who found limited construction supply chain relations with second, third and fourth tier suppliers and manufacturers although there were signs of supply chain collaboration and interdependency extending beyond the traditional boundaries of supply networks (Tennant, Fernie, 2012). Tennant and Fernie saw the primary supply chain relationship as the client and main contractor which was highly client centric, a view supported by Akintoye (2000) who found more arrangements with clients than suppliers and most of these were contractual. Traditional procurement creates a more transitional rather than relational work relationship as network actors continue to pursue self-interest (Hughes, Williams & Ren, 2012, Akintan, Morledge, 2013).

6.3 The value of collaboration

As noted in Section 6.1.1, collaboration has multiple meanings to different actors within the supply network, and indeed within Carillion teams and individuals. This affects not

only how collaboration is implemented but how it is valued. Carillion defined collaboration, one of their four core values, as 'we achieve together'. They identified this as the ability 'to build strong, open and trusting partnerships' (Carillion plc, 2016c). In their 2014 annual sustainability report (Carillion, 2015) they expanded on the role of collaboration, stating that 'in sectors like construction and services, which rely fundamentally on working with partners, it's important to recognise that collaboration is key to success'. They also noted that it was critical to the implementation of sustainable outcomes. The value of collaborative working was echoed by major clients, especially within the public sector. As a member of the SC team noted, 'Network Rail during their 2016 supplier conference, identified that they were looking for suppliers who could offer innovation, collaboration and sustainability' (SC-P1). However, others within the company were more sceptical about collaborative working, seeing only minimal evidence of client support, and that it could conflict with the primary focus in construction procurement; lowest cost. Many of the SC team did not identify it with success, rather identifying collaboration instead 'as the new buzzword' (McKolsky, 2014). Indeed, Carillion themselves noted that 'collaboration can often be a cliché' (Carillion, 2015).

The company's corporate sustainability strategy (2020 Strategy: Leading the Way) primarily focused on affecting and reporting activities directly under Carillion's control, such as their own estate and the construction site; the boundaries tightly drawn around the company. Within the Annual Sustainability reports (2014-2016) the sustainability team attempted to demonstrate the value of sustainability, both qualitatively, using case studies, and through quantitative methods; recorded cost savings. Carillion Business Unit's had annual targets to meet both key corporate KPIs. Generally, supply chain sustainability initiatives were seen to add value to the company as they helped meet legal requirements, and the expectations of clients and investors at a corporate level, even if this did not always convert into action at project delivery. This balance between rhetoric and delivery was exemplified by a statement on the Carillion intra-net. It claimed that

> 'procurement is at the heart of Carillion's 2020 strategy, Leading the Way. Sustainable procurement means meeting our own and our customers' need for goods and services,

which achieve value for money on a whole life basis, taking into account the community and minimising the impact on the environment'.

There was some truth in all the elements of this statement but how this was applied varied by client need, the supplier offer, price and the knowledge and expertise of the procurement team. Sustainable supply network initiatives remained primarily reactive responses, developed as new client requirements or issues arose; the company had no foresighting capability. As will be seen in Chapter 7, most of the senior team, both within sustainability and Supply chain, had only a limited knowledge of life cycle approaches and how this mapped across supply chains and built assets.

6.3.1. Increased value

Beyond the corporate sustainability team and sustainability champions, references to the non-monetary value of sustainability were limited. As discussed in earlier chapters sustainability was not a major issue for most intra-company teams unless it was specified by the client or if team members had a personal interest. Teams were, however, aware of the company's strong reputation for sustainability, but this was frequently identified as a corporate issue. There was a strong perception from many of the medium-level decision makers that sustainability was something that you had to be seen to support. However as noted by one supplier it only had limited value, 'sustainability has to be a driver up front but it's one of the first things to get pushed out of the way (when costs have to be cut)'. Only with its support of FSC timber did Carillion lead a sustainability focused collaboration that successfully operated across supplier boundaries. Clearly FSC had reputational and assured network compliance value to Carillion but more surprisingly it persisted as part of the SC Team procurement process even though it was associated with increased cost. It was strongly associated with the company's ethical stance and 67.7% of those that responded to the 2017 online survey (66 participants), believed that that the most important reason for the company supporting responsible sourcing of timber was to ensure that forests remained alive for future generations (Supply Chain Survey 2017). The confidence level for this result was 84.7%)

Carillion procurement teams and several suppliers did provide positive examples of tangible value that was derived from collaborative working. The SC team offered a practical illustration where collaborative working was impacting on environmental issues:

> '……..Drywall work we are doing. We now only work with one supplier and have a number of high quality, reliable companies who fit out. We can work with the supplier to minimise waste prior to fit …..such as making sure that panel sizes work for site. They (the supplier) also offers a takeback scheme for any offcuts. It does cost money, but then you would have to pay to have it taken away anyway. This opens up the possibility for much greater transparency in the supply chain and the opportunity to develop new products or processes.' (SC-D CD).

This collaboration provided positive environmental benefits, but it also identified a tension that was regularly noted by participants, that of potential trade-offs between sustainability improvements and cost. This was vividly articulated by a sustainability expert in one of the main manufacturers when the Sustainability Director of SUP commented:

> '……if you are swopping suppliers all the time and if you're always going on about a price ……that's not the way to affect change. So in quite a few of our supply chains we've collapsed the supply chain – in the Indian example we only have one supplier, which from a procurement point of view is probably horrendous,…… how do we know we are getting the best prices. ……we can't live without him and he can't live without us. So that's either very healthy or very unhealthy depending on what your viewpoint is. What it does mean is that the supplier is now fully engaged with the social agenda that we have, as well as the business, the pure economics of supply.

This underlying level of uncertainty is not merely a concern for sustainability initiatives but as an approach collaboration itself may be problematical:

> 'Rail suppliers tend to come from a small pool, are reasonable stable and smaller in number. This can create a positive base for collaboration…… longer term relationships with experienced suppliers interested in longer term developments. However, it also reduced the leverage that can be brought during negotiation and procurement' (SC-P1).

Despite identifying value from collaboration, especially where there were more stable long-term relationships, procurement professionals were cautious when considering sustainability, noting that frequently there was a balance between positive outcomes

such as sustainability, quality and innovation and potentially higher costs, reduced leverage and increased risk. There was also a concern that collaboration associated with fewer suppliers could limited competition and without strong industry or external pressure, reduce the pressure for innovation and, of course affect the ability to achieve lower costs. This was understood and acknowledged by sustainability professionals such as SUP-10 who reflectively commented

> 'broadly for sustainability it works but some of it gets a bit murky. You get into economics and what you're doing on the social sides and all the rest of it, ……but generally working together….. the collective benefit, it's being more than the individual.'

6.3.2. Increased costs

Collaboration across the network to improve sustainability such as the FSC 'Chain of Custody', was seen to increase costs. For the main contractor this included guidance and training material for Carillion procurement and operations staff and ongoing, intensive engagement with suppliers and subcontractors bringing timber onto site as part of contract works packages. It also required extensive labour to input site data and manage internal monthly reporting of timber usage (SC-DH2). FSC timber could often be more expensive because these some of these costs were also incurred by multiple network actors. The company did not monetarise the additional costs associated with FSC.

With FSC Carillion SC team had corporate support and an embedded process for FSC timber: 'that's just what we have to do' (SC-RM1). However, when CM-3 tried to offer 'more sustainable temporary on-site accommodation' he found it difficult to implement. The units were more expensive but could be used multi – times'. It was quickly clear that the problem was who was responsible for the cost.

> 'One job (project) wasn't going to pay more (for the sustainable unit) even if the longer-term benefit came to the company. How do we get around this? They just couldn't see, or weren't structured, to look at the whole life costs' (CM-3).

Supply chain team members were also concerned about the costs of sustainability standards to their suppliers, especially SMEs and were reluctant to mandate standards such as ISO14001, unless demanded by the client. They felt standards could both increase costs to the Carillion but would also limit the pool of suppliers they could draw

from, a major issue when the industry was expanding. There were also examples where the cost of standards or accreditation also constrained the sustainability team. SC-PM noted that

> 'Carillion had received a very positive assessment of our procurement approach by CIPS, they had been impressed by our work on sustainability. Carillion were logged at 'Standard' level (researcher note: this was the Chartered Institute of Procurement & Supply (CIPS) Corporate Certification Standard). There's a separate sustainability level (researcher note: the CIPS Sustainability Index) but it's expensive'.

The company understood that working with the Sustainability Index would incur the company with additional expense but were reluctant to proceed as it would add costs to suppliers (SC-PM). Those working on site could be even more blunt about sustainability and added costs. As noted S-SA saw the operations team approach as one where they saw sustainability as adding cost and complexity; 'they just have to do it……..and make sure it doesn't get in the way of building'.

6.3.3. The value of early engagement

One final aspect that is alluded to but not fully explored in the examples above is that network actors believe that collaborative engagement, early in the project development, can enhance value. Repeatedly network actors stated they could have done so much more if only they had been involved earlier (D2, D3, D4, D8, D10). This was enthusiastically illustrated by one of Carillion's suppliers:

> 'What people don't realise is you can make real innovative changes – using SUDs you can take out huge tanks usually put into basements and free up space – at £2000sqm that really makes a difference - you can use it for gyms or retail. But what we've found is to get this message across you have to collaborate and discuss much earlier.' (SUP-3)

Another supplier also commented that failure to engage early on sustainability creates an impression that it is expensive. When implementing 'BREEAM Excellent……people come at it too late they end up trying to retrofit answers/solutions and of course it costs more' (SUP-8). Again, there are examples of tensions between the perceived benefits of early engagement with clients and designers and commercial value. As the Carillion design team noted, 'It's a big issue for clients. If they appoint earlier in the process (RIBA

stage 2) they may not be getting the best value for money……but rather a reasonable price' (D-HD).

Collaborative value was not however confined to corporate benefit but for several of the supply chain team, and indeed suppliers, it offered a more personal meaning. Collaboration between network actors could offer a less adversarial and creative space in which to work, such as the experience of SC-JV. He had worked on a PFI hospital where the commissioning trust had a vision to be the most sustainable hospital yet built. This clear goal and the collaborative approach of the client had remained vivid in his memory, ten years later.

> 'I really enjoyed the challenge……..able to put anything on the table…all ideas were ok. We all (clients, main contractor and key suppliers) then worked through them (the ideas) – only taking them out when they proved unfeasible'.

Equally, the failure to collaborate could also be professionally frustrating as D-HD pointed out 'concept design is often better – here the contractors are much more involved – probably the closest to collaborative work – more than anywhere else. But it is still very constrained.'

6.3.4. Comparison to literature

Whilst there is a considerable range of literature on collaboration across supply chains, there remains debate as to the value of collaboration to the construction network, and more specifically, individual actors. The research on the value of supply network and collaboration within this sector is limited. Value is presented in two forms, intangible value such as reputation and innovation and these directly related to monetary benefit. Studies that have focused on project level collaboration within the construction sector have identified improved project performance due to supply chain integration (Dainty, Briscoe & Millett, 2001, Briscoe, G., Dainty & Millett, 2001, Eriksson, 2006, Kadefors, Bjo¨rlingson & Karlsson, 2007). Bresnen and Marshall (2000)and Constructing Excellence (2015) note that collaboration on construction projects can deliver a number of cost based benefits such as lower building costs, higher profits for the contractor, shorter project time and a reduction in the severity of disputes. The industry also believes that collaboration can create an environment for innovation and encourage continuous

improvement (CE). Industry wide research into the sustainable management of supply chains has also identified more relational value in collaboration such as increased trust (Simpson, Power, 2005, Alvarez, Pilbeam & Wilding, 2010), better communication (Cheng, J. -H, Yeh & Tu, 2008), commitment (Simpson, Power, 2005), learning (Carter, 2005, Carter, Rogers, 2008a) and less tangible, informal relational safeguards (Touboulic, Walker, 2015, Alvarez, Pilbeam & Wilding, 2010). However, there is also concern that proofs supporting the claimed successes of collaborative projects is limited (Bresnen, Marshall, 2000, Briscoe, G., Dainty & Millett, 2001, Beach, Webster & Campbell, 2005) and it is argued that collaboration may have no direct impact on project performance (Nystrom, 2007).

The willingness of clients to consider a wider definition of value rather than using cost minimisation to achieve effective and efficient means of meeting a projects goals affects network behaviour (Beach, Webster & Campbell, 2005). UK Government research suggests that construction clients struggle to articulate what value means to them, and too few projects develop a clear brief that defines their business, social and environmental requirements. Indeed, several papers note that main contractor-led supply chain membership is typically based on a number of performance criteria of which lowest price remains first among equals (Eccles, 1981, Hartmann, Caerteling, 2010). Sustainability could be seen as a 'code word' for pricing negotiations. Indeed, in other sectors sustainability initiatives that led to lower operating costs which were often hidden from the client to prevent demands for price reductions (Brockhaus, Kersten & Knemeyer, 2013). Dainty et al. (2001) identified that subcontractors, often operated within a low trust relationship with main contractors, were unconvinced that collaboration offered them value. They believed instead, that collaboration offered main contractors the opportunity to improve their cash flow and survive the volatility of the construction business (Tommelein, Ballard, 1998). When collaborating the balance between costs and quality can be valued differently depending on which 'side' of the project a party operates from (Udom, 2013).

Collaboration on environmental and social issues also increased costs, it was not free. Indeed, substantial investments had to be made by the firms beforehand, compelling

managers to answer the crucial question what value they were willing to allot to ecological and societal concerns (Gold, Seuring & Beske, 2010a). This is echoed in work by Touboulic (2015) who highlights a need to increase resources to change practices. When considering the demands of greening the supply chain it was clear that for many suppliers, especially SMEs, the innovation required to achieve greater resource efficiency required a high level of investment in knowledge, people, IPR, technology and equipment. These often offered limited or unknown return and the risk of other suppliers following suit with much lower investment costs (UNEP, 2014). Brockhaus (2013) also identified a reluctance by focal companies to incorporate sustainability criteria in supplier selection. He believed this was either due to a perception that monitoring costs for assessment would be high or because they were lacking the tools to qualify the sustainability requirements from their supply network (Wolf, C., Seuring, 2010, Brockhaus, Kersten & Knemeyer, 2013). There were also indications that many suppliers placed only limited value on sustainability demands as the main motivation was not to improve their own performance but to meet focal company demands. Many of them saw limited or no internal benefit (Brockhaus, Kersten & Knemeyer, 2013).

The literature has only limited focus on early engagement, but UNEP (2014) do note that integrated intervention at an early stage has a large impact on building performance at relatively low financial cost. However, this point of engagement remains problematical and there is an increasing move to try and compress the construction supply network, focusing on modern methods of construction, for example offsite building techniques (Fernie, Tennant, 2013). From a supply chain management perspective this approach will become more aligned with manufacturing supply chain management. Upstream construction providers will benefit from a near continuous stream of work which will limit excessive fluctuations in demand and supply (Hartmann, Caerteling, 2010). It is anticipated that offsite manufacturing will reduce the need for flexibility and thus fragmentation upstream and will enhance the opportunities for collaborative value.

6.4 Case studies

Whilst it was clear that collaboration remained limited, difficult and often counter to contractual requirements, examples of cross network collaboration did emerge from interviews, surveys and meetings. Many of these were product or issue specific, often linked to project activity and frequently only encompassing a limited number of network actors. This research does not attempt to map all collaborative activity across the supply network but is rather trying to draw from the industry conversations the types of collaboration that they see as useful or effective, and to draw from these examples common approaches that support a successful collaborative process. Several examples of extensive network collaboration were identified during the early phases of the research (D2, D3) and these were probed further through survey questions, additional interviews, attendance at meetings and the review of Carillion documents. From this work three different collaboration formats, all of which were either highly focused on sustainability or incorporated some elements within their remit, were identified; Category Managed, Goal Driven and Industry led. Key features of the case studies were reviewed (Table 23) and it was clear that they represented cases initiated by a range of drivers, they operated beyond the project level, had multiple network stakeholders involved in their delivery and met a range of Carillion aims. In the short studies that follow the researcher draws out the main features of these collaborative actions, considers how successful they are in supporting wider systems-based sustainability issues and the ability of the main contractor to lead this process. Using insights derived from interviews, observations at internal Carillion meetings and external workshops and conferences the researcher has also attempted to identify those areas that had a high or low focus on sustainability. This is incorporated into Table 23 below.

Table 23: Examples of supply network collaboration identified by Carillion supply chain team 2015-2017 (D2, D3, D4, D5, D6, D7, D8, D10)

Case Study		Driver	Carillion Project/company based	Carillion Initiatve Launched	Carillion lead	stakeholders involved in delivery		Carillion Primary Aims	Researcher assessment of level of focus on sustainability issues
						Intra-company	Inter-company		
Category Management		Carillion	Companywide	2012	Head of Supply Chain - Corporate	Supply Chain	Manufacturers	Bulk Discounts	Low
						Operations	Specialist suppliers	lower price based on increased corporate level volumes	
						Commerical	client - limited	improved knowledge	
						Work Winning	engineers/designers	relationship building with key clients	
						Design			
Specific Goal Oriented	FSC	Primary: NGO and corporates Secondary: EU Legislation	Companywide	1997	Head of Supply Chain - CCS	supply chain	communities	Values based concern over deforestation	High
						operations	raw material suppliers	Legal compliance	
							manufacturers	Corporate Sustainability credentials	
							wholesalers		
							Tier 1		
							Other suppliers		
							clients - limited		
	Modern Slavery	UK Government - Legislation	Companywide	2015	Head of Supply Chain - Corporate	supply chain	contractors	Legal Compliance	High
						HR	Labour contractors	Risk mitigation	
						Operations	other suppliers	conditions	
							manufacturers	Corporate Reputation	
Industry Forums		UK Government - Policy: NGOs, Contruction Corporates	Companywide	various	Head of Supply Chain - CCS	supply chain	see Table 14	Corporate status	Low
						sustainability		Knowledge acquisition	
								Reduced cost - joint development	High
								relationship building	High

6.4.1 Carillion category management

Carillion began to develop a category management system to support procurement prior to 2011 'but it was refreshed in 2013' (SC-D1). It was an approach that they knew, from discussions with their peers in the industry, was 'not widely used in construction' (CM-D). The company had defined the benefits of category management and how it would be operated;

'The category management approach is one where Carillion's external spend has been analysed and segmented into "categories". Each category in turn has been allocated to a supply chain professional to manage with the objective being to deliver the business and functional requirements of reducing cost, improving performance and driving innovation year on year. It is not an approach that is confined to the supply chain function but requires the active participation of and engagement with stakeholders, functions and individuals across the business to make it successful……Along with costs, capability, cultural fit, flexibility and partnering ability will be evaluated when selecting preferred suppliers.' (Carillion Intranet 2015)

In the definition provided above Carillion stressed the importance of collaborative working across business teams and indeed they identified the importance of category management to work winning teams. Here they looked to utilise supplier relationships, developed by the category management team, in tender content which would 'maximise our competitive advantage and ensure value engineering through enhanced expertise and knowledge'. Carillion Supply Chain Policy (D8). Category management allowed Carillion earlier engagement with their strategic subcontract partners and suppliers to ensure they worked with them to meet the requirements of the Client and 'offer innovative cost saving advantages' (D8). The category managers also worked closely with the supply chain team and operational teams at a project level. It is also important to note that the company had also identified the importance of aligning key preferred suppliers, not just on lowest cost, but also in terms of their ability to align with other Carillion values and needs, including the ability to partner. To help support the category management team with decision making they had adopted, and adapted, The Seven Step process (Figure 30), based on a procurement method developed by A.T. Kearney in 2001 (Dolan, Fedele, 2004).

Figure 30 Carillion "Seven Step" strategic category management process

Senior Carillion supply chain members saw category management as a strategic tool which would achieve the best supplier selection for operational needs; identify additional value; create opportunities for better processes and evaluate the performance of suppliers (D8). An analysis of Carillion procurement areas had identified 5 key categories that would support supply chain procurement. These were described as;

1. M&E (mechanical and engineering)
2. Building and Finish, which means fit out
3. Envelope…… brick, block, big glazing and so on
4. Externals ……. landscaping, drainage ……this may include groundwork;
5. Pre-lims (Preliminaries)…. that's onsite support, which would include cabins, welfare, PPE, and scaffolding' (CM-D).

New team members, recruited in 2013/14, were originally delineated as Category Managers but by 2017, acknowledging the increasing importance and value of the roles, they were re-rated as Head of Category posts. The senior supply chain team members acknowledged this growing importance as they recognised the skills the category

management team were bringing to the business. By 2016 the CM-D noted that the 'key aim is to allow experts to be able to work in areas of high knowledge and have oversight over all projects to enable specific work to be bundled together.' The Carillion supply chain team valued the category approach in breaking down project and team silos. However this was not only happening internally, the category team were quite clear that they 'didn't just work with Tier 1….. we talk to tier 2 and 3'. A high-level decision maker explained this in more detail.

> 'Through their (category manager) knowledge of certain products, they can identify that, whilst the company might be buying through a number of Tier 1's who then might have up to 50 Tier 2s, for some product areas, say curb stones, there are actually only a few manufacturers. In some cases, Carillion may be buying from them direct, on some projects, as well as through other Tiers so by looking at this, as a whole, we can influence. Here the supply chain looks more like a diamond than a pyramid shape' (SC-D).

Undoubtedly procurement by category continued to be driven by a strong cost saving motive and the Category team were responsible for managing volume-based discounts with Tier 2 and Tier 3 suppliers. This point was reinforced by CM-1 'my role is to build relationships and to do deals with the suppliers, including manufactures, who ultimately work with Carillion. They provide volume discounts and Carillion work to specify their materials'. Rather than asking subcontractors for product information the Category Managers were asking Tier 3 manufacturers when they supplied to Tier 1 subcontractors and therefore, they gained much greater visibility of the materials and product quality being used' (CM-D)'. This was not always simple as, frequently, product manufacturers could not find any sales data for Carillion as they were not listed as customers in their accounts systems. CM-D candidly noted that greater engagement was linked to rebate system but it 'was also giving the category managers much greater insight into product sales to subcontractors and increasingly they were using it to require subcontractors to use the products they selected'. 'This gives the company more control' (CM-1). Trust was also building in these relationships. As Tier 3 suppliers (manufacturers) were gradually co-operating as they found that 'Carillion nominated them to sub contractors' (CM-1). This was witnessed by the researcher in a category management review meeting where CM-2 provided one of Carillion's three preferred ceramics manufacturers details

of upcoming client tenders and discussed how to work with them on these. He was clear that the same review would be held with the two other Carillion preferred suppliers of this product group.

Category management was seen to have several benefits by Carillion senior managers. Firstly, it reduced costs by bundling work and giving key contractors a greater proportion of Carillion spend. Secondly it engendered greater relationship building with suppliers which led to opportunities to co-operate on innovation. The example used was working with Tarmac to utilise their low energy Asphalt on a new contract. Finally, it was seen as an opportunity to require Tier 1 suppliers (subcontractors) to work with nominated manufacturers or wholesalers. Carillion increasingly nominated three preferred suppliers within subcontractor's contracts. This allowed the Tier 1 to tender the work, but the SC team know that Carillion would get the right quality of work and at the right price. (CM-D). This level of control brought greater transparency to the supply process and improved the main contractors risk management profile. (CM-1). Whilst this did bring benefits it also created some operational issues. The category management system appeared to generate issues of internal responsibility. A good example of this was SC-SM3 who stated that 'there are lots of old wives' tales and legends. I found when I came here (to work for Carillion) that if Company X and Company Y did a rubbish job on site no one included it in their SPI (supplier rating) because they were category managed.' This resulted in ongoing poor service as none of the senior supply chain or category team were aware of the issues.

It was also clear that the category managers only managed relationships upstream to the manufacturer level. They had limited links with component manufactures or raw material suppliers and had undertaken no formal hotspot analysis. Relationships with clients, designers and engineers appeared to operate on a project basis, usually supporting standard contract processes. There was one example of category manager pre-tender engagement with a potential client, the outcome of which was unknown at the point of Carillion's demise. It was therefore not possible to evaluate if the spent staff time and knowledge transfer was effective. Internal systems also restricted the intra-company benefits of category manager multi-tier engagement. The Carillion supplier

system, “My Register”, had only been developed to manage direct suppliers, which left information on major manufacturer engagement in category manager files and excel spreadsheets.

6.4.1.1 Category management and sustainability

The diagram below (Figure 31) is part of a wider presentation on sustainable procurement which was launched in 2011 by the Carillion corporate sustainability team. This diagram, created by Carillion, recognised the importance of the category management team and identified that they were responsible for identifying their categories key sustainability impacts, incorporating them in the procurement process and ensuring tracking of KPIs.

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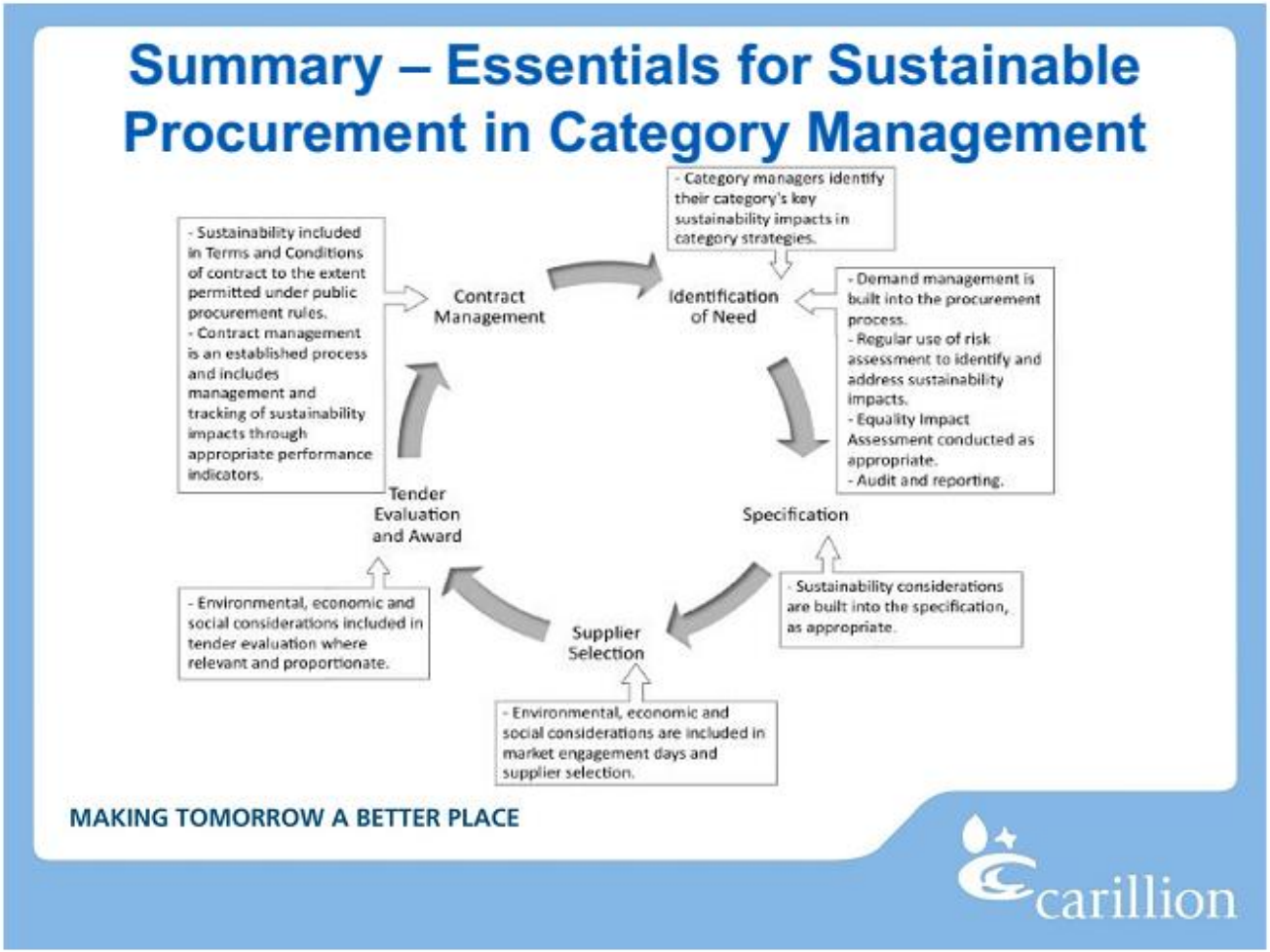
Figure 31 Carillion sustainable procurement guidance for category managers



Whilst this was a reasonable approach, in practise the category management team, by 2017, only comprised nine team members, and much of their time was spent co-ordinating preferred supplier discounts and cross project procurement. During the period of the research, May 2015- December 2017, category managers did not follow the processes outlined in Figure 31 and they had no personal sustainability targets (CM-D). However, this did not mean that the category team were personally uninterested or unknowledgeable about sustainability issues. Indeed, their specialist roles allowed them to keep up to date with technical developments and construction issues within their field of knowledge. They were familiar with examples of new sustainable products and were comfortable articulating the sustainability benefits. Examples of this were Knauff offering a new plasterboard that 'you can add colour to spray finish. This removes the need for one whole coat of paint. Also, the board is using low levels of water compared to normal plaster' or from a whole team visit to Tarmac they had 'seen a new low carbon asphalt'. They also engaged with other Carillion team members when visiting key manufacturers as exemplified by:

> 'we've been to a SIKA plant recently. They produce flooring and panels and have a huge R&D programme. We went with the Carillion SE Design manager (D-HD) who is looking at embodied carbon ……clients are starting to ask for information' (CM-D).

However, the team often found articulating sustainability to smaller or less knowledgeable suppliers difficult as CM-3 noted 'all of us have found it hard to express this (sustainability) sometimes at a project or supplier level. If you say sustainability, they all say carbon or waste'.

The category management team were very aware that many of the largest manufacturers were doing a great deal of work on sustainability, especially on waste, water and carbon. But even if they did buy 'sustainability' they were unclear 'how do you record all this good stuff. We don't record what we buy and certainly not through subcontractors' (category management meeting 2016 (D10)). Indeed, they believed that many suppliers were already offering recycled, lower carbon products which Carillion may be buying but are not aware of, and certainly not recording. In a Category such as groundworks management of large-scale excavation waste had always been a major issue and finding alternative uses, which removed it from landfill', was a major cost

benefit to the company. The category manager, CM-4, provided several examples of where this had successfully occurred. It was just a normal part of project management. In addition to working across projects the category team were also approached by senior corporate members to look at group wide initiatives. CM-2 had been tasked by the Carillion board to look at the opportunities for "Green M&E", an area felt to have commercial potential (CM-2). Another "environmental" project had recently been initiated by increasing pressure on urban sites due to air quality concerns. Led by the CEO of the CCS Business Unit, CM-2 and CM-3 were starting to look at emissions from small tools/equipment. They were assessing the top 10 value/emissions products and asking the supplier to traffic light rate them. Green for least emissions, red for worst. Green rated products would be recommended as preferred with Carillion SC buyers. They would also look to develop new products with suppliers.

The category team considered how category management could support sustainability more effectively. CM-5 felt it needed to be 'shoe horned in …… we need to make sure that it is understood and included at tender stage' a position agreed by CM-6. The team agreed that

> 'having sustainability in the strategy was important but to ensure it is operationalised it needed to be included as part of the delivery schedule. The delivery schedule is shared with suppliers of materials as well as going to the sub-contractors who may be buying the product. This makes everything run more smoothly' (CM-5).

CM-1 and CM-2 offered to support a pilot to test this approach on a single issue that was currently an area of concern for the corporate sustainability team, that of recycled content. For the pilot they considered a selected range of sanitary ware, pipes, cabling, and insulation, a group which comprised approximately 15% of by value of spend of all materials within the M&E category. Unlike electrical products they had 'reasonably manageable component parts and all had at least one preferred supplier to talk to'. It was also important to the category team to ask the suppliers how they would approach this type of issue; 'it's good to get suppliers involved……..to get their buy in' (CM-2)'. CM-2 invited the researcher to attend the next review meeting with one of their preferred ceramic suppliers and to listen to their work on sustainability. The sales team of SUP-1 brought their sustainability manager to provide information which was clearly focused

on their own production facility. Due partly to the issue of subcontracting discussed earlier but also due to data being company focused it was not possible to provide Carillion with CO_2 or recycled data for the products they were using. CM-2 was surprised that they were not much more engaged in sustainability. The sales team did not know about the sustainability work or that it had a value to some of their clients. Equally the sustainability manager did not have a strong relationship with the sales team and CM-1 felt that all the data they were recording was just wasted. He felt the meeting had 'opened up his eyes to some of the risks' (CM-2). None of the SUP-1 team had looked at Carillion's Annual Sustainability Report before the meeting. They were 'not aware that it was a major issue for Carillion' (SUP1).

Further supplier interviews were carried out, and these are referred to throughout this thesis, providing further illuminating insights into key manufacturer knowledge and capabilities and their perception of the main contractor. However, the demise of Carillion prevented this specific pilot project being completed.

6.4.1.2. Observations

Category management, as part of a wider supply chain management process did have the capacity to operate beyond Tier 1 suppliers and build trusting relationships. They were able to function across multiple internal teams and work with both upstream and downstream network actors, albeit downstream engagement was more limited. They were able to overcome the project based siloed working within Carillion yet whilst many of the examples they provided were positive they also acknowledged great frustration with supply chain and operational colleagues who would ignore recommendations as they focused on lowest price, ease and not infrequently 'buying from someone they knew' CM-4. They still struggled to overcome inter-company fragmentation, especially at the sub-contractor level but had combined relational approaches with the more transactional use of delivery schedules. The category management approach at Carillion offered many of the pre-requisites of collaboration that have been identified as necessary to support sustainable build. However, they were not being utilised to achieve this goal. The company still maintained a siloed approach to supply chain strategies and

corporate sustainability strategies linked only by a small number of sustainability KPIs that the supply chain was tasked to meet. These are highlighted in Table 24.

Table 24: Carillion 2020 sustainability KPI's requiring supply chain delivery (2013-14)

Carillion Team	Schedule of Reporting - 2020 Key Performance Indicator (KPI)	Responsibility of	Researcher Notes
Supply Chain	100% of purchased products and materials are responsibly & ethically sourced by 2020	Category Managers/Performance Mgr sust. Team	KPI based on 3 questions in My Register. Many suppliers simply did not answer them or smaller companies, many organisations struggled to understand the questions and smaller companies had little capacity to comply. No audit of responses
Supply Chain	Sourced timber will meet FSC or equivalent standards	Contracts/SC-D1 approver	Implemented and strongly monitored. Reported annually. Highly time-consuming process - major commitment for Carillion
Supply Chain	We will target our top 250 suppliers to collaborate on the development of enhanced sustainable products and services by 2013	Category Managers/Performance Mgr sust. Team	Category managers working with key or preferred suppliers. Development of enhanced sustainable products driven primarily by manufacturer. Some collaboration with main contractor to improve process e.g. Knauff panels. Limited demand from clients

Carillion Team	Schedule of Reporting - 2020 Key Performance Indicator (KPI)	Responsibility of	Researcher Notes
Supply Chain	100% of our suppliers will be benchmarked through Carillion's accreditation process by 2013 and we will provide guidance to those who only meet our basic requirement	Category Managers/Performance Mgr sust. Team	By 2015 all suppliers had to be on My Register to be awarded contracts. However, the benchmarking had proved to be weak and no guidance was provided to suppliers
Supply Chain	Maximise local spend including SME, measured as a % of supply chain spend	Not identified	No. of SME's and local spend standard requirement for all government contracts. Managed primarily by the supply chain working with Tier 1 suppliers. Definitions varied by contract, time consuming to manage

Whilst the notes provide an observation on the status of each KPI the main point of this illustration is to demonstrate that the company had no holistic approach to sustainability across the supply network, rather responding in an ad hoc fashion to client, risk or legal pressures. Except for FSC timber, Carillion was not leading the way.

6.4.2 Goal Setting

In the two examples selected for this study the researcher explores situations where a shared goal reaches across the entire network and requires collaboration at a global level. In both examples Carillion have been actively engaged in the goals during the research period and they highlight two different approaches to goal setting at a network level; that of "Bottom-up and "Top -down".

6.4.2.1 "Bottom-up" goal setting: Forest Stewardship Certification

The Forest Stewardship Council (FSC) Chain of Custody represents an attempt to frame objectives, targets and requirements that can be shared throughout the supply network

for forest products. The FSC originated in the early 1990s through discussions between the World Wildlife Fund (WWF, now Worldwide Fund for Nature) and several major UK DIY chains, concerned about the impact their procurement of wood was having on rainforests and the risks this entailed (Murphy, D. F., Bendell, 1998). The group, WWF95+, wanted an industry-wide approach to ensure that the timber they purchased could be "guaranteed" as ethically sourced. From the outset, FSC took a non-governmental approach, harnessing commercial drivers to effect change. FSC has striven for, and increasingly achieved, a membership-based approach to forest management and governance is overseen by a board elected by the membership. Decisions on forest management include indigenous people through local consultation and local workers are prioritized for employment (FSC, 2017). The social and environmental benefits and the associated reduction in risks resulting from this local, ethical approach to forest management are then propagated through the supply network, with the "Chain of Custody" assured by recording each step in the process. Evidence from WWF indicates that many smaller producers have benefited financially from FSC [48]. Since its inception in 1993, FSC has grown to be a significant market mechanism to promote responsible forest management, now covering 180 million hectares of forest in 112 countries.

Carillion, driven primarily by corporate environmental values and reputational risk management, published a Sustainable Timber Policy, ratified by the Carillion board, to purchase only timber and wood-derived products with FSC Chain of Custody certification or, where this could not be achieved, to use sources that were independently verified as legal and sustainable. Carillion accepted that, without a certified standard, it could not guarantee it was not colluding with or procuring timber from illegal logging operations; FSC provided a way for Carillion to ensure that its supply network did not contribute to illegal and destructive deforestation and thereby to avoid potential reputational risk. However, it was also made clear that Carillion's aim reached beyond its own network, 'to promote demand and improve competitive pricing for FSC timber within the construction industry as a whole' (Carillion, 2000, p.31).

Requiring procurement teams to source only certified sustainable timber represented a major commitment, and it is clear from interview comments that this continued

irrespective of client demand: 'no client ever requested FSC apart from occasionally' (SC-RM2). The principle was communicated to clients, sub-contractors and other suppliers. Operating the FSC "Chain of Custody" demanded additional commitment by the main contractor. This included guidance and training material for Carillion procurement and operations staff and ongoing, intensive engagement with suppliers and subcontractors bringing timber onto site as part of contract works packages. As noted by SC-D1, 'whilst it remains outside the industry norm you just have to continuously communicate it. People still don't really know what they are buying. They don't know how to maintain chain of custody'. The company also had to set up internal systems to manage the monthly reporting of timber usage. High-level decision makers within the SC team regularly worked with WWF on certification queries and developed long term relationships with the NGO, as well as considerable knowledge on FSC. Medium and limited-level decision makers in the SC team were highly informed about the ethical issues but appeared to struggle with commitment when price was such a key feature of procurement. Engagement was more limited in the sector's downstream value chain: whilst certified timber does gain credits within building standards such as BREEAM, few clients directly specified FSC or other responsibly sourced timber materials. Furthermore, unlike companies supplying the consumer market, there little direct communication between main contractors in the construction sector and the end users of the structures, most of whom would buy assets unaware of timber sources. By 2009, timber with no certification represented only 7.9% of Carillion's total purchases and continued to reduce, with annual fluctuations, to 5% during 2015 (GFTN, 2016, Carillion, 2017) Carillion was committed to 100% purchases of certified sustainable timber and wood by 2020.

6.4.2.2 "Top-down" goal setting: modern slavery

As noted in chapter 2 the social dimension of corporate sustainability can be positive, such as the provision of jobs, engagement with local communities and increased skills. In the UK it is also associated with improved standards of employee health and safety. However, many negative social aspects continue to exist within the construction sector, not least of which is issue of forced labour, employed directly or more remotely through supply networks. This has for some time been addressed through voluntary codes of

conduct such as that promoted by the International Labour Organisation (ILO) or the UN Global Compact. However, the UK Government, in 2015, passed the Modern Slavery Act (UK Government, 2015b), requiring all UK companies to address the issue of modern slavery in their own businesses and their supply networks. Today UK companies, and their subsidiaries with a turnover of more than £36m must demonstrate the action they are taking and publicly report this on an annual basis. Modern slavery is considered to be delineated by bonded labour, poor wages, working and living conditions, intimidation and violence or human trafficking. It is estimated that 45 million people globally (Walk Free Foundation, 2016) endure modern slavery, with construction identified as a major area of concern because of its high reliance on flexible, temporary labour and highly diverse global supply networks. Companies primarily manage labour issues as part of their product supply networks but the high numbers of products and components, often originating from unknown global sources, makes it difficult to ensure transparency in employment practices. Even in relatively short supply networks, such as within the UK, mapping labour practices can become complex. Complexity can make the different forms of modern slavery, which are frequently informal and transient in nature, hard to detect and therefore persistent (Allain et al., 2013, Gold, Trautrims & Trodd, 2015, New, 2015). In setting this legislation, the Government has imposed values and specified the process by which all UK companies must engage with this issue, in marked contrast to the way FSC certification has developed more organically.

Carillion first used assessment tools in 1999 to review the environmental performance of suppliers. From this work, they identified that only 50% of suppliers broadly met requirements. As a result, Carillion began to address the social aspects of its suppliers' services and products by engaging with suppliers to promote sustainable sourcing of products and materials, 'with high risk suppliers being encouraged to change practices rather than being delisted' (Carillion, 2000, p.31). The company made it clear that ensuring human rights was a key company principle and that they had 'an ongoing commitment to improve the living and working conditions … not just for direct employees but also for our subcontractor teams' (Carillion, 2000, p.31). Along with many of its peers, Carillion included questions on their supplier registration system relating to human rights, asking for confirmation that companies had employment practices in line

with the ILO or UN Global Compact on human rights, i.e., that they ensured fair wages and freedom of association, with no forced labour. They also asked companies if they engaged in responsible sourcing within their own supply networks.

A senior-level working group within Carillion reviewed existing company approaches and risks and, as a result, accepted that for many smaller suppliers, the Act and the concept of modern slavery represented a little-known issue. This was reiterated by the supply chain team with one member stating, of suppliers, 'There is limited knowledge out there and even less on how it will be implemented' (Anon: Carillion supply chain survey 2016). A large part of the company's efforts was therefore directed at engagement and awareness raising. At a company level this was achieved by direct communication with Tier 1 suppliers, changes to the supplier registration process, information and awareness raising via Carillion's own website and Carillion's own externally facing supply chain teams and operational staff. Questions on the internal supplier registration system were expanded to include the term 'modern slavery' and, to support smaller companies, and in 2016 Carillion's Labour Standards Charter was developed (Appendix 1, Figure 47) which suppliers could sign and adopt if they did not have their own processes in place.

However, Carillion also identified that slavery was an industry-wide concern which, whilst highlighted by legislation, strongly resonated with the values of their peers and would benefit from collaborative efforts. In 2012, to meet gaps in sub-sector specific sustainability skills, Carillion, other main contractors, clients and major manufacturers worked collaboratively, through a SSCS working group (see section 6.4.3.2) to create new slavery guidance directed specifically at the construction industry. Skills modules on Modern Slavery and the Act, along with video materials and written information, were developed and promoted by main contractors and clients to organisations in their supply networks (Action Sustainability, 2016). However, progress of awareness across the network remains slow, with 21% of Carillion supply chain team identifying, in 2017, that most or many of the Tier 1 suppliers they worked with did not know about the Modern Slavery Act (Carillion Supply Chain Team Survey 2017).

In 2009, Carillion established a business subsidiary in Qatar to provide construction, infrastructure and facilities management services; it grew to employ approximately 1100 people directly, with a further 6000 employed through subcontractors (Carillion plc, 2016a). Carillion entered into a commitment that employees would be paid in accordance with Qatar Labour law but, in addition, that employees would also receive flights home, holiday pay, health insurance and accommodation and food. They set standards for accommodation that landlords had to meet prior to contracting and required accommodation to be audited to ensure the standards continued to be met. Carillion put in place processes to ensure that employees had freedom of association, routes to express grievances and worked to the same Health and Safety standards as in the UK, replicating the "Don't Walk By" culture used on all UK construction sites.

However, in 2014, they were publicly accused of having subcontractor labour on site who had been forced to surrender their passports and were living in poor accommodation and receiving only a small part of the promised wages (Lloyd-Roberts, 2014). In response, Carillion implemented a similar approach for workers employed through sub-contractors. In one of the most contentious areas, that of recruitment, Carillion worked with "preferred suppliers" who had been reviewed for financial, ethical and professional conduct. It also carried out spot checks and terminated contracts with companies that charged excessive fees or had been unethical in their approach. A company like Carillion does not have direct control over its subcontractors; however, they were expected, as a minimum, to comply with Qatari labour laws. Carillion proactively reviewed and monitored the employment practices and accommodation of its suppliers and their subcontractors; only those that met Carillion's standards were included in the preferred supplier list. When the Business and Human Rights Resource Centre approached the top 100 construction companies working in Qatar and UAE Carillion responded publicly to their questions (BHRSC, 2016).

6.4.2.3. Observations

Based on the studies reported here, we suggest that the bottom-up approach is ultimately more likely to be successful because it promotes alignment of goals and/or principles between the different actors in the supply network, so that all actors can gain

benefit from the relationship and have the flexibility to focus on the goals that are most relevant to them. The FSC multi-stakeholder approach highlights the practical value of shared goals and principles as the basis for long-term supply network relationships and collaboration. NGO oversight and certification creates transparency and ensures compliance even by actors in the supply network whose commitment to the goals may be weaker. FSC appears to operate most effectively at a sector level rather than just a single supply network: what started as a "bottom-up" approach has developed into a shared position of network power. Interestingly, whilst aligned goals support a shared vision, the complementarity between the roles of FSC and Carillion in the supply network could ensure the achievement of sustainable outcomes: FSC represents those directly involved in forestry, working to overcome environmental and social issues associated with illegal logging, whilst Carillion offered the economic driver to deliver change. The Modern Slavery approach demonstrates less well-developed collaboration within the supply network: collaboration may reach beyond the first tier of contractors but lacks the clarity and consistency provided by a Chain of Custody process. Collaboration on slavery may also be nascent as The Act, confirmed in 2015, has only recently placed these requirements upon industry. FSC has been operating for more than 20 years. This study has confirmed how construction companies, such as Carillion, with strong social and ethical stances will implement policies, undertake audits, and work collaboratively with employees and local groups in an attempt to prevent slavery.

6.4.3. Industry Led

As noted in Chapter 4 section 4.2.2, construction professional bodies, product manufacturers and network actor representative groups all drew together members to develop CPD, training, guidance and in some cases agree technical specifications. Furthermore, several suppliers highlighted product specific sustainability groups that extended beyond their own peers. An excellent example of this was:

> 'look at some of the work done by the Sustainable Concrete forum ……its' quite bizarre really as we're a member of it but so are some of our suppliers too; our aggregate suppliers and our cement suppliers. So effectively everything upstream in our supply chain are actually in those meetings and collectively we are setting targets for driving

change on this whole bunch of sustainable issues. So, all of us work on them but we all go away and work out how we drive it' (SUP-10).

This level of collaboration was seen to exist because

'for things like health and safety the trade body decided a number of years ago it was a non-competitive agenda item' and 'it's (sustainability) completely off the competitive radar……it's working together, sharing good things' (SUP-10).

Other suppliers noted they had created non-competitive forums to support collaboration during pre-tender discussions. They achieved this by organising thematic workshops, but which importantly, they appointed a high-profile independent chair to facilitated discussions:

' we have just done this with the Greater London Authority. We pulled together the Structural Engineer, designer, pre-tender team and the Local Authority to look at water management ……they were really interested to know more. But we needed an independent chair…….we had one of Sadiq Khans commissioners to chair. The discussion was very focused, and he was challenging to both the 'experts' and the GLA team. Really good……useful to have an external person' (SUP3).

Whilst this work was undoubtedly supporting improvements within major product groups the work remained focused on the manufacturer and materials suppliers. It did not offer collaboration at a network level.

Accepting that sustainability is a system issue the research was also interested to identify forums which provided a platform for collaboration on sustainability issues across the network. The Carillion supply chain and sustainability teams identified five formally constituted groups that met these criteria. They also highlighted the more episodic and informal work of standards and guidance bodies, which will be discussed later in this section. The formal groups are listed in Table 25, which also provides information on the breadth of network actors involved in each organisation and which type of actor led the group (CLC, 2018, Green Construction Board, 2018, SCSS, 2018a, UKGBC, 2018a, FSC, 2018).

Table 25 Review of Pan Network Collaborative Groups

Group	Description	Raw Material Supplier	Manufacturer	Logistics	Wholesaler	Sub Contractor	Main Contractor	Engineer	Architect	Quantity Surveyor	Consultant	Client Building	Client Infrastructure	Investor	User	Government	NGO	Ind.Assocations	Academia
	Construction Leadership Council																		
1	Green Construction Board																		
	Supply Chain Sustainability School																		
2	UK Green Building Council																		
3	FSC Timber Chain of Custody																		

Key

Participant in group Participant and group lead

All groups are both engaged in implementing some element of sustainability across the entire network and are supported in this by multiple network actors. The UK Green Building Council (UKGBC) and the Green Construction Board (GCB) are focused primarily on environmental issues, whilst the Supply Chain School (SCSS), FSC and the Construction Leadership Council (CLC) address environmental, social and economic impacts. It should also be noted that the GCB is a sub group of the CLC.

These organisations can also be grouped into three types, based upon their function:

Group 1: Supporting Government Strategy and Policy Implementation

Group 2: Industry Funded Sustainability Knowledge Development Forums

Group 3: Commercial Chain of Custody

6.4.3.1 Group 1: Government led

Whilst the CLC was referred to by Carillion staff they were not particularly engaged with its work but recognised it affected industry targets. The GCB had been created to 'provide leadership and action to enable the whole value chain to become more environmentally sustainable, more productive and better placed to exploit the growing global market'. The Carillion 2015 CCS Sustainability Strategy identified the GCB as one of the industry groups the company would support (Carillion, 2017). The GCB identified specific, practical, environmentally focused, industry-wide projects and had supported the Infrastructure Carbon Review, published by HM Treasury (2013). They had a remit to work across industry, at an asset level and commissioned strategic cross network research. This had included a roadmap identifying the levels of carbon reduction different network actors would need to achieve to meet Government targets of an 80% carbon reduction by 2050 (Ove Arup and Partners Ltd, The Climate Centre & WRAP, 2013).

One of the key outputs of the Review was to develop a new publicly available specification (PAS 2080) Carbon Standard for low- carbon road and rail infrastructure. Whilst the GCB and the British Standards Institute (BSI) oversaw the project and appointed Ove Arup and Mott MacDonald to manage the process, network actors, including Carillion, were part of the working group providing expertise and funding. Meetings were hosted by the UK Department for Business Industry and Skills (BIS), and

chaired by a major non-governmental infrastructure client. The meetings were well attended and included infrastructure clients, main contractors, manufacturers, professional and standards bodies and designers (D9). The resulting standard developed offered a 'common framework for all infrastructure sectors and value chain members on how to manage whole life carbon' (BSI, 2017b). The standard took a holistic view of the construction process, accepting that different network actors had different impacts relevant to their role. PAS2080:2016 guidance and standard was published in 2016 (BSI, 2017b)and was freely available for any member of the supply network to download and utilise, although in reality few smaller organisations were likely to have the capacity to undertake the work needed to achieve the standard.

6.4.3.2 Group 2 Industry funded sustainability forums

1. The UK Green Building Council (UKGBC)

UKGBC has an agenda setting role; looking to achieve green building through pan industry collaboration. It was set up in 2007 by 36 leading companies, including British Land, Hanson, Arup, MacAlpine and Barratt Homes with the 'aim to bring together a highly fragmented industry and unite it around a core set of purposes' (Seagar, 2007). It has a strong focus on research and innovation, policy and advocacy and education, supported by the membership and its networks. UKGBC is a charity, funded by a membership base, and is not aligned to any specific type of network actor or Government (UKGBC 2018b). It also affiliated to the World Green Council (WGBC) which has representation across the majority of South America, Asia (including China and India), North America, Europe, Australasia and increasingly in Africa. The WGBC secretariat operates in London, alongside the UKGBC team. Carillion were gold standard members of the organisation and had engaged in several working groups and expert panels. This included the UKGBC Innovation Lab, which looked at systemic challenges in the built environment and attempted to find solutions through collaborative and sustainable innovation (UKGBC, 2018b). They had also supported more specific work, such as the development of a client guide on embodied carbon. The researcher was invited to attend several of these meetings. The group comprised of primarily downstream network actors, a main contractor, client, engineering firm supported by a standards body and was chaired by the UKGBC who were also acting as secretariat and

primary author. The voice of the client was important as it provided insight into how the process of specification was undertaken and brought experience of similar activity. The consulting engineer and main contractor both identified the issues arising from responding to client briefs. Technical lifecycle and standards knowledge was provided by industry experts including the UKGBC. Drafts were taken to several industry workshops for review and comment and the final publication was peer reviewed by two academics, identified by the standards body as experts in the field of embodied carbon in buildings. Whilst containing a high level of technical material the guide was designed to support clients to write a low carbon brief. The publication was practical, authoritative and freely available.

2. The Supply Chain Sustainability School

Initially founded and funded by UK main contractors, The Supply Chain Sustainability School was set up as a learning platform for their subcontractors and suppliers. It has a strong focus on sustainable procurement practises and provides e-learning modules, training and networking days, CPD points and self-assessments and action plans to support implementation. Primarily targeted at SMEs, its materials offer simple introductions on sustainability topics through to more advanced technical information. All learning is free to the user and has been written by industry participants. Over the last 2-3 years the School had expanded its remit and the scope of its funding partners to include clients, designers, engineers and manufacturers. The board now sets development topics, funds working groups to examine complex topics and recently completed a member and partner-wide review to agree the values which underpin its work. Its vision statement is 'The world class collaboration enabling a sustainable built environment' (SCSS 2018c).

The working groups and special interest groups, to which any partner or member can contribute, provided a collaborative platform for highly specialised sector focused work. Recent topics have included Social Value, Modern Slavery and Sustainability Metrics. The school had recently (2017/18) begun to consider the role of category management and are now piloting several key product areas. Materials generated by these special interest groups are developed into sector relevant online learning. The groups and

networking events provided network actors with a forum in which to meet and learn without being excluded due to high costs or size of company. Engagement between different groups facilitated network actor exchanges and increased understanding of actor perspectives. An excellent example of this was highlighted by SC-RM3;

> 'I went to an SCSS meeting last year which was specifically for rail. Surprisingly there were a large number of SMEs in the room. For them lots of this stuff (sustainability) was a given. Naïve of us to sit in the grand chair and talk down to SMEs.'

Others accepted that drivers could differ between network actors 'we find that a little bit with the supply chain sustainability school - you sit around the table and the contractor issues might not be our issues. I guess we have to work with fixed assets' SUP-8. However, this discussion platform was seen as a positive step

> 'I think the issue for Carillion, as a main contractor, is getting all the contractors working together to have a shared view. This would help up as suppliers. It would also be great if this could provide us with opportunity to collaborate with UK contractors group or clients or specifiers to ensure that what we're doing is what is right' (SUP-8).

The SCSS was increasingly performing the function of a non-governmental (state) market driven structure, albeit one only comprising UK members at present. Whilst Carillion supported SCSS they had not initiated either group; the SCSS had, however, been the idea of one of its main competitors, Skanska (Carillion Supply Chain Survey 2016).

3. Standards and Certification Groups

Commercial bodies such as BRE, BSI and ISO created collaborative sector groups to develop or review standards. Not-for-profit organisations, such as CIRIA, would work with stakeholders to identify areas of construction requiring guidance and then engage with larger sector actors, including universities, to fund and provide guidance content. A recent example, and one which the researcher was able to observe, was the production of a handbook for procurement teams titled 'Minimising Risk through Responsible Sourcing'. Chaired by an academic, well respected in the industry, CIRIA provided the administrative and technical support. They asked key stakeholders to fund and steer the project and in total 65 contributors, from across the network, were actively engaged in the project. This was achieved through workshops, online and offline

meetings, content development, workgroup reviews of material and feedback. The resulting guide provided information on key product supply chains, it was designed to support supply chain teams 'understand the complex social and environmental impacts within the supply chains of product and labour purchased within the industry' (Nicholson et al., 2017). Those personally engaged in this type of contribution and engagement expanded their knowledge and often developed new contacts. The guide, as with most developed standards, was a commercial offer and not available to the industry without a fee. This limited wider dissemination.

Whilst facilitating discussion and collaboration across the sector, standards and certification had proliferated, as commercial bodies looked to develop the market and meet industry gaps. This created further fragmentation and confusion in the market and through competing offers. An example of this was:

> 'I was asked to attend a meeting on PAS91 last week. I found it really confusing. Company X were pushing hard to ensure that everyone works to PAS91. I could see the value of a standard set of questions but uncomfortable that suppliers had to pay for the service and members £1000 per day for auditing. Really being pushed hard to agree to the standard……CEO sign off level. I felt I was being bounced into having to commit….. feels could just be putting other groups out of business. Quite heavy.' SC-PM

6.4.3.3 Group 3: FSC product chain of custody

Whilst FSC has been covered in some detail in section 6.4.2.1 above there is an additional point to be made about its role as an industry forum. All other forums highlighted by the Carillion teams generated strategic information, supported policy, created guidance or developed standards. They were also primarily funded or supported by major UK corporate companies associated with the sector. Whilst this work was valuable at an industry level, and indeed increased sustainability knowledge amongst those participating, it appeared to remain relatively siloed with Carillion senior managers or corporate sustainability reporting. It was possible to engage and yet implement little. FSC, and to a lesser extent PEFC, was the only example where industry collaboration was directly linked to a commercial output; that of delivering a sustainable product, offering end users traceability to source.

6.4.4. Comparison to literature

There is minimal literature on the role of non-competitive pan-network sustainability forums within the construction sector. However, it seems clear from comments by Carillion team members that those, especially driven by industry, have a useful role to play in setting a sector relevant agenda, to increase sustainability knowledge and shape standards or industry approaches. With the exception of FSC, there appears to be little link between such groups and monetary gain, although members of the supply chain school have identified using knowledge to win new contracts (SCSS, 2018b).These types of private governance or non-state market driven (NSMD) structures, have grown in number over the last three decades (Schouton, Gasbergen, 2011). Such NSMDs are increasingly used to address sustainability issues, where it is recognised that, to be successful, a global network or supply chain approach must be undertaken. These sustainability forums, bring together network actors, including direct competitors, to focus on specific sector issues. Recent examples are the multi-stakeholder Sustainability Consortium, comprising retailers, manufacturers, research institutes, and NGOs (Sustainability Consortium, 2011) and the Round Table on Sustainable Palm Oil (RSPO) which is comprised of global multi-stakeholders operating through agreed governance structures (RSPO, 2018). Creation of such groups are frequently a response to a lack of data and traceability, increasing resource pressures, and the potential for efficiency and value-added (Sustainability Consortium, 2011). Schouton et al (2011) identified, in their work on RSPO, their position in setting agendas and the importance of working groups to engage multiple actors. These not only supported group legitimacy but provided the platform to examine complex and difficult challenges (RSPO, 2018). They also identified that it was important, for legitimacy, that the roundtable had a moral justification for its work, even though implementation was frequently led by member self-interest. As with FSC the role of the NGO, operating as an integrator (Elkington, Fennell, 1997) has become increasingly important in offering oversight and legitimisation of global industry led forums.

As the research identified, the UK Government is one of the few organisations that has an interest spanning all life stages of an asset and that can affect sustainable consumption and production by setting fiscal and sustainability policy frameworks that

support greater transparency (Gold, Seuring & Beske, 2010a, Tennant, Fernie & Murray, 2014). They could also assert sustainability pressure on supply chains through legal demands, regulation and by shaping public opinion (Reefke, Sundaram, 2017). Whilst industry do lobby on regulation, it may be that industry interest is more closely aligned with Governments secondary role, that of major client. The Government had a clear agenda setting role, which was to drive industry improvement. They identified this as reductions in cost, project time, carbon emissions and the trade gap (CLC, 2018). However there still appears to remain a gap between intention and practical application as, in the examples given by Carillion team members, the Governments best value continued to be strongly linked to low cost.

6.5 Conclusions

The ability to have a holistic view of sustainability, across the span of the entire supply network, and to be able to implement key actions through collaborative working, is seen as critical to reducing negative sustainability impacts associated with a built asset. This conflicts with doubts, or at best, limited proof, of the benefits of collaboration across a network. This is unsurprising when at an industry level numerous Government reports have highlighted the importance of collaboration in reducing industry fragmentation, yet fragmentation offers clients the low cost, flexible supply network that everyone is prepared to pay for. Such conflicting demands are not specific to the construction sector. An interesting analogy is seen in the work of Locke (2013) looking at modern slavery in the electronics sector. Hewlett Packard spent millions of dollars auditing companies and educating suppliers to prevent employee abuse. However, whilst instructing their suppliers to 'do better' they put commercial pressure on them to support just-in-time, short run products that demanded long working hours and agency labour. Carillion teams and suppliers recognised that these types of tensions existed between sustainability and commercial demands.

There is limited material on collaboration and sustainability within the construction sector and this research expands the understanding of how network actors perceive collaboration. For Carillion supply chain staff collaboration primarily remains something that they demand of suppliers and may be required to do by clients. Like sustainability,

the term collaboration has multiple meanings with different network actors and is frequently identified as an output rather than a management process. There is no holistic management of the supply network by Carillion, with the supply chain team rarely working beyond Tier 1 suppliers, although the category management function provides a structure to increase reach to manufactures, where sustainability knowledge and innovation exists. Only occasionally does the other main focal point in the network, the client, take on the role of network manager, primarily in major infrastructure contracts. There was no evidence that the supply network was being managed to support sustainability at a whole life asset level, although there were many examples of ad hoc activity, undertaken through dyadic relationships.

Whilst the literature suggests that sustainability is most effectively implemented through relational and non-contractual practices the focus on transactional led, risk-based contracting appears unlikely to provide the basis for this at a network scale. The examples of personal relationships beyond the boundaries of the firm, where trust has been built, do offer opportunities for collaboration but they primarily support local and often ad hoc sustainability interventions. The case studies illustrate that collaboration can occur, across multiple network tiers but this appears to be most effective when network actors at the top and bottom of the 'chain' have agreed goals. In the case of FSC chain of custody it is also clear that the main contractor and other network actors have outsourced the sustainability expertise and audit function to FSC and WWF; they continue to operate within 'hollowed out conglomerate' model. Industry forums provide valuable knowledge development and exchange platforms, but the resulting work only has value if it can be incorporated into client demands. Of the three studies presented only category management offers a route for the main contractor to lead collaborative working. Category managers, as industry experts, did not manage supplier contracts. This removed a major adversarial issue from network relationships, but, they were seen to have the authority to include key suppliers in Carillion's sub-contractor contracts. This drove collaborative working with key manufacturers and suppliers and increased the category managers knowledge and value. This was identified as an asset for some clients and their designers, as they could benefit from a relatively impartial view of the category sector and product selection. There was not, at the time of this research, any major

strategic engagement by category managers with sustainability issues but the approach could be adapted to incorporate this function. However, such collaboration would be unlikely to have major impact as Carillion remained unable to address the issue of a network level, holistic approach to sustainability.

Chapter 7: Knowledge

7.0 Introduction

In chapter 6 the literature suggested that for sustainability to be successfully implemented across a supply network, not only must network actors have a holistic or whole system-based approach, but also the capacity to collaborate As noted by Stewart (1997), an organisations ability to innovate is dependent it's customer relations, the knowledge it has been able to embed within business processes and the knowledge of its staff. Each network actor's knowledge of sustainability underpins this implementation. In this chapter one of the key issues to emerge from interviews, surveys and meeting notes was the different levels of knowledge on sustainability impacts held by team members and the knowledge silos that exist within the network (see chapter 4, Section 4.6). This final chapter explores the SC team knowledge of sustainability and their perception of sustainability knowledge upstream and downstream within the supply network. Building on the sources of sustainability information identified in chapter 4, Section 4.22 the nature of knowledge acquisition is examined. Finally, the Carillion team, and many key suppliers, highlighted concerns on how knowledge was shared, both in terms of the materials and also the tools used to enable increased business capacity. This chapter considers if Carillion teams have the necessary knowledge to engage with a whole life approach and thus their ability to lead the network in a whole life sustainable approach to construction.

In each section the findings from the research are compared to the existing literature base. It should be noted that knowledge of sustainability in construction as a research topic is limited, with only twelve relevant papers being identified in this field, and of these just three focused on the wider role of supply chains. For the purposes of this research the more extensive literature on the role of education and sustainability has been excluded as this thesis focuses on knowledge within a wider business context.

7.1 Who knows what

At a philosophical level there is considerable debate about the definition of knowledge but to engage in this is beyond the scope of this paper (Fernie et al., 2003). For the purposes of this discussion the three most widely accepted, although still contested, epistemological types of knowledge (Joyce, 2014) are used as the basis for defining knowledge held by people within the supply network: that of

1. knowledge by acquaintance, which we acquire by having some experience of whatever it is we have knowledge of
2. practical knowledge or knowledge-how (in philosophy) or know-how (in ordinary English). We acquire knowledge when we acquire skills or abilities.
3. knowledge-that, or propositional knowledge, which we acquire by learning facts.

In examining the breadth of sustainability knowledge within Carillion teams it appeared to be motivated by two main drivers; values and functional demands. Sustainability was reinforced by values, with many individuals across the company having strong personal beliefs often relating to specific social or environmental issues. These values had consciously or unconsciously led them to acquire knowledge and enabled them to talk thoughtfully about their interests. The company too had clearly articulated corporate values which were applied to economic, environmental and social issues –'we care; we achieve together; we improve and we deliver' (Carillion, 2017). These were recognised by senior and middle management team members, were communicated to suppliers and clients and were strongly linked to corporate sustainability reporting.

7.1.1 The main contractor's knowledge boundaries

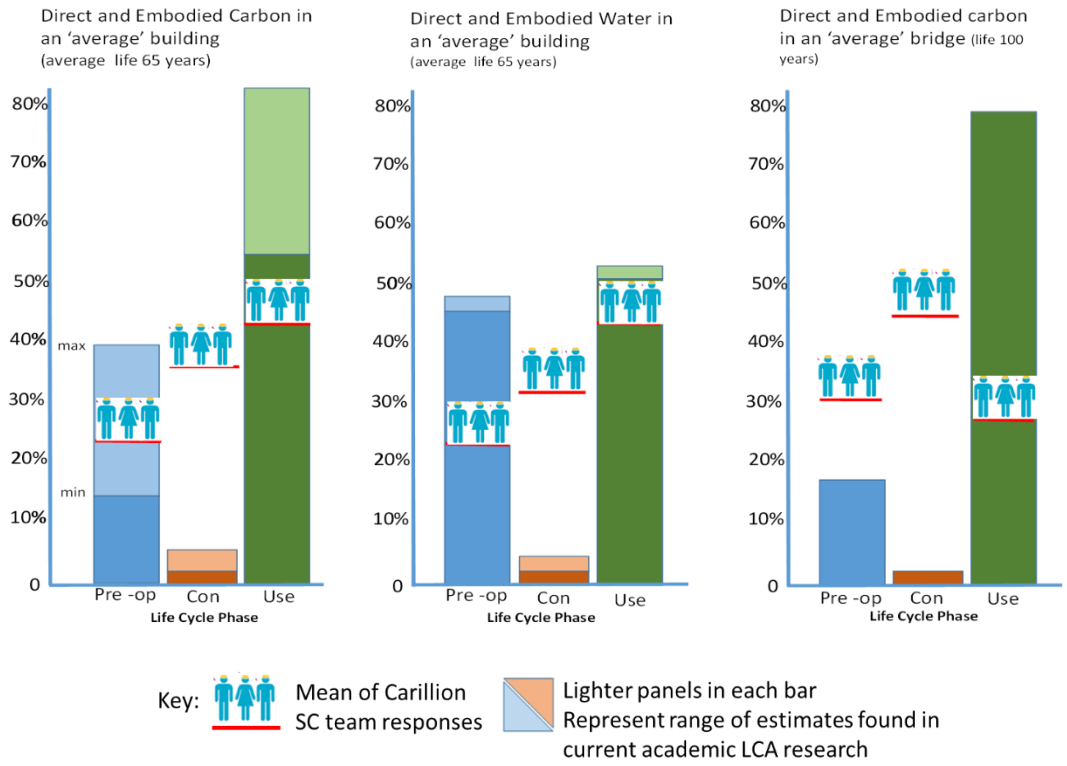
Whilst the commitment to take a grounded theory approach precluded a major literature review as the starting point of the research, one area of academic literature was considered at the commencement of the PhD study. This was the context in which the main contractor operated; the impact of the construction sector on environmental, social and economic issues. This initial analysis provided insight into the scale and nature of the issues generated by the UK construction supply network. (See chapter 1). From this work it was clear that academic studies, were limited in providing insight into key impacts by life stage on a sector basis. Although, like most of the work by industry

bodies, they were primarily focused on carbon emissions, this was difficult to fully explore as some of the most sophisticated mapping was derived from commercial databases and project data records. These were not publicly available. Few studies considered sector-wide social issues and as was noted in chapter 1, Social Life Cycle Assessment is still in its early stages of development.

Early interviews with Carillion high level decision makers (D2) indicated that there was very limited knowledge of impacts across the whole life of an asset, even those of carbon emissions, one of the most developed areas. As noted in chapter 6 it was clear that reporting boundaries primarily operated at the limits of direct corporate control and only a few sustainability issues extended beyond this such as FSC, modern slavery and some minor corporate scope 3 carbon emissions reporting. To further understand the limits of the knowledge of Carillion SC team members to supply network-wide impacts a workshop exercise was included in the company's annual supply chain conference (D4). SC team members were asked to estimate the percentage of carbon emitted and water used during three phases of a building's life cycle; pre-operational (materials production and logistics to site), construction and in-use. A similar exercise was carried out on a bridge but due to lack of LCA water use examples, solely for embodied carbon. For this exercise participants were told that the three phases represented 100% of total emissions. Anticipated lifetime of each asset was provided (See Appendix 3h, Figure 58) for materials presented). The methodology for this process is described in chapter 3, section 3.1.3, Action 2 and the visual material provided is presented in Appendix 3h Figure 58.

From the team responses the average emissions for each stage were calculated (represented by 'people' graphic) and plotted against academic and industry data. Variation within academic and industrial studies, frequently based on the nature of the built asset, was illustrated with minimum and maximum portions to each bar. Only one representative study was found to illustrate carbon emissions during the lifecycle of a concrete road bridge. The data was provided in a format designed to engage the SC team and embed their perspective within a topic they found confusing and remote (see Figure 32).

Figure 32: Direct and Embodied Carbon and water estimated by Carilion's supply chain team in three life stages of a building and a bridge (Supply Chain Workshop, 2016 (D4))



The results were mapped against the findings of research identified in chapter 2: for embodied carbon in buildings (Levine et al., 2007, Acquaye, Duffy, 2010, BIS, 2010b, Ove Arup and Partners Ltd, The Climate Centre & WRAP, 2013, RICS, 2014), carbon embodied in infrastructure and water embodied in buildings (Crawford, Treloar, 2005, WRAP, 2012). High levels of variation in the data, due to different scales of buildings or infrastructure, and methodologies, were represented in the chart by minimum and maximum levels. No data was available for the comparison to embodied water in a bridge, therefore it was excluded from Figure 32. It is immediately clear that the SC team over-estimated the importance of the construction phase in carbon emissions. For buildings, the asset type most of the SC team were engaged with, participants had estimated impacts within lifecycle variation at the pre-operational and in-use stages. However, the participants were much less accurate when considering the bridge, both overestimating the pre-operational phase and offering a low in-use phase. Water use in buildings showed a similar pattern to carbon estimates but whilst SC team members were accurate on direct water use, they were less aware of pre-operational water. Following the workshop these results were discussed with several team members. They

were all aware, from corporate communications, that reducing CO_2 and saving water were major issues for the company, and that project teams were required to record data on "Capture"[9] to support publicly reported KPIs. They were completely surprised by the low level of carbon and water use during construction. This raised questions about corporate focus. They also felt that the graphs made clearer why the management of the supply chain had a major impact on the whole life emissions of carbon, something they had not appreciated prior to the exercise. Whilst high-level decision makers accepted that building longevity was important in calculating the proportion of impacts by life stage and planning for long life could change the design and materials, this felt disconnected from the procurement function. As one team member commented 'longevity of buildings … is this relevant – they don't belong to Carillion' (SC-PM). Lifecycle analysis was not a concept most SC team were familiar with but there was a general acceptance by participants that the 'in-use' phase of a building included occupier generated emissions or water use. These had been factored into their estimates. However, in the example of the bridge they did not consider user emissions, indeed, they believed 'it was 'cheating to include the cars' (medium-level decision maker – SC team). They did not have the same perception of the use phase being included in infrastructure. This simple experiment suggests a disjuncture between supply chain team knowledge of life cycle thinking, and the life stages at which environmental impacts occurred.

To further explore how SC teams perceived sustainability in relation to procurement they were asked during the online survey in 2016 (D3) to identify 'which of these phrases fit best with your thinking on sustainable procurement? Participants were asked to select one answer. The five phrases were drawn from comments made, primarily by high-level decision makers, in the supply chain and sustainability teams during the process of purposeful sampling (D2).

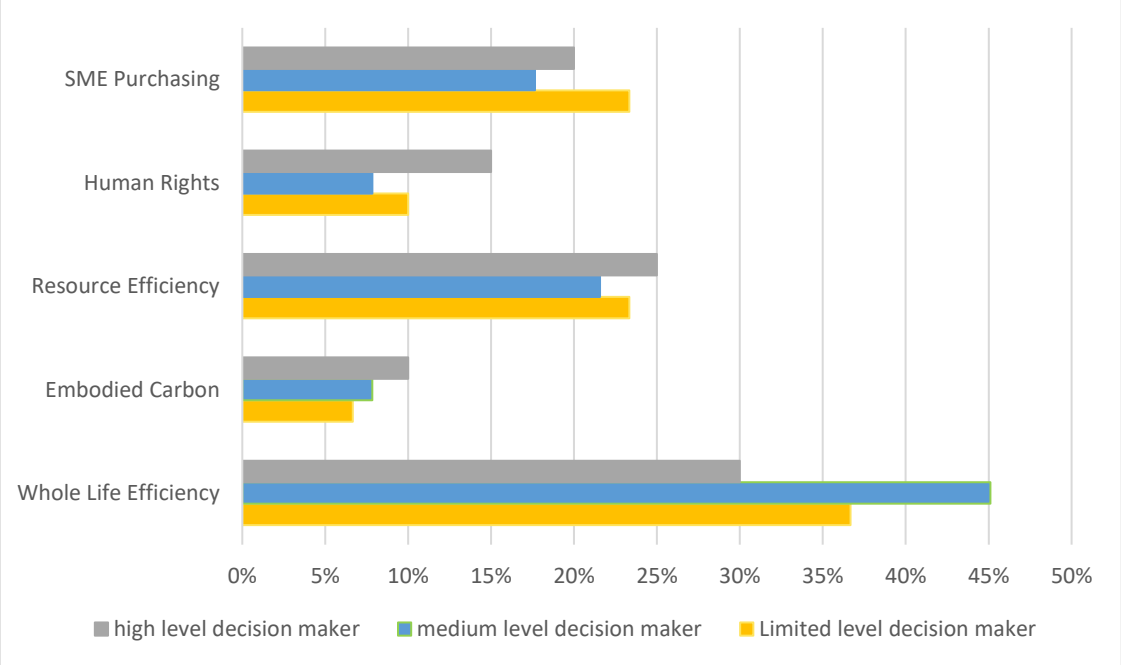
[9] Carillion's data capture system, called "Capture", was used to record information from each project site. All information had to be entered manually by site staff. To support corporate sustainability metrics this included waste data and FSC timber details.

The phrases were:

- purchase from SMEs and local companies where possible
- that companies we purchase from comply with human rights
- expect suppliers to commit to resource efficiency and waste reduction goals
- ensure that we buy products with lowest embodied carbon
- when assessing products use a 'whole life' (from raw materials used to demolition) approach

The results are illustrated in Figure 33 and the most striking outcome of the responses was the strong correlation between sustainable procurement and that of a whole life approach to products and their impacts, with 59.4% of recipients selecting this option. This was thought provoking as it was clear from the building and bridge life cycle analysis that the SC team had limited knowledge of impacts by life stage, and indeed a restricted view of sustainability and its implementation. Yet they recognised that sustainability needed to operate across the whole life of the asset, something that surprised SC-DB when responses were evaluated.

Figure 33: Which of these phrases fit best with your thinking on sustainable procurement? (please select one). (Supply Chain Survey 2016, 69 responses (D3)



The second most common response related to resource efficiency, which was primarily related to the management of onsite waste. This topic has been a focus within the

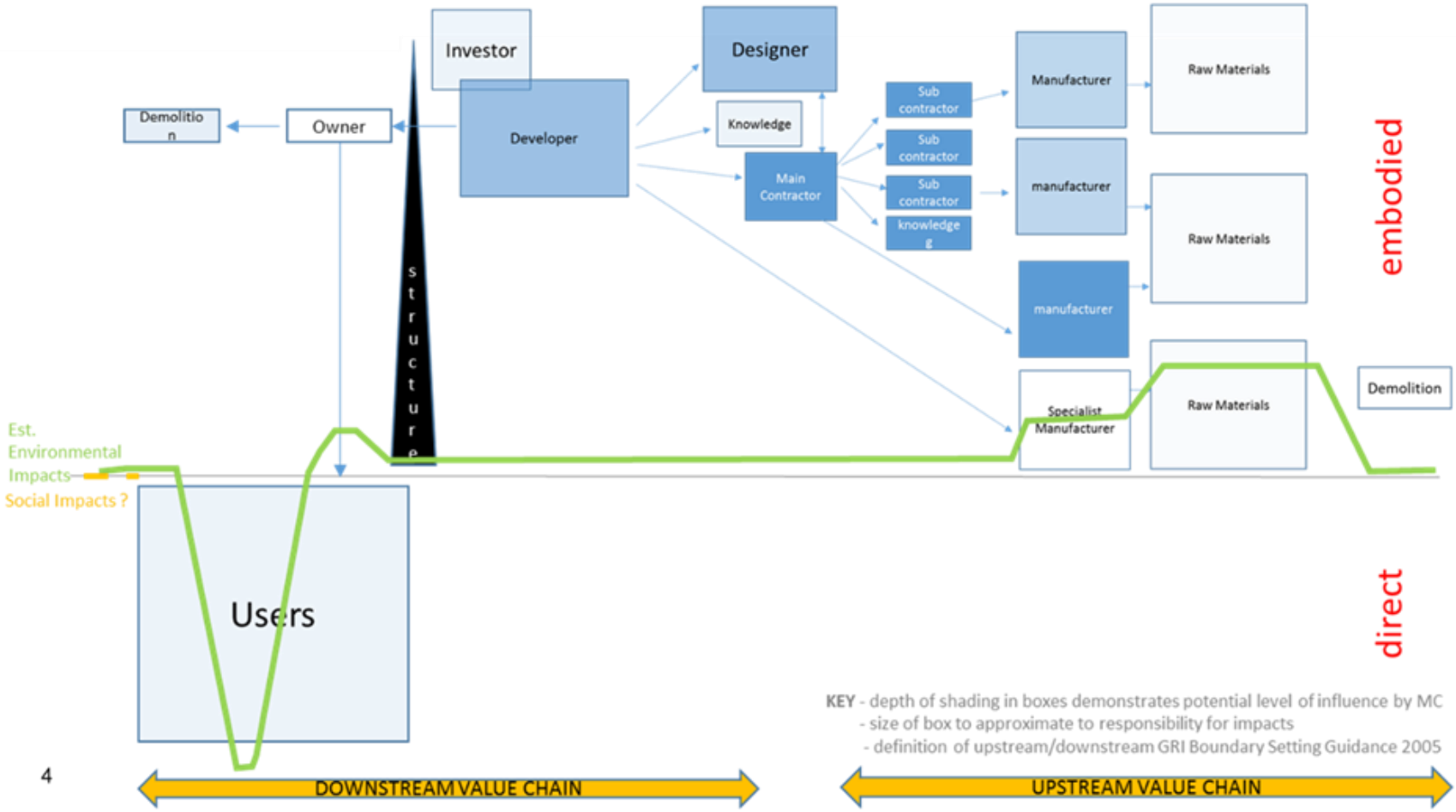
industry for more than 20 years, and it was likely that many SC team members would have experienced projects or programmes where this had been implemented. Embodied carbon, despite it being a major element of Government climate policy, had little resonance. It did not relate to their operational roles or experience. In contrast the medium ranking of procuring from SMEs may at first appear surprising, but all contacts funded through Government demanded that the main contractor ensured a percentage of all project suppliers were SMEs, and often local SMEs. This was a difficult target for the procurement team who frequently worked with large sub-contractors, and, to maximise efficiency, were streamlining their supply base. It was a target they frequently had to address and front of mind. Human rights were not strongly linked to sustainable procurement, although senior decision makers, many of whom were engaged in defining Carillion's response to modern slavery identified a stronger alignment.

The graph illustrates that even within one team in one company there were multiple views on what sustainability meant in the context of procurement. There was also a major issue that phrases, or descriptions were themselves siloed, as new standards, or topics or client demands changed. An example of this was a discussion with SC-PM where it was clear that he was working to update long-standing ethics questions on the "My Register" database and at the same time introduce a question on Modern Slavery. He had no perception that the two were related, and that indeed that their existing ethics questions included forced labour. In another example a high-level decision maker was asked by Carillion to support sustainability and he noted 'it was couched just as being about community. This didn't feel right as it wasn't the only area that Carillion affected' (D-HD). Similarly, there was only limited understanding amongst the SC team that ethical procurement, sustainable procurement and responsible sourcing were addressing related issues.

From academic sources identified in chapter 2, and from knowledge provided by the Carillion supply team, a simplified schematic of the UK construction network was devised to support built asset and supply network discussion. This provided information not only on the structure of the industry but attempted to indicate the level of influence the main contractor (in this case Carillion) had on different actors within the network

and the impact each actor had on environmental issues. Overlaid on this outline was a simplified graphic demonstrating environmental impacts by each life stage. This was derived from multiple academic, Government and industry research and was intended to only offer a broad guide as to impact by life stage. No similar data could be provided, even at this very generalised level, for social issues. The figure indicates the level of impacts embodied within the materials and those created in the use phase of the built asset; the direct impacts. In the schematic below (Figure 34) increasing environmental impacts are represented by peaks above and below the line. The Figure also indicates whether these impacts occur upstream or downstream (GRI, 2015) within the supply network, with the main contractor operating as the central node within the network.

Figure 34: Simplified Construction supply network and life stage sustainability impacts (derived from D2, D4, D8, D10)



This diagram was presented to high-level decision makers in several Carillion teams (SC, design, health, safety and sustainability, and corporate sustainability). It was refined with feedback from participants. The diagram offered teams a strategic view of the supply network and the impacts that it created; it also provided the basis for discussion. It was clear that for many of those reviewing the diagram, they were acquiring a different, more holistic perspective of sustainability. One participant commented, 'that has been excellent –it's the first time I have really been given an overview of how this sustainability stuff all fits together' (HSS-H). It also provided senior team members the opportunity to consider sustainability at a more strategic level, rather than purely meeting unconnected client or corporate KPIs.

This would indicate that many senior decision makers did not have a holistic view of sustainability and that this would prevent them from considering the implications of a built asset life cycle when making strategic decisions. Corporate sustainability had had several companies 'offer a service to carry out 'hotspot' work' across their supply chain but were unaware this was based on environmentally extended input output modelling (EEIO). They also felt it was more 'applicable for retailers than for Carillion' (S-CM). There was a knowledge of life-cycle approaches and a senior director noted that Carillion had been 'looking for years' at how to reduce and capture embodied carbon data in the context of long-life projects (SC-D1) and similarly 'all too often we are procuring for the "now" whereas full life cycle would be better' (Anon Supply Chain survey 2016).

Several team members also understood that lifecycle thinking could increase complexity or uncertainty in decision making:

> 'A good example is when we opened a buying office in China. This was seen as negative by some Carillion staff as they talked about carbon cost of delivery to the UK. Several of them argued that the buying teams should be buying local; a fair point…… but for the Supply Chain team many of the goods being bought locally, especially tools, had been made, or had components made in China – so what was better?'(SC-D1).

Another thoughtful example was recorded during a discussion between the researcher and SC-DR and SC-D when they were asked to name the most sustainable main contractor in the sector. They picked out Skanska as leaders in the industry.

> SC-DB noted that 'they had just finished building their new HQ which if they could have built it from recycled toilet rolls, they would have……it has every other sustainable feature possible'. SC-D1 commented 'that this was no doubt a great improvement from their last HQ which was modernistic and had very little sustainable about it'. They then reflected on Carillion's recent office update. 'Carillion have refurbed (refurbished) an old 60's building by repainting it and updating internal fitments. Not as glamourous (as Skanska) but it saved a great deal of demolition cost and waste……so which one is better?' (SC-DB)

It should also be noted that knowledge of life cycle impacts at the product level were also generally restricted to sustainability experts. This appeared to be the position not only with the main contractor, but also with many manufacturers and consulting engineers. This was despite many manufacturers producing environmental product declarations (EPDs). As SUP-12 commented 'we have been trying to help companies understand how to use EPDs and have a training process for all the member companies to be able to learn more'.

7.1.2 The sustainability knowledge of other network actors

In chapter 4 Section 4.2 the role that the fragmentation of the sector played in creating trapped sustainability knowledge was considered. This section illustrates how the Carillion SC team perceived the sustainability knowledge of upstream and downstream network actors.

7.1.2.1 The sustainability of upstream network actors

The Carillion Supply Chain team members were clear that the size of the supplier affected the level of sustainability they were able to expect. As highlighted by SC-RM1 they 'got more collaboration and better support for sustainability and environmental accreditation from the larger companies, and smaller specialist contractors.' The SC team identified problems that smaller companies experienced with capacity; overstretched staff struggling to manage their time, a lack of linking technology, and a lack of willingness. They also believed that that SMEs had a limited ability to take on new knowledge; the absorptive capacity of a firm. There was a strong sense amongst SC and Sustainability teams that currently for most businesses

> ‘sustainability is about stuff they have to do. ….it’s not really high priority…….more productivity related ….. do something on carbon, green travel. It’s also about what do I need to do to meet target’(S-SA).

This was reinforced by SC-JV who was working directly with many small labour contractors; ‘Lots of the suppliers I work with would have very little interest or capacity to think about sustainability’ and another team member noted that its ‘very difficult to get SME’s and social enterprises into the sustainability agenda, they’re very much the bread and butter guys’ (SC-RM1). One of the SC team also noted ‘there is limited knowledge out there and even less on how it will be implemented above what is stated within the sub-contracts’ (SC Survey 2017). Here the participant links two important issues. Firstly, it highlights the transactional nature of workflow up the supply network but also that smaller companies have not invested in knowledge unless it is required to meet contractual demands. Indeed, the capacity of SMEs to undertake sustainability initiatives was an industry wide concern, and one that was addressed by the Supply Chain Sustainability School. Carillion was an early member of the school, which provided free online content, funded by industry partners, to support increased sustainability knowledge and operational capacity within the sectors SMEs. Carillion noted that their engagement with the School was ‘a clear commitment to raising sustainability skills and working with our suppliers across the built environment’(Carillion, 2015).

Whilst this created a positive signal to the industry and was a valuable resource available to all sizes of companies, it was interesting that Carillion did not appear to place similar focus on developing sustainability capacity in their Tier 1 subcontracting partners. They acknowledged, within their sub-contractor’s manual that, ‘Our success in achieving this (a reduction in negative environmental impacts) is dependent on the cooperation of our subcontractors who undertake a significant part of our business’ (Carillion plc 2015). Category Managers noted their frustration when trying to engage with sub-contractors and one of the responses from the Carillion supply chain survey highlighted the importance of this interface as ‘we buy sub-contracts not products direct, so much (is) left with sub-contractor’ (Carillion Survey 2016). The relationship between contractors and sub- contractors was limited and transactional. SUP-04 commented ‘sub-

contractors will just do what them main contractor tells them to do – it's all about cost'. At this crucial point in the supply network, a highly adversarial and competitive interface still exists.

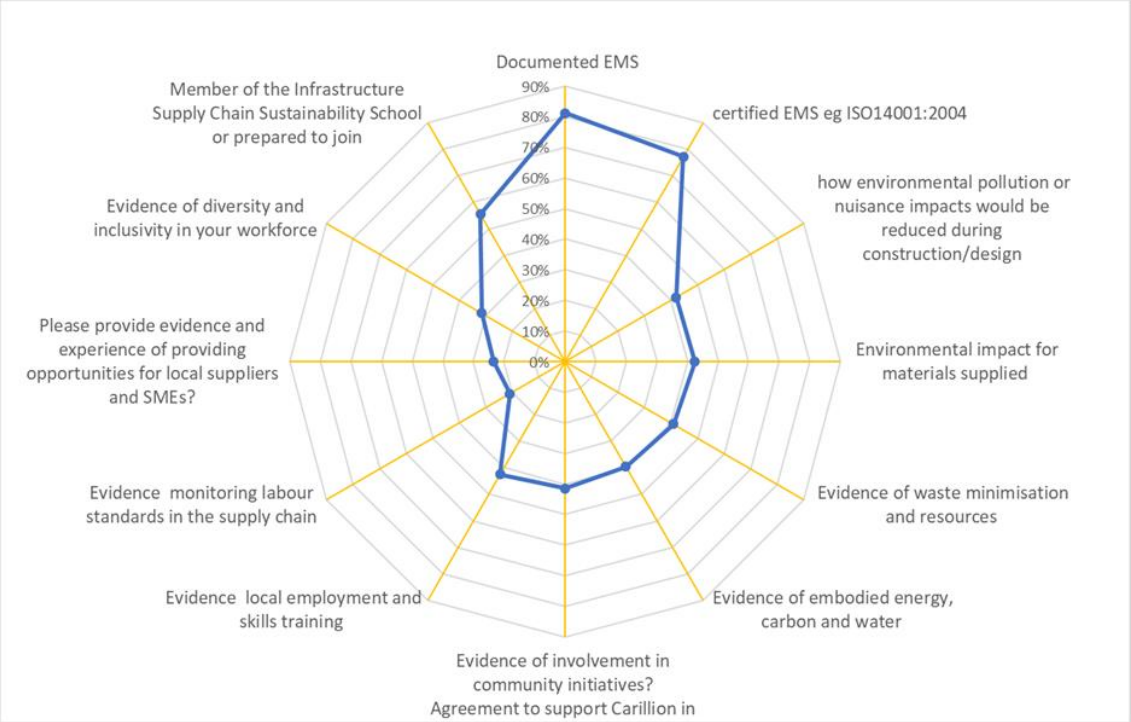
> 'In good times, such as construction in London at the moment (2016), batching up contracts (for subcontractors) is fine but in bad times main contractors try to cut out the sub-contractors and deal with the producers directly. This cut cost and builds up greater product knowledge, but it increases the risk' (O-BIM).

This increased risk occurs as the main contractor can no longer pass down to the sub-contractor the risks assumed by them under the client contract.

A different, and often more arms-length relationship existed with large and specialist manufacturers. These firms could contiguously occupy multiple points within Carillion's supply network but most frequently operated at Tier 2 or Tier 3. Whilst sustainability expertise was not universal across manufacturing, many of the companies with the greatest environmental impacts, such as the aggregate, cement and steel sectors, had highly knowledgeable teams of staff, and expertise in product development. In a rare insight into the tender process the researcher was given access to the scoring of four anonymised PQQs within Carillion's infrastructure programme. The PQQs were not for primary manufactured items such as aggregates, steel and concrete, although these may have been included as components in the supplier offer. The company were piloting a 20% weighting at the PQQ stage based on key client and Carillion sustainability criteria and which had been selected and framed by S-I. The sustainability element of the PQQ comprised of six questions relating to environmental issues and six on social issues. In total 33 large and specialist SME companies responded to the 4 PQQs and 32 of these completed the sustainability questions. The question set, with issues categories, is available for review in Appendix 7. Each supplier's response, including supporting evidence, was fully evaluated and scored by S-I, a highly experienced and qualified sustainability expert in this sector. The responses provided a unique opportunity to identify the existing state of supplier knowledge and its implementation across a range of sustainability issues.

The analysis first considered the overall average scores achieved for each question (Figure 35) to provide a general overview of supplier capabilities. This identified a low level of capability within for all but two of the PQQ questions, with the response to modern slavery, workforce diversity and the employment of SMEs being the least engaged. In contrast the number of companies able to evidence their implementation of an EMS system was high and of those that responded positively, most were certified to ISO14001. It should be noted, however, that the % scores for the latter two points are 'artificially' high in comparison to all other questions. Both of these questions were treated as binary with scoring either being 0 for no or 10 for yes. All other responses were graded out of 10.

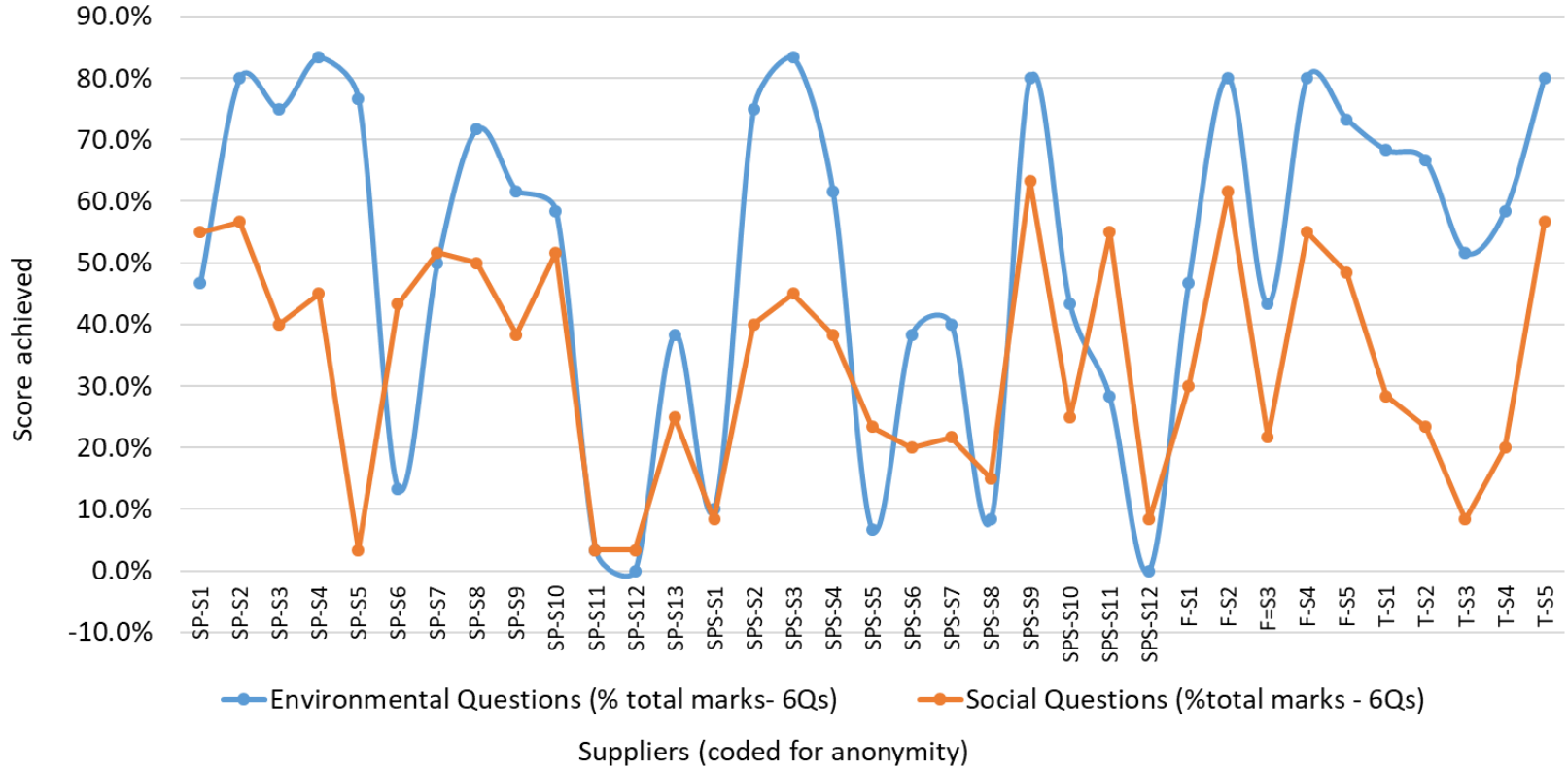
Figure 35: Average scores for each sustainability question (base 32 companies) (D6)



This data was then further analysed to understand if there was variation by supplier or by category of data. In Figure 36, social and environmental responses were rated as a percentage of each issue category. It is immediately clear that there is a wide variation in the environmental and social competencies of suppliers. Environmental issues have been an operational consideration for many years and it is unsurprising that most companies achieve their highest score in this category, driven by EMS and ISO14001 accreditation (see note above on binary scoring). In each case where companies

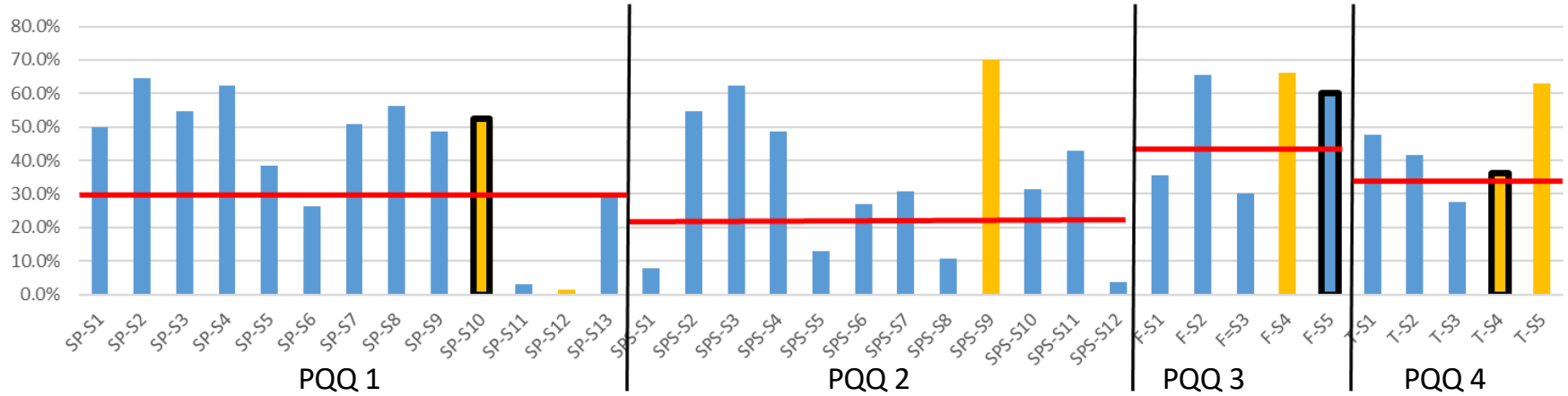
exhibited higher social scores than environmental it was due to failing on one or both of these questions. The exception to this was SP-S12 who failed to provide any environmental responses and has been removed from the mean scores.

Figure 36: Four PQQ tenders and the scores of 33 respondent companies (2017) (D7)



Social issues have had less focus within the sector and it is possible that the gap between the two categories is due to a time lag. This was especially notable in the response by suppliers on evidencing and monitoring labour within their supply chains, a request linked to the Modern Slavery Act reporting requirements (UK Government, 2015b). For this question 52% of all PQQ respondents scored no marks. All the large companies did respond and achieved the highest responses of those who scored marks on this question. Variation not only occurred between individual suppliers but variation in sustainability capabilities was seen to occur between each of the infrastructure product groups represented by the four PQQs (Figure 37).

Figure 37: Total scores by PQQ by supplier illustrating size of company and tender winning company (D7)



Key: specialist SME large supplier, company selected after tender to supply

average score per PQQ

In this sample of suppliers, whilst the largest companies scored relatively highly, they did not perform better than many of the specialist SMEs in the product groups represented by PQQ1 and PQQ3. However, the highest scores achieved in the remaining PQQs demonstrated strong leadership from the larger companies. Clearly different product sectors have attained different levels of knowledge and implementation. Overall PQQ2 suppliers achieved only an average of 22% compared to the PQQ3 suppliers where the average was 43%. Despite financial stability, price and examples of previous similar work accounting for 80% of the PQQ scoring, it is interesting to note that the companies who were then invited to tender all achieved sustainability scores above the average for the product sector. The large, and highly respected supplier, who failed to submit a response to environmental section of the PQQ, explained that 'they didn't think anyone was going to bother to look at the information' (S-I), in other-words that previous experience suggested that the invitation to tender would be based on lowest cost and financial stability. This pilot provided a much more rigorous review of supplier sustainability knowledge, and its implementation, than standard project procurement. The results of the analysis were shared with senior SC and Sustainability team members and there was surprise at the low average scores. It was felt that the high scores for EMS systems, a long standing and regular demand in PQQs, was masking a poor performance on other environmental and social issues. There was interest in developing this scoring and analysis into a benchmarking offer to enhance supplier awareness and knowledge.

The importance the of Modern Slavery Act (UK Government, 2015b) was gradually being integrated into supplier discussions. However, Carillion found an unexpected consequence of increased supplier knowledge; their suppliers became less ethical. Carillion had included, within "My Register", three questions which required suppliers to confirm if they complied with global ethical initiatives, such as the UN global compact or ILO Standards. The company aim was to have 100% of their suppliers 'ethical' by 2020 i.e. that they all answered positively to these questions, with an annual target in 2013 of 45%. Initially they had an encouraging response, 52% of companies answered positively to the questions, but over time the number decreased, and by 2016 only 25% of suppliers conformed. This was a confusing position as training courses and

publications within the industry were promoting ethical sourcing and the Modern Slavery Act had been implemented. To understand this change SC and sustainability team members talked with suppliers. It appeared that many suppliers, who had initially ticked the ethical section without much thought, had become less confident in their responses as they gained greater awareness of some of the issues. The questions were complex and as one S-SAC noted there was 'confusion around how to answer the questions. Suppliers were not sure they were doing everything they could, especially relating to sustainable sourcing. If they weren't doing everything they couldn't answer yes'.

7.1.2.2. The perceptions of Carillion suppliers of the main contractor's knowledge

As highlighted in the section above the SC team primarily saw manufacturers and specialist SMEs as having the capability to address sustainability issues, and in many product sectors to lead the industry. To sample larger, key suppliers the Category Managers were asked to provide the details of companies they identified as 'sustainable'. Suppliers were identified in four categories, M&E, Groundworks/External Works, Envelope and Finishes, but due to the Grenfell fire tragedy those within the 'Envelope' Category were not contacted: the sector had other issues to address. From the interviews carried out it was clear it appeared that network actors in the steel, aggregate and cement sectors indeed met the SC team perception of sustainability.

Many of these companies had for some time been required to reduce energy and improve environmental performance due to legislation and, as one supplier noted of their drivers:

> ' you are in an extractive sector …..it's planning. If we are wanting to extend a quarry, we have to do the environmental, biodiversity and habitat. We have to do all of these surveys and you know at one time no one was interested in listening to it…… now lots of people are interested' (SUP-10).

Response to legislation and European CO_2 reduction targets, backed by financial penalties, had impacted major extractive, polluting and high energy using network actors. Legislation had provided a level playing field with European peers and advanced knowledge and implementation practice. Many of the issues were also identified at a sector level and competitor collaboration seen to be powerful amongst

cement/aggregates/concrete and steel network actors. This frequently required both financial and long-term strategic thinking, exemplified by nascent cement industry collaboration on carbon capture and storage. Key extractive and manufacturing industries were working to longer time scales as exemplified by a comment from SUP-12;

> 'in many cases this capacity had been built up over a period of many years and had expanded to meet growing industry needs. We initially started to bring together the industry to work on quality. We wanted to be able to offer customers a guaranteed quality which removed the need for additional testing'.

However, it was equally clear that not all suppliers, especially those removed from direct product manufacture had reached this stage: 'We have a sustainability policy at a group level. But when it comes to products it is much more basic. Our baseline is that everything in stock will be legal' (SUP-4).

For the suppliers, especially those in product sectors who were leading research and development in sustainable products, downstream actors continued to be a great source of frustration, something also noted in chapter 4. An excellent example of this was a large energy consuming company who had carried out extensive energy reduction programmes and had detailed information on product CO_2 data. They were frustrated that many clients and main contractors were not working with them to improve building performance. Rather, as one senior Sustainability manger noted, 'embodied carbon….. 90% of the requests we get for carbon data is retrospective. It's for reporting, not for designing out carbon or changing processes.' Indeed, this was acknowledged by a senior member of the Carillion Supply Chain team who commented that

> 'major manufactures and trade associations are already working on some of these areas (sustainability), for example UK CARES, but Carillion is not asking about it or capturing the work. There is some real frustration (amongst manufacturers) about doing the work and it not being used.'(SC-D)

Major manufacturers were developing and implementing eco-design processes (SUP-2), improved logistics (SUP-4), developing closed loop water management systems (SUP-3), trialling natural capital valuation and biodiversity (SUP-8), circular economy (SUP-8, SUP-11), recycling (SUP-8, SUP-12) and even working on carbon capture and storage (SUP-7).

However, many of them struggled to get this information translated into useful knowledge within the industry. It was also difficult to find out what end users were wanting:

> 'what we're not aware of is how sustainability is translated to the FM (facilities management) world. Our theory is the FM companies are still expecting a shelf full of manuals to operate the new structure, and as a result, new buildings are not operated to full efficiency. So, we could be investing in things for no good reason' SUP-1.

They frequently found there was little demand for their sustainable products or services they could offer. For the wholesaler sustainability had limited resonance, indeed they noted that the 'only time we ever get asked about sustainability is to hit BREEAM points!' (SUP-4). One of the suppliers also accepted that their sales teams were not particularly knowledgeable about the sustainability benefits of the products they were selling. As SUP-8's Sustainability Director commented 'they have to build up their confidence in the product. It does also reflect how many customers are asking these questions'.

Suppliers also admitted that the lack of demand could lead them to be less comprehensive in their provision of product information. As SUP-8 noted 'actually most of our products have recycled content….but we probably don't make that clear in the product description that goes on specs – only if the client asks. We should think about that'. This point was also highlighted in the exercise carried out by Carillion SC teams where they were asked to evaluate the sustainability of selected products. They were frustrated by the poor quality of sustainability information provided by the manufacturer.

These preferred, or key suppliers interviewed, found the intermediary role of the main contractor equally difficult. Despite occupying a major focal node, they did not observe main contractors to have an understanding the role of the whole network in delivering sustainability or to be prepared to take on the role of managing this. As one noted

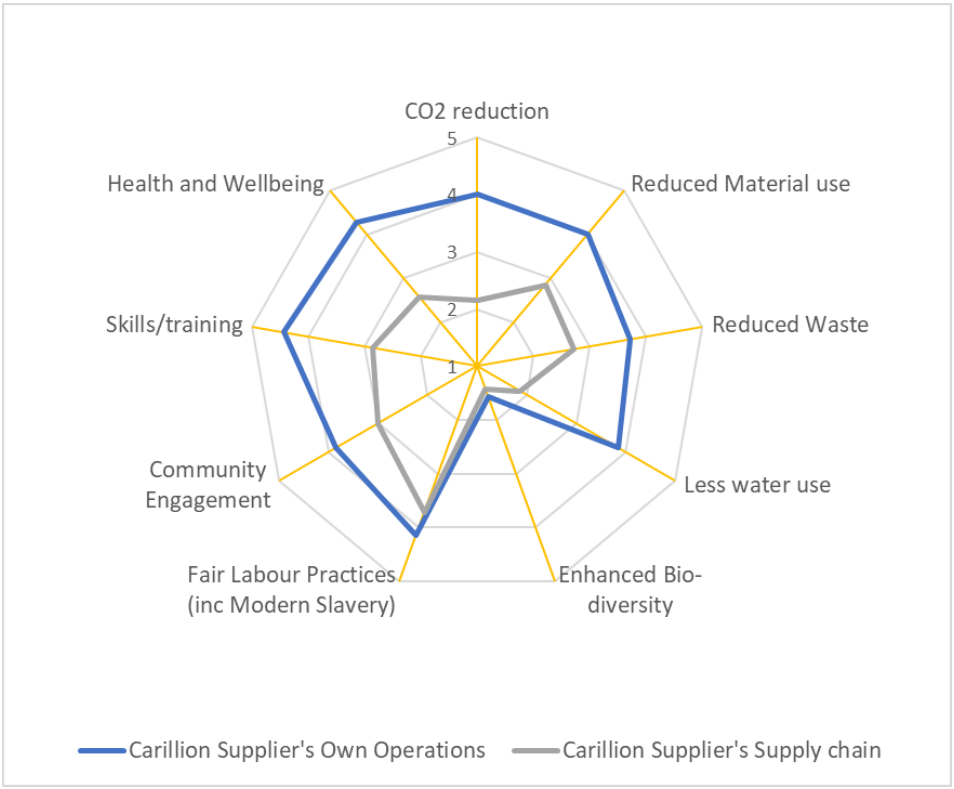
> 'our biggest problem is how to avoid value engineering. Product just gets replaced to save cost. 'we have to try a different way of working'. It's not just looking at one cost or a product – it's how do we look at the whole ecosystem' SUP-8.

There was a strong impression that suppliers, engaged strongly with sustainability, were searching for a more holistic approach. As a supplier acknowledged 'we need to consider

the whole process rather than the bits we see …….or want to see!' (SUP-8). One major supplier, wanted this led by one of the main focal points in the network, stating that it would be valuable to understand 'from the perspective of the main contractor, the capacity and capabilities of other network actors and their ability to respond to these issues' (SUP-10).

As part of the semi-structured interviews with preferred suppliers (D8) participants were asked to rate the sustainability knowledge and implementation of their own supply chain. The rating was on a scale of 1-5, with one being least aware and five fully aware and implementing action (Figure 38). Biodiversity was seen to be the area of least knowledge and implementation at all levels of the supply chain. As the graph illustrates all Tier 2 and Tier 3 suppliers interviewed were much less confident that their suppliers had the same level of knowledge and capability as themselves. This included considerable lack of confidence in the supply chains ability to support all environmental issues, especially CO_2 reduction.

Figure 38: Self-Sustainability rating of selected Carillion preferred suppliers and their perception of their own supply chain (D8)



What was not clear, and which offers a further point of research, would be to understand the different attributions that supply chain actors place on their attainment of sustainability. As one supplier noted; 'it's tricky, what does sustainability mean, it's different to many people'.

7.1.2.3. Sustainability knowledge in downstream network actors

Downstream within the commercial supply network, Carillion teams also believed clients, and designers were struggling to identify the rationale for many sustainability actions, and this limited their ability to engage the wider network on sustainability issues:

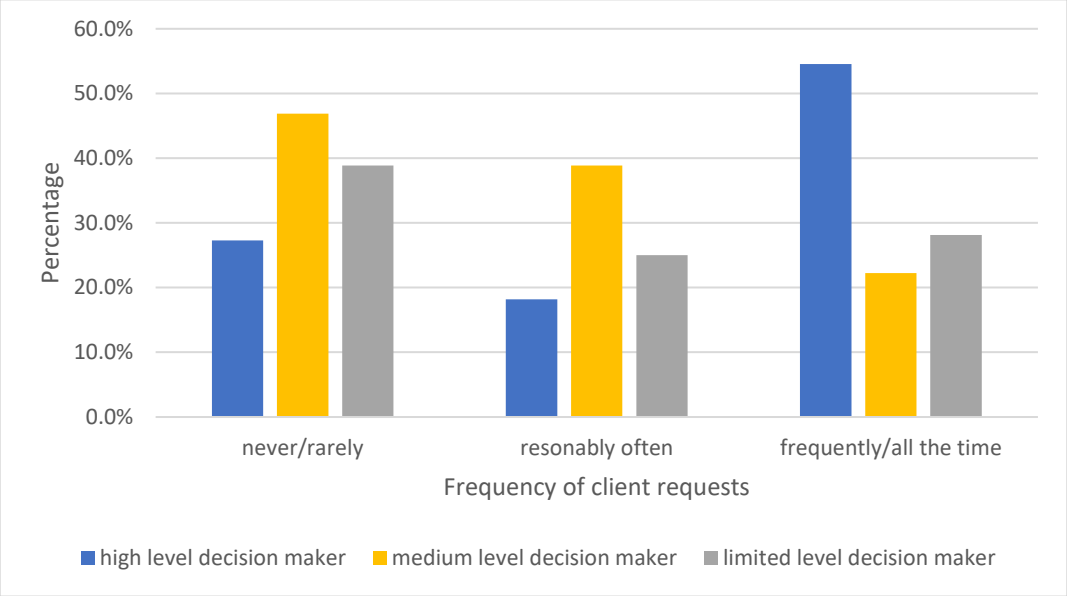
> 'Sustainability is just one of the factors that come into any bid and the industry is still buying very much on cost rather than value. They (the clients) are very focused on material costs rather than necessarily working with people that understand – have the capabilities – and this feeds down through the supply chain' (SC-RM2).

Carillion teams remained sceptical that sustainability, especially environmental sustainability had value to a client, 'the client isn't bothered about the running costs – they're not keeping the building anyway'. This impacted on the selection of systems and specifications which were 'very much client led. But often clients don't have the knowledge to challenge architects/designers' specs – especially the smaller clients' (Anon – Carillion Supply Chain Survey 2016). This failure to incorporate sustainability into assets was echoed by S-BM who stated that 'much, if not all of this stems from client instruction and requirements. Do they understand what is required, and what they should, or could, be specifying to achieve excellence?'

When asked how frequently clients asked the SC team to make sure the products procured had sustainable credentials 41% of all supply chain team members had never or only rarely been asked. The response to this question was then further analysed by decision making level. Those who worked frequently or all the time to meet client sustainability credentials (31%) were most likely to be high-level decision makers (Figure 39). This offers several possible scenarios. Senior supply chain members, with direct access to clients, may have been more aware of client requirements, especially those working on infrastructure projects. It is also possible that their wider knowledge of

sustainability could have been used to identify sustainability issues with clients. There is, however, no direct information to support either point.

Figure 39: With the exception of responsibly sourced timber, how often are you asked as part of the client requirements to make sure the products you buy have sustainable credentials? (tick one answer) (61 responses, Supply Chain Survey 2016) (D3)



Whilst the SC team made a clear distinction between the private sector and Government funded projects it was felt that 'even public bodies put (sustainability) questions into PQQs and they really don't understand what they are asking' (S-SA). Many clients struggled to apply lifecycle knowledge to their asset developments. As one senior procurement Director from a UK London council commented 'I've no idea how much carbon appears at different life stages…. it's probably all operations.... could be 99%'. This gap in knowledge was identified by industry bodies such as the UKGBC and was the driver for the Embodied Carbon Brief initiative (Ford et al., 2017). The category management team identified speculative building by developers as the worst case of unstainable build. 'You created something not knowing what the user wanted and probably had to then make many changes to suit the new owners' (CM-4). There was also a strong impression with the SC team that social issues had a much stronger resonance with clients, especially Government funded projects. As the S-SA highlighted 'the real input for them (the work winning team) is when they are working on the social side e.g. someone in prison now working on site – that's much easier to sell'. Carillion

focused strongly on these social areas, often to the frustration of Business Unit sustainability managers who felt that environmental issues, were neglected.

In a thoughtful exchange the issue of client specifications and sustainability were discussed by the senior SC team. They questioned the main contractor's role, asking 'Should it be our responsibility? Should we set the standards and make sure the clients are working to these regardless of whether they specify them? (SC-DB). SC-RM2 was concerned. He stated that 'Carillion buying teams were focused on meeting client needs, changing this to a corporate position would create a tension.' There appeared to be little appetite to initiate such a radical move and concern that it could be a high cost to the company.

7.1.3 Comparison to literature

One of the difficulties in taking a systematic approach to sustainability across the supply network are the multi meanings ascribed to sustainability. This is considered in greater detail in chapter 2 but can at its most expansive, encompass economic, environmental and social impacts or take a narrow approach such as energy management or waste. There is no agreed industry definition, or operationalisation; sustainability in the construction sector remains novel and a contestable concept (Kibert, 1999, Venters, Cushman & Cornford, 2002). This position is exacerbated as new concepts are introduced to the sector, as noted by Glass (2011a), responsible sourcing, was ascribed multiple meanings by industry practitioners; supply chain management and ethics and corporate social responsibility. As a result, Demaid et al (2006) identified, in their work on the construction industry, a 'huge scope for misunderstanding'. They also noted a high risk of misinformation, misinterpretation and 'faith' which operated in place of knowledge. The literature suggests that a company's corporate sustainability function plays a major role in overcoming this confusion, through strategy implementation (Schnieder, Wallenburg, 2012). Within the Carillion case study, extending corporate knowledge into operational teams appears to be limited to construction site metrics. There is also no construction sector body of literature that suggests which actors are responsible in taking on this role at the network level.

Considerable research has been undertaken, using lifecycle approaches, to analyse the impacts of specific construction products, and to identify CO_2 emissions during the life stages of a structure. However, there is no literature embedding this thinking with the construction supply network and associated procurement processes. Demaid et al (2006) highlights that there is no consensus in the sector on which are the important issues, and whilst there are many checklist and assessment tools a structured approach is still required (Shelbourn et al., 2006). Rather sustainability is seen as a risk to be managed (Cushman et al., 2009), and indeed, innovation such as adopting practises to contribute to sustainable construction may not be in the company's best interest if it added to risk and up-front costs (Demaid, Quintas, 2006). These concerns are corroborated by several of Carillion's senior SC team members. Others identify actioning sustainability knowledge as a response to multi-stakeholder expectations (Schnieder, Wallenburg, 2012). They note that these views may also be myopic; grounded in their own agendas, commercial positions within the network and positions of knowledge. This was identified in chapter 6 where key stakeholder materiality assessment reflected stakeholder interests, in this case represented by the SDG's they believed Carillion were able to support. Indeed, Cushman et al (2009) suggested most sustainability innovation appeared to be due to 'quirky clients seeking (usually) prestige projects, or as a response to a more strenuous regulatory environment (building codes)'. Failure to take a systems approach to sustainability could result in the unintended consequences identified by Demaid et al (2004)when they demonstrated that glass bottle collection and recycling was not an inevitable 'good for the planet' but was promoted heavily by an industry wishing to remove the need to bear the cost of disposal.

Rather than the supply network having access to shared sustainability knowledge, silos were identified across the network (see chapter 4, Section 4.6). For sustainable sourcing to be successful, however, the literature suggests that knowledge flows between intra and intercompany actors needs to be undertaken in a systematic manner (Schnieder, Wallenburg, 2012). Siloing of expertise was seen to be detrimental to project sustainability and cost and led to an unstable knowledge base (Demaid, Quintas, 1999). The construction sector, comprised of fragmented expertise, required focal companies who did not possess internal knowledge, to breach corporate boundaries and leverage

supplier capability (Pagell, Wu & Wasserman, 2010). There is evidence that early integration of suppliers in the construction sector can reduce a focal company's exposure to social issues (Saunders L.W. et al., 2015). They suggest that where suppliers have high technical capabilities, large companies should transition them to strategic partnerships. Similar findings have been have been identified for improved environmental performance benefits (Lee, 2008, Pagell, Wu & Wasserman, 2010).

7.2 The Acquisition of Knowledge

The way in which knowledge was acquired emerged as a strong narrative from the research. Using the epistemology of knowledge proposed by Joyce (2014) the MAXQDA knowledge-coded sections of text were further analysed, utilising the framing of knowledge acquisition highlighted in section 7.1. The three types of knowledge were coded as

1. knowledge by experience
2. practical knowledge acquired with skills or abilities
3. propositional knowledge acquired by learning facts.

Sustainability knowledge was acquired through a wide range of sources and as these were mapped within the Carillion SC team it became evident that these were driven by both values, which included a strong emphasis on personal experience and skills development, and functional demands, with a greater focus on factual knowledge acquisition. Values exhibited were primarily personal, and often deeply held, but additionally all Carillion staff worked within a clear set of corporate values that were regularly reiterated. The information derived from the multiple interviews and discussions (D2, D4, D5, D8, D10) was used to develop the matrix presented in Figure 40.

Figure 40: Knowledge Acquisition Matrix - Carillion Supply Chain team (D2, D4, D5, D8, D10)

Knowledge Acquired through:	Knowledge type	Driver		Nature
Previous work experience	1	Values	Personal Values	Moral/ethical position on social and environmental issues
Professional CPD	2,3			
Personal experience and learning	1,2,3			
Each value offered guidance on the behaviours expected from staff.	2,3		Corporate Values	Set by board, defined within corporate literature and promoted to organisation
Planning specifications, industry standards e.g. BREEAM,	2,3	Functional demands		Client demands, external reporting, peer pressure and risk management
Reporting Bodies	3			
Transactional KPI's	3			
Industry groups and professions, Government led groups e.g. Green Construction Board	2,3			
Supply Chain School	2,3			
'Sustainability Experts – internal and external'	1,2,3			
Case Studies	2			
Technical product reports	3			

In sections 7.2.1 – 7.2.3 the types of knowledge acquisition driven by values and functional demand within the Carillion SC team, are examined in more detail.

7.2.1 Knowledge underpinned by personal values

Whilst participants most frequently focused on transactional knowledge transfer such as contractual requirements, targets, and standards, there was also evidence of more

deeply held personal beliefs and knowledge, frequently associated with senior team members who championed sustainability initiatives.

Many of those most engaged in the topic area had developed their knowledge through work experience, and where they were exposed to sustainability issues. For example, SC-RM1 worked for Carillion in the Middle East and was very animated about the work he had done on sustainability. One of his major achievements had been on-site water collection. As he noted 'water use was a major issue and it really made sense'. In a similar situation D-HD had first started looking at CO_2 when working on the XXXX site. He had no training in LCA but had built up a reasonable level of understanding through his own reading and research. It was clear he had continued to have a personal interest in CO_2. He had continued this work because he felt it was right to do this even though he could not envisage his work having 'an end goal beyond capturing the data and see where it led……. at the moment I don't really didn't see it having a direct value to clients or the company'. SC-D1, responsible for the FSC timber programme had regular contact with WWF, and from this had developed considerable knowledge on the topic area. There was also an awareness that knowledge derived from projects was not being embedded in industry practice. SC-P1 was directly involved in managing Carillion's Olympic work and he talked knowledgeably about the sustainability programmes they had developed. However, 'he felt disillusioned that all that learning was not being applied'. Those who had strong personal values, frequently underpinned by experience, self-directed continued knowledge development appeared to have the greatest influence on sustainability actions with Carillion. However, all of those individuals who met these criteria were also operating as high-level decision makers, which was in turn more likely to influence a sustainability outcome. It was not possible, during this research to separate these two interactions.

As presented in Figure 24 (chapter 5, Section 5.3), SC team members highlighted how they would judge whether a product or service was sustainable. For medium and limited-level decision makers, engagement with propositional knowledge acquisition, was primarily based on their relationship with suppliers. The SC team would turn to their product suppliers and ask them to identify their most sustainable product or service. As

one team member noted the SC team needed to 'learn from our supply chain. They are the experts in what they deliver and are always looking for ways to improve, very much like us' (Anon, Supply Chain Survey 2016). They suggested that running B2B events and external meetings were a good way to achieve this as it temporarily moved the main contractor-supplier relationship into a less commercial position. From the participants comments it was clear that for several major manufacturers this knowledge exchange had developed, over time, into a strong position of trust with main contractor and manufacturer working closely to meet a client need. Surprisingly a high proportion of the team considered that 'common sense is a good marker for what is or isn't sustainable' (Anon, Carillion Supply Chain Survey 2016). Indeed, common sense was seen by the SC team as more important than working to client specifications. Only one team member noted the use of trade journals for guidance and there was no reference to the role of professional bodies. Using records from previous project records was noted by only one participant. Interestingly senior decision makers were less comfortable with the supplier or common sense as a method for acquiring knowledge and were more focused on independent, technical data, such as EPDs or the Green Guide. No explanation was provided by high-level decision makers for this difference of approach, but it is possible that more of the senior team had a greater exposure to sustainability through previous experience or involvement with industry groups and recognised the importance of independent product data. It may also be that they were more sceptical of the ability of many suppliers to support enhanced sustainable practise. When SC team members were asked to select from a list of options about how they would embed sustainability in the supply chain (Figure 41), the two options linked to changing behaviour (highlighted in yellow) ranked highly; these were leadership and education of the supply chain. They wanted to see senior individuals in key supply network focal companies offering direction and guidance, utilising their sustainability knowledge and ethical stance to drive change. They believed that a propositional knowledge approach was the most effective method to support sustainability across the supply network. Part of the leadership role was identified as well-informed senior decision makers communicating sustainability effectively to other network actors. As highlighted by SC-D1

'so much of it is about communication – people don't see how they can really contribute to some of this but actually when you talk to them they come up with ideas and they see why and how it is important'.

It was also notable that four of the most senior supply chain directors were all involved with Supply Chain Sustainability School boards or working groups. Whilst this was encouraged by Carillion's corporate sustainability team, they all felt a personal responsibility to offer their experience to support, industry development and SME supplier engagement with the topic, but it was notable that they also gained considerable satisfaction from these roles.

Figure 41: What do you think is the best way to embed sustainability throughout the supply chain? (Carillion Supply Chain survey 2016, 67 responses) (D3)

However, examples of effective sustainability actions were frequently identified as the transfer of knowledge applied in a practical situation. A striking illustration that challenged existing experience-based knowledge was provided by D-HD;

'At a job we did at the XXXX I told the project team that they were allowed just one skip per week to remove waste, based on the design. They were horrified….just one skip…….impossible. I then pointed out that based on what we had designed in as expected waste they would still be throwing away the equivalent of the whole of the ground floor of Carillion head office. It made them think differently'.

Knowledge based on experience was valued within the sector and an asset for team members such as the category managers who were appointed based on their extensive category experience. However, as noted in the example above, experience-based knowledge could also form the basis of 'traditional views' and restrict the acquisition of new knowledge. A more thought-provoking example of this, at a Carillion corporate level, was the comment from SC-DB on the requirement he set a Carillion project team who had the responsibility to manage site waste. He stated that

> 'we have been looking at the sustainable development goals….. to form a new framework for targets…….But as a group they don't have expert knowledge in the area and this makes discussion more open, everyone is prepared to look at ideas as they are new, and no one has a strong stance based on previous experience. In fact, this is how sustainability feels compared to say purchasing where there is much more of a push back from people where ideas are much more fixed based on experience'.

The contrary argument to this was that without understanding the interrelated nature of sustainability impacts it was difficult to manage effective change. Indeed, what did good look like? This was seen most clearly when the life cycle thinking, presented by the researcher, was discussed at board level. Board members were unaware that, albeit based on a limited number of case studies undertaken, the construction process only accounted for 1-3% of the water associated with the whole life performance of a building or infrastructure asset. Carillion had spent considerable effort and cost to reduce on-site water wastage. There was a realisation that, whilst they should continue to minimise water wastage on site, there were other major water issues that were embodied within the products they procured. This newly acquired lifecycle-based knowledge prompted the Managing Director of CCS to suggest that 'if water scarcity is such an issue then we should consider restricting our purchases from those countries'. This concept had been incorporated into the sustainable procurement strategy which was at final stages of approval when the company went into liquidation in 2018. Whilst there were many hurdles to implement this effectively this was a strong visionary challenge to the SC team to address issues beyond traditional corporate boundaries. It raised questions about the value of communities and ecosystems outside the UK in a different way to that managed through FSC. There, the responsibility for the supply

chain and end producers had been sub-contracted to the FSC chain of custody and was a bottom-up process. Carillion taking issues directly to the raw material stage of the supply chain was a strong values-based application initiated by increased knowledge.

7.2.2 Knowledge underpinned by corporate values

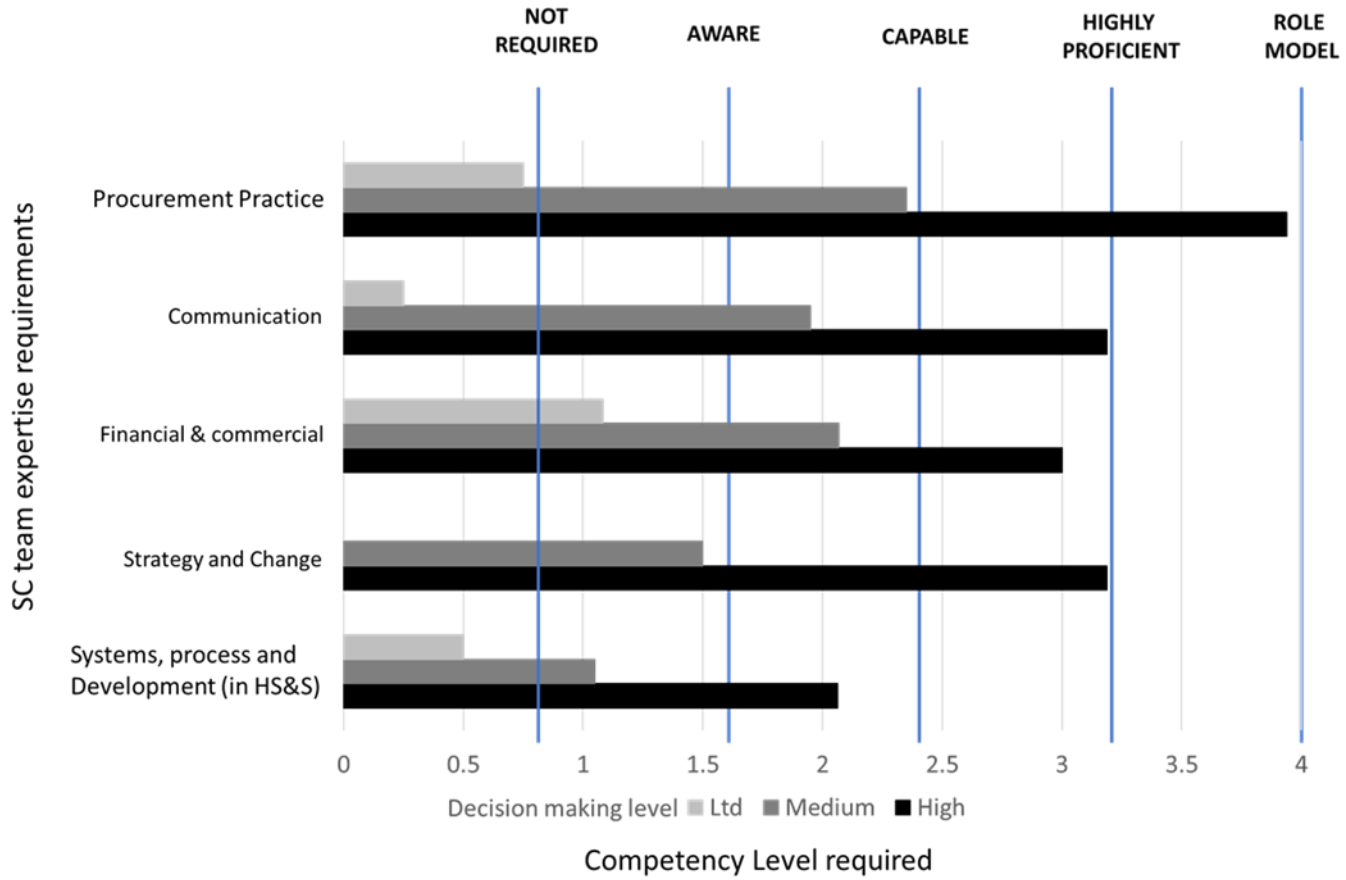
At a corporate level the company identified that 'one of the past failings was that the corporate team presented their annual sustainability report and assumed that everyone in the company knew all this stuff, that it was instinctive…..but they realise that this is not the case' (S-CSO). Carillion offered staff internal online, internal and external training courses and supported them with time for continuous professional development (CPD). Carillion CCS sustainability team offered their colleagues 10 online training modules with additional corporate modules on ethics, modern slavery and bribery and corruption. The opportunity to 'learn and adapt our ideas and experience' represented the company's response to one of their four core values, 'we improve' (Carillion, 2017). However, the take up for sustainability training was not high, even when this was a mandatory requirement. This was highlighted by SC-RM3 who said

> 'modern slavery –it's not just suppliers who don't know – it's something our own people aren't good at supporting either. I've been getting reports on who has completed the modern slavery epod (Carillion online training module). 150 people still haven't done it. I've chased them, (colleague X) has also been pestering them – so even our own people aren't doing it – it's very poor'.

Whilst this may seem surprising it was useful to view this alongside the requirements that CCS placed on their procurement teams in terms of general personal competencies. This was not a matrix designed to assess sustainability, but rather sustainability was included as part of the overall Health, Safety and Sustainability agenda (HS&S). For those at the limited and medium decision-making level they were only expected to have basic awareness or awareness of sustainability (see Figure 42). Senior level decision makers were required to be capable in dealing with more complex issues and have knowledge of the topic. It is worth highlighting that not only did Health and Safety have a much higher profile, both within the industry and the company but incorporating sustainability within this team identified it with a more traditional approach, primarily based on

managing and auditing on-site environmental performance. In this competency model, sustainability is quite separate to procurement practice.

Figure 42: Adapted from Carillion Competency Matrix - Supply Chain team 2014 (D9)



KEY:

Level 0: NOT REQUIRED/NOT AWARE: Competency not required OR has basic awareness and may need guidance

Level 1: AWARE: Capable of dealing with a variety of issues, may need limited guidance

Level 2: CAPABLE: Proven ability, confident in dealing with complex issues, demonstrates ability on a regular basis

Level 3: HIGHLY PROFICIENT: High level of ability, advanced knowledge and techniques to pass on to others

Level 4: ROLE MODEL: Recognised within the business as an expert, clarifies issues on behalf of the team

This example reinforces the siloed nature of sustainability. Here corporate teams, working within Carillion values required SC team members to undertake training, acquiring propositional knowledge, on sustainability topics, yet sustainability was not identified as a major competency for SC team members. Team members did not have a strong driver to incorporate sustainability into procurement practices and some senior staff members saw it as 'asking people to do a huge range of stuff on top of everything else and that they were being bombarded with too much' (HSS-H). This was confirmed by a senior SC team member who was very positive about sustainability 'but the company is continually developing new initiatives – there seem to be new ones every month and sustainability is just one of these' (SC-RM1).

7.2.3 Knowledge underpinned by functional demand

Whilst the previous sections considered how knowledge acquisition was underpinned by personal and corporate values a high proportion of knowledge was highly in practical nature and functional in its acquisition. From the interviews and discussions, it was clear that for many participants sustainability knowledge was primarily acquired in response to external information required through client demands. This appeared to differ from values-based knowledge in that it frequently had a project specific application and did not inform wider SC team thinking. It was primarily process driven and SC team members, under huge time and cost pressure would know only that portion of a topic that was required to fulfil a business need.

For the majority of SC team members, only a limited number of sustainability issues impacted their procurement activity. Indeed, Carillion project procurement plans only included FSC and waste targets. From interviews and meetings, the sustainability topics with which SC team members directly and regularly engaged were identified. These were mapped against the Carillion corporate 2020 strategy (Table 26) issue categories. The requirement to engage with SMEs and local companies was most difficult to fit into the company's sustainability categories.

Table 26: An assessment of the sustainability demands reaching Carillion procurement team 2017 (D2, D3, D6, D8, D10)

Carillion corporate sustainability issues	Sustainability topics reaching SC team						
	BREEAM, CEEQUAL, LEED	FSC	Waste	Community relations - site	Direct community involvement	SME and Local	Modern Slavery
Climate Change/Carbon							
Environment							
Biodivesity							
Resource Use							
Fair Employment							
Health and Wellbeing							
Impact on SC team:							
1. Time consuming							
2. Contentious/Difficult							
3. Fits normal 'buying' processes							
4. Additional cost	should be in price'						

Key

- identified as difficut by SC team, outside percieved normal roles
- can be achieved but adds time and complexity
- generally accepted as part of SC role

The researcher then used SC team comments to describe aspects of these sustainability demands e.g. time consuming or additional cost. From interviews and SC team meeting notes a simple traffic light approach was applied to each requirement identifying how they saw these topics in relation to their 'normal' procurement work. Whilst these traffic light allocations were reviewed by S-BM and a senior SC team member there was not an opportunity to test them with a larger group of SC team members. Most of the demands aligned with standard buying practices although Community involvement, SMEs and FSC were more complex to incorporate. All the approaches were seen as adding time and difficulty to procurement, with the exception of community relations on site which were frequently sub-contracted to the Considerate Contractors scheme and the Modern Slavery Act, which was primarily handled at a corporate level through "My Register". Waste, whilst a major topic area and one in with the SC team were repeatedly engaged with suppliers, was 'business as usual'; a part of all contracts. It was recorded as part of sustainability but internally was identified as a separate issue. It should also be noted that it was defined as the management of waste, primarily maximising recycling rates to minimise landfill costs. There was no internal knowledge on wasted procured materials.

BREEAM and other building standards could result in unexpected work for the SC team if value engineering created a shortfall of points. This frequently resulted in additional costs. Only FSC and the Environmental Building Standards covered multiple Impact categories. The list of sustainability issues noted in Table 26 were the topics that supply chain team staff regularly encountered and would be required embed within their work. This could be a minor inclusion in a tender, such requiring the sub-contractor to be a member of the Considerate Contractor's scheme to working with a major wholesaler to ask them to identify products that supported a BREEAM level. Crucially in many instances the SC team member would only know if the supplier had met these criteria through feedback from project sites. An interesting example of this was highlighted by CM-D when considering setting sustainability case studies as personal targets for Category Managers. CM-D saw one of the key problems to this approach as;

> 'to do a good case study the supplier would need to know what we wanted to know. The category management team did not feel they were able to technically do this….even though they were developing a better understanding of the issues'.

It appeared that the need to develop fact based or propositional sustainability knowledge was quite low for medium and limited decision-makers, but senior team members were increasingly being required to expand their knowledge. This was seen in connection with a powerful external driver, new legislation. In 2015 senior SC team members were provided with a summary of the Modern Slavery Act (UK Government, 2015b). They had to translate the legal requirements with their experience of supply chain risk management and implementation processes to develop an internal strategy and implementation plan for Carillion's supply network. Here legislation required the development of new sustainability knowledge which was viewed as critical to managing increased business risk. This was acknowledged by SC-DB who noted that

> 'recently there has been the modern-day slavery act which is sort of raising the awareness, and therefore the need to do something, (about modern slavery in the supply chain) higher up the chain (internal Carillion hierarchy), into the boardroom'.

Whilst the legislation drove action it was highly focused and such initiatives remained siloed, with no one connecting different strands of information. As noted in section 7.1.1 a member of the SC team (medium-level decision maker), managing the implementation of Carillion's modern slavery approach, had only acquired the very specific knowledge required to complete his task. He saw his work in complete isolation to other Carillion initiatives; unable to appreciate its function within Carillion's wider commitment to the UN Global Compact, existing ethical questions and labour policies. There was also a surprising lack of foresight on forthcoming regulation, which was not specific to the SC team. When discussing client PQQ requirements WW-PC stated 'Yes we get asked so many questions now (on the Modern Slavery Act)……. it just came out of the blue'. Other examples were the European Union's work on conflict minerals, which came into law in May 2017 (The European Parliament and the Council of the European Union, 2017). This was highly relevant to consider as part of the company's approach to modern slavery and, in 2016 went raised at the conference workshop had very low awareness amongst both sustainability and supply chain teams.

A similar, narrow approach applied to building certification schemes such as BREEAM, or quality standards like ISO14001 or responsible sourcing; BES6001. BREEAM and other

similar green building schemes were the only industry-wide method that both implemented and offered a strong demonstration of a built assets environmental credentials. BREEAM was frequently a requirement of planning applications and was noted as a major tool for enhancing sustainability in Government contracts. Whilst this should have provided a strong focus for SC team knowledge building surprisingly 29.7% had never worked on a project requiring them to support the standard (supply chain survey 2017). Many of the supply chain and sustainability teams felt they were getting less demand from clients, with 36.9% of the SC team identifying a decline over the last five years. Internally, responsibility for the management of BREEAM was transferred to an internal design expert who reviewed BREEAM specified building plans. They ensured that the correct number of BREEAM points were achieved, even as materials and build design were value engineered to save costs. This specialisation of roles required only limited knowledge within SC teams, a point reinforced by one supply chain team member,

> 'I have only a loose understanding of BREEAM. I have not encountered CEEQUAL or LEED before and do not know what these terms mean' (Anon, Supply Chain Sustainability Survey 2017).

Similarly, there was a surprisingly low level of knowledge about standards such as ISO14001 which was regularly used as a proxy for a supplier being 'environmental'. The SC team did not understand this in any detail and consequently were not aware that products provided by these companies may not be sustainable. Knowledge of new standards appeared to take time to reach the SC team, unless they were alerted by client requests or peer pressure. An example of this was the standard for Responsible Souring, BES6001, which had first been introduced by BRE in 2008 specifically for the construction sector (Upstill-Goddard et al., 2015). However, it was not specified by clients and in a Carillion meeting in 2015 only two members of the team were aware of it and they had 'only just come across Tata Steel with the standard' (SC-D1, SC-RM2).
Most frequently sustainability was an 'add-on', something extra to be navigated whilst trying to meet low cost targets. Spending time acquiring knowledge was often seen as unnecessary and as one busy senior manager said of sustainability 'just tell me the three things I need to do' (SC-RM2). Whilst this section has focused on knowledge acquisition

by Carillion teams one of the Senior SC team offered an interesting insight into how they found, in some of their suppliers, the very issues that frustrated their own internal sustainability team and the fragility of the knowledge;

> 'It's not just an issue of control of stock but also of knowledge – more understandable at branch level but Carillion are still getting problems even though have run numerous training sessions. He cited the case of one plywood supplier where the buyer had attended more than one training session and yet they were still bringing PEFC onto projects. Now they have finally 'got it' and are just supplying FSC. But it just takes a change in buyer and it could all change……..the knowledge may not remain in the collective memory' (SC-RM1).

7.2.4 Comparison to literature

A company's ability to acquire knowledge and to be able to share this internally and with other stakeholders is acknowledged as a major competitive advantage for a business (Spender, 1996, Argote, Ingram, 2000, Dyer, Hatch, 2006). Within the construction sector professional knowledge is derived primarily from experience at a project level. This type of knowledge is identified by Lave et al (1991) as 'situated' and this type of tacit knowledge is seen as difficult to acquire through other forms of learning (Quintas, 2002). The industry is seen to be adept at capturing explicit project knowledge but has not yet developed systems to manage tacit learnings (Grover, Froese, 2016) and indeed they conclude that personal networks rather than technology are more effective in supporting this process. It is suggested that individuals who acquire knowledge are not merely driven by 'personal exploration' but also the 'ability to convince (or be convinced by) others' (Cushman et al., 2009). Demarest (1997) suggests that knowledge can not only be embedded within individuals and but through social interchange within the company itself. The view of knowledge and its management being a consequence of social interaction is supported by Venters (2002) and indeed Nirmala and Vemuri (2009) indicate that companies should focus not on individuals but their relationships within a wider knowledge network (Brass, 1995). Others consider that knowledge results in a change of the perceptions of individuals who institute change in practises that can alter group behaviour and increase understanding (Shelbourn et al., 2006). However,

acquisition of knowledge has a cost for the individual and may not have short term application or benefit for the company (Demaid, Quintas, 2006).

From the Carillion data, suppliers are a primary source of knowledge, especially where trust has built up between SC team members and supplier companies. Dyer and Hatch (2004) noted that the supply chain was an effective external source of knowledge and technological innovation. This was also observed by Caniels et al (2007) where long term strategic partnerships existed or where there was a strong reliance on the focal firm. The supplier's relative size was also seen to have an impact on the implementation of sustainable sourcing (Sharma, Henriques, 2005). It is suggested that smaller companies see themselves as knowledge consumers whilst larger companies acquire knowledge to improve their reputation for innovation (Cushman et al., 2009). However it is questionable that without sustainability-orientated norms and values or professional capabilities, either within an individual, or driven by a senior member of the procurement team, that procurers would initiate sustainability knowledge exchange with suppliers (Bowen, Cousins, Lamming & Farukt, 2001, Paulraj, 2011). Instead, best quality and lowest cost would be their primary focus (Bowen, Cousins, Lamming & Faruk, 2001). Whilst suppliers are acknowledged as an important source of knowledge concerns arose if a supply chain team focused solely on this source of knowledge, failing to identify other stakeholders importance in the context of sustainability (Schnieder, Wallenburg, 2012). For example NGO's are identified as trustworthy sources of knowledge across the supply network (Schnieder, Wallenburg, 2012) but also have role from a position of expertise to challenge and critically assess company performance (Reuter et al., 2010).

It is suggested that this unifying stakeholder and directing role is fulfilled by corporate management, providing a either strategic direction or acting as role model and enforcing corporate values in decision making (Schnieder, Wallenburg, 2012). Within the construction sector these business ethics are most frequently driven by compliance (Glass, Achour, Parry et al., 2011a). Some large corporations, who are identified as adopting leading sustainable practises, appear to have the necessary 'shared,

organisation-wide long-term vision' and exhibit 'core values and cultures and a sense of purpose beyond the economic bottom line' (Carter, Rogers, 2008a, p. 368).

In a traditional view of supply networks this is demonstrated by the focal company acting as the driving force for implementing CSR through selective commercial pressures on organisations in its upstream supply network. It operates on the implicit assumption that the principles of the corporation have precedence over those of other organisations within the network (Spence, Bourlakis, 2009). This is echoed by Jorgensen and Knudsen (2006) who note that larger buyers, acting as change agents, exert pressure on their supplier tiers to comply with their environmental and social requirements.

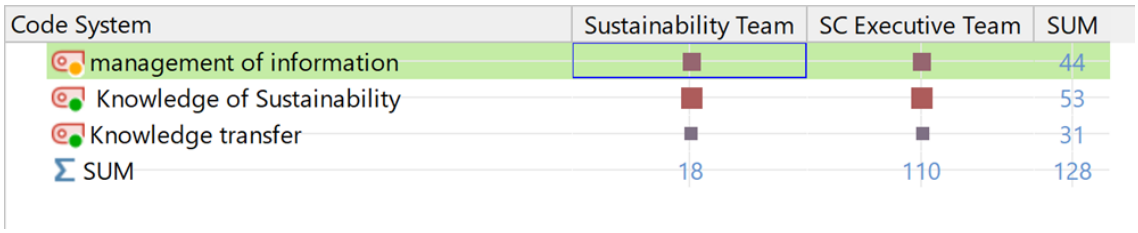
Whilst knowledge can be derived from good practice and standards the contextual appreciation of sustainability goals and their application across organisational boundaries is equally important to the development of 'new resources and expertise' (Shelbourn et al., 2006). Venters highlights that new understanding can come through innovation and dialogue but dismisses the concept of adapting learnings from high profile sustainability projects to general construction. It is suggested that formal rather than experiential learning may be effective in acquiring knowledge, such as training programmes that can expand purchasing managers perception of stakeholder positions, improve their communication and networking skills (Schnieder, Wallenburg, 2012) or by companies participating in academic research projects (Cushman et al., 2009). Indeed, Hay et al (2014) identified that strategic education could be used to reframe sustainability thinking, offering a more holistic understanding. However, there remains in construction the constraint that client demands retain the highest priority and their standards have primacy (Carter, Jennings, 2004), even, as we have seen in chapter 5 when these are unsustainable.

7.3 The trapping of sustainability knowledge

As highlighted in chapter 4 the number of internal stakeholders engaged with the SC team is extensive. Yet, visualisation of the most numerically dominant knowledge codes, drawn from sustainability and senior SC team documents, indicates that both teams had

proportionately similar positions on several key knowledge issues. Sustainability knowledge, of both inter and/or intra company actors, information management and knowledge transfer (Figure 43).

Figure 43: Differences in team approaches to elements of sustainability knowledge (Interview and meeting notes – Carillion sustainability team and SC team executive members (D2, D4, D5, D10)) visualised using matrix browser; MAXQDA



This provides confirmation that the SC executive team, as evidenced through both interview commentary and meeting notes (11 documents), were engaged with sustainability issues. The coding intensity highlights the importance of network actor sustainability knowledge yet, surprisingly both teams had only limited commentary on the transfer of sustainability knowledge between actors. Possibly both teams saw this in terms of information management. Analysis of SC team documents identifies that information management is a major issue for all project teams, a recognised barrier to efficiency, and is not confined to sustainability data or knowledge. This would appear to be a reflection of the transactional nature of procurement within this sector.

Information detailing client demands is primarily in the form of contracts held digitally and in paper, information flows to and from the project site through telephone calls and emails, and suppliers respond to PQQ and tender documents. Internally, Carillion design teams liaise with procured consulting engineers and architects, consult with work winning teams and estimators and work with the supply chain team to support value engineering. This section considers knowledge exchange at the two main points of dyadic collaboration within the network; client and Carillion, and Carillion engagement with their suppliers. It also assesses the role of technology in facilitating the exchange and embedding of knowledge across the supply network.

7.3.1 Client contracts and main contractor impotence

The importance of the client in driving sustainability across the network was noted in chapter 5 and it is through contracts that their construction demands and approaches to main contractor engagement are primarily implemented. In the construction sector standard contract formats are published by several organisations which are adopted, and usually adapted, by clients and contractors for each project. There has been a continual drive to develop these contracts and NBS identify that many now contain collaborative clauses such as NEC 3 suite of contracts and CIOB Complex Construction Contract 2013. They also note that from 2009 most JCT contracts contained supplemental provisions, which provide tools for collaborative working (Udom 2013). Government procurement, often related to large scale infrastructure, now frequently operates on framework agreements which provide longer term contractual security and the opportunity for relationship development. However, it is argued that as contracts are frequently amended by the main contractor, or client, to pass elements of risk to sub-contractors and other suppliers, effective collaboration is reduced. Indeed, Klein argues that the inappropriate allocation of risk generated by amended standard contracts or bespoke contracts contributes to the uncompetitiveness of UK construction (Klein 2018). This short overview of collaborative approaches within construction contracts is intended only to provide a brief insight into the context in which the Carillion supply chain team were operating. This serves to highlight how the Carillion supply chain team and the network actors perceived contracts in relation to collaborative working, identified as a requirement for the exchange of knowledge and implementation of sustainable build.

Both Carillion and the major suppliers saw the industry and the relationships within it driven by legal compliance, whether this was meeting regulation or contract demands. As one supplier noted ‘we are very, very legislation driven’ (SUP-4) and for Carillion ‘at a senior level there is only one strong driver and that is legal’ (SC-DB). There is a general acceptance, within the network, that contracts are punitive, with clients passing a high level of risk to the main contractor, who in turn pass elements of this to sub-contractors. Transferred risks to the main contractor normally include issues such as regulatory compliance, compliance with planning, sustainability standards, building performance,

and cost (BIS, 2013b). This engenders a highly transactional approach, frequently supported by the maintenance of extensive evidence trails, as network actors attempt to meet detailed client, or contractor demands. Carillion plc identified contracts as the second highest potential risk area to the business (Carillion plc 2017). This pressure created an atmosphere where initiating innovation (including sustainability) or additional complexity was difficult. As one supplier noted 'we're in an industry where most people just do what they have always done. Everyone is worried about risk' (SUP-8). Main contractors and many suppliers (SUP-3, SUP-8, D-HD, S-BM) believed that earlier engagement in the procurement process, would improve performance, both of their own business and project delivery. As S-SA noted 'set up should be the perfect time to discuss sustainability with the client….at the moment we can just tinker about at the edges. It's all been done'.

Whilst there is variation in how different network actors perceive early engagement, there is a general agreement between the manufacturer and Carillion that to affect sustainable product selection and process design, it must be early in the planning stage. Both the Carillion supply chain team, design team and manufacturer pinpoint this specifically as RIBA stage 2. This is an element of the RIBA Outline Plan of Work, used by architects and designers to plan the design process. At this point the Concept Design is produced in line with the requirements of the Initial Project Brief. Two important issues occur at this point; the design process is linked to the client selected procurement route and strategies are prepared. Indeed, RIBA note that the Sustainability Strategy is likely to be a fundamental component of the Concept Design (Sinclair, Beck & Tait, 2013). Early engagement by manufacturers and contractors at this stage appears to suffer from the belief by many clients that highly competitive procurement processes would offer them best value and that they, and others within the network, were constrained from pre-tender site specific product or delivery discussions by anti-competition law. The Carillion BIM team noted this as an issue with early stage product specification in the BIM model, highlighting that it was difficult because 'Carillion worked to EU procurement guidelines so it's an issue at design stage. At present 'designers tend to include a 'generic' door in their specs (specifications), as they're concerned about being anti-competitive if they name products' (O-BIM). This concern was endorsed by SUP-4 who said the delay in

being able to input product knowledge into a building specification was partly legal, it's the way people see contracts and tenders'.

Where network actors felt collaboration on sustainability was occurring more regularly was on large public contracts, especially those linked to major infrastructure projects. Frequently these were supported by long term framework agreements or ongoing engagement with long term projects. As the Carillion Work Winning team noted '…it's much more collaborative, even though it's a competitive process, different people within the Carillion bidding team will be working almost daily with the potential client – for example engineering meetings, development, and even sustainability' (WW-PM). Knowledge was exchanged and developed constantly through these interventions and as part of Governments contractual demand sustainability learnings were retained through legacy offers, primarily websites offering open access to case studies. This was first seen where Carillion worked on the London 2012 site but was also a major output for the Crossrail programme (Crossrail, 2018). Carillion also used case studies to capture examples of sustainable construction and these were regularly used in response to client tenders but remained un-used as an internal form of knowledge exchange.

There was a strong indication from Carillion's sustainability team members that PFI contracts offered similar collaborative benefits. S-BM stated that in his experience PFI 'allowed much more joined up thinking with the client and in the design teams'. He also identified that it was not just improved systems or contract terms that were beneficial but highlighted personal contact in which relationships were built and trust between network actors developed. He noted that there were

> 'certainly more workshops and discussions. There was a clear structure of End User, Client, Contractor and designer – all of which were based in an open plan office – aiding discussion …….(working) very much as one team' (S-BM).

However, whilst this may have been seen by the sustainability team as a positive structure, SC-DB noted that commercial imperatives still remained, and that PFI contracts were 'just a bit better than some of the straight developer led jobs'. There were also concerns by the Carillion SC team that collaboration and early engagement

may not be beneficial to them, indeed commercially, early engagement during the tendering process, had problems. SC-D1 stated that 'to engage with the designer, alongside possible key contractors, adds a lot of cost to a bid and loss of knowledge that may not be won back'. Tendering cost the Carillion many millions of pounds each year and the company was concerned that providing too much detailed expertise before tenders were awarded could increase costs and be transferred to built assets they did not benefit from financially.

7.3.2 Carillion and their suppliers

For the purposes of clarity, the key Carillion corporate documents referred to in this chapter are noted in the table below (Table 27).

Table 27: Carillion Operational Documents referred to in chapter 7

Document Name	Application	Reference
Carillion Sustainable Supplier Charter (2017)	Published Charter noting expected Carillion and Supplier Behaviours	Appendix 1, Figure 47
Carillion Labour Charter (2017)	Published and sent to suppliers	Appendix 1, Figure 50
Carillion Annual Sustainability Report	Published – primary focus is investors and clients	Various reports are included in the References of this thesis
SAF Score	Single score to rate supplier's environmental performance	N/A
SPI Reporting	Project site supplier rating	N/A
Carillion Project Procurement Strategy	Mandatory document completed by SC teams at outset of each project	N/A
Carillion Sustainability Policy (2017)	Sent to each supplier	Appendix 1, Figure 49

The provision of sustainability knowledge to Carillion from Tier 1 suppliers was at two levels and was through two routes. Firstly, with was through the registration of the supplier on the Carillion bespoke system "My Register". This primarily required the supplier to confirm and evidence of compliance or attainment of environmental or social standards. The second level of knowledge exchange was then then interaction with the SC team, either through response to PQQ or more project specific tender questions. With key suppliers there may also be additional meetings and conversations, both with

the SC team and category managers. Information on the sustainability requirements of the main contractor were identified in PQQ and tenders. Carillion's Sustainability policy (See Appendix 1, Figure 49) was provided to suppliers at their inception meeting. Carillion had created a Sustainable Supplier Charter (See Appendix 4, Figure 47) to illustrate how they expected their suppliers to support Carillion's aspirations, and most recently a Labour Charter (See Appendix 1, Figure 50), which set the standards expected from suppliers on fair labour.

The "My Register" supplier management system held an immense amount of data on their suppliers. It required each supplier to answer an extensive set of questions, more than 400 at point of registration. Of these the majority related to sustainability issues. All data was available to all approved Carillion staff through the company intranet and was searchable by company name. It was originally intended to provide the basis for extensive feedback on various aspects of supplier performance and to indicate where supply chain teams could support suppliers failing to meet certain categories. Medium and limited decision makers in the supply chain team saw My Register as providing an 'assessment regarding sustainability' (Carillion Supply Chain Survey 2016) and that 'Subcontractors and suppliers on "My Register" have the Carillion minimum requirements regarding sustainability… (so we would only have to ask more) ….if there is anything beyond this; we would work to the client specification'(Supply Chain Survey 2016). It is the researcher's belief for this element of the SC team, "My Register" provided an unquestioned, positive statement about Carillion supplier's sustainability credentials. This contrasted with the senior decision maker perception 'it's just about ticking boxes' (SC-PM) or making a similar point about data quality 'No one checks to see if its real or not anyway' (SC-P1). One senior member of the SC team more cynically noted "My Register" is seen purely as a risk management system – i.e. suppliers have been asked and therefore Carillion is covered' (SC-D1).

When reviewed in 2015, most of the supplier information appeared to sit unchecked, with many sections incomplete. Internal staff were fully engaged in checking supplier financial viability and validity of insurance and had not been trained on assessing sustainability data. "My Register" was also infrequently used to review supplier

sustainability; the S-BM was not even aware how to access the data or the range of information available. Vast amounts of data were unused and failed to be converted into useful knowledge. Initially intended as a secondary outcome of the data collection, by 2015 its primary use was to provide sustainability data for the Annual Sustainability report and potentially to 'give guidance to suppliers on sustainability issues. Despite its failings it was considered the best information available, and key metrics were drawn from the data and verified by external auditors.

One approach, to try and translate this excessive and complex data into usable knowledge, was the development of a simple sustainability score. Suppliers were rated solely based on their environmental management systems; the SAF Score (See Table 28). In 2015 when this research commenced the score had very little recognition or use by supply chain teams and was generally regarded by sustainability practitioners as a poor representation of broader sustainability goals as it only rated a supplier by sustainability policy, EMS or ISO14001. Information was not complete, and it was not clear how much effort suppliers made to keep information updated. This was illustrated when PQQ1, reviewed in section 7.1.2.1., verified 12 of the 13 suppliers with ISO14001; "My Register" had none of these suppliers coded A, the rating indicator for ISO14001 accreditation.

Table 28: Carillion Supplier Score (SAF) (Carillion Intranet, 2018)

The Scoring matrix is as follows

Code	Quality	Health and Safety	Sustainability
A	Must maintain accreditation to ISO9001 or equivalent - UKAS Certified. N.B. The only quality standard as from January 1, 2004 is ISO 9001. If a certificate shows ISO 9901:1994 or ISO9002:1994, they are no longer valid	Must maintain a safety management system in accordance with OHSAS 18001 PLUS the organisation provides specific information of: 1. How Health and Safety is controlled and measured. 2. How suppliers are appraised and vetted for Health and Safety management systems. 3. How suppliers are vetted for projet specific competence.	Maintain accreditation to ISO14001, UKAS Certiied, EMAS, BEA Environmark Diamond or equivalent. Sustainability Plan. Positve response to the questions related to employment practices of the supplier and the supplier supply chain, and the ability to provide evidence that goods are ethically and responsibly sourced.
B	Uncertified quality management system	Uncertified safety management system	Uncertified environmental management system
C	Quality policy statement	Health and Safety policy statement	Environmental policy statement
D	Agree to Carillion's policy	Not valid for this area	Agree to Carillion's policy

The other main method for understanding a supplier's sustainability rating was the SPI score. This was given much greater weighting by the SC team as it was generated at a

project level by the project manager. It was an effective review of supplier performance. Project managers were provided with a set list of questions and ratings for the supplier which they completed on an annual basis (see Table 29). This primarily rated supplier's on-site performance. The single sustainability question considered environmental, social and legal impacts in terms of risk and its mitigation. As with other SPI questions, suppliers were scored 0-4, with 4 equating to excellent. The language used in the question was confusing. Level 1 rating assessed sustainability awareness, Levels 2-3 related to the effectiveness of sustainability systems and to achieve a level 4 rating the description confusingly refers to both environmental and sustainability impacts. Suppliers were also expected to mitigate all likely risks to achieve this top score.

Table 29: SPI Sustainability Scoring (Carillion Intranet 2017)

Identification and mitigation of environmental, legal and social risk.
0 - Not Applicable
1 - Unacceptable. Little sustainability awareness and no system for identifying impacts
2 - Requires Development. Some impacts identified and attempts made to implement systems to mitigate them
3 - Acceptable. Systems in place to recognise and mitigate negative impacts.
4 - Excellent. Pro-active assessment of environmental impacts.A genuine culture of sustainabiity. All likely risks mitigated for all activities

Senior level procurement staff did not appear to know the basis of the sustainability scoring. When they were presented to SC-RM3 during a skype meeting she was surprised and felt this was not giving them the insight they had expected. She commented wryly 'Can't see a company getting a 4 unless they came to work on wind power'. It would suggest that sustainability was not a criterion that SC teams focused on when reviewing performance.

At the point Supply chain teams interfaced with the suppliers the knowledge of sustainability that extended upstream to them was limited. The Carillion standard Project Procurement Strategy required only two mandatory sustainability aspects: that of waste management on site and use of FSC timber. Additionally, teams required suppliers to support SME engagement, local supply, apprenticeships and community engagement which were frequent public-sector requirements and had been incorporated into Carillion Corporate sustainability KPIs. Specific client requirements, such as BREEAM or a similar standard, and other project specific demands, most frequently on major infrastructure projects would be incorporated in contracts. All

suppliers were sent a copy of the Carillion Sustainability Policy (see Appendix 1, Figure 49) at the first stage of tendering, it was resent to them with their order and again at the pre-start meeting (SC-D1).

Suppliers found it equally difficult to transfer information downstream through the network. One major manufacturer stated that

> 'we try to do this through our annual reports, presence at places like Ecobuild and through our online innovation portal…..but most of it is through our National Contract Managers. We tell them about the new products and sustainability activity and we hope it filters down to the project' (SUP-8).

Another supplier equally frustrated with getting information into the 'hands of the right people' noted that

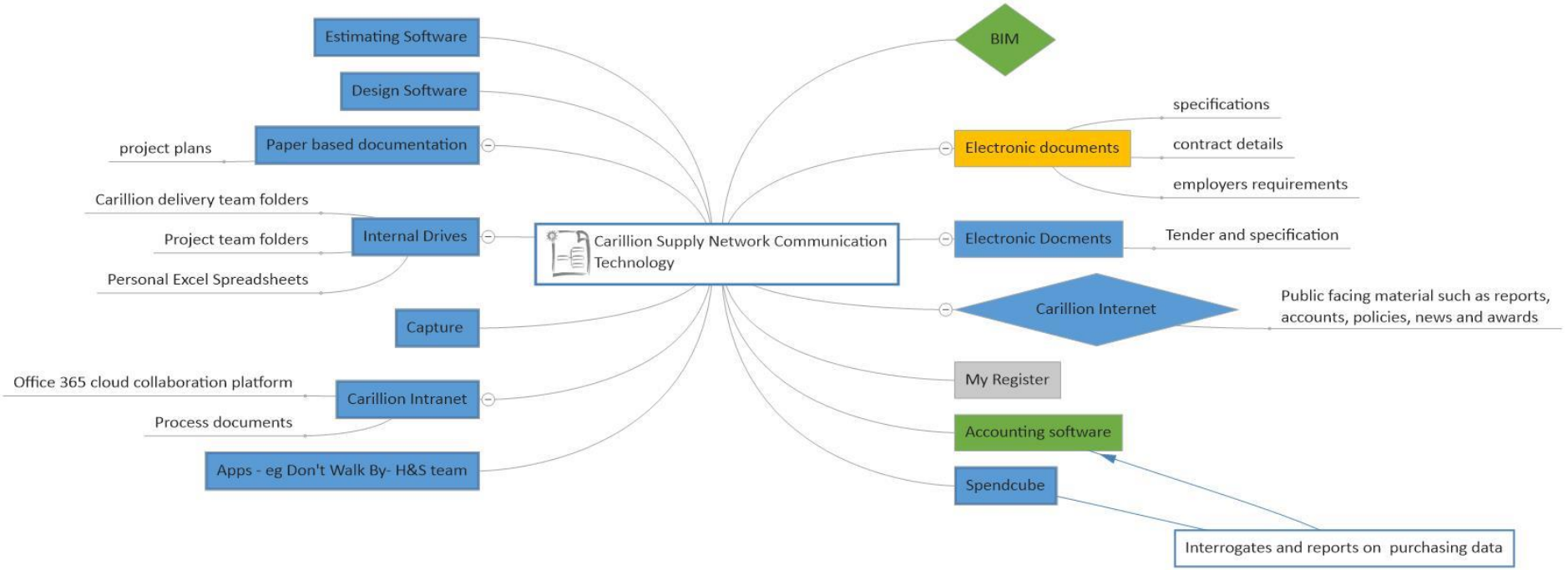
> 'we're often well down the chain – contractor, sub-contractor and sometimes even below that they let it out to someone else. We can be down at Tier 4. We just can't get innovation to a client' (SUP-10).

7.3.3 Technology and knowledge transfer

The main contractor operates as the central node in multiple contiguous supply networks. Each network produces a complex and unique product, and the main contractor is required to manage multiple suppliers, sites, clients, time constraints and cross cutting themes such as health and safety or sustainability to achieve the final asset build. Many other industrial sectors have adopted new technologies to support inventory management, logistics planning, and supply chain communications. However, it would appear from this research that whilst Carillion was increasingly implementing technology to enhance intra-company communication wider network engagement remained limited (see Figure 44). In this diagram, drawn from multiple interviews and observations, a range of intra and intercompany communications, were identified. All non-public information, such as intra company or private communications with network actors, is contained in rectangular boxes, publicly visible data in diamond panels. Where panels are coded blue this indicates the material presented has been developed by Carillion and is primarily used for internal communication. Grey illuminated panels are those where suppliers provide information. Orange coded panels are where information

is developed by clients and transferred to the main contractor. Finally, green panels indicate the forums where a data interaction occurs between Carillion and the wider supply network.

Figure 44: A Map of Carillion technology implementation relevant to supply network operations (2017).



A high level of traditional communication still occurred within Carillion's Tier 1 and client engagement. This frequently involved face to face meetings, especially with major suppliers at project inception, and were supported by telephone, and increasingly, Office 365 skype. Personal contact was recognised as a major method of developing relationships, building trust and exchange of knowledge. Traditional communication was increasingly being complimented by e-tendering and digital invoicing and payments. Whilst project plans continued to be printed and based at each site, shared servers were increasingly being utilised by intra-company project teams to store password protected project files. In 2017 the company adopted Office 365 with its cloud-based storage facility to improve internal communication and document management. Theoretically this provided much greater opportunity to share data, but the companies major project focus created data silos around each job. The company had attempted to provide greater clarity on company-wide procurement by using purchasing data, drawn from the finance system, and interrogated it using a software package, spendcube. This was able to provide purchasing data by value, by project, by supplier and using additional coded fields link the supplier to the most relevant construction phase, for example groundworks and the category of the product or service supplied. This, whilst offering greater clarity, had several flaws. Firstly, suppliers could only broadly be allocated to a category and whilst, for example, this might be titled 'ceramics' it could include a relatively wide range of related products and included labour costs, logistics and other services, including fitting. The category managers were very 'dismissive of spendcube' due to 'suppliers incorrectly allocated between them (the product categories)'. CM-6 felt that

> 'the spendcube had not been designed by anyone with an idea of construction procurement, and it would have been far better if it had been designed to use NBS (originally the National Building Specification)…….you could talk to any supplier using NBS spec numbers and they would know exactly what you were talking about'.

Category managers, who procured across project boundaries, spent time replicating procurement data in excel spreadsheets 'to keep track of materials and suppliers' as they felt it was 'the only way to get really accurate levels of information by product' (CM-5, CM-6).

“Capture”, the Carillion data capture system for all site-based reporting, annually required manual input of thousands of items of information. The coding was extensive, especially for detailed waste recording and the WWF Three Trees scheme linked to the FSC chain of custody programme. This data provided the basis for the environmental and social targets presented in Carillion’s annual report. There was a concern that ‘often “Capture” stuff was rubbish’ and data was regularly reviewed by the sustainability managers to remove numerous errors, often linked to incorrect units of measure being used. The reporting function was limited, and most managers downloaded data and manipulated it through excel pivot tables, a time-consuming process. It was a one-way flow of data and “Capture” did not provide a platform for suppliers to contribute or receive information. This created high levels of re-inputting of information. SC-DB did accept that in theory it could be useful for key suppliers to be able to input data, especially if you look at waste. Instead this was a major internal data exercise as one senior SC team member noted,

> We rely on waste transfer notes coming back to Carillion (from the waste contractors) with the breakdown figures post collection (from the construction site) and then some member of the contract team has to put them to onto “Capture”’ (SC-D1).

Carillion had elected, with spendcube, and two other data management systems, “My Register” and “Capture”, to develop adapted in-house programmes rather than utilising shared cloud-based, collaborative platforms. This was a strategic move to protect data and its perceived value to the company. The sites were managed by an external provider and rather than offering a flexible reporting function, each report request had to be individually funded. This dramatically reduced the value of the data and despite senior supply chain teams being keen to produce supplier benchmark reports no feedback was provided. The siloed nature of the data was further exacerbated as none of these major internal data management platforms were connected. Both “My Register” and “Capture” were created to provide Carillion with information, but both failed to offer the basis for enhanced network collaboration and knowledge.

Only one technology process was identified as providing a pan-industry base for collaboration, the Building Information Management (BIM) system. With its antecedents back to the 1970’s the current version of BIM was developed in the early

2000's and adopted by the UK Government in 2011 (UK Government 2011). BIM had been designed to enhance collaborative working by facilitating early supply chain involvement, underpinned by digital technologies. It was developed to support more efficient methods of designing, creating and maintaining built assets and does this through providing open asset data. Members of the Carillion design and supply chain teams saw the key characteristics of BIM as 'communications and information sharing, co-ordination and co-operation, joint decision making and problem solving and not least data management (D-HD). It did not comprise of one technology platform, but used multiple commercially developed software programmes, to support the different elements of the build and maintenance process. Indeed, a review of software identified 41 programmes currently available across different life stages or applications. These included seven programmes supporting sustainability, primarily on environmental issues (Bayyari 2015). BIM was still seen by the Carillion supply team as a new design and project management tool and was operated only on a small number of large Government projects, supported by an internal BIM team. The Carillion BIM team were working closely with the UK Governments BIM team (Digital Built Britain), but were finding it difficult to implement effectively. As one senior team member noted in 2016 'I'm very disappointed with the supply chain, and that's both consultants and sub-contractors. Just for basic BIM engagement it's like getting blood out of a stone' (O-BIM). A member of the Carillion BIM team was also concerned about the level of collaboration that was occurring, 'at Level 1 there should be coordination and design savings but we're seeing lots of designers not able to work with BIM' (O-RBIM).

Whilst created to reduce complexity and improve collaborative working the current limitations are summed up by an exchange between S-BM and O-BIM when discussing the potential of BIM to support the reduction of embodied CO_2.

> O-BIM: 'Consultants will create an indicative design. The product doesn't usually come in at this stage, it tends to be later in the design stage where actual product is selected.
> S-BM: 'Could we think about concrete; where we have done some considerable work on carbon?'

O-BIM: 'The structural engineer would specify the concrete type, it would be fully specified by the them. So, in theory this should be simple. But at some stage Carillion might decide to alter the specification.

O-RBIM: 'the spec is more about strength and load, depth and relevance – the engineer will deal with that. Carillion might choose to trim, or value engineer the concrete…..(they) would usually would redesign with the consulting engineer.'

S-BM: 'How do we manage this? How can we find out the carbon footprint of say the concrete used in the building?'

O-RBIM: 'Well, the BIM model would tell you how much concrete is poured. The design is owned by the consultant, but Carillion could get access.

O–BIM: 'BIM may not give you what we buy. The spec is put in by engineers and then may be amended by designers. The model may be 'as built'. Designers may update it with actual products but unless it is in the spec to provide this information then the contractor won't know. The people who will know will be the Quantity Surveyors'.

Here it is clear that whilst multiple parties are engaged with the BIM model, implementation of different elements of the work remains highly fragmented and knowledge is siloed. Surprisingly actual material or product use, unless this is specified by the client, may not be available through the BIM model. Just as with the main contractor, even with BIM, the client may not know exactly what they have bought. This has major implications for developments in design for disassembly, resource management, potentially health and safety issues and the efficient management of the facility.

Several engineering consultancy firms had started product testing scenarios which incorporated embodied carbon within BIM models. This was uncommon and most engineers, where they had the capability, ran carbon databases and models offline. The reluctance to incorporate sustainability factors into BIM models appeared to be due to capacity issues with staff grappling with the basics of new technology, a belief that requirements needed to be set up from the start of the project and a lack of flexibility in scenario testing. Separate analysis could also helped protect investment in consultant funded carbon databases. However, it must be noted that this was not a major element of the research and would warrant further investigation, Other sustainability data such as water use was not found within a BIM models used by Carillion, but it was clear from

discussions within the industry (D10) that consultants were beginning to develop other impact metrics within their databases. They were also interested in how to address social impact which they saw as a useful option for clients wanting to address social value within asset build. Whilst sustainability metrics could be incorporated into a BIM model there is uncertainty about how BIM could be utilised, especially in supporting environmental impacts. As noted by a sustainability manager within one of the UK's product manufacturers noted:

> 'There is a thought that BIM is a way of collecting data. But I think if we are not careful the BIM model file will get so big that actually, although the idea is there, the reality is that it's going to be a nightmare to do' (SUP – DM)

And for another manufacturer there were still major concerns about how information could be shared:

> 'BIM – it might drive change, but at the moment it is only a few jobs using it, and whilst you can add generic BIM objects, and it could be carbon or recycled content, there is no way to share the information – that's a problem' (SUP-8).

The scale of BIM is ambitious, and it is endeavouring to provide a transparent universal 'bill of materials' and features that can be accessed by all actors within the supply network to create building models. How this can be utilised to improve the sustainability of an asset is still unknown, although a reduction in wasted materials and improved asset use and maintenance phases are key parts of the existing programme goals. This would be a major achievement. However, discussion with Carillion team members would suggest that the technology alone is not going to achieve collaborative working and the development of shared sustainability knowledge. In another project, operating as a PFI the Sustainability Manager noted;

> 'At project XX we had a clear shared platform which design teams and client accessed and could see developments. There was definite collaboration. The technology gave us a shared platform for design and specifications without the usual contract style/payment constraints linked to outputs/deliverables' (S-BM).

Here the example indicates that whilst the platform provided the mechanism for collaboration it was the nature of relationships that enabled collaboration to thrive.

7.3.4 Comparison to literature

It is recognised within the industry that there is a need for knowledge sharing or the management of knowledge to support the diffusion of new sustainability ideas throughout the supply chain (Egan, 1998). Indeed, engagement also must operate across project, firm and professional boundaries (Cushman et al., 2009). Kurtz (2012) suggests that knowledge flowing across organisational boundaries, through multiple actors creates, competitive advantage for the whole supply network. Knowledge transfer from suppliers, who have detailed product or process knowledge, at an early stage of project development is identified as critical for success (Saunders L.W., Kliener et al. 2015). However, it is also acknowledged that lifecycle-thinking and influences are frequently undervalued, and often considered only in the later stages of a construction project (Eriksson, Westerberg 2011).

Yet, the study of knowledge transfer and flows in networks and inter-firm relations has been limited (Dyer, Nobeoka, 2000, Sorenson, Rivkin & Fleming, 2006) and has only had minimal application to either the construction sector or more specifically that of sustainability knowledge. In conceptualising the supply chain as a system, Smimov (2000) suggested the function of knowledge management within the supply chain is to promote knowledge transfer thus optimising knowledge amongst its actors and sharing risk and revenue. However, (Fernie, Tennant, 2013) note that in the construction sector the translation of supply chain management 'appeared disconnected from views that supply chain management meant holistically managing chains or networks'. Indeed, Schneider (2012) suggests that some companies may not recognise that sustainable sourcing is an integral part of corporate sustainability and needs to be implemented in a systematic way. Indeed, Carillion had only begun to map out a sustainable procurement strategy in 2017, strongly driven by learnings from this research. This would appear to be supported by a survey of 2244 global companies by McKinsey in 2017 which identified that the top reason for companies to address sustainability (46% of respondents) was their alignment with corporate mission, values and goals, yet only 26% had embedded sustainability in their supply chain management (Bové, D'Herde & Swartz, 2017). It was also noted that integrating corporate sustainability policies into project management systems was difficult (Corder et al., 2012). Glass (2011a) found a

lack of knowledge and understanding in some key areas of sustainable construction, which suggested a gap between corporate values and operational expertise on the ground, a position strongly corroborated by this research.

Research into knowledge sharing or flows identified they are impacted by both individuals and the context in which they are operating (Waheed, Fernie, 2010). Working in another industry sector, research by Singh demonstrated that once interpersonal ties have been accounted for, the effect of regional or firm boundaries on knowledge flows is reduced; interpersonal networks affect knowledge transfer (Singh, J., 2005). This was exemplified by the Heathrow Terminal 5 project where contractors were required to jointly identify project risks. Initially difficult, through dialogue they were able to overcome feelings of vulnerability and lack of trust to find solutions. They realised that they shared common ground and from this understanding they were able to develop integrated working (Demaid, Quintas, 2006). This would suggest an aptitude towards knowledge sharing is dependent on both context (Reagans, McEvily, 2003)and personality traits (Hendriks, Hofstee & Raad, 1999).

One of the greatest barriers to collaboration and knowledge exchange identified by Carillion procurement teams, contract terms, are well established with (Tennant, Fernie, 2011a) noting that the selection of 'the contract type by the client is pivotal to the ongoing client-contractor relationship'. However, many respondents observed that, on the whole, clients were at best lukewarm towards a genuine collaborative approach (Bishop et al., 2009). Although other types of contracts more aligned to sharing and developing knowledge have emerged, such as NEC 3 and partnership contracts (see section 7.3.1), have emerged traditional contracting still remains popular (RICS, 2007) despite its adversarial and short-term approach (Briscoe, G. H. et al., 2004). Traditional contracts also assume that risk is passed down the supply chain and it is argued that this makes it more difficult for subcontractors to engage (Akintan, Morledge, 2013). There is little or no evidence of the use of collaborative tools in traditional contracts (Eriksson, Laan, 2007).

This research identifies major tensions between legal barriers to early engagement and pressure on network actors to collaborate. This is corroborated by (Tennant, Fernie & Murray, 2014) who note that competition, enshrined in EU law, has created major commercial barriers to the adoption of collaborative practices such as knowledge transfer during early engagement. It is at the concept stage that procurement strategies are determined and lack of stakeholder engagement at this point is seen to limit resource efficiency (UNEP, 2014). In research with sub-contractors, Akintan and Morledge (2013) noted that main contractors failed to include their Tier 1 suppliers in the decision-making process because they themselves were not involved. He felt this was doubtful as they controlled the flow of information, but this research would suggest that main contractors also struggle to collaborate effectively with clients and designers. Main contractors, in interviews, confirmed they had different relationships with subcontractors on different projects depending on the contract type (Akintan, Morledge, 2013) and project context (Green, S. D., Fernie & Weller, 2005).

The UK Government believed that construction companies abandoned partnering behaviour, if they had ever adopted it, and returned to transactional based contracts as soon as economic conditions weakened (E.C Harris LLP, 2013). It is suggested that strong relationships and knowledge exchange can exist only where longer pipelines of work occur (Green, S. D., Fernie & Weller, 2005), such as those that operate within framework contracts (Green, S. D., Fernie & Weller, 2005, Udom, 2013). Egan (1998), in his major industry review, Rethinking Construction, identified the adversarial approach embedded in contracts as a major barrier to the development of a more efficient sector. He believed that with time contracts could be phased out and hoped that, 'If the relationship between a constructor and employer is soundly based and the parties recognize their mutual interdependence, then formal contract documents should gradually become obsolete'. Whilst not dismissing the role of contracts, but the need for them to support collaboration, Shaun McCarthy, previously Chair of the Commission for a Sustainable London 2012, stated in an industry publication:

> 'If I had a magic wand I would tear up all the forms of contract we have in the industry now and start again. I would draft something similar to the Heathrow Terminal 5 agreement that allocates collective responsibility, risk and reward to all the businesses

> contributing to a project. This would require collaborative behaviours. What you contract for is what you get' (McClelland, 2015).

The importance of the approach used at Terminal 5 was endorsed by the Head of the Infrastructure and Projects Authority who identified this as template for future industry projects (Hancock, 2018). Even when controlling for different contract types it appears that positive relational attitudes significantly enhanced collaboration and contributed to project performance (Suprapto et al., 2016).

Whilst there is extensive comment on contractual impediments the literature also highlights that these need to be seen within the industry context. Indeed, it is argued that the nature of the industry, with ingrained practices and incentive systems, institutionalises adversarialism rather than collaboration and knowledge sharing (Cox, A., Ireland, 2002, Ng et al., 2002); contracts are merely a reflection of this approach. An obsession with reducing costs incentivises procurement teams to focus on lowest price, and yet at the same time clients and senior managers recommending collaborative working (Bishop et al., 2009) as it is seen as the route to improved efficiencies and innovation. Eriksson also identified client desire to increase cooperation but no willingness to change their procurement practices. This dichotomy led to constant 'commercial corporate gamesmanship', a point reflected in the difference between corporate rhetoric and on-site delivery (Tennant, Fernie & Murray, 2014). Others suggested that partnering in the supply chain was seen as important but that network actors lacked an understanding of the concept and the ability to implement (Akintoye, McIntosh & Fitzgerald, 2000, Saad, Jones & James, 2002).

In an industry where, transactional processes are the primary method of engagement between network actors, it often left to individuals at the point of contact on site to develop spontaneous relationships. This operates in a 'knotworking' style, not dependent on central controls. As a result, collective learning and knowledge-sharing occurred in a largely informal, ad-hoc fashion (Bishop et al., 2009). To overcome the limited dispersion of knowledge created by the project focus, there has been an increasing use of technology. However, there is a perception that the construction

sector has been slow to introduce new technologies. Work by Akintoye and McKeller (1997) identified integrated information systems as having low status in comparison to other sectors and additional survey results in 2000 suggested that one of the least important factors in developing supply chain relationships were information systems (Akintoye, McIntosh & Fitzgerald, 2000). In 2005, Green and Fernie noted that some major national contractors still did not even possess a centralised database of their subcontractors (Green, S. D., Fernie & Weller, 2005). Shelbourn (2006) and Maunula (2008) note that managing knowledge and co-operation with their supply base, has increased as construction companies have improved their information management systems, primarily through the use of IT. Work by McDermott et al. (2004) confirmed that project participants were increasingly realising the benefits of information sharing but this was contradicted by the work of (Dainty, Briscoe & Millett, 2001). They found poor information sharing between main contractors and sub-contractors, especially under traditional contracting procedures. Not unique to the construction sector, a similar lack of alignment of systems and technologies has been identified more recently as a challenge in the food sector supply networks (Touboulic, Walker, 2015).

In response to information failures, both in terms of project and asset management, the UK Government elected to mandate the BIM system for all public contracts. Whilst this is primarily a collection of factual data BIM allows information to be shared with all actors and promotes collaboration. UNEP believed that BIM would facilitate life cycle decision making and supply chain collaboration, supporting network actors' early input into the design process (UNEP, 2014). More recently Grover (2016) states that BIM is moving the construction process from "lonely" to "social" data, where network actors can easily share information with each other. However, use of BIM is not standard across the industry and research by BIS suggested that 'it was not in front of mind of many supply chain participants' (E.C Harris LLP, 2013, p.92).

The role of BIM in enhancing knowledge exchange through collaboration remains contested. Some researchers note that there are encouraging signs of collaborative working amongst supply chain members (Owen et al., 2013) whilst other question how BIM relates to the dynamics of supply chain management and collaboration (Dike,

Kapogiannis, 2014). There are several researchers who suggest that BIM can promote rich information exchange which cross-functional and cross-organisational communication (Singh, V., Gu & Wang, 2011, Bryde, Broquetas & Volm, 2013). Yet frequently there appears to be a disconnect between what the system can do and what happens at an operational level. To test this Grover (2016) worked with BIM during a live project to assess its usefulness for the capture and reuse of tacit knowledge at both a project and building asset level. Based on only 44 interactive comments, it suggested that the platform had limited impact, but could offer continuous feedback between network actors and increased collaboration.

Many of the technology approaches to improving exchange across the supply network are information based, a suitable use for digital technologies. As, however was noted in Carillion's use of their internal data capture systems "My Register" and "Capture", having information and deriving useful knowledge from this are two separate issues. Demaid and Quintas (2006) note that there is 'an inexhaustible and recurring demand for easy solutions to ill-structured problems'. The conversion of tacit to explicit knowledge is still seen as a holy grail (Tsoukas, 2003) and whilst computers offer effective ways to analyse systems they are less effective at portraying complex systems using narrative and information representation (Demaid, Quintas, 2006).

7.4 Conclusions

Carillion procurement and sustainability teams had only limited knowledge of lifecycle thinking and did not have a holistic view of sustainability impacts across the supply network. Indeed, presentation of existing academic and industry research, led the company to question where they should be 'putting time and effort' (S-BM). Individual members within teams had different ideas and perceptions of what sustainability entailed and there was a sense of trying to achieve disconnected outputs that frequently contradicted efficient working by teams, such as the engagement of SME suppliers. Major building clients did not appear to be driving sustainability demands or expertise exchange through their supply networks, a different position to that occurring in major Government infrastructure projects. Here main contractors, such as Carillion, were being challenged to develop expertise in embodied carbon and biodiversity through

framework requirements. This knowledge was developing in infrastructure operational management, but primarily still retained by specialist sustainability teams; failing to extend into wider intra-company learning.

The insight, provided through Carillion team member interviews, identified the importance of experiential learning for many of the participants. The most engaged individuals appeared to be those whose knowledge was underpinned by personal values and for whom the acquisition of knowledge further reinforced and developed their views. They also appeared to be most open to the acquisition of propositional or learning from facts-based knowledge. Strongly motivated individuals also saw themselves responsible for sharing their knowledge and attempting to implement change, despite limited client demand. Category managers offered a potential route to span sustainability siloes across the network, building relationships with key manufacturers, where knowledge resided. Working directly with preferred manufacturers through a framework type approach allowed earlier supplier engagement in the tender process, a major barrier identified within the client-main contractor tendering process. This is an area unexplored by existing academic literature. The contracting process, despite increasing 'collaborative clauses', guidelines on collaborative working, and partnering contracts, still reflects an adversarial approach where risk is offloaded from focal company to suppliers. Whilst many academic papers focus on the lack of sustainability knowledge within the upstream supply network, this research suggests that it is also an issue within the main focal node; the client. The client sustainability demands remain limited at point of project procurement; indeed, it could be argued that sustainability knowledge is not being developed by Carillion teams because there is little requirement to learn. Professional bodies, who have strong representation in the construction sector, require continued professional development and offer extensive guidance and learning materials. It was surprising that they received little reference within SC team discussion, although this could be that CIPS, have traditionally not offered sector specific guidance.

Whilst information technology has increasingly been deployed by the construction sector, it has both created new fragmentation and barriers as well as supported

increased transfer of information. Carillion's data management systems did not communicate with each other, they were expensive and difficult to navigate, often requiring communication with specialist data managers and with exception of e-invoicing and supplier data entry directly to "My Register" did not provide a platform for external network collaboration. Similar issues appeared to exist amongst many other organisations. As noted by Demaid, Quintas (2006) frequently technology was seen as a solution but often did address the problem, in this case the exchange and development of tacit sustainability knowledge by network actors in an industry where 'sharing' remains culturally and financially unrewarding.

Chapter 8. Discussion

This research was undertaken to assess if a main contractor, represented in this case study by Carillion plc, plays, or could play, a leading role in sustainable construction. The review of existing academic research, primarily focused on corporate sustainability or dyadic relationships, identifies that this subject has received limited attention. The potential for the main contractor to lead sustainable construction at a holistic level, encompassing upstream and downstream construction network actors, is a major gap in knowledge. Three research questions were framed, to address this overarching issue. The first questioned the capability of the main contractor to manage the supply network, the second their ability to manage sustainability issues across the supply network and thirdly, their capability to deliver sustainable built assets. This discussion draws from the findings of the four themes that emerged from this grounded theory research to consider these three issues and the extent to which this work has been able to answer the research questions posed.

Through the theme findings, multiple gaps in knowledge, relating to the UK construction industry, have been identified and greater illumination provided. These include the impact of fragmentation on supply network sustainability, the nature of sectoral fragmentation, and the failure to operationalise a holistic approach to sustainability. The research identifies not a construction supply chain but a supply network, where sustainability is considered, operates not much as a global value chain but has greater similarity to global production networks where 'non market' actors are acknowledged and incorporated into the network. Research on inter and intra-company collaboration and the role of sustainability knowledge within UK construction supply chains are themselves major gaps in knowledge, with little academic work having been undertaken in this field.

8.1 Introduction

The importance of this network actor as a valid point of study was confirmed in literature, being identified as one of two major focal nodes within a construction supply

chain, the other being the client (Tennant, Fernie, 2011b). The main contractor, on behalf of the client is responsible for procuring products and services and manages the construction of the built asset. However, the process is not aligned with sustainability goals. As Glass et al (2011a) note, there is an apparent failure of the main contractor to lead the management of the supply chain with the aim of achieving a sustainable built asset. Failure to adopt supply chain management is identified by Egan (1998) as a major barrier to greater efficiency in the sector and by Akintoye, McIntosh & Fitzgerald (2000) to a more equable allocation of value across the network. Assessing Carillion on the Lockamy III and McCormack (2004) supply chain maturity matrix (Table 1) suggests they were operating primarily at a low level of maturity; Level 2 i.e. they had some structures in place but operated with little change in traditional working practice. Only for major infrastructure projects did they reach maturity Level 3: the increased collaboration, trust and developing strategy identified by Lockamy III and McCormack (2004). The recent adaption of SCM to encompass sustainable supply chain management (SSCM) also offered the main contractor a method to manage suppliers to support sustainable practices. It is certainly clear from an extensive literature review and this case study, that there are continued sustainability failings across the UK construction supply network, including poor resource use, exploitative labour issues, high wastage, minimal traceability of materials, slow adoption of technology and limited innovation. However, the concept of SSCM has only limited global adoption and it remains relatively unknown in UK construction. The Carillion SC team were not aware of sustainable supply chain management practice and whilst sustainability was being incorporated within the delivery requirements of construction network actors this appears to have been fragmented, uncoordinated, unaudited and poorly recorded.

This work contributes rich information, based on the practices and perceptions of a main contractor's procurement and sustainability teams. This has been supported and triangulated with insight from key manufacturers and other network actors through interviews, publicly available materials and discussion. Open access to supply chain teams and sensitive commercial information is unusual and offers a perspective rarely observed in this sector. The use of a grounded theory approach required the researcher to be led by the perspective of the main contractor teams, from which emerged key

themes relating to sustainability in construction. This created a complex response that better reflected the cross cutting, multi-disciplinary approach that reflects the real-world view of sustainability. Throughout this discussion the researcher has attempted to reflect the findings within a life cycle thinking or systems perspective. This discussion has been structured to focus first on the main contractor, its team members and their perspectives, before broadening the debate out to the construction network, and finally to the consider the whole life of an asset.

One further point needs to be noted at the start of this discussion section. This is to establish the relevance and applicability of findings derived from the case study participant, Carillion plc. The company, as noted in earlier chapters was identified by both the UK construction sector and wider industry as a leading example of a company adopting sustainable practises. They had publicly reported on sustainability issues for over twenty years, won awards for their work and were respected for their sector engagement. However, in January 2018, primarily driven by low margins and cashflow issues (The Economist, 2018), the company went into liquidation. The primary research material for this thesis was gathered between May 2015 and June 2017. The researcher does not believe that the sustainability approaches and thinking observed at an SC and sustainability team level, the major internal focus of this research, were practically impacted by financial pressures beyond those normally observed across this sector.

8.2 The capability of the main contractor to manage the supply network

The academic literature places a major focus on UK construction as a project led industry. Carillion were operating not so much as a single company, but as an internal network of complex and often conflicted specialist teams. Whilst bound by corporate values and a requirement to meet corporate targets, team members coalesced within constantly shifting project groups, which were often managed at a sub-regional level. In 2015, Carillion's construction business managed 702 active sites and the project focus led to both team fragmentation and regional differences in practise and approach. The demands of clients for bespoke assets required the main contractor to be adept at managing complexity, time pressure and be able to draw the relevant expertise and materials from the supply network. The contractor had developed working practises to

manage this flexibility, with high levels of independent decision making at site level. However, in this highly transactional sector, short term projects left participants with little time to develop relationships with clients. This appeared to inhibit the adoption of new approaches and supports the findings of Gadde and Dubois (2000). Only at the level of senior decision maker and corporate team was a more holistic view of the supply network and sustainability identified. Frequently, procurement and operational teams considered company sustainability targets as 'extra work' rather than integral to their roles and SC teams questioned the responsibility of the main contractor to operate at a level of sustainability beyond that required by project.

Internal information systems were primarily created to deal with project demands which, although becoming technically more sophisticated, still reinforced siloed working. For example, most information was held in project files accessible only by authorised team members. Whilst this was a necessary part of managing, often confidential data, after project completion there was little attempt to derive future value from lessons learnt. This was identified as a failing by high-level decision makers, as knowledge frequently remained locked into project team experience. Recognising these issues, Carillion had implemented computerised technology systems, online access to supplier records and electronic invoicing to improve information from site and suppliers. However, by mirroring paper-based systems, they failed to provide the platforms for streamlined collaborative exchanges. Whilst they did provide high volumes of data, both "Capture" and "My Register" (Carillion data management systems), were poorly audited and understood, and report generation was expensive. They operated mainly to provide information for corporate reporting and financial management, missing an opportunity to create interactive knowledge exchange between suppliers and the main contractor.

The Carillion sustainability team and Carillion SC team felt highly constrained by client specifications, unable to make substantial changes even when they operated a Design and Build contract. All members of the supply network were concerned about legal challenge if discussions occurred between the client and suppliers prior to tendering. Senior team members were also concerned that this could result in the unpaid transfer

of knowledge. Tendering for contracts drew together Carillion bid development teams, work winning teams, the supply chain team, and internal design teams. Yet, despite tenders frequently taking months to complete, teams felt they were engaged too late in the discussions to 'make a real difference'. This concurs with existing literature where network actors identified early engagement as a route to improved outcomes (Alwan, Jones & Holgate, 2017). Carillion SC team and design team highlighted RIBA stage 2 as the design stage at which design could be influenced, yet, as noted in chapter 4, 80% of Carillion contracts were tendered at RIBA stage 3; too late to affect the design sustainability strategy or influence asset design. This frustration was not unique to Carillion but was also seen in key manufacturers.

However, it is important to note that the concept of 'making a real difference' most often appeared to be associated with 'value engineering' where procurement teams identified and eliminated unnecessary costs. Where clients did incorporate substantive sustainability requirements these frequently appeared to be a mandatory response to planning requirements, primarily for BREEAM or CEEQUAL standards. Only 6.9% of the SC team noted they regularly worked to client sustainability specifications. This would suggest that many clients are either not specifying, or if they are, this is not reaching procurement teams. Clients also appeared to value earlier engagement, but legal restrictions and fears of anti-competitive challenges were also identified by them as the primary reason for failing to collaborate at the development stage. It was also noted by SC team members that clients continued to believe that the tendering process offered them the opportunity to achieve the 'best price'. Framework contracts identified by Carillion SC team, primarily in connection with infrastructure projects, appeared to reduce this tension and, combined with longer project lifespans, increased both the dyadic collaboration between main contract and client and built relationships between contractor peers and with key manufacturers.

Extensive use of subcontracting made management of the supply chain for sustainability unlikely in an industry where relationships beyond Tier 1 are rare. Analysis of Carillion's CCS procurement data evidenced for the first time the extent of this approach, with 65% of the company's 2015 purchases being for services, such as sub-contractors, specialist

consultancy, and wholesalers. This also identified that 81.9% of spend was with just 181 companies and of the top 80% of the spend 60% was procured directly with sub-contractors. In effect main contractors were frequently talking to network actors who, like themselves, had limited direct social and environmental impact and equally extensive and transient supply chains. Whilst Carillion did indeed have direct control of the procurement of materials and services, although a few clients procured in bulk, they were often constrained by the requirements of a client specification or the cost prices they had quoted. However, as seen in chapter 4, Section 4.2.3, the requirements for each asset were grouped into packages, often relating to build stage, such as groundworks, or M&E and tendered to Carillion's suppliers. The sub-contractors in turn then procured the necessary services and materials to complete the specified work package. Carillion SC teams were distanced from the suppliers who were generating the greatest environmental and social impacts, with major manufacturers regularly operating at Tier 3 or even Tier 4 within the network.

Most startling was that the siloed nature of project information and the practise of procuring work packages resulted in the main contractor only able to identify procurement at supplier level and broadly defined product category and sub category level. This meant that Carillion plc, at a group level, had no idea what products the company was buying. Discussions with other main contractors suggest this was not a unique position. There appeared to be three primary reasons for this; firstly, the scale and variation in products procured, for example their key wholesaler supplied them with 5000-6000 product lines annually, secondly the autonomous management of projects at this granular level and finally, the value of this information to the main contractor was less than the cost of acquiring it. Another major barrier to the procurement of sustainable products was that the SC team identified sourcing new and innovative products as time consuming. This conflicted with highly time and cost pressured roles and appeared to offer the company little short-term benefit. Selecting sustainable products without a specific client requirement conflicted with the prime aim of minimising short-term costs. Taking on a focal sustainability role within the network was not seen as benefit by the SC team, as they felt it could increase risk. This was magnified

if the client was not specifying sustainable products, as the main contractor operated at minimal margin and did not have the flexibility to lead the network.

Through interviews and surveys this research has also provided a more extensive insight into the knowledge and operationalisation of sustainability by a main contractor's SC team than any previous work. It found that SC team members have limited experience of sustainability and, except for those operating in the infrastructure sector, limited client demand. Whilst senior decision makers had a more nuanced understanding of sustainability their procurement teams identified sustainable products with increased cost and did not believe sustainability added value to the main contractor. This contrasted with the promoted message of Carillion's corporate sustainability team who identified multi-million-pound savings annually from sustainability practise. At a corporate level, Carillion did not identify corporate financial risk from environmental issues, whilst social risks noted were primarily linked to legal compliance (Carillion, 2017).

SC teams were not aware of the high impact of the pre-operational phase in the existence of a built asset (Figure 34), nor its increasing importance as 'in-use' impacts declined. Despite identifying a whole life product approach as most closely aligned to sustainable procurement, their lack of knowledge on lifecycle impacts of a built asset led them to undervalue the importance of their role. There was little demand for Environmental Product Declarations or similar LCA type information to support product procurement, instead the preference of medium and limited-level decision makers was to rely on supplier guidance or to use common sense, in effect basing decisions on existing knowledge and judgement. The acquisition of knowledge was strongly identified with experiential learning by SC team members, under-pinned by personal values. However, this created gaps in understanding as project sustainability requirements were often limited; manifested as waste management, FSC timber or the percentage of SME procurement contracts achieved. The SC team identified a strong synergy with supplier and colleague values, which suggested a basis for more relational engagement. Indeed, it appears that running in parallel with the transactional process, there is a level of

informal relationship between suppliers and main contractor. For the majority of SC team members engagement with downstream actors remained transactional.

8.3 Managing the supply network for sustainability

Supply chain management practise had been integrated into Carillion procurement but was perceived primarily as the management of multiple Tier 1 supplier relationships, and therefore SCM operated in a weakly adapted form. This concurs with work by King and Pitt (2009) and Fernie and Tennant (2013). In 2015 Carillion operated not one, but 702 supply chains, each unique to a built asset and requiring multiple services and products. It can be argued that this complexity of component parts is not unique. Indeed, many large multi-product manufacturing companies exhibit even wider product inventories, yet they operate under different supply chain conditions; requiring continuity of supply over a mid to long term time period. Construction supply chains change frequently during each build phase and exhibit a high level of non-conformity between different asset types. Construction supply networks can exist for just a few months or extend to several years. To illustrate this, Carillion had nearly 17,000 suppliers on its database, yet only 7929 of these were required to provide product or services in 2015. The company was operating a large number of supply chains which formed a complex network of constantly engaging and disengaging actors, rather than a linear upstream and downstream structure. Indeed, in Carillion's database major manufacturers were operating contiguously at Tiers 1, 2 and 3; industry peers could be both competitors and suppliers, and designers might operate as both supplier to the main contractor on one project and as a client representative on another.

The complexity of construction projects, the scale of the supply network, its episodic nature and the passing of major workpackages to sub-contractors appears to have limited any mapping of construction supply chains by the main contractor. The Carillion SC team only recorded information on Tier 1 suppliers, although during the tendering process suppliers in a higher risk category, such as clothing, were required to disclose the country of origin of procured materials. This would appear, from industry discussions, to be a reasonably common position. The research also indicates that network actors have their own horizons or boundaries within which they operate and

as the FSC case study illustrates, the actor position within the network affects the relevance and importance of different sustainability goals. This supports the findings of Schmidt et al (2017) who identified that each supply chain actor has its own perspective of sustainability, dependent on their position within the network. This questions the effectiveness of focal companies to manage sustainability by imposing a standard set of sustainability targets on their suppliers. In reality, sustainability goals will vary in importance between type of actor and the role or roles they play within the supply network. This would suggest that sustainability targets could be more effectively implemented if they were aligned with network actor function. Indeed, at an industry level, targets could be based on an analysis of the whole-life of a built asset and identification of environmental and social hotspots analysis across the supply network. The industry does not currently take this approach and there is no network actor who currently has an oversight across the whole life of a built asset. Only in the sphere of climate change and greenhouse gas emissions is there any form of alignment as Government policy, legislation and public-sector procurement demands combine to meet The Climate Change Act and the Paris Agreement targets. Elsewhere there is no indication that the supply network is holistically managed by either the client or main contractor to drive sustainability improvements, but rather it acts as an autonomous network of actors responding to ad hoc initiatives, driven either by legislation or project demands.

The research clearly shows that sustainability was not the lens through which the construction supply network operated. Indeed, for many of the SC team it was just ‘another new initiative’ to be managed, in addition to building the asset. For Carillion the strategic focus was to consolidate their supply base to improve internal control, whilst ensuring a wide enough base of financially stable organisations able to offer low prices and quality through competitive tendering. Sustainability of either product or process was not a primary supplier management goal. Much of the literature ascribes the failure of the sector to change practice due to its maintance of traditional work practices e.g. the continued craft approach to building processes (Tennant, Fernie, 2011a), adversarial contracting (Bishop et al., 2009), cost cutting (Fawcett et al., 2012) or the passing of risk between client, main contractor and sub-contractor. Whilst these

offered considerable barriers to change the senior SC team members were highly competent problem solvers. What appeared to be lacking to drive sustainability forward, in this highly transactional industry, was client demand.

This was not to suggest that Carillion did not promote sustainable practices but that there was a disconnect between corporate vision and implementation. The company had multiple sustainability policies highlighting expected supply chain behaviours, and they requested extensive sustainability information when a supplier registered with the company. This however, appeared to have little value to the SC team, it was frequently seen as a 'tick box exercise' by suppliers and was used primarily for KPI and corporate sustainability reporting. Most SC team members considered the tender process as the most effective way to gather current supplier information which was relevant to the project requirements. This continued to result in siloed information and prevented the benchmarking or sharing of supplier data at a company level. The other major difficulty experienced in managing, even Tier 1 suppliers, for sustainability was that with 65% of Carillion suppliers offering a service primarily based on labour the subsequent environmental issues had limited relevance. The majority of these suppliers were sub-contractors who managed specific works packages and who operated in a state of mistrust derived from the main contractor passing down project risk, continued cost cutting and high levels of litigation. This barrier limited the main contractor's ability to collaborate directly with those who had both the greatest topic knowledge and impacts, the product manufacturers.

Only Carillion's category management approach appeared to have the potential to make strategic cross-network connections. Although initially working with manufacturers to support product volume discounts it was clear that category managers engaged directly with the manufacturers or key service providers. They had product and sub sector expertise, were able to bridge the gap between client and manufacturer and most crucially, the role removed them from the direct negotiating and often adversarial role of the SC team. From discussions and observations these relationships appeared to build trust through sharing commercial information and offered increased collaboration. Category managers were able to review key suppliers within their sectors of knowledge

and, working cross company, select those providing the best quality, range, ability to innovate and price. Carillion had started to flag these preferred suppliers on their database. Category managers working with these suppliers on a framework basis, collaborated with them on client bids. Increasingly, the SC team required sub-contractors to ensure Carillion's preferred suppliers were included in their work package sub tendering. Just as with procurement processes, sustainability was not a major element of discussion with suppliers, as highlighted by the example in chapter 6, Section 6.4.1.1, where the sales team of a key Carillion supplier were unaware both of their own company's sustainability actions but also of Carillion's interest in this area. Despite this failing this research would suggest that the category management approach has potential to link actors responsible for sustainability impacts, with clients, designers and stakeholders beyond the main commercial network. This would also offer a less adversarial and more collaborative space in which to operate. Category management could provide an effective approach to develop the strategic partnerships suggested by Saunders et al (2015); i.e. support earlier engagement with environmental and social issues.

8.2.1 Sustainable procurement

The SC team viewed client demand for sustainable procurement as minimal but acknowledged that an increasingly number of tenders were requesting the contractor's sustainable procurement strategy. This created a tension between clients working to minimal legal compliance and with low cost, on-time and risk management as key priorities with a more holistic approach to environmental and social challenges. For the procurement team at Carillion, whilst many had personal interests in sustainability issues, their actions were driven by client demands. Client sustainability requirements that were most regularly managed by the SC team were either legislatively driven, such as green asset standards and contractor waste management, or public-sector policy requirements for engagement with SME or local suppliers. Clients would of course expect main contractors to meet all other legal requirements related to the operational site, such as pollution control, and health and safety. Only with FSC timber did Carillion's corporate policy dominate, regardless of client specification. This was driven by senior decision maker commitment and high-level board support. However, it was a position

with which senior team members found it difficult to enforce both with procurement and operational staff, and suppliers.

As highlighted by several senior SC team decision makers, the client's sustainability requirement had primacy over Carillion's corporate strategy goals. This created tensions between corporate sustainability teams, relying on Carillion business units to integrate sustainability into operational practise and deliver the companies sustainability targets. This was particularly difficult in building projects where the main contractor often had limited short-term relationships with the client and where the developer had little interest in the longer-term performance of the built asset. There was a strong belief that if the project was a speculative build that 'it was going to be unsustainable ……. sustainable procurement would just make it less so' (CM-4). Infrastructure projects were noticeably different. Here clients were frequently quasi-governmental and thus strongly impacted by policy requirements, in addition to legal compliance. The assets, usually managed by the commissioning client, had long-life spans and developments were subject to greater public scrutiny. Sustainability policies and strategies were integral parts of asset delivery programmes and framework contracts allowed for greater collaboration between client and suppliers, frequently over longer periods of time. The difference of approach between building and infrastructure was reflected within Carillion, where sustainability initiatives primarily had to be funded from project budgets. Infrastructure, especially rail, had a strong sustainability team that was increasingly working on more innovative projects such as net positive biodiversity, embodied carbon data capture. The infrastructure procurement pilot reviewed in this thesis (chapter 7, Section 7.1.2.1) was the outcome of the latter collaboration. In the Carillion buildings sub-sector, the sustainability team was small and narrowly focused on site environmental compliance.

8.2.2 The development of sustainability knowledge

Whilst the SC team considered 'everyone responsible for sustainability', intra and inter-company, and non-commercial network actors had a different understanding, perspectives, drivers and approaches to sustainability which affected their implementation. Just as Carillion teams operated within a plethora of 'sustainability'

definitions and an increasing number of competing or overlapping standards so this was observed in other network actors. Sustainability was seen by procurement, sales and operations teams as a complex, specialist subject which was constantly evolving and, just as with other areas of construction specialisation, was frequently 'sub-contracted'. This was to corporate sustainability teams, specialist companies, NGO's, academia, trade bodies, and Government departments. This resulted in knowledge silos, with sustainability actors frequently operating at the periphery of the commercial network. Even where sustainability expertise was high, as in heavily regulated manufacturing sectors or commercial consultancies, sustainability teams could be marginalised or struggle to embed sustainability as a primary business driver. Knowledge held by non-commercial actors such as NGO's and academia was highly specific and was often focused on a particular campaigning remit or area of academic research. Whilst these actors were engaging with Carillion and other main contractors to support the commercial application of this knowledge, it appeared that their most valuable role for the network was that of a critical friend. Only Government engaged with a broad range of sustainability issues across the life-time of an asset. Whilst Government regulation drove change, their role as a client appeared to inhibit collaboration.

Industry based sustainability experts, engaging in collaborative practise, were frequently involved in knowledge developing and sharing forums, such as those for the development of new standards e.g. PAS2080, industry funded sub-sector groups e.g. CIRIA and UKGBC, or social and educational platforms e.g. BITC, Supply Chain School. Collaboration was open, and relationships and trust developed between participants, unaffected by commercial constraints. These non-state market driven (NSMD) structures offer a second, relatively unexplored, construction actor-linking function. They strongly contrast, in this research, with the highly transactional and low collaborative structures observed within the main construction process. However, it should be noted that the implementation of NSMD generated knowledge or guidance was considered by participants to be weak and with limited industry reach. This failing occurred even when sustainability experts from main contractors, clients and manufactures collaborated in these forums; the knowledge remained siloed. This was outside the scope of this research but suggests an area of further exploration.

8.2.3 The role of the two focal nodes

The sector has been identified as operating two focal nodes, that of the client and the main contractor (Tennant, Fernie, 2011b). This research suggests that whilst this is true, they occupy different functional roles within the network. The main contractor operates as the focus for the process of construction whilst the client is the focus for the built asset and indeed the owner of the final product offer. The client is acknowledged as the primary source of contractual information, initiating the asset design and setting the specifications for the primary contracts. It is these requirements that flow through the network, via contract documentation and setting out the relevant, if frequently adapted, specifications for each network actor. Clients strongly shape the strategic relationship with main contractors (Briscoe, G. H. et al., 2004) and increasingly the use of long term framework agreements by major infrastructure clients has led them to consolidate their supply networks (Fernie, Tennant, 2013).

When considering the product being procured by the client, i.e. a built asset, its material composition, construction, use and demolition are not individual operations but processes that operate across the lifetime of an asset. If this lifecycle approach is adopted, the client or commissioner of the asset must be the prime focal point; the leading organisation within the network. Indeed, this has been recognised by RIBA with the introduction of Stage 0 in the RIBA plan of works. Stage 0 is used to ensure that the client's business case and the strategic brief have been properly considered before the initial project brief is developed (Sinclair, Beck & Tait, 2013). This research suggests, that the public sector, primarily central Government, is in the strongest position to provide the leading focal role on sustainability within the network. The important role of public sector clients is further endorsed by the work of Briscoe et al (2004). Furthermore, the public-sector operates as the most dominant UK construction client, procuring 23% (by value) of all UK construction in 2017 (ONS 2018). However, whilst they continue to undertake green procurement, operated through their 'Greening Government' initiative (HM Government, 2015), their position offers leverage, its dual role of both regulator and client may create conflicting targets. Sustainability appears to remain marginalised in the drive for industrial growth, the primary focus of the UK's industrial strategy (UK Government 2017).

8.4 The capability to deliver sustainable construction

To create a sustainable building requires informed knowledge about environmental and social impacts embodied within the supply chain, to prioritise outcomes and to accept trade-offs between impacts at key decision points. It also requires the ability to assess the built assets future impacts and create high value reuse at point of demolition. Carillion did not have a holistic view of the environmental and social impacts associated with a built asset nor understand how they related to the activities of different actors within the supply network. For Carillion, their primary sustainability focus was the construction site which comprised of CO_2 emissions from fuel use to site and on-site activity managing water, waste, community engagement, worker health safety, fair labour and staff skills development. They were not unique in this position. As noted by a manufacturer's sustainability expert 'the industry was failing to recognise that the network had to look at the whole ecosystem, not just focus on one part' (SUP-8). Research was frequently separated by sustainability issue, with few studies offering a holistic view of both social and environmental impacts.

This breadth of vision was also hampered by the limitations of available information. Few academic papers took a lifecycle approach suitable for sector level analysis (EIO-LCA) and those available only assessed certain issues; CO_2 (Acquaye, Duffy, 2010, Kucukvar, Tatari, 2013) and water (Crawford, Treloar, 2005). Several private consulting firms had built LCA based carbon databases, but they were not freely available and only utilised by a few clients at the design stage. The Bath ICE database was considered out of date and RICS had not been able to update and publish an embodied carbon benchmark (Ford et al., 2017). This literature was unknown or poorly understood by most actors within the construction industry and this included Carillion sustainability teams.

Evidence from Carillion suggested that capturing detailed data on these issues was time consuming and costly. Additionally, in a sector with high variability in annual operations, direct comparisons of impacts or benefits on an annual basis could mask decline and improvement in performance. Working upstream they had extended their boundaries, creating a supplier database that offered data on supplier sustainability, but where

information remained unconnected to products. To extend this work to capture similar metrics for each built asset would require major investment in data systems and technology, not only for the main contractor, but also its suppliers. As noted in chapter 4, a main wholesaler in the construction sector (SUP-4) carried over 90,000 product lines; the variation and complexity were immense. Whilst the main contractor was better placed in the network to undertake data capture than an occasional speculative developer, it had been Government who took an industry lead. Government, initially driven by failings in its own estate management, had sponsored the use of BIM. Whilst not currently a feature in BIM, it is feasible that environmental and potentially even social impact measures could be incorporated into each BIM model at design development stage. This research only identified a small number of cases where carbon allocations had been tested within BIM models.

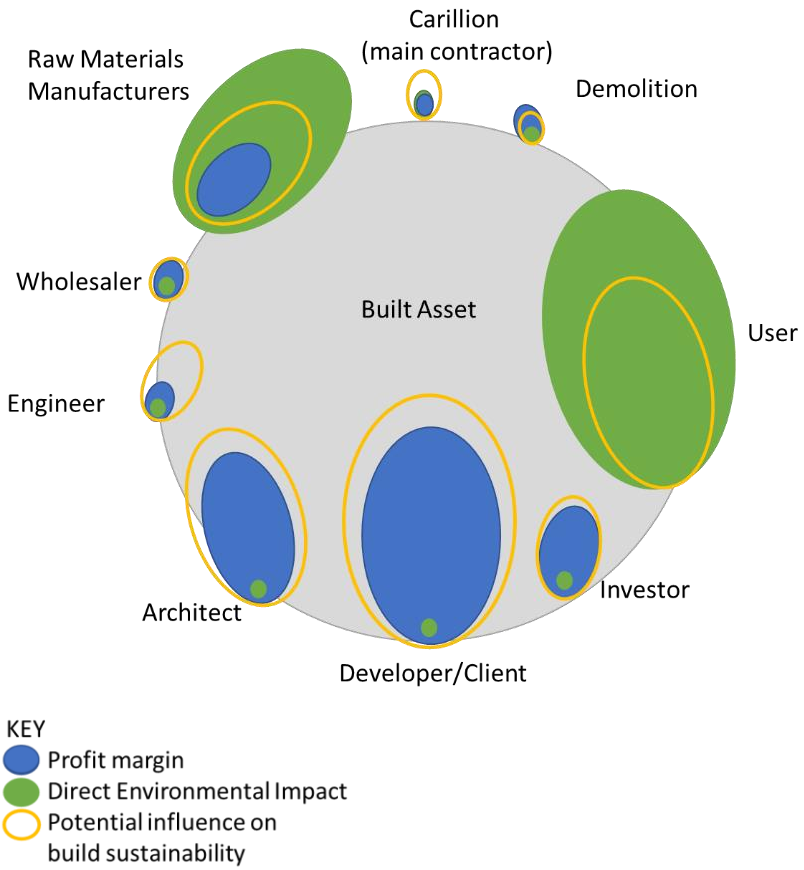
Infrastructure clients were starting to adopt a more holistic approach to construction and incorporating sustainability requirements into contracts, including the measurement of embodied carbon. This was being led by the UK Government, the primary client for major UK infrastructure projects, and was driven by the Climate Change Act (UK Government, 2008a) and the Paris Agreement (UK Government, 2016b). Whilst they initiated national strategies, policy, and legislation to support carbon reduction implementation was still limited, often focusing on major flagship projects (De Silva M., Paris R., 2015). In contrast, few private developers of buildings were taking a whole life sustainability approach. Primarily focused on 'construct and sell' they had little financial penalty for poor in-use building performance, even when building emissions were being underestimated by 3.6 times the anticipated in-use phase (Innovate UK, 2015, Palmer, Armitage, 2014). It could be argued that without clearly defined whole life approaches the main contractor was striving not so much for sustainable construction but rather construction which included sustainability.

The analysis of network actor goals confirms that there is no standard set of KPIs for the sector and that actors select KPIs and targets primarily driven by external pressures such as legislation or client demand. Carillion, with their operational boundaries set at site and estate level, demonstrated that a blanket application of GRI reporting targets led to

an unbalanced match of effort, cost and effect when wider whole life thinking was applied. Weighting of targets was primarily driven by customer demand or legislation. The research also suggests that targets varied in importance by job role, in addition to network position. For example, Carillion's SC team identified that achieving the 'SME procured' target as more important than the company's carbon reduction goals. There is no indication that network actors in construction are focusing on targets that are most effective on a whole life basis. For Carillion, sustainability targets were primarily focused on a percentage reduction on company baseline environmental data or a percentage improvement in social impacts e.g. number of hours of staff volunteering. Each impact was targeted separately, and they had no decision-making process in place to consider trade-offs between impacts internally, or across the supply network. The supply network approach taken by the UK Government's carbon 'Routemap' (Ove Arup and Partners Ltd, The Climate Centre & WRAP, 2013), requiring an 80% reduction in carbon by 2080, provided sub-sector targets. These had not been integrated into Carillion's KPI methodology. At a global scale application of planetary boundary thinking, working within earths operating limits (Clift et al., 2017), has not been considered in UK construction, with only limited awareness of the concept amongst sustainability experts within the industry.

Whilst Carillion operated at a focal construction node, with little profit margin, minimal site based environmental impacts and limited influence over design, it was difficult to see how they could play a leading role in the sustainability of the built asset. Just as this research has identified the knowledge silos that exist within the network, so academic literature frequently operates within fields of expertise. In Figure 45 the researcher has brought together an economic and environmental representation of the main network actors. This utilises profit margin data reviewed in Table 18, and estimated environmental impacts presented in chapter 2. Influence has been included but this is highly subjective, and is an estimate based on literature, interview notes and other materials.

Figure 45: Schematic illustrating estimated direct environmental impacts, annual net profit margin (2016) and influence over the sustainability of the built asset



The figure demonstrates that of all network actors the main contractor can least afford to undertake an innovative sustainability position unless funded by the client. This would include taking responsibility for sustainable procurement and SCM or SSCM. They also operate at a point within the network where their direct impacts (based on construction activity and own estate) are low and economic return on managing them is relatively limited. Contrast this with raw material suppliers or manufacturers and the final end users (assuming they are tenants). Here impacts, such as CO_2 emissions, are high but benefits for improved efficiency are equally relevant. Most dramatic is the role of the client or developer where their direct environmental impacts are minimal, yet profits exceed any other network actor. This analysis would suggest that whilst the main contractor is highlighted in the literature as the most able to affect sustainable or responsible procurement (Glass, Achour, Parry et al., 2011a) they are failing to do so because of limited client demand for sustainability. This is especially so in the buildings sub-sector with punitive contracts reducing the main contractor's capacity to fund innovation. It also undermines the assumption of supply chain theory that to be effective

benefits must be accrued equally across the supply chain (Akintoye, McIntosh & Fitzgerald, 2000).

This research identified that not only was there a disconnect between network actor role and influence, there still remains considerable variation in the approaches being adopted by network actors to achieve sustainable construction. Client contracts primarily focused on environmental compliance, except in infrastructure projects, where embodied carbon and biodiversity are becoming an increasingly common issue. Environmental compliance requirements were understood by main contractors and, providing no unexpected issues arose, could be costed reasonably effectively into tenders. Where the implementation of sustainability became much less clear was in social engagement. Here many public-sector clients expected high levels of local community engagement and volunteering, the management of skills programmes, local employment and SME suppliers. These were in addition to legal compliance such as health and safety, environmental standards and fair treatment of workers. The Social Value Act has increased this pressure as public-sector procurers are now legally required to review the opportunities for enhanced social value in all tenders. This is seen by Government as 'an opportunity to drive more value through every pound spent' (DDCMS, 2018). Whilst this formed part of the tender package it was clear that an element of social value was expected to be delivered as part of the companies CSR programme. This created 'sustainability inflation' whilst price continued to be pushed down. This research indicates that the line between a procured requirement and social responsibility has become increasingly blurred.

As the client sub-contracts the processes of procurement and construction to the main contractor, they pass on the associated risks, as well as the likelihood of expensive litigation. This suggests that even simple innovation may be a high-risk strategy, as voiced by the SC team and emphasised by their view that leading on sustainability in the sector would not be in Carillion's interest. Examples where this barrier appeared to be overcome were led by changes in client behaviour. Firstly, during a PFI hospital project, sustainability was set as a prime client requirement. Main contractors, client and

suppliers worked together to problem solve, with project cost savings shared between network actors. During the construction of the Olympic Park for London 2012 the Olympic Delivery Association (ODA) addressed the issue of economic benefit and value across the supply chain by incentivising either through share of savings or through awards and recognition. An example of this was the roof for the Veledrome which was amended to a steel cable-net structure which used only 1/10th of the materials originally planned. This change also reduced installation time and improved health and safety. This was supported by a contract that was based on a target price and provided for flexibility in design and a share of savings (DEFRA, 2013). A second type of approach was seen at Heathrow Terminal 5 where the site owner did not pass on risk to the contractors. This both incentivised and increased the ability of contractors and other suppliers to collaborate and problem solve (Demaid, Quintas, 2006).

Chapter 9. Conclusions and recommendations

9.1 Contribution to knowledge and practice

This research has attempted, through an inductive, grounded theory approach, to understand the role of the main contractor in the construction of a sustainable built asset. The research has evaluated the question through a life cycle, or systems, approach, viewing the main contractor not as the pinnacle of a supply chain but as one actor within a network that is itself embedded in the whole life of a built asset. Operating as a major focal node within the construction supply network, the main contractor fulfils three vital roles, that of materials and services procurement, the process of construction and as a pivotal point for upstream and downstream network actor engagement. Based on these functions this work questioned their ability to play a leading role in creating sustainable built assets. Firstly, the main contractors' ability to drive sustainability at the construction site level and secondly to create sustainable built assets. The latter focused on their ability to ensure that products utilised within the build had minimal embodied environmental impacts and maximised social benefits whilst offering built asset users best in-use performance over its anticipated lifetime.

Based on the Carillion case study, this research concludes that the network role currently played by a main contractor prevents them from leading on the whole life sustainability of a built asset. Despite their focal position within the construction supply network, Carillion did not have a strategic network-wide perspective of sustainability and could not offer a clear, long term vision for other network actors. The company perceived improved sustainability as one of incremental change, primarily at site level. Their sustainability targets were shaped by client demand, legislation, reporting standards and corporate values. This approach to target setting created a fragmented, siloed, shifting and expansive set of goals which offered no prioritisation focused on outcome (the long-term sustainability of an asset) or the basis on which to identify and manage complex sustainability trade-offs. The research also suggests that this top down target setting, fails to prioritise issues by network actor function and can lead to a disproportionate company focus on low impact areas. Similarly, at a built asset level, sustainability offers value collectively to all stakeholders, but its value will differ between network actors. Sustainability, in the form of energy savings, and therefore

cost, may be highly advantageous for manufacturers or building users but it had little cost benefit to Carillion or indeed for speculative developers. Value gained from sustainability improvements are not shared equally across the network. Working with very low profit margins the main contractor's ability, or interest, in innovation was limited primarily to process improvement or value engineering that provided immediate cost benefits. Thus, for Carillion, and many other main contractors, sustainability activity remained primarily focused on areas of direct company influence with little commercial appetite to extend this beyond corporate boundaries.

For the Carillion SC team members, able to manage constant change and high levels of complexity, it appeared that sustainability knowledge, whilst important at a corporate CSR level, was not perceived to offer operational value. The research found no evidence that social or environmental issues were strongly embedded in supply chain team knowledge or in procurement processes, unless specifically demanded by clients. In an industry where experiential learning is important, little direction from clients, and operating within a network actor where sustainability offered few cost benefits, limited the SC team's understanding of sustainability issues embodied in each project supply chain. Furthermore, their ability to effect change across a highly fragmented supplier and product chain was restricted. this research found no evidence of effective supply chain management practice, or indeed sustainable supply chain management beyond Tier 1 suppliers. Increased specialisation of network actors and procured expertise, as described by Green (2009, p. 34) is not unique to this sector, nor is the rise of complex intra-company networks. However, this research suggests that there is an element of fragmentation that is unique. This is the fragmentation created by a multiple client base which drives non-uniformity of assets and operates with a complete separation between production of the asset and the 'consumption' of the end user. This has created a situation where neither main contractors or clients are aware of what is embodied within the built asset and nor do they have a vested interest in how it will perform in the future.

The research clearly identified that two subsectors, with different approaches to sustainability, operated within the industry: infrastructure and buildings. The former

worked under conditions that appeared to favour the embedding, however imperfectly, of sustainability into the build process. These include dominant investor demand (Government or utilities), a long-term investment perspective and client led network wide collaborative sustainability groups which embed new sustainability protocols into commercial contracts and build specifications. In the building subsector there was little evidence of investor demand, developers had limited interest in building performance and sustainability requirements were implemented mainly to conform to planning regulation. In both subsectors, Carillion's SC team relied upon asset specifications to manage procurement and were highly frustrated that they were often unable to collaborate with clients at an early stage of design. The SC team estimated that 80% of projects were contracted at a design stage which only offered minimal opportunities for Carillion to influence the asset build. It should be noted that in the building sub-sector, where there was limited client demand for sustainability, and no sustainable procurement strategy in place at Carillion, there was little evidence to suggest that earlier collaboration would focus on sustainability. The research also highlighted a more disturbing position; that low client interest in sustainability, transmitted to procurement teams via specifications, not only failed to drive sustainability into the built asset but reduced intra-company focus on Carillion's own sustainability goals.

Cross network collaboration on sustainability issues, similar to that witnessed within infrastructure projects, was also occurring in the building sector. Rather than being client driven this was often led by NGO's and comprised of industry working groups. However, these collaborative forums appeared to function on the periphery of commercial activity with findings and recommendations often failing to be operationalised. Whilst the research was not able to fully explore the role of category management it appears to offer a hybrid approach to collaboration; removed from direct commercial pressure but firmly embedded in procurement practice. Indeed, including category teams in industry working groups could support the development of the 'devolved collaborative supply chain clusters' proposed by Stevens and Johnson (2016). Of all the network actors identified, the UK Government was in the position of greatest strength to provide the oversight necessary to refocus the supply network to deliver sustainable built assets. Where this has been attempted, for example through

the work of the Green Construction Board, Government has focused only on one issue, carbon. Their 'Routemap' did offer a long-term vision, based on the UK's national 2050 emissions reduction targets, rather than focusing on incremental improvements. However, with no methodology available to allocate this goal across the supply network, or on how to relate it to individual organisations, targets were not being integrated into company operations. This research found, a supply network separated not only by sub-contracting and project-led positions but by expertise, systems and knowledge siloes, rather than one collaborating to support sustainable issues.

9.2 Recommendations to enhance construction network sustainability

Drawing from the grounded theory research findings, which provided the basis for the research question discussion in sections 8.2-8.4, recommendations for the construction sector have been undertaken. Whilst some of these points are well established within the industry as barriers to supply chain efficiency, this research highlights that they are not merely an issue affecting productivity, time and costs but additionally they have major implications for the management of sustainability across the network. Sections 8.4.1- 8.4.9 below identify the practical recommendations that have been developed from this research.

9.2.1 Set network wide goals at a network boundary level, both at a global level and network actor

Drawing from the findings of the theme on knowledge sustainability issues remain strongly focused at corporate or business boundary positions. However, this research suggests that to be effective sustainability goals must relate individual network actor goals to asset sustainability. These must operate across supply network, engaging not just direct commercial suppliers but also clients, designers, professional bodies and government. Therefore, the recommendation is that:

- goals should be set by actor type
- one language set and definitions must become the norm
- goals should have longevity, even if projects do not
- Do not presume that main contractors can act as 'mighty buyers', the work must be collaborative

9.2.2 Set goals based on outcomes, not incremental improvement, and prioritise

Within the current business model this research has identified key issues that need to be overcome to ensure future built assets are not merely more sustainable but that they are sustainable. With the undoubted urgency of the issues of climate change and the recent declaration of a climate change emergency the researcher would suggest that environmental issues, especially CO_2 reduction should be the primary goal of the sector. This is in line with current Government policy and is a key feature of the Construction 2025 strategy. Whilst sustainability remains an overarching aim this research suggests that complex, boundary crossing issues, such as CO_2 emissions (both embodied and in-use), have lower priority from network actors as individual companies focus on issues within their own corporate boundaries. In this case study the main contractor offered a wide range of sustainability actions but frequently these were focused at a corporate level and isolated from the actual built asset, this was especially true of those related to social and community engagement. Environmental issues received less attention and focus as they have to be managed through multiple tiers of suppliers as part of the project procurement, often without the support of client requirements.

9.2.3 Create client benefit from retained risk

The passing of risk from the client to the main contractor, and thence down the supply network creates little appetite for any form of innovative practise or 'untested' materials: the barrier of 'clients want innovation but not if its new' (SUP-10) leads to 'most people always doing what they have always done' (SUP-8). In examples where clients have been prepared to take on risk, such as Heathrow Terminal 5 (Demaid, Quintas, 2006) collaboration between contractors has occurred as trust is developed and values become more closely aligned. This has led to shared problem solving and re-evaluation of work practices, including sustainability.

9.2.5 Link sustainability expertise across the network and into commercial process

Sustainability knowledge continues to be the remit of experts, siloed in areas of the supply network. Whilst NGOs and other non-commercial actors within the construction network have been successful in bringing together industry actors to develop new guidance, training materials and standards their knowledge frequently remains trapped

within company silos or at the level of the individual participant. To support the building of sustainable built assets, knowledge must not only be linked across network actors but be incorporated into the commercial process. This research suggests that category management has the potential to fulfil this function. With category managers embedded within procurement teams and expanding their product expertise to incorporate sustainability issues they have the capacity to link upstream and downstream actors.

9.2.6 Sustainability becomes a key project goal – not a peripheral requirement

The phase 'make sure it doesn't get in the way of building' is a pithy analysis of the current position of many sustainability issues within construction. This research focused on a main contractor respected for its sustainability stance, yet found little evidence that project aims, or operations were focused on enhancing sustainability. Carillion's requirement for the use of FSC timber, despite little demand from clients, was one of the few areas where sustainability was considered as an important element of product quality. Examination of PQQs and tender documents illustrated that even during the contracting process sustainability was identified as an 'additional section' rather than embedded in quality or technical requirements and rarely generating scores above 5% within tender assessments. This approach and attitude to sustainability must change, moving it to the core requirements of a project; indeed, where procurement becomes synonymous with sustainable procurement.

9.2.7 Develop network knowledge

Sustainability of an asset is multi-faceted, looking not only at the materials used in the build but the way in which they are combined to minimise future impacts during use, refurbishment and deconstruction. The sustainability of a built asset includes environmental, social and economic issues and at build or use stage this demands continued consideration of priorities and trade-offs. As discussed in chapter 7, section 7.3 much of the expert knowledge on this subject is retained in industry silos. Whilst it can be difficult to translate expert technical information into general knowledge it is vital that this is undertaken, and that personal knowledge is expanded. Presentation approaches utilised during this research, supported by interview notes, suggest that visual representations of issues are useful and when linked to interactive discussion

based on actual work experience are highly effective in embedding knowledge. Participants in the research interviews and workshops also found it useful to see how sustainability operated at a network level but then have this translated into the key impacts they could address. Failure to ensure this specific engagement, translated at both inter and intra-network actor level, is likely to result in the position that 'everyone is responsible for sustainability; so, someone else will be doing it'.

9.2.8 Overcome rational self-interest

Individual companies within the supply network are highly focused on their own corporate aims, attempting to maximise their profits by managing their risk and engaging in value engineering to cut costs, whilst still meeting their contractual requirements. However, as established in chapter 2, sustainability of an asset can only be achieved by engaging with all issues and impacts across the supply network, over time. This creates tensions between actors as this can lead to inequality of actor benefits. This is illustrated in the literature where measures such as energy efficiency gains frequently offer most benefit to manufacturers and community action may be a cost to sub-contractors but help main contractors meet client contracts, and indeed clients to achieve planning requirements. This inequality of benefit creates a situation where working to achieve the sustainability of the built asset is likely to be irrational for individual network actors, even though they may perceive this as morally valuable. To create a network with shared sustainability goals, this rational self-interest must be overcome. Examples of where this has been achieved were highlighted in the research and these have been noted below (Table 30):

Table 30: Examples of projects with shared sustainability goals

Cited examples of change	Scale	Lever	Driver	Underlying public/private initiative
Heathrow terminal 5	Asset	No passed risk and cost + profit	Client	Private
PFi hospital	Asset	Shared goal setting and sharing cost benefits	Client	Public/private
London Olympics	Asset	Value sharing, awards, high profile	Government policy	Public
Greening Government	Asset/Product	Procurement process	Government policy	Public

This would suggest that the client, whether in the private or public sector, has a major impact on setting a clear framework at the outset of projects which provide clear sustainability goals and share the benefits, or potentially costs, that may come with this stance.

9.3 Recommendations for policy makers

This research has value both to major construction network actors and to Government as they develop the UK's Clean Growth strategy. Encouragingly Government, within its most recent Sector Deal (UK Government 2018), highlights an aspiration to move away from direct cost to whole life asset cost. The findings from this research suggest several approaches that could be undertaken to support this position. Firstly, Government must appreciate that rather than dealing with a supply chain they are operating within a highly complex but effective, if not efficient, constantly shifting supply network. This creates difficulty in managing top down requirements. As seen in the example of FSC timber, goal setting was driven by the network role and there was little overlap in SDG goal selection between those working in global forests and the stakeholders of the main contractor. Understanding the perspective and role of different actors could make leveraging and supporting impact reduction more effective. It would also suggest that driving one set of targets down through a supply chain may not only divert focus and

resources from locally more important issues but also lead to a false belief in the magnitude of sustainability achieved, as in the example of Carillion and on-site water management illustrated.

Equally important is that there remains only limited research on impact hotspots within the UK construction network, for both environmental but most especially social issues. This research would suggest that understanding, and applying, these hotspots at a network level would allow key issues to be identified with the relevant network actors and thereby enabling the development of pan network clusters to drive implementation. This collaborative approach has been demonstrated for product groups at a sector level, with member organisations such as MPA or CARES supporting collective environmental and social change. These however remain focused on individual product improvements rather than being set within the context of a built asset's whole life impacts. Category management also offers another cross-network approach that warrants further research. This would allow expertise to develop across product stakeholder groups, but importantly would remain embedded in the commercial process, increasing the likelihood of implementation. However, it unlikely that such mobilisation would be enough to drive change. Egan (1998) believed that increasing alliances within the supply network were important in modifying the demands of less informed clients. This research suggests this is unlikely to be a successful strategy if main contractor supply chain teams continue to prioritise client demands above more sustainability focused corporate aims. Change must be supported by interventions that continue to drive client specifications and target support at high impact supply network issues. However, without established methods and tools to evidence change it will be difficult to measure the effects of any interventions. This research found local data capture to be of poor quality, often difficult to access, and where data was collected overlaps occurred between network actors.

Finally, the inductive nature of this research has provided greater insight into behaviours and knowledge within a main contractor than any previous research. The SC team members had only limited awareness of life cycle thinking and where major sustainability impacts occurred within the supply network, they overestimated the

impact of the main contractor. As noted by (Thormork, 2006) materials procured with an understanding of their impacts can dramatically improve the outcomes and the evidence from Carillion commercial teams is that their knowledge of sustainability is narrowly focused and often mis-informed. There is no hierarchy of importance between sustainability impacts, and teams have little awareness of the trade-offs that may be required, although this concept is one they deal with as part of everyday commercial practice. There were no examples of industry tools that would support this decision-making process. And finally, whilst there were examples of research in other sectors, further work on Behavioural Supply Chain Management (BSCM) could be valuable in construction, not least to support the development of enhanced collaboration.

A case study approach was deployed in this thesis as it offered a 'bounded example' through which greater understanding of problems can be derived when examining a complex system, in this instance, a construction supply network. Whilst it is accepted that case study findings are unique, this research has endeavoured to provide external viewpoints on the key themes identified. Whilst this thesis is based on a single case study, triangulation of emergent information with key suppliers and other industry organisations provides greater confidence that the findings, derived from Carillion's role as a main contractor, are transferrable and provide guidance to inform further research. The impact of Carillion's demise on the applicability of the data has been considered and, as noted in chapter 8, is unlikely to have affected the outcome of the data gathered during May 2015- June 2017. It should also be noted that the researcher experienced a high degree of openness from interviewees, both within the company and in key supplier organisations. There was no obvious sense of reticence in the responses to questions.

9.4 Limitations and future research

By taking a grounded theory approach, and being undirected by previous research, themes could emerge from the extensive interviews, meeting notes and surveys. However, it must be accepted that regardless of how impartial the researcher attempted to be, that in some way the values and bias of the researcher will have shaped the research. This would have occurred during the semi-structured interviews, a form of 'directed' conversation, and in the process of coding. Indeed, this interaction is accepted

and reflects 'the interaction between the observer and the observed' (Charmaz, 1995, Charmaz, 2003, p. 32). In this case study the researcher would argue that such a relationship was a positive asset to the research process as it built trust and engagement. One further criticism, which this study has attempted to overcome, is the concern that grounded theory fails to extend the significance of findings to the broader world (Layder, 1992). Positioning this work within the context of whole system thinking endeavours to deflect this criticism.

For a research project embedded within a major public company, one of the key intended outcomes was to ensure that elements of the research could be utilised by the industry sponsor. During 2015-2017, the research was increasingly being utilised to support strategy development and in the latter period the supply network and lifecycle thinking shaped the development of the company's first sustainable procurement strategy. However, embedding the outcomes of the research findings within Carillion work practise was not possible due to the company liquidation. The researcher has attempted to ensure the research offered wider industry benefit by presenting the research to Carillion's industry peers.

In section 9.2 recommendations for future industry action are presented, and in section 9.3 considerations for policy makers. However, this research has also identified several areas where future academic work could be highly valuable. Whilst fragmentation of supply networks has been studied across multiple sectors examining the episodic nature of construction would support a gap in knowledge. Also poorly understood, and a major barrier in the development of sustainable construction, is the relationship between economic benefit and sustainability criteria across the construction network. Finally, this research would suggest that the role of category management, or indeed other boundary spanning roles should be examined in greater depth.

Appendix 1 Carillion policies, and guidance

Figure 46: Carillion Supply Chain Policy (2015)

SUPPLY CHAIN POLICY

Scope

The scope of this policy encompasses all Supply Chain activities within Carillion Services with the exception of Joint Ventures whom may adopt their own procedures as may be approved by the respective Joint Venture Board.

Purpose

The purpose of this policy and its associated procedures is to provide:

- A single, standard, consistent approach to Supply Chain practice within Carillion Services;
- Increased visibility of processes and procedures, providing focus for Supply Chain and Operational staff;
- Segregation of duties, better allocation of resources;
- Improved quality, speed & efficiency;
- Alignment of processes with those of other Carillion Plc businesses and of our Clients and key Supply Chain Partners;
- Reduction of waste and associated cost;
- Greater control, retaining appropriate degrees of flexibility;
- A single direction on mandated practice and;
- Standard Supply Chain documentation templates.

Associated Documents

Carillion Services Supply Chain Work Winning Process (extranet)
Carillion Services Supply Chain Mobilisation Process (extranet)
Carillion Services Supply Chain De-Mobilisation Process (extranet)
Purchase card / Cheque Procedure (extranet)
My Register Performance Management Procedure (extranet)
Carillion Services Supply Chain Order Matrix (extranet)
Carillion Services Supply Chain New Major Package Award Process (extranet)
Carillion Services Supply Chain Bid Procurement Strategy (extranet)
Carillion Services Supply Chain Project Procurement Strategy (extranet)
New Supplier Request and Supplier Accreditation Procedure (extranet)
Carillion Sustainable Supplier Charter (extranet)

Policy

All staff within the Carillion Services business, whether within the Supply Chain Function or otherwise, shall be responsible for ensuring that the correct processes and procedures are followed. This applies to any activities that they carry out themselves, but similarly to any work that they are aware of and may be able to influence, independently, or through others. All users are responsible for keeping adequate records to demonstrate compliance with these procedures under audit.

Policy and Principles

- All practices must be carried out in accordance with the process flowcharts within this procedure. All Forms referred to are available on the intranet and may change. It is important that users of these procedures access the most current versions each time they are used;
- The "Guidance" section of each process flowchart is non-auditable. The Flowcharts also contain both optional and mandated elements.

1. Supplier Accreditation and MyRegister (Refer to specific policy New Supplier Request & Supplier accreditation Procedure on Phoenix)

Basics
Carillion employs an online system called MyRegister which holds details of all suppliers who have been accredited for use on Carillion projects. MyRegister must be searched for suitable vendors before making any requests to add new vendors. To request a new vendor, you must first complete a New Supplier Request form, which can be found through the MyRegister link on the Carillion intranet home page.

MyRegister supports the spend category coding structure, streamlining the links between suppliers and specific categories and gives the business a reference point for up-to-date supplier information.

Reducing the number of suppliers to ensure consistency and uncover volume value is a key objective of the Supply Chain Department. There is also a focus on identifying suppliers who are as committed to Sustainability and Health and Safety as we are. Using MyRegister gives us the opportunity to reassess the credentials of suppliers and identify where they are supplying Carillion across a number of business units.

Accreditation and the Supplier Accreditation Form (SAF)
Once a request has been made to accredit a new supplier and add them to the MyRegister system, the Systems & Assurance team (S&A) will review the request for completeness and forward to the appropriate Category Manager for approval. If approved, the S&A team will issue the Supplier Accreditation Form (SAF) to the nominated supplier via an electronic link.

The SAF is a comprehensive list of questions that the supplier must answer to provide Carillion with evidence and assurance that they meet all of Carillion's minimum requirements to trade. The supplier is able to upload documents (such as proof of insurance) into the MyRegister system.

Please note that it is the responsibility of the requestor to ensure that their nominated supplier has received the request to complete a SAF and completes it in a timely and comprehensive manner.

The full process flow from request to supplier approved can by found in the New Supplier Request and Supplier Accreditation Procedure. You should note that the standard timeframe from request to the approved supplier being added to all appropriate Carillion systems is thirty working days.

General Business Rules
In summary, MyRegister should be used to search for preferred suppliers and sub-contractors. Please note that the suppliers are segmented on the database as follows.

- Preferred (Generally Category Managed)
- Achieved Basic Accreditation, Achieved Full Accreditation or Suspended
- A restricted classification of Self-Certified is also classed as Achieved Basic Accreditation

An amber light against a supplier record means that they are still accredited, but should be used with reference to any cautionary note.

'Achieved Basic Accreditation' suppliers only have a very basic level of assurance. If they are marked as such, this means that they have completed a reduced SAF form and their details are available on the database. In simple terms, all we have from these suppliers are:

- Trading account information
- Health & Safety, Environment and Quality documentation.
- Potentially some performance reports.

In essence it is your responsibility, as the requestor, to ensure all significant risk packages have at least gone through the supplier accreditation process, before committing yourself to awarding the contract or issuing a Purchase Order. It

is Carillion Supply Chain Policy that no work commences without this approval and without a valid Purchase Order.

For current suppliers if there are not sufficient SAF details (SAF Expired/Suspended) orders should be held back/prevented. You should note that if a supplier has commenced work prior to completing the proper approval process, an order cannot be raised and payment may be significantly delayed or refused, you may also be subject to audit review and disciplinary processes as a result.

Notwithstanding the supplier accreditation process, it remains your responsibility to ensure you are using competent suppliers and sub-contractors on your site. This will involve complying with the separate Health and Safety procedures.

Suppliers identified as Suspended must not be used. The suspended comments field will also indicate why the supplier is currently suspended. This could be due to Health and Safety issues, unreturned, expired documentation or a number of other reasons.

On site Requirements
Whilst the SAF and completed accreditation process provide assurance that the supplier is able to suitably evidence competence in a number of key areas, operational staff must still satisfy themselves of the following:

(a) As stipulated within local Health & Safety procedures: full risk assessments, environmental damage assessments and detailed task-specific method statements must have been received and reviewed by competent qualified Carillion operational representatives prior to works commencing on site
(b) The competency of the vendor and their staff must have been assessed in line with local Health & Safety procedures and Carillion operational representatives must have ensured that adequate insurances are in place prior to works commencing on site
(c) Any Carillion-appointed supplier that wishes to sub-let any part of its work must gain prior approval from the Carillion responsible person. The person ordering the services is responsible for ensuring that this condition is contained within any applicable order. Sub-letting should be agreed as early as possible in the process (ideally as part of contract negotiations) and in any case must be approved prior to any sub-let suppliers being appointed and allowed on-site
(d) Where Carillion or any supplier has a requirement to erect scaffolding on a site, *only* Carillion-approved scaffolding suppliers may be used. For the avoidance of doubt this applies to scaffolding works awarded by any supplier at any tier of the supply chain for the project in question. The person ordering the services is responsible for ensuring that this condition is contained within any applicable order.
(e) The supplier is briefed locally on Carillion's Corporate Ethics Policy

General Validity
All suppliers who are to be paid by Purchase Order must go through the accreditation process. There are no exemptions for small vendors or those that are not considered "strategic". Where operational and supply chain staff deem it appropriate that (due to the nature of the supply relationship) a full accreditation process isn't necessary, an alternative payment route via Purchase Card is possible. See Purchase Card / Cheque Procedure

2. Additional Health, Safety & Environmental Stipulations

Project or tender-specific Health, Safety & Environmental requirements must be defined by Operations and IMS and relayed to vendors by Supply Chain or Operations, where appropriate, at the following stages of the procurement cycle:

- Inception/Planning/Pre-tender
- Tender / Purchase Order
- Contract Award
- During the contract
- Following completion of the contract

The Operations Manager/Director shall appoint competent Operational representatives to be responsible for the management of each procurement package/vendor. Amongst other management responsibilities, these

representatives shall be responsible for providing vendors with known general and specific information on health, safety and environmental risks and controls that may impact on design or delivery of the relevant package.

All Supply Chain Representatives and all vendors shall have access to utilise competent health, safety and environmental advice and the Project Health & Safety file at all stages of the procurement cycle.

Carillion and all of its vendors shall comply with UK and/or International Legislation as well as the Client's requirements in respect of contract conditions, standards, procedures, control measures and specific instructions in regards to Health, Safety and Environment practices.

Vendors shall be instructed to co-operate with all parties with regard to Health, Safety and Environmental requirements.

3. Sustainability Stipulations (Carillion 2020)

Carillion's Group Sustainability Vision is that 'We want to be recognised as a leading sustainable business and the leading sustainable support services company.' In order to do so we need to ensure that our approach to external spend is ethical and responsible.

The following are guidelines, and wherever possible, should be followed through all procurement activities to ensure that we are aligned to Carillion's Sustainability agenda:

- All Supply Chain staff will have sustainable procurement objectives;
- Procurement decisions will follow the Carillion 2020 Strategy;
- The Supply Chain function will follow the steps of the Sustainable Procurement Task Force (SPTF) Flexible Framework.
- Procurement activities must adhere to the guidelines set out in Carillion's Sustainable Procurement Charter.
- In line with the accreditation process all suppliers must be accredited on the Carillion MyRegister system and complete the mandatory Sustainability questions. The Supply Chain function will, wherever possible, ensure that guidance is given to any supplier only meeting our basic requirements.

For more on our Carillion 2020 Strategy please see the sustainability webpage

4. General Ordering

NO labour, materials, plant or services should be provided without a specific purchase order being in place prior to the event, except in the case of emergency out of hours call-outs, where urgent work is necessary without PO cover being in place. In this case, a PO MUST be issued on the next working day.

All purchase orders over the value of £50k (in a single order or in aggregate per annum) must be approved by an appropriate Supply Chain team member, within the relevant ERP systems.

Any arrangements involving the free-issuing of materials to a sub-contractor or supplier by Carillion requires the prior approval of the Supply Chain Director. Under such circumstances the Project Team shall be responsible for demonstrating the existence of adequate controls around the administration, storage, issuing, insurance, title and recovery of funds for damage/destruction of such free issue materials

For all Category Managed goods and services, sourcing should be led by the Category Management team who will follow an appropriate sourcing process. Details of category managed commodities and trades can be found by accessing the Supplier Catalogue on the intranet. In any case, all orders and contracts over £200k pa should follow the SC6 – New Major Package Award >£200k pa. For all orders and contracts less than £200k pa, governance within the relevant procurement system applies and 3 quotes must be obtained where appropriate and practicable. This procedure will apply for all new packages of work awarded, irrespective of whether the award is made to a preferred or non-preferred supplier.

All Capital Expenditure/Fixed Asset (Cap-ex) purchases must also refer to any applicable Finance procedures. Orders must be pre-authorised and include the applicable authorised sanction number. Orders must only be allocated to certain authorised contract numbers and cost codes (available from Finance).
Supply Chain should engage with the Treasury Team when seeking to commit to any purchase from an overseas supplier (whether in sterling or other currency), as they can provide assistance in terms of managing the currency risk and exchange rate.

All non-UK subcontract organizations in the Construction trades working for Carillion in the UK must hold UK CIS Tax Certification/Documentation where relevant.
All authorisations conducted under these procedures shall first make reference to the current Financial Authorisation List (FAL), available on the intranet, together with the Supply Chain organisational authorisation list.

Letters of intent are strictly prohibited. Guidance must be sought from the Supply Chain Director. The Supply Chain Director may then issue an approved "Instruction To Proceed". This individual is the only person authorised to issue "Instructions To Proceed".

Supplier Interfaces & Procurement Activity In Carillion Services – The Responsibility Matrix represents company policy on segregation of duties. Please refer to this matrix for details of roles and responsibilities and mandatory activities.

5. Contractual Principles

The Supply Chain function's engagement must be sought prior to negotiating and agreeing any contract with a supplier over £50k pa in value. Systems ordering limits shall reflect this.

Exclusivity Agreements including any at pre-contract or tendering stage are an exception to the rule and may only be authorised/issued by the Supply Chain Director.

No reference should be made within orders or contracts to vendor quotation terms or their standard terms of business unless approved by the Supply Chain Director or Head of Supply Chain.

All contracts and orders must be sent out in the name of the appropriate legal entity. Similarly, all supplier invoices must be addressed to the corresponding legal entity.

All contractual templates which link to any Main Client Contract are to be reviewed and accepted by the Commercial and Legal Departments in conjunction with the relevant Supply Chain representative.

Where there is a requirement for the subcontract to be back-to-back with the client, such contracts should be signed by the subcontractor and the copy of the contract should be retained in accordance with the Document Control Procedure It is the responsibility of the Commercial contract lead to ensure that a schedule of all sub-contractors should also be maintained on site. It should include a log of all change instructions raised to the subcontractors.

For significant packages, all applicable order terms and conditions should be issued to vendors at enquiry stage and rates agreed based on these conditions.

No Subcontractor or Supplier should receive an order without being aware of the standard Carillion Terms & Conditions of trading in advance and any appropriate negotiations having been conducted and agreement reached. Carillion standard Terms & Conditions are available to download from the following location
http://star.carillionplc.com/po_terms/

Any deviation or changes to the standard Carillion Terms & Conditions can only be authorised by the Supply Chain Director or Head of Supply Chain.

The Supply Chain team, where necessary and when beneficial to the business, should implement Preferred Supplier Trading Agreements for mutually beneficial long term strategic partnerships. When entering into Preferred Supplier Trading Agreements the Supply Chain team should ensure;

- Carillion's terms and conditions are in place to mitigate business exposure.

- The most cost advantageous pricing/schedule of rates have been negotiated.
- Acceptable insurance levels are in place.
- Key Performance Indicators and service level agreements are in place to meet all operational requirements.
- Robust Health and Safety and environmental plans are in place, with the chosen Supplier having a proven track record in both fields.
- Due attention must be given to the value of the proposed order against the vendors annual turnover and the value of the order should not exceed 30% of the vendors turnover unless approved by the Supply Chain Director.
- Due consideration must be given to potential TUPE implications.

Variations to existing contracts and/or purchase orders must present best value and be pre authorised in accordance with the original contract. All variations in excess of £200k per annum must be treated as a "New Major Package Award" in accordance with SC6.

RF120 and Early Payment Facility
All suppliers should be encouraged to sign up to the Carillion Early Payment Facility (sometimes referred to as RF120). Please speak to your Supply Chain contact for further information on this scheme.

Demand Plan
The Demand Planning tool is an important resource which helps Carillion plan and leverage spend with suppliers across the business. All contract leads should ensure that the Demand Plan for their contract is up to date and accurate. Please speak to your Supply Chain contact for information and guidance.

6. Efficiency and Optimisation

Purchase Order Efficiency:
Any person responsible for ordering shall, wherever possible, seek to reduce the number of orders and transactions of less-than-significant value (refer to the Order Matrix for guidance). This requires better Operational Project Planning and increased levels of "Requirements Aggregation".

Staff shall move away from low value repetitive orders and seek to create higher value, capped bulk orders (where Operational staff directly call-off against such) – this applies to labour, plant and materials.
Supplier invoices should be consolidated wherever possible and we should aim not to receive more than one invoice per supplier per month on any cost centre or contract.

Use of Purchase Cards (Company credit cards):
Purchase Cards (or P-cards) are an approved method of purchasing goods and materials which reduces the overall transaction cost to Carillion. In most cases, p-card purchases of Labour, Services and sub-contract works is expressly prohibited. Some general principles are outlined below:

- The main aim of purchase cards is to reduce transaction costs associated with ordering and reduce the delay between identification of goods and their receipt.
- The Purchase card is a business to business method of payment and should be used for low value and high volume purchases of a material/commodity nature only.
- Purchase cards can be used to purchase emergency goods and materials, however card holders must use Carillion preferred suppliers wherever possible.
- More information about the use of purchase cards can be found on the intranet, including guidance on purchases which come under the remit of the CIS tax scheme.

E-invoicing:
Improving our transaction processes with external providers is one our key areas of focus. One initiative that has been adopted by Carillion is known as electronic invoicing (or e-Invoicing). An overview is given below:

- E-invoicing is considered mandatory with all Carillion preferred and approved suppliers. As per Carillion's policy, every effort must be made to encourage suppliers to submit their invoices through the electronic invoicing route. Any exceptions to e-Invoicing will need to be approved by the Supply Chain Director.
- E-invoicing means all suppliers sending an invoice to Carillion will send the invoice as a data file via the internet rather than a printed invoice, posted in an envelope with a stamp.
- Electronic invoicing has a number of benefits for both Carillion and our suppliers:
  - Less environmental impact
  - Fewer delays in payment due to invoice queries
  - Reduced processing costs for the transacting of circa 65,000 supplier invoices a month

More information about Electronic invoicing can be found by on the intranet

7. Conduct, Ethics, Integrity and Anti-Bribery

All activities are to be carried out in accordance with the Chartered Institute Of Purchasing & Supply (CIPS) Code Of Ethics and the Carillion Sustainable Supplier Charter.

In addition to the above, all staff are required to have successfully completed the Carillion Ethics, Integrity and Anti-Bribery training programme. If you have not yet done so, please refer to the following link, where further information can be found on the intranet

8. Work Winning Pre-Contract

Supply Chain shall support tendering prospects and opportunities in conjunction with the Business Development Team and Centre of Excellence. This will include the early development of Supply Chain tendering strategies which will include early Subcontractor and Supplier involvement where strategic relationships through the Category Management Team will maximise our competitive advantage and ensure value engineering through enhanced expertise and knowledge.

Where suitable, in conjunction with Category Managers, the Supply Chain team shall develop solutions with Strategic Subcontract Partners and Suppliers where commonality exists across the business and industry. These solutions will be developed to ensure we are aligned with our strategic partners to the win themes required by the Client and offer innovative cost saving advantages.

9. Recording and Authorising Cost Reductions

Supply Chain should be mindful of commercial and operational interests; Supply Chain should therefore confer with key stakeholders on how cost reductions should be arranged / administered e.g. discount or cost variance.
Where a cost reduction opportunity has been identified, agreed and fully implemented, it must be recorded on a GR03 document which will require 2 levels of sign off:

1. Level 1 - either the local Contract Manager or Finance Manager signing to accept the savings will be made and indicating whether they are additional to latest forecast / budget;
2. Level 2 – Sector Head of Supply Chain and/or Sector Financial Controller. Where the savings are within a managed category, then the Category Director shall also authorise these.

Each GR03 with annual savings over £50k will also need to be signed off by the Supply Chain Director and/or Finance Director once Contract and Sector level signatures have been obtained.

10. Conducting and Recording Negotiations over £200k (Inline with Major Package Award)

All negotiations involving suppliers which are over £200k pa in value should be recorded clearly and precisely. Post-negotiation, all stakeholders involved in the process should sign-off these records.
Negotiations may involve several variables which can include (but not be limited to) the following:

- Payment Terms

- Rates
- Cost structure
- Programme and capacity
- Damages (including for delay) – Unliquidated/Liquidated
- Terms of Contract
- Attendances
- Daywork Rates
- Scope / Specification
- Retention
- Vesting Agreements
- Guarantees/Bonds
- Documentation
- Subletting
- Resources

We do not negotiate on our minimum requirements with regard to Safety, Quality, Environmental, Performance or Capability issues.

All Category Managers must comply in full with this policy when awarding framework agreements. This will include conducting pre-let meetings and negotiations for their responsible categories and complying with the authorisation processes, for example.

Outside Category Managed goods and service lines, Supply Chain representatives must be invited to conduct negotiation meetings for all packages over £200k in value or where there is a significant health and safety, environmental or commercial risk.

11. Bid Procurement Strategy and Project Procurement Strategy

Any Procurement Strategy should align itself to both the Supply Chain Management Policy outlined in this document and also the set Project Strategy as detailed by the operational team.

Bid Procurement Strategy
A Bid Procurement Strategy is mandatory for all bids and eventual contracts which are projected to be above £5m in annual turnover. It must be authorised by the appropriate Head of Supply Chain and Supply Chain Director. For bids or contracts below this level, a Bid Procurement Strategy can be used at the discretion of the supply chain lead. Where required, the purpose of the Bid Procurement Strategy is:

- Set out the delivery strategy for all service lines;
- Summarise the suppliers being asked to provide a proposal for all outsourced services and their prices;
- Outline any particular suppliers partnerships or exclusivity arrangements which are being sought;
- Describe the commercial terms against which suppliers are being asked to provide proposals for, including stipulations of the client Head Contract where known;
- Outline the key win themes, Carillion differentiators and initiatives underway during the bid phase, including any particular client requirements.

To assist in the production of a Bid Procurement Strategy, a template is provided as a guide. This template should be amended to suit the requirements of the particular project.

Project Procurement Strategy
A Project Procurement Strategy must be completed for all new projects which have a turnover in excess of £5m per annum. It must be authorised by the appropriate Head of Supply Chain and Supply Chain Director. For projects below this value, a Project Procurement Strategy can be used at the discretion of the supply chain lead.

The purpose of the Project Procurement Strategy is to:

- Set out an agreed procurement plan for the project, following on from the authorised Bid Procurement Strategy;
- Incorporate fundamental elements of the Mobilisation Supply Chain strategy (see procedure) and to drive efficient continuation of those strategies already initiated at bid stage;
- Ensure all Procurement is performed accurately and consistently in line with policies stated in this document, and yet provide a flexible framework to respond to specific project needs as defined in the Bid Procurement Strategy;
- Detail suppliers to be selected for each outsourced service / trade, their annual price, cost reduction strategies and contract types;
- Outline a re-procurement plan and associated timescales;
- Set-out the transactional strategies to successfully mobilise the new Project (e.g. p-cards, accreditation trackers etc.).

To assist in the production of a Project Procurement Strategy, a template with a series of appendices is provided as a guide. This template should be amended to suit the requirements of the particular project.

12. Standard Forms

All applicable Forms are referenced in the associated documents section within the procedural process flow charts. These forms are subject to regular reviews and updates and may therefore change randomly.

It is important that users of these procedures access the most current versions each time they need to be used. The current versions of all forms can be found on the Supply Chain intranet site / Phoenix. Only the documents stored on Phoenix are version controlled.

The forms may be varied by Supply Chain on the approval of the Supply Chain Director or by adopting different (Joint Venture, Alliance, Client or Partner) procedures within the mobilisation phase of a particular contract.

Forms sourced electronically via the intranet must be saved to the user's personal hard drive prior to being amended/completed. Any files that appear on the shared drive are usually password protected but MUST NOT be amended, deleted or moved by anyone other than the registered authorised owner/controller of the document.

Figure 47: Carillion Sustainable Supplier Charter, October 2017

ISSUE DATE: October 2017

Sustainable supplier charter

Sustainability is key to our business and commitment to sustainable procurement is embedded in our 2020 Sustainability Strategy. Our aim is to work with our supply chain to deliver sustainable solutions for our customers. We will promote best sustainable practice and meet or exceed guidance set out by government and regulatory bodies. Carillion applies the principles of the UK's Chartered Institute of Purchasing and Supply's (CIPS) Policy on Purchasing Ethics, and the equivalent Canadian Institute for Supply Management (CISM) principles and operates in line with our Ethics and Business Integrity Policy.

	Health & Safety	Sustainability	Ethical Working and Values	Continuous Improvement and Innovation
Carillion commits to:	• Engage and collaborate with our supply chain to provide a safe environment and a safe supply chain	• Meet its needs for goods and services, in a way that achieves value for money on a whole-life basis and generates benefits not only to the organisation, but also to society, whilst minimising environmental damage • Collaborate with our suppliers on the development of enhanced sustainable products and services • Collaborate with our supply chain to develop inclusive community engagement strategies that involve their employees working on our projects • Benchmark suppliers' capability through our accreditation process providing guidance to those who only meet our basic requirements • Use sustainability criteria in the award of contracts • Maximise local (with Indigenous focus in Canada) spend and employment including SMEs • Source timber that meets FSC standards	• Use ethical and transparent methods of working • Ensure all appropriate suppliers are subjected to Carillion's accreditation process • Ensure that we and our suppliers comply with the Modern Slavery Act, the International Labour organisation's core conventions and the UN Global Compact as well as local labour laws and regulations • Provide clear and fair procurement methods and develop long-term relationships • Recognise excellent supplier performance through repeat business opportunities • Make payments in accordance with agreed payment terms	• Consult with, listen to and act on suppliers' suggestions for continuous improvement • Lead continuous improvement programmes within the supply chain • Deliver solutions that exceed customer requirements
Carillion expects suppliers to:	• Provide safe, capable and competent employees • Incorporate safety into design and work to approved method statements and risk assessments	• Purchase products and materials that are responsibly & ethically sourced • Effectively manage and mitigate their environmental impacts • Continually improve their social and environmental performance • Identify opportunities and implement actions to reduce carbon and fuel • Submit prices and suggestions for more sustainable alternatives on a whole-life cost basis • Source timber in compliance with Carillion's Responsible Timber Procurement Policy	• Comply with our Labour Standards Charter • Treat people fairly and with respect, so there is a culture of equality and equity • Deliver to the agreed specification, on time and to agreed cost • Submit complete tenders on the agreed dates • Apply the principles of this charter fairly and consistently to their supply chain to ensure that key risks are understood and managed	• Commit to and participate in continuous improvement programmes • Move towards integration of their own management and information systems with Carillion's • Share and promote new innovation with Carillion • Understand our safety, sustainability, quality, time and cost management requirements and provide competent people that will continuously deliver to our standards
Together we shall:	Provide a safe and healthy workplace • Act to positively influence our people's health	• Deliver leading edge sustainable solutions to our clients that exceed their expectations • Make tomorrow a better place	• Work in accordance with the Carillion Values of we care, we improve, we deliver and we achieve together • Deliver a "right first time" customer solution through better planning, performance improvement and risk management • Deliver to agreed programme, quality and cost so that that our customers' success becomes our success • Support the United Nations Universal Declaration on Human Rights to ensure that all parties working with Carillion are protected and treated fairly • Take a non-adversarial approach to dispute resolution	• Reduce cost and eliminate waste through continuous improvement • Deliver value for money to our customers • Develop and deliver innovative solutions • Promote a two-way engagement process that encourages continuous improvement of sustainable issues and cost reduction

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Keith Cochrane
Interim Group Chief Executive

Emma Mercer
Chief Financial Officer

David Picton
Chief Safety & Sustainability Officer

Figure 48: Carillion Collaboration Policy, May 2017

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Collaborative Working Policy

This statement sets out Carillion's commitment to working in a collaborative business relationship when ever the opportunity arises.

Building long-term, trusted partnerships is a Carillion core **business strategy**, and **our vision** is to be the trusted partner for providing services, delivering infrastructure and creating places that bring lasting benefits to our customers and the communities in which we live and work.

The Board recognises that our policies and procedures are not enough and, in order to achieve consistently high standards of governance and service excellence, we have to ensure that our values are at the heart of everything we do. **Our values** are helping to shape the culture, character and beliefs of our business. More than any policy document our values define the way we behave, with each other, with our customers and partners, and how we approach our challenges and opportunities on a daily basis. Our values are detailed as:

- **We care**. We respect each other and we do things safely and sustainably. It's good for our people, our business and our local communities.
- **We achieve together**. We value the contribution of each individual and we work together to build strong, open and trusting partnerships.
- **We improve**. We listen, learn and adapt our ideas and experience into better solutions and services for our customers.
- **We deliver**. We set ourselves stretching goals, taking pride in doing a great job and helping our customers and partners to succeed

Our **collaborative objective** is straight forward and sets a commitment to satisfy all applicable requirements and the continual improvement of our collaborative business relationship management system. In meeting our corporate strategy, our **collaborative objective** is the implementation of a collaborative approach with our clients, supply chain partners and other stakeholders that will encourage greater levels of innovation and through our commitment to continuous improvement will deliver better value. It is through collaborative working methods that sound, cost efficient solutions will be found. Working together with our clients and supply chain partners from the early stages, will enable us to apportion and coordinate our efforts to better manage risk.

Our integrated management system (IMS), and particularly our collaborative working procedure and Relationship Management Plan (RMP) templates provide us with a framework for setting collaborative objectives and developing the process and procedures required to establish successful collaborative relations with our clients and key supplier chain partners.

Aligned to our corporate strategy, the **collaborative benefits** of our approach should result in:

- Resources are used to maximise value through the avoidance of unnecessary bureaucracy
- Negotiation of additional workload
- Early supply chain partner involvement to help drive innovation, unlock value and control risk
- One team approach with everyone focused on achieving agreed outcomes

These may be realised through our KPIs:

- Improvement in Net Promoter or equivalent customer feedback scores – target NPS +45
- Improved project efficiency – every project produces at a least 1 process improvement case study per annum
- Project outcomes are equal or better than tender – target UK Construction >3.6%; Support Services >5.4% operating margin

The policy is available to our stakeholders and should be communicated as appropriate, is included in our collaborative working training, and can be found on our IMS for use by Project Senior Executive Responsible (SERs) to support the development of RMPs.

Adam Green
Corporate Senior Executive Responsible (SER)

May 2017

Figure 49: Carillion Sustainability Policy, October 2017

ISSUE DATE: October 2017

Sustainability policy

This statement sets out Carillion's strategic commitment to sustainability.

"We want to be recognised as a leading sustainable business and the leading sustainable support services company".

Carillion is a leading support services company with a substantial portfolio of Public Private Partnership projects and extensive construction capabilities. The Group operates across the UK, Canada and the Middle East. We are involved in every stage of the development of the built environment and sustainability is a key priority for our business.

We will deliver sustainable solutions with our people, our customers, and our supply chain for the wider community and environment in which we work and live.

We will lead industry by promoting best sustainable practice and exceeding guidance set out by government and regulatory bodies. This policy reflects our commitment to ensuring that sustainability is paramount to all activities in our business. It will be delivered through our 2020 Sustainability Strategy, other supporting policies and six positive outcomes as follows.

Building a successful business
"Through our sector leadership and role in creating a more sustainable economy, we will increase shareholder value."

Governance: we will conduct our business with integrity and ethics in accordance with our Values to deliver our Sustainability Strategy and goals.

Shareholder value: we will increase shareholder value and become a more profitable business that people want to work for and with, as employees, suppliers and partners.

Enabling low-carbon economies
"Our services will help Carillion's customers work towards carbon neutrality, so that together we become the lowest carbon producers in our respective sectors."

Reduction and offsetting: we will actively reduce our use of energy and emissions arising from our operations including facilities, transport, design, construction and maintenance of our clients' operations. We will offset our remaining operational emissions.

Design: we will achieve excellence in project lifecycle design creating lowcarbon solutions in order to deliver tangible benefits to our customers.

Protecting the environment
"We will work with our customers and suppliers to be best in class in reducing waste, managing our use of water and raw materials, and protecting biodiversity wherever we operate."

Biodiversity: we will understand and manage our impact upon biodiversity and seek opportunities to enhance and restore the wildlife and habitats for the future.

Resource use: we will manage our environmental impacts by monitoring and using natural resources efficiently, sourcing responsibly and reducing waste and by helping our customers do the same.

Supporting sustainable communities
"Our leadership in creating employment and skills opportunities, coupled with our understanding of the needs of our communities will ensure we make a significant and positive contribution everywhere we work."

Training and employment: we will make a positive difference to the development of our local communities, enabling them to thrive and prosper, with a clear impact in areas such as employment, skills, training, local community-based initiatives and improvements to local environments.

Community needs: we will develop and implement community needs plans in all our contracts in order to engage and understand our neighbouring communities and make a positive contribution to their environment and quality of life.

Providing better prospects for our people
"We will maximise the prospects of our people by offering opportunities for continual learning and development, and creating safe, healthy places to work."

Health and safety: through the way we work and behave all our people and stakeholders will be protected from the risks of occupational injury or ill-health.

Our people: we will attract, motivate and engage talented people who share our Values. We will promote diversity across our people, championing a culture of respect and upholding equality of opportunities to all.

Leading the way in our sector
"We will be recognised as the benchmark in sustainability and innovation, in turn driving demand as the service provider of choice for customers."

Customers: we will develop strong relationships with our customers and exceed their expectations by sharing expertise, driving innovation and adding value to our services to ultimately create sustainable solutions that impact beyond our immediate operations.

Supply chain: we will work with our supply chain through the Sustainable Supplier Charter to deliver sustainable solutions that maximise value for our customers.

Our policy will be delivered by:

- managing the impacts and opportunities arising from our products, services and supply chain;
- driving this strategy externally, helping our customers to meet their sustainability objectives, whilst contributing to the creation of a lowcarbon economy and supporting vibrant, healthy communities; and
- ensuring the real involvement of all our people, our customers, our supply chain and stakeholders.

Business units will implement plans to ensure this policy is delivered.

Policy review:
This policy has immediate effect and replaces all previous versions.

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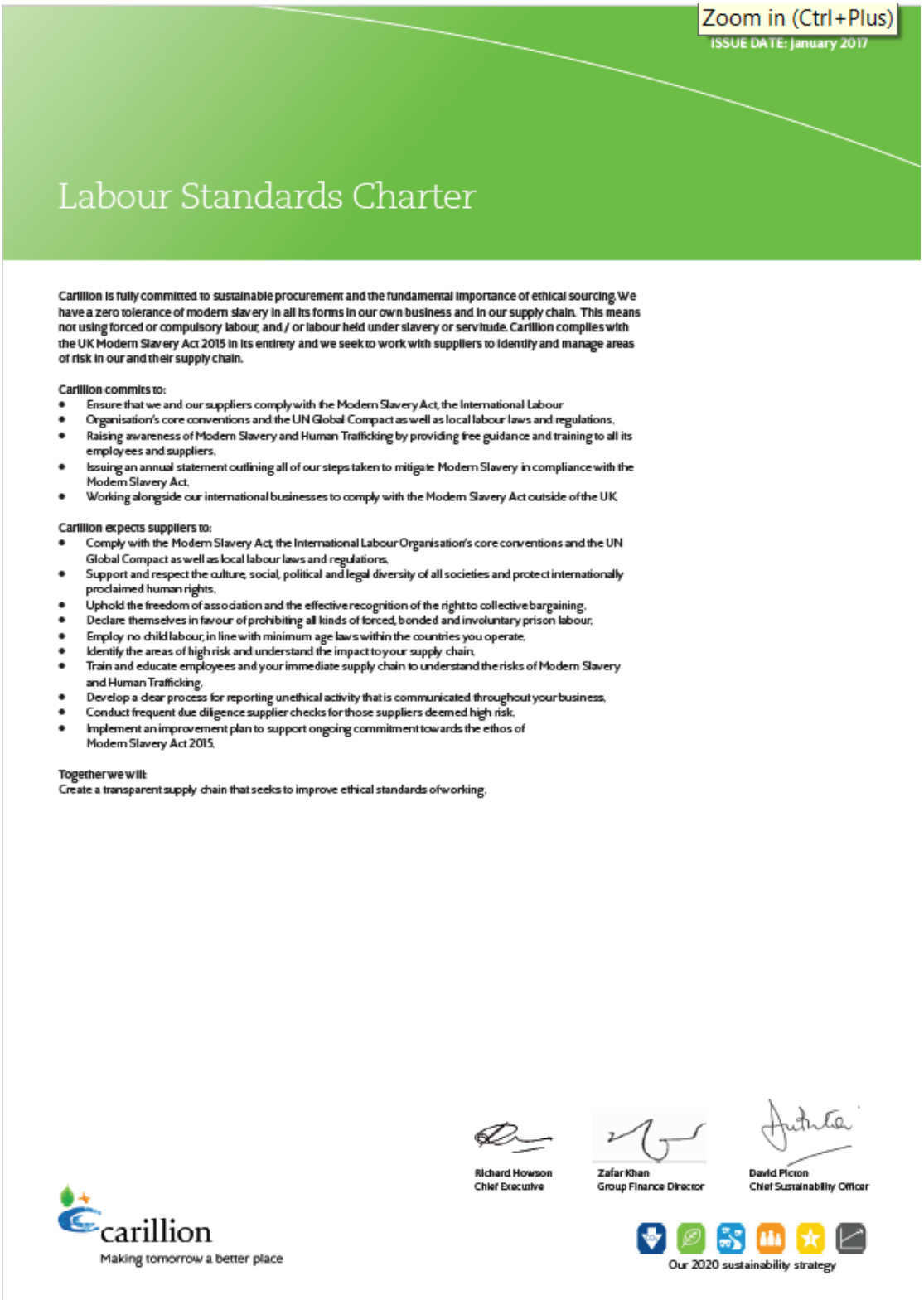
Keith Cochrane
Interim Group Chief Executive

Emma Mercer
Chief Financial Officer

David Picton
Chief Safety & Sustainability Officer

Figure 50: Carillion Labour Standards Charter, January 2017



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ISSUE DATE: January 2017

Labour Standards Charter

Carillion is fully committed to sustainable procurement and the fundamental importance of ethical sourcing. We have a zero tolerance of modern slavery in all its forms in our own business and in our supply chain. This means not using forced or compulsory labour, and / or labour held under slavery or servitude. Carillion complies with the UK Modern Slavery Act 2015 in its entirety and we seek to work with suppliers to identify and manage areas of risk in our and their supply chain.

Carillion commits to:

- Ensure that we and our suppliers comply with the Modern Slavery Act, the International Labour
- Organisation's core conventions and the UN Global Compact as well as local labour laws and regulations.
- Raising awareness of Modern Slavery and Human Trafficking by providing free guidance and training to all its employees and suppliers.
- Issuing an annual statement outlining all of our steps taken to mitigate Modern Slavery in compliance with the Modern Slavery Act.
- Working alongside our international businesses to comply with the Modern Slavery Act outside of the UK.

Carillion expects suppliers to:

- Comply with the Modern Slavery Act, the International Labour Organisation's core conventions and the UN Global Compact as well as local labour laws and regulations.
- Support and respect the culture, social, political and legal diversity of all societies and protect internationally proclaimed human rights.
- Uphold the freedom of association and the effective recognition of the right to collective bargaining.
- Declare themselves in favour of prohibiting all kinds of forced, bonded and involuntary prison labour.
- Employ no child labour, in line with minimum age laws within the countries you operate.
- Identify the areas of high risk and understand the impact to your supply chain.
- Train and educate employees and your immediate supply chain to understand the risks of Modern Slavery and Human Trafficking.
- Develop a clear process for reporting unethical activity that is communicated throughout your business.
- Conduct frequent due diligence supplier checks for those suppliers deemed high risk.
- Implement an improvement plan to support ongoing commitment towards the ethos of Modern Slavery Act 2015.

Together we will:

Create a transparent supply chain that seeks to improve ethical standards of working.

Richard Howson
Chief Executive

Zafar Khan
Group Finance Director

David Picton
Chief Sustainability Officer

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Our 2020 sustainability strategy

Appendix 2 Analysis of Annual Sustainability Reports 2014/15 (Balfour Beatty plc, 2014, Carillion plc, 2016a, Skanska, 2016, Keir Group Plc, 2016, Laing O'Rourke, 2014, Interserve Plc, 2014)

Analysis Group	Company	Activity	Full Sustainability Report	Sustainability Vision	GRI Reporting Used	Signed up to UN Global Comapcct on Sustainability	KPIs	Key Stakeholders
Carillion	Carillion	Carillion is one of the UK's leading integrated support services companies, with extensive construction capabilities, a substantial portfolio of Public Private Partnership projects and a sector-leading ability to deliver sustainable solutions. Vision: We are making tomorrow a better place	Yes	General Carilion Vision noted in report - no sustainabiilty vision other than a specific comment for a building project	Yes	No, A rated in CDP (only 1 of 187 companies in world). Also FTSE 350 Climate Disclosure Leadership	Highlighted in full and with outcomes clearly listed	people, clients, shareholders and investors, supplier partners, charities, industry organisations and people living in the communities where we operate. We use a stakeholder framework
UK Main contractor peers	Balfour Beatty	Balfour Beatty is a leading international infrastructure group. We finance, develop, build and maintain innovative and efficient infrastructure that underpins daily life, supports communities and enables economic growth.	Yes	Purpose of the scorecard: ---- a convction that sustainablity strategy should be central to how we run the buisness and artucltes hw we will prosper as a Group in the Long term----Branded SUSTAINABILITY, A Collective Responsibility				10 stakeholder groups identified - -have two stakeholder panels - discussion page on website
UK Main contractor peers	Interserve	Interserve is one of the world's foremost support services and construction companies. Their vision is to redefine the future for people and places. They are a growing, international business: a leader in innovative and sustainable outcomes for their clients and a great place for people to work They offer advice, design, construction, equipment, facilities management and frontline public services. They are headquartered in the UK and listed in the FTSE 250 index.	YEs	Launched SustainAbilities Programme in 2013.	Not stated	Not stated	Clearly stated aims, targets, tracking and year on year progress	Investors, Clients (especially public procurers)Communities, Suppliers -

Analysis Group	Company	Activity	Full Sustainability Report	Sustainability Vision	GRI Reporting Used	Signed up to UN Global Comapcct on Sustainability	KPIs	Key Stakeholders
UK Main contractor peers	Kier	Kier is a leading infrastructure, buildings, developments and housing group	No – CSR Report 2014	Not in report	Yes, Summary included in this report - audited by KPMG. Considering whether to adopt G4 approach		Included in report	report notes the stakeholder s that were engaged in the Materiality review in 2014 - includes clients, investors, employees, NGO and supply chain represented by Supply Chain School
UK Main contractor peers	Laing O'Rouke	Laing O'Rouke is a privately owned engineering company that funds, designs, manufactures, constructs and maintains the built environment.	Yes - note only reviewed the UK section (Australia excluded)	Engineering Sustainable Futures - Making a positive contribution to the social economic and envrionmental challenges our industry faces..ESF sets out our committement to creating high quality careers, enabling low carbon living and generating value for society	Not stated	Not stated	Not stated	Not mentioned

Analysis Group	Company	Activity	Full Sustainability Report	Sustainability Vision	GRI Reporting Used	Signed up to UN Global Comapcct on Sustainability	KPIs	Key Stakeholders
UK Main contractor peers	Lend Lease	A leading international property and infrastructure group with operations in Australia, Asia, Europe and the Americas.	Incorporated into Annual Report 2014 - a strategic decision	Creating a sustainable future isn't new to Lend Lease – it's been an integral part of our culture for more than 50 years. We believe in creating a future where the places we create enhance people's lives and allow communities to prosper. Places where people want to be, places that contribute to communities, places that are productive and profitable. We do this by improving the wellbeing of the environment, society and economy.	Yes - since 2005 - summary online			Identified as Customers, Investors, Staff and Communities in which they work.
UK Main contractor peers	Sir Robert McAlpine	A family owned building and engineering business.	Not found	We recognise our responsibility to protect and enhance the natural environment and have a positive social and economic legacy within the communities in which we work.				

Analysis Group	Company	Activity	Full Sustainability Report	Sustainability Vision	GRI Reporting Used	Signed up to UN Global Comapcct on Sustainability	KPIs	Key Stakeholders
UK Main contractor peers	Skanska	Skanska is involved in some of the UK's most prestigious building and infrastructure projects, working with both private and public-sector clients. We also deliver numerous smaller schemes, including public-realm improvement, hard and soft landscaping and utilities projects.	Yes	To be an Industry Leader in sustainble Devemopment, Particularly I occiupational health and Safety, the environment and ethics HOWEVER not included in CORPORATE VISION		Yes	Not published as part of the Sustainability Report	no mention in Sust Report
UK Main contractor peers								
UK Main contractor peers	Willmott Dixon		Yes	Being a Responsible Business means that we play our part in raising standards across our own sector, while setting an example within our own operations…	Yes and summary noted in this report		Yes - audited by Bureau Veritas	Not mentioned

Analysis Group	Company	standards	H&S	Health	Ethics	Community	Environmental
Carillion	Carillion	Aim to have all suppliers 100% to ethical sourcing standard by 2020. 99% of timber sourced in UK is FSC. Management systems certified to OHSAS 18001	51% reduction in All Accident Frequency Rate, work to standard BS OHSAS 1800. Launched One Road to Safety campaign and trialled BIM modelling for vehicle movements on highways site	Updated Health Like Safety Strategy. Global Corporate challenge on increased activity to improve fitness, Over 2000 empoylees took part . Supported conversations on mental health working	No specific information on Ethics. Ethical sourcing and responsible business mentioned.	1% of pretax profits given to communities, largest trainer and employer of apprentices in UK (1700). Target: 100% of projects have a community needs plan.	reductions in water, carbon and waste on sites. CDP Climate A grade, met 2020 carbon reduction targets by 2015, incorporating hybrid vehicles in fleet. Working on scope 1 and 2 with small amount of level 3.
UK Main contractor peers	Balfour Beatty	CDP reporting done by GHO Sustainability		Zero Harm foucs - use DNV to audit	Code of Conducts-----2 elearning modules and 'Listen up' programme. Where control the specification BB purchase either directly/through supply chain from recognised responsbile sourcing schemes		Basic Waste, water and CO2 scope 1 and 2 emissions
UK Main contractor peers	Interserve	Construction Industry achieved, BS11000 Collaborative Buisness Relationships ----- Gold Food for Life Cateriing Mark in Bristol school---- Footsie 4Good rating	Standard commentary	SustainAbilities plan includes improved quality of meals for staff and clients - staff wellbeing plan in place ----reduction in health and safety issues. Looking to see reduction in staff sickness and increased productivity.	Signed up for National Equality Standard in 2014 ---Transparency seen as very important - fair reporting of progress against targets a clear indication of work	Measure volenteering staff time, donations, fundraising and value of in-kind goods - £1.18M in 2014. Starting to use social value mapping tool. Employees can volenteer for 2 days per annum	carry out standard water effiency action but accept main issues are in areas of the supply chain. Work with procurement to monitor these risks on their operations, Carbon - target to half emissions on sites/own estate and travel. In 2014 piloted new method to measure supply chain emissions, an inventory of top 20 suppliers and an analysis of supply chan spend (?). .

Analysis Group	Company	standards	H&S	Health	Ethics	Community	Environmental
UK Main contractor peers	Kier	Footsie4 Good,----new government CAESER (Corporate Assessement of Environmental, Social and Economic Responsibility	Work with HSE benchmark AIR and train all supervisors to CSSSafety Training Scheme.		Has Group that manages whistleblowing fraud . Madatory Elearning courses on bribery and corruption-----has business ethics policy	See themselves as a responsible business - 161799 staff hours worth 2.9m. -----Aim to launch traineeship in 2015, ----Keir Foundation supports many charaties	report scope 1 and 2 emissions, Keir won the most Green Contracts in the UK (25) based on data from Analysts Barbour ABI (criteria appears to be BREEAM excellent or outstanding)----waste 78% diverted from landfill, NCWRP take wood and Takeback schemes with Kingspan and Protec. -----Water, looking to establish water footprint
UK Main contractor peers	Laing O'Rouke	All businesses ISO14001 accredited-----Explore Industrial Park(EIP) is accredited GOOD for BES6001 - looking to extend to BISON business in 2015. Want to achieve BES6001 Excellent by 2020 ---NOTE have	General H&S practice, October 6th Annual awareness day - Take 5. challenges those to take action if see issues. 45,072 hazards raised in 2013/14-----1:1 H&S interviews with all new employees ----£5.6m in H&S training ----	Annual and new start medicals available - specific health appointments, and random or with cause drug and alcohol testing. 3.08% returned positive results, mainly for canabis-------developed 1 day IOSH course 'building a healthier workforce' will be		Volunteering - 3231 people, also staff raised funds and goods were donated. Support Transforming the future.	Targets for waste (50% reduction by 2020, currently hitting 97.3% diverted), water (setting baseline) and carbon. However looking further at embodied carbon and energy efficiency of the completed asset as offering greatest long term value. Have tested traditional methodologies against their 'Desing for

Analysis Group	Company	standards	H&S	Health	Ethics	Community	Environmental
UK Main contractor peers	Lend Lease	CDP reporting + Dow Jones Sustainability Index	In general terms as part of policy documents		Not mentioned	We create places for people. 1.Work collaboratively to engage communities and increase participation, to build respect and understanding and help create vibrant places where people thrive and prosper 2. enhance employee development, through skilled volunteering initiatives	Water: Target of creating more clean water than they use, aim to have buildings they design use 50% less water. ----- Waste, Aim is to eliminate waste - no data as 2014 set as baseline----- Energy - general aim to reduce and use more renewables. Good clear graphs highlight by project, office and asset.
UK Main contractor peers	Sir Robert McAlpine						

Analysis Group	Company	standards	H&S	Health	Ethics	Community	Environmental
UK Main contractor peers	Skanska	ISO14001 -all businesses certified globally	Fairly standard but did run a contractors week with 29 of their leading companies to focus on H&S	health check every 3 years - + on site activity based working and 'stretch and flex' workouts	Seen by stakeholders as an honest and responsible partner. Wants to become recognsied as a role model in ethics by 201 5- Skanska Code of Conduct, SCC Hotline, Ethics Scorecard, Group Ethics Committee, Skanska Ethics Roadmap and Ethics	KPIs developed in 2014 - report demonstrates through case studies	Resource reduction in carbon, energy and materials. Working on Scope 1,2 reporting of Carbon. No 1 in CDP nordic report. 93% of waste diverted from landfill, Skanska have set a Deep Green Approach - zero waste, zer unsust materials, zero hazardous materials. Initial focus on
UK Main contractor peers							
UK Main contractor peers	Willmott Dixon	Carbon Trust Standard---Carbon Neutral----Gold Investment Standard, Investors in People Construction Div				Value of time, skills, donations and other in dnd £1.37m------4250 people learnt new skills at the Wilmott Dixon Acadamey 4Life---- visits to schools and children to sites----Consider constructors 39/50----Apprentices 83 including 20 shared with other organisations	Aim to decouple carbon emissions from growth. Record Scope 1. 2 and 3

Analysis Group	Company	staff and skills		Idenifying value of sustainability to the business	Materiality	Scarcity of resources	Sustainable Supply Chain	Natural Capital
Carillion	Carillion	EPOD online training, graduate placements. Diveristy and inclusion programmes. In work time volunteering - up to 6 days per year.		Monetarised - BaSB programme. £33.8m of sustainability attributed savings	1st review carried out in 2014. The independent review included workshops, interviews and an international online	Water noted as issue in the MENA region.	Achieved Level 5 of Flexible framework. All suppliers asked to complete sustainability questions as part of registration to supply Carillion. Target of 40% buying responsibly - Sustainable Supplier Charter. All supply chain team have	Not mentioned
UK Main contractor peers	Balfour Beatty	Have staff satisfaction surevey					Work in partnership - through code of conduct, guide, workshops and Meet the Buyer days	
UK Main contractor peers	Interserve	Annual internal SustainAbility conf for managers, 762 managers have sust metrics in their targets, created SustainAbilites elearning and toolbox talk modules 5000 employees completed. Set up group wide award scheme to recognise '4 capitals' + values + team of year----- 1076 workplacements, apprenticehips----setting up Construction Technical Apprentice Acadamey iwth Stephenson College in Leicestershire. Dev new apprenticeships starndards with gov for FM work---Through aquisition of Employment and Skills group are now a provider for DWP and Skills		See contracts being won not only on financial value. They define and measure added value through qantitative inputs, outputs and peformance against targets. Measure business in terms of Four Capitals - Knowledge, Natural, Scoial and Financial	Not mentioned	Not mentioned	Have supply chain code of conduct. ---- SustainAbilities is embedded in the procurement process, audit of top suppliers in 2014 to see how they were performing. Part of BITC committement to 'Acess Pledge' - 52% of business let toc ompanies within 50 miles of site. SME contracts is a target (61% achieved) - have adapted procurment process to facilitate this including payment terms------targetted 1500 subcontractors with a sustainable procurement	Have working group - main role is to work with procurement teams on the impact of forest products and grounds maintanance contracts

Analysis Group	Company	staff and skills		Idenifying value of sustainability to the business	Materiality	Scarcity of resources	Sustainable Supply Chain	Natural Capital
UK Main contractor peers	Kier	continue to invest in training, 20% more apprentices		Look to add social value to work for clients, CSR teams support bid team.	Major focus group work held in 2014 and expectations and importance ranked over several 19 different aspects of sustainability. Working with British Land on a project to test this as part of their supply chain sustainablity charter	Not mentioned	Work in collaboration with Afety Schemes in Procurement SSIP, Constructiononline, Achilles, Santia to help reduce burden on supply chain. Constructionline helps develop releationship with SMEs through workshops. Worked with MAS and BCSA to help 100 members of supply chain becom compliant with construction products regulations for steel. -------member of supply chain school -----Achilles audits Keir for compliance	not mentioned
UK Main contractor peers	Laing O'Rouke	Commitment to staff skills and career enhancement. Young Guns leadership development programme. Apprenticeship+ scheme --new 'Construction Assembly Technician Apprenticeship' - part of UK Gov Trailblazers + trainee steel fixers. 2 co-developed MSc programmes with Imperial and Cambridge Uni, + sponsor 13 PhD students		not monetarised	not mentioned	not mentioned	Note importance of supply chain, host supply chain forums x 8 415 external attendees. Offer subcontractors toolbox talks and 2047 completed --- as part of Construction Leadership Council agreed to prompt payments to SMEs. ------Aug 2013 audit showed that 63% of procument spen on UK central gov contracts was with SMEs.	not mentioned

Analysis Group	Company	staff and skills		Idenifying value of sustainability to the business	Materiality	Scarcity of resources	Sustainable Supply Chain	Natural Capital
UK Main contractor peers	Lend Lease	Committed to increaseing staff skills and key aim for post 2014 is to improve the Global Employee Engagement Survey score.		Not mentioned	Carried out an assessment with 200 key staff drawing on issues raised by key stakeholders over previous 3 years. Long list of 48 issues, cut to 30 and then through internal and external validation created key list of 12 (incorporated into Lendlease Sust framework)	Not mentioned	We will use and buy materials responsibly: 1. Implement a global sustainability procurement policy and strategy on responsible sourcing of materials 2.Ensure all primary contractors and key suppliers we work with will undertake environmental, social and financial prequalification 3. Procure 100% of Timber used for construction from sustainable sources (re-used, FSC, AFS or PEFC) 4. Include recognising Indigenous and Minority Procurement	not mentioned directly but do highlight importance of nature
UK Main contractor peers	Sir Robert McAlpine						70% of contracts on major Glasgow project awareded to SMEs	

Appendix 3 Interview, workshop and survey questions

Appendix: 3a Semi-structured orientation interview questions (D2)

Note: The original survey included additional prompts for several of the questions based on corporate procedure. Some of these details are confidential and have not been included in this Appendix.

Question to be asked by Interviewer to prompt discussion

1. Please could you outline your role and how this fits within the supply chain (SC) team.
2. How do you select suppliers and monitor supplier performance?
3. What typically is the relationship/communication routes that the SC team have with suppliers?
4. How do you see Carillion's supply chain? (those involved in face to face meetings to be shown the three basic models, Figures A1–A3).
5. How far down the chain do you think Carillion have direct or indirect influence currently?
6. When you report KPIs for Carillion, how far down the chain do you report?
7. What do you think suppliers understand about sustainability? (Does it matter? to whom)
8. When, as part of tendering process, is Sustainability flagged as an important criterion?
9. If you talk to suppliers what do you say are the key sustainability goals that Carillion are looking to achieve through their work.
10. How do you keep up to date with the company's sustainability objectives/goals?
11. If suppliers don't know about sustainability where do you suggest they go if they want help?
12. Can suppliers respond to requests for more innovative approaches/more sustainable approaches? (prompt: Examples of success)
13. What do you think are the big barriers/issues that need to be turned into opportunities?

Figure 51: Upstream Tier 1 Supplier Model.

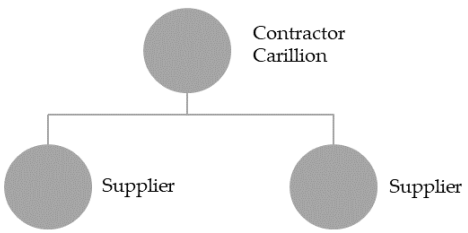


Figure 52: Upstream Multiple Supplier Model.

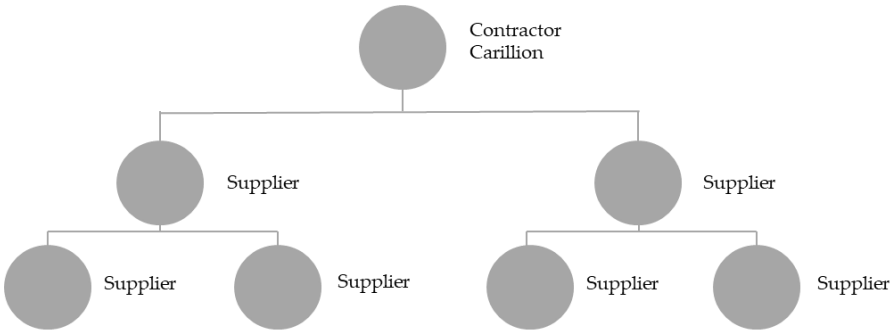
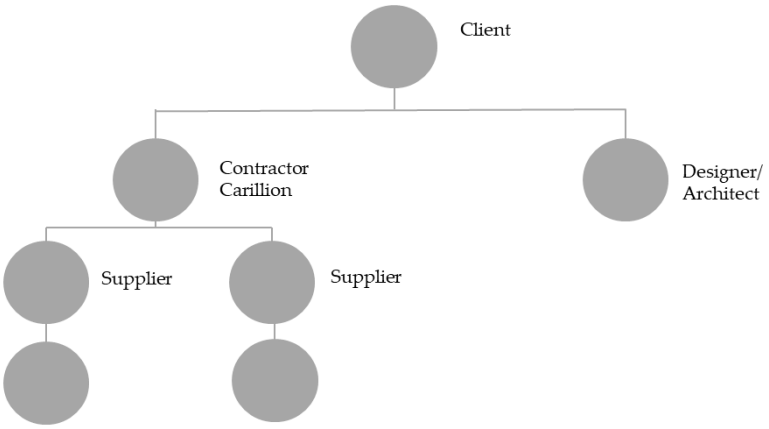


Figure 53: Upstream and Downstream Supply Network Model.



Appendix: 3b Semi – structured interview questions (D5)

Understanding the 'Sustainability' Demands of Clients

Briefing Note

Aim: To support the development of a CCS hotspot analysis, metrics and feedback loop.
Background: The hotspot analysis/decision matrix work is being piloted by CCS Supply Chain team and is a 3 year project with the University of Surrey. It aims to understand where the major sustainability issues are both upstream (suppliers) and downstream (clients/ends users/demo), the risks and opportunities associated with these and where the company can influence change.
Work completed to date:

1. 6 key client strategies have been analysed and short reports created
2. KPIs and other metrics that 6 key clients report to stakeholders have been mapped

Further analysis required:
It is frequently stated that extensive requirements from clients at PQQ/tender stage do not appear to follow through into their purchasing requirements. We would like to investigate this further by requesting expert help/opinion from the Work Winning and Bid Development teams:

1. To map sustainability questions at PQQ, Tender and then at contract specification on 2-3 projects (ideally 2 public sector/1 private) and understand variation
2. To overlay these findings onto client strategy and KPIs
3. To understand through discussion how/when the 'message may be lost' (see below for semi-structured questions)

Support required from WW/BD teams

1. Based on aims of work to offer any guidance/thoughts prior to the analyse that would make it more effective/useful! Feedback by email or tel con with Carillion Doctoral Researcher - June 2016
2. Select and provide 3 contracts for review ideally from the following client list – Argent, Highways England, MOD, Network Rail, NHS Trusts. To allow access to the information to a Doctoral Researcher based in Carillion CCS to analyse. If needed to offer some tel guidance. June 2016
3. To meet and discuss presentation and offer expert analysis and recommendations for improvement – end July/Early August 2016

Semi-structured question areas:

Confirm team and role of participant: if involved in a specific project, note.

1. Explore how they are informed about client sustainability requirements.
2. How is this information provided?
3. If applicable understand the engagement the team has with the client
4. Has this changed – are clients more or less demanding, are certain areas more 'popular' than they were?
5. As members of the Carillion team how do they feel clients see sustainability
6. Does the company get feedback from the client on PQQs, tenders and indeed the built environment.

Version 1 7.6.16

Appendix: 3c Semi – structured interview questions (D8)

Version 2 24.4.17

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Confidential and in Confidence

Project: Carillion Supply Network Sustainability

Brief to Suppliers

Outline of research:

We are working with a PhD student from the University of Surrey to develop an approach to enhance our ability to directly manage or influence key environmental and social issues across the whole life of an asset and thus at all levels of the supply network.

This is a major challenge with many unknowns but we are setting ourselves goals that look forward to 2030.

One of our key focus areas is, of course, our supply chain and we feel that talking to our key suppliers, many of whom work in areas of high impact, is a sensible place to start this discussion. If you feel there may be some issues of confidentiality please discuss this with the Category Management team.

How you can help:

We want to consider a couple of key questions with you:

Question 1: Can we develop a simple set of metrics that allow us to easily include the negative impact reduction or positive impacts of the products you supply us into our procurement decision making and reporting, and thus to clients and design teams.

Question 2: How do we maximise the work that you are doing to minimise the impacts (or indeed enhance positive impacts) of the products/service you supply? This might be supporting getting more sustainable products into common use or the introduction of more innovative products with greater environmental credentials that you may be developing.

Next Steps:

At our next SRM (Supplier Review Meeting) we would like to bring with us the student + member of our sustainability team to explore your thoughts/information on the following points so we can start to map out how we can approach this problem. It would be helpful if you could work with your own sustainability teams to prepare your thoughts in advance and draw together materials to support this work. It may be very helpful if someone from this team could join us on the day.

Our thoughts on Question 1

1. **Do the issues that matter to us also resonate with you?**

Understanding what matters to you: Which of the following issues are you working on and are these just within your own organisation or do you work to extend this into your supply chain? Please could you complete each box using a scale of 1-5 to highlight the extent to which you feel you have addressed these issues and 0 if not applicable.

Issue	CO2 reduction	Reduced Material use	Reduced Waste	Less water use	Enhanced Bio-diversity	Fair Labour Practices (inc Modern Slavery)	Community engagement	Skills/ training	Health and Wellbeing
Own operations									
Our product or service									
Our Supply Chain									
Not relevant to this business/ product									

Scale: 1 – no action 2 – limited action – 3 made some progress 4 – baseline set and good incremental progress, 5 – responding with major changes to processes/materials and models

2. **How do we simply capture what is already happening in a way that aligns with our systems?**

Version 2 24.4.17

To help us with our strategic decision making we would like to be able to create a simplified management tool that provides information on key impacts in the supply chain.

The question to think about!!

Based on our purchases from you (either directly or indirectly), can we estimate, using environmental (and eventually social data) the impacts of the products we use?

We would like to discuss this with you using two 'issue' examples:

Issue 1: CO_2e

Issue 2: Reducing resource use / solution: increased recycled content

Below are two ways we think could work but we would like your thoughts.

Problem to overcome

How can we measure CO_2e/Recycled material and create relevant baselines to demonstrate improvement?

Eg Option 1:

Carillion allocated % of supplier total CO2e based on % sales with supplier. Use GRI reported data or other accredited CO_2e data,

Positives -	Accredited Data
	If reporting as part of corporate requirement should be relatively easy to estimate
Negative -	not directly allocated to a product unless mono supply
	Currently unlikely to offer embodied carbon beyond scope 1&2
	Data may not be available due to sub-contracting scenarios

Eg Option 2:

Based on estimated product sales to Carillion, supplier to provide either volume data or value data by product on a qtrly basis and use EPD or similar data to estimate impacts per unit of sale

Positives -	simplified approach that can be integrated into existing systems
	Product related, therefore links to BREEAM, CEEQUAL and LEED
Negatives -	may be too generalised to create meaningful data
	may be too generalised to create baseline for improvement
	Data may not be available to develop conversion metrics
	Data may not be available due to sub-contracting scenarios
	May fail to capture all embodied impacts

We would welcome your thoughts on both of these scenarios.

We think our suppliers would be more likely to be able to meet option 2 as they are generally outside of the EU and are actively developing an environmentally acceptable approach to manufacturing.

Our thoughts on Question 2

We know that our key suppliers are already tackling many of the issues that Carillion themselves are addressing.

What immediate changes do think Carillion could make to benefit from your work on these issues? We are not working on these issues.

And thinking about the longer term.....

Where do you think your future innovations will focus? Which issues will you be addressing?

How do you feel we need to 'sell these' benefits to investors, clients and designers?

And next steps

We see this work as an ongoing process of development and testing:

Do you feel comfortable/have the resources to support this work?

We would like to develop case studies with our key suppliers from the materials you have supplied and the collaborative development that we undertake. We would like to be able to use these with investors, clients and designers. Would you be able to support this approach?

Appendix: 3d Survey 1 questions (D3)

Survey – Supply Chain Team (Final Version: 5/13.4.16)

We are working with a PhD student from the University of Surrey to support our Sustainable Procurement strategies and we need views and opinions to help shape this. Be honest in your answers, none of them will be wrong! All responses to this survey will be amalgamated and therefore any data presented will be 'anonymous'. The findings will be shared with everyone who attends the conference. Your thoughts and feedback will also help the speakers at the conference shape the information they provide.

PART 1: Your Role

1. *Which team are you in?*

   Supply Chain
   Commercial
   IMS
   Other

2. *Which of these job descriptions best fits your role? (Please tick)*

   Graduate
   Assistant Buyer
   Buyer
   Supply Chain Manager
   Category Manager
   Head of Supply Chain
   Supply Chain Analyst
   Other (please specify)

PART 2: What do you think about sustainable procurement?

3. *Which of these phrases fit best with your thinking on sustainable procurement (please select one)*

   When assessing products use a 'whole life' (from raw materials used to demolition) approach and their impacts
   Expect suppliers to commit to resource efficiency and waste reduction goals
   Purchase from SMEs and local companies where possible
   That companies we purchase from comply with human rights
   Ensure that we buy products with lowest embodied carbon

4. *Why do you think sustainable procurement matters to Carillion ? (Rank this list 1-5 with 1 being most important)*

   It reduces financial Risk

Reduces Costs
Satisfies Clients demands
It is part of the Legislation we have to meet
Offers Value for money

5. *In your opinion where does the responsibility for sustainable procurement lie? (tick one answer per line where 1= not at all, 2= minimal, 3= reasonable, 4= fairly high, 5= high)*

Carillion Corporate Sustainability team
Carillion Operational Teams
CCS Health Safety and Sustainability Team
Carillion Supply Chain/Procurement Teams
Our suppliers
Designers
Our clients

Other (free text)

6. *Should any other teams within Carillion also have responsibility for Sustainability? If so which*?

Open question – respondents invited to comment

7. *What do you think is the best way to embed sustainability throughout the supply chain? (rank this list 1-6, with 1 being most important)*

through contracts
specify in Tenders
helping educate the supply chain on the issues
Set clear targets
Provide strong leadership
provide better analysis and data to help decision making

8. *When you talk to suppliers how important is it to show that Carillion is also taking up the sustainability challenge? (tick one answer from the options: not at all, slightly important, some importance, quite important, very important)*

9. *Where do you see the most impressive innovation taking place? Select one.*

External to Construction sector
Design and Technology
Working processes or practices
Sustainable product and/or services
In specific locations (e.g. cities)

PART 3: what do we do now?

10. *How effective are the following teams in helping Carillion deliver sustainable (positive environment, social and economic) solutions? (tick one answer per line) (Score each 1-5, 1 being not at all, 2- very limited 3 – reasonably effective 4- effective 5 - highly effective)*

    Carillion Corporate Sustainability team
    Carillion Operational Teams
    CCS Health Safety and Sustainability Team
    Carillion Supply Chain/Procurement Teams
    Our suppliers
    Designers
    Our clients

11. *What issues are most important when you buy 'sustainably'? (Rank this list 1-5 with 1 being most important)*
    Using materials sustainably
    Making sure materials have been ethically sourced
    Products support energy efficiency
    Products support water efficiency
    supporting the local economy and SMEs

12. *How often does the SPI Sustainability rating of a supplier influence your purchasing decision? Score 1-5 (i.e. 1= never, occasionally, sometimes, often, 5= all the time)*

13. *How often does the SAF Sustainability rating of a supplier influence your purchasing decision? Score 1-5 (i.e. 1= never, occasionally, sometimes, often, 5= all the time)*

14. *How do you normally judge how sustainable a product or service is? (select all that apply)*

    The company had a standard such as BES6001, ISO8903, CEMARS
    Look at the EPD certificates
    Products rated in the Green Guide
    Use common sense
    Ask supplier for information
    Work to a client specification
    Not sure – difficult to tell sometimes.
    Other (free text)

15. *Q15 Please say why do you feel this is/these are the best ways to judge the sustainability of a product or service*

16. *With the exception responsibility sourced timber what proportion, by value, of the products you purchase have sustainable credentials? 0-10%, 11-20%21-40%41-70%, 71-100%)*

17. *With the exception of responsibly sourced timber how often are you asked as part of the client requirements to make sure the products you buy have sustainable credentials? 1-5 (never, rarely, reasonably often, frequently, all the time)*

18. *Do you consider there to be modern slavery in the supply chains of companies you buy from? (tick one)*

    No
    Probably not, all the suppliers are UK based
    Don't know
    It is possible, some products include non-UK components
    It's highly likely

19. *Which suppliers do you think are at high risk of having modern slavery in their supply chains?*

    free text

20. *What would you do to make our supply chain more sustainable?*

    free text

Thank you for completing this survey. We will be sharing the findings with you at the supply chain conference on the 27th April.
If you would like to read more about the Sustainability work being undertaken across Carillion please go to the newly released Annual Sustainability Report (hyperlink)

END OF SURVEY ON survey monkey:

Appendix: 3e Survey 1 covering email (D3)

15.4.16 – Carillion internal email

Dear Colleagues
I am really looking forward to seeing you all at our annual CCS Supply Chain conference and sharing with you all some of the developments and thinking around sustainable procurement, our theme for the day. But it's not a one-way street. I also want to know what you think. On the day we will have a chance for questions, hear from members of the team and of course try to generate plenty of discussion, and time for you to network. I would very much like the whole team to shape the content and presentations.

To do this I want to get your views on a range of issues and would like every member of the team to contribute. Please be frank and open with your answers, this is much more useful!! All responses will be collated into an anonymised set of results and will be fed back to each speaker to make sure they respond to your views.

Link to Survey …….surveymonkey.co.uk/r/supplychain…….

All surveys must be completed by Thursday 21st April 2016

Regards

SC-SSD-D

Appendix: 3f Survey 2 questions (D6)

Survey – Supply Chain Team (Final Version: 2/9.4.17)

This is our second year of working with a PhD student from the University of Surrey to support our Sustainable Procurement strategy. We want to update the insight we gained last year. Be honest in your answers, none of them will be wrong! All responses to this survey will be amalgamated and therefore any data presented will be 'anonymous'. The findings will be reported back to everyone who attends the conference. Your thoughts and feedback will also help the speakers at the conference shape the information they provide.

PART 1: Your Role

1. *Which team are you in?*

   Supply Chain
   Commercial
   IMS
   Other

2. *Which of these job descriptions best fits your role? (Please tick)*

   Graduate
   Assistant Buyer
   Buyer
   Supply Chain Manager
   Category Manager
   Head of Supply Chain
   Supply Chain Analyst
   Other (please specify)

PART 2: What do you think about sustainable procurement?

3. *In your opinion where does the responsibility for sustainable procurement lie? (tick one answer per line where 1= not at all, 2= minimal, 3= reasonable, 4= fairly high, 5= high)*

   Carillion Corporate Sustainability team
   Carillion Operational Teams
   CCS Health Safety and Sustainability Team
   Carillion Supply Chain/Procurement Teams
   Our suppliers
   Designers
   Our clients

   Other (free text)

4. *How effective are the following teams in helping Carillion deliver sustainable (positive environment, social and economic) solutions? (tick one answer per line) (Score each 1-5, 1 being not at all, 2- very limited 3 – reasonably effective 4- effective 5 - highly effective)*

   Carillion Corporate Sustainability team
   Carillion Operational Teams
   CCS Health Safety and Sustainability Team
   Carillion Supply Chain/Procurement Teams
   Our suppliers
   Designers
   Our clients

5. *How do you normally judge how sustainable a product or service is? (select all that apply)*

   The company had a standard such as BES6001, ISO8903, CEMARS
   Look at the EPD certificates
   Products rated in the Green Guide
   Use common sense
   Ask supplier for information
   Work to a client specification
   Not sure – difficult to tell sometimes.
   Other (free text)

6. *In 2016 were clients asking us to meet BREEAM, CEEQUAL or LEED material/management standards more or less than they were 5 years ago? (select one)*

   Not been asked to do this at all in 2016
   Less than previously
   The same
   more requests in 2016
   Other (please specify)

7. *How have suppliers responded to the issue of modern slavery - 1 year on?*

(reply to all by noting in your experience the most common position - i.e. none, a few, many, most)
Don't know about the Act
We're too small and it's not relevant to us
No slavery in 'own business' but don't know about our suppliers
Have a plan in place to work with their supply chain
Have already started working with suppliers
Can guarantee no modern slavery in supply chain
Any other thoughts...

8. *If you have worked with any company that has confirmed they can guarantee they have 'no modern slavery' in their supply chain could you confirm who they are and how they have achieved this. We want to share best practise.*
(open response)

9. *Why do you think buying FSC timber matters to Carillion? (tick 3 you feel are most important)*
Clients request it
The chain of custody aligns with Carillion's ethical values
Chain of custody reduces risk of unethical sourced materials
FSC is a mark of quality
FSC supports SMEs in the supply chain

10. *We are seeing increasing concern about air quality and pollution in urban areas. What can we, as the supply chain team, do to improve this issue on and around our sites?*

Appendix: 3g Survey 2 covering email (D6)

Draft v1 7.4.17
Dear Colleagues

I'm looking forward to the Supply Chain Conference, with our focus this year on value. We are, once again, doing a short survey prior to the conference, which will help support the work of our PhD researcher and shape speaker thinking. The survey repeats 5 questions from last year and then asks for your thoughts on three additional issues. The survey will take no more than 5 minutes.

Last year a high number of you supported this work but I would like every member of the team to contribute. Be frank with your answers, it's more useful! As last year, all responses will be collated into an anonymised set of results and you will be sent a copy of the insight generated.

Link to Survey
All surveys must be completed by Thursday 21.4.17.

Regards
SCSSD-D

Appendix: 3h Workshop materials (D4)

Figure 54: 'Ice Breaker' Cards (D4)

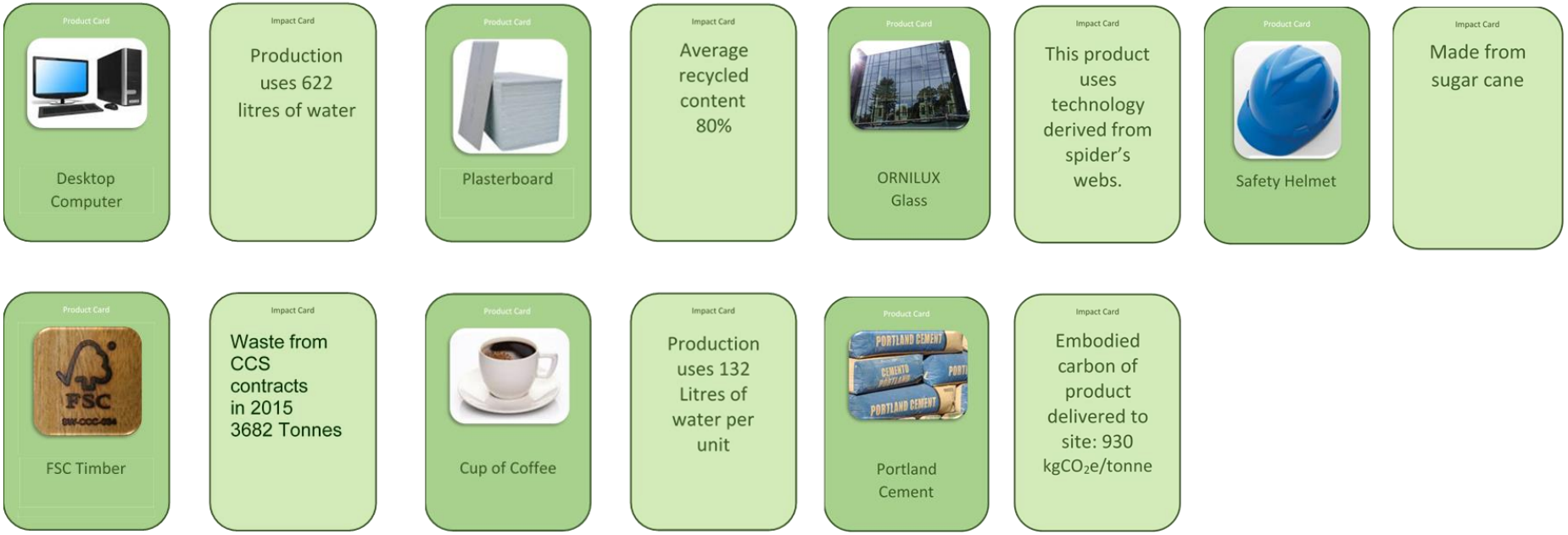


Figure 55: Product Review Sheets (D4)

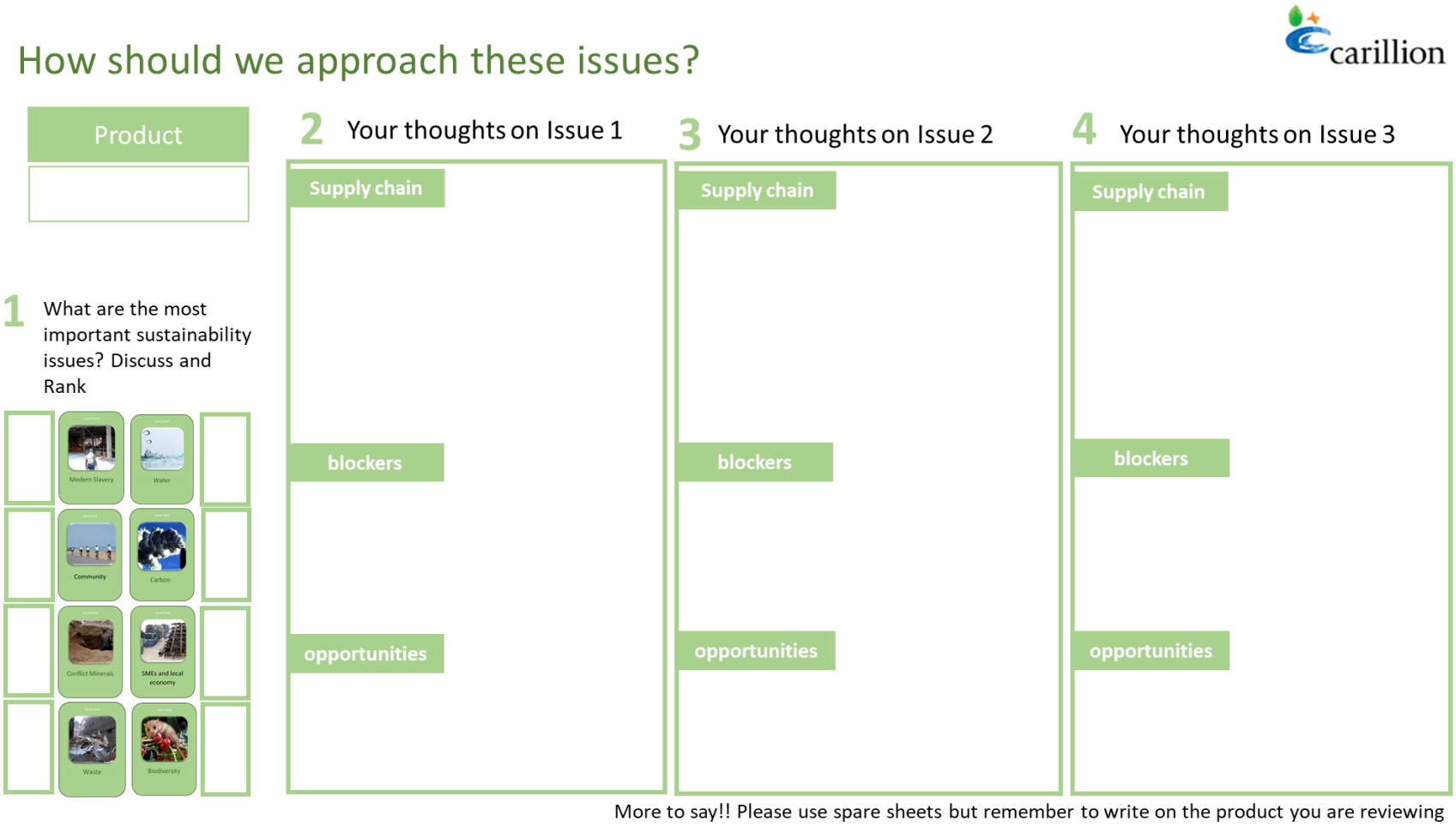


Figure 56: Workshop Issue Cards (D4)

Figure 57: Visual drawn from animated presentation: Lifecycle of a Pencil (D4) (Lepech, 2009, Derwent Pencils, 2013)

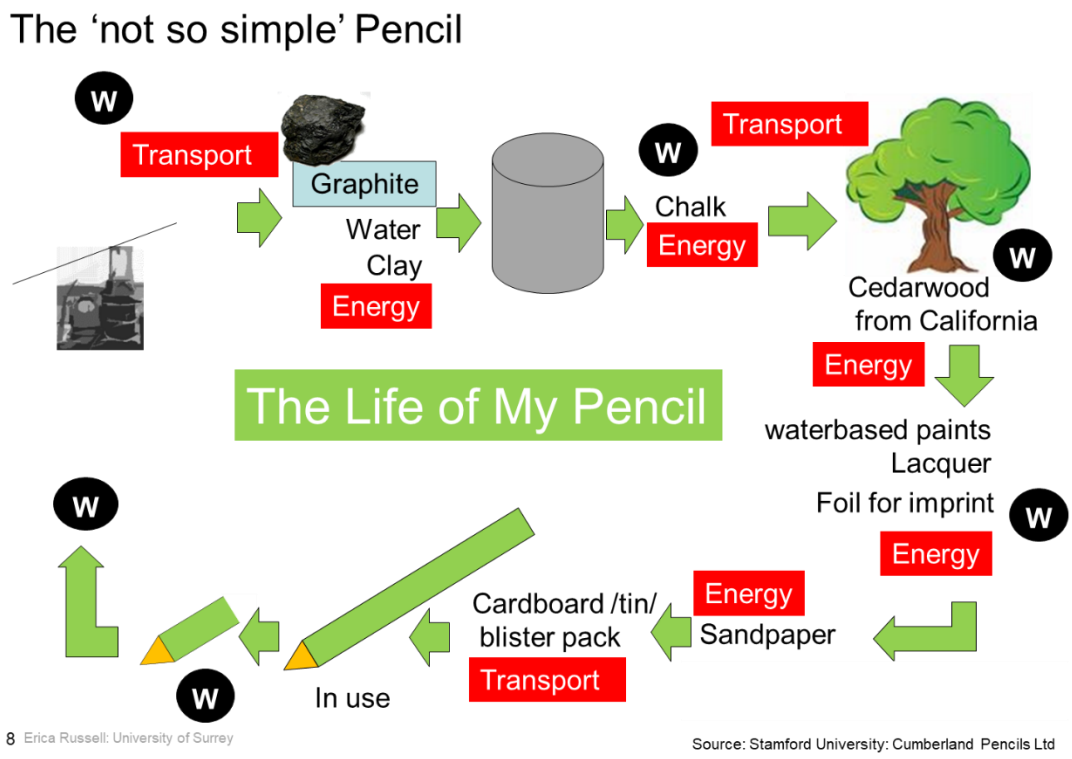


Figure 58: Building and Bridge Lifecycle (D4)

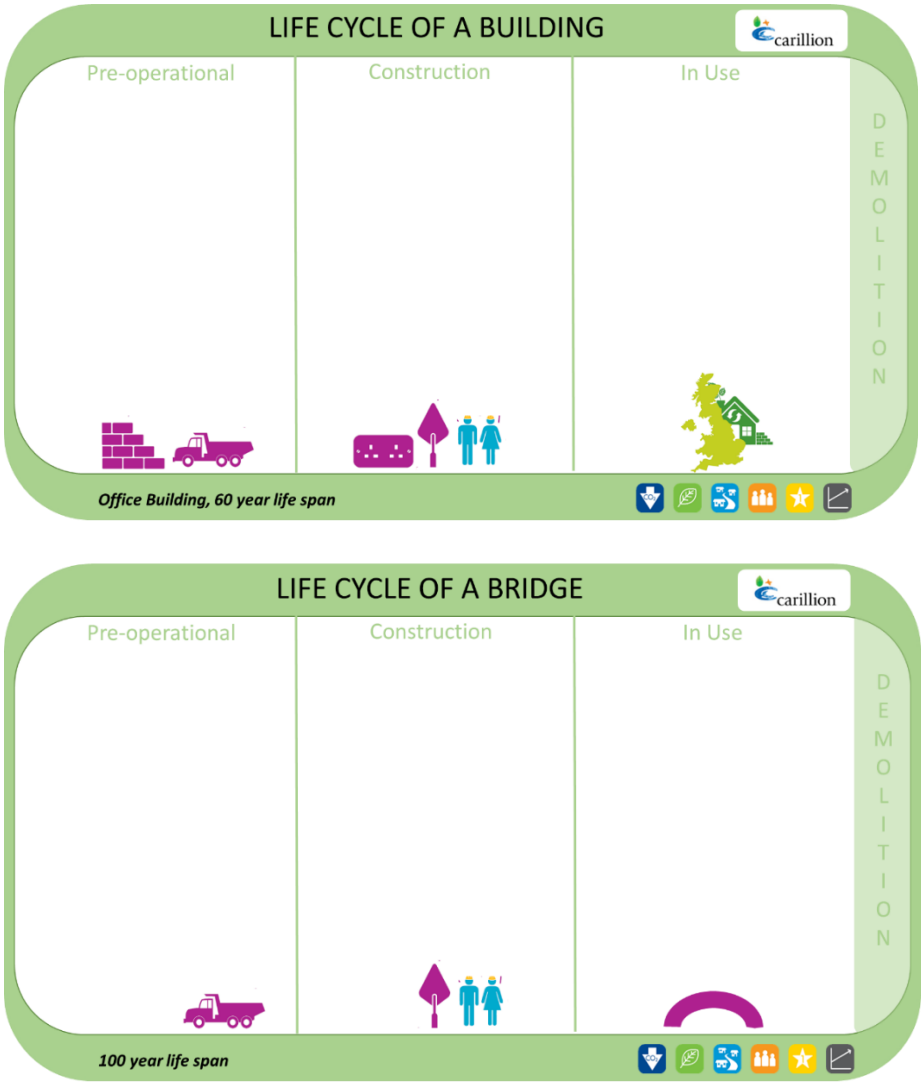
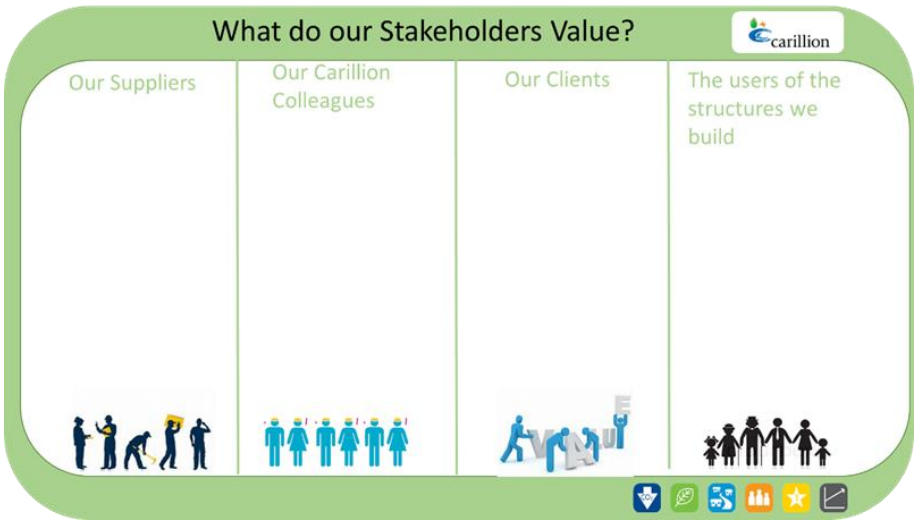


Figure 59: What do stakeholders value? April 2017



Appendix 4: MAXQDA Code book

1 neutral
The statement is factual - it provides neither a positive or negative view but provides insight into some level of procurement
2 positive
A statement which positively supports Sust proc, facilitates it or is openly positive - an enabler
3 negative
A statement which does not support sustainable procurement, is openly negative or appears negative - a barrier to sust proc
4 Barriers-Enablers
4.1 Barrier
4.1.1 Silos
Description of internal teams or external organisations with specific roles within the network operating in isolation - taking decisions without consulting others in network
4.1.2 time pressure
time prevents people from taking action
4.1.3 Cost
Participant description
4.1.4 risk
Specifically mentioned or where context suggests this is an enabler or barrier to action
4.1.5 Env/Social Issues
Any general issues which prevented action
4.2 Enabler
4.2.1 BIM
Building information modelling - major innovation in construction - data platform to provide information on building components and allow 3 D modelling. Mandated by Government on their contracts. Has potential to include sustainability data such as carbon
4.2.2 new models
Description by participants of new business models
4.2.3 legal
reference to legislation either directly or in how it may affect behaviours
4.2.4 mandated
Not legal but could be a client demand, a company requirement such as FSC timber
4.2.5 Return on investment
either a participant description or an obvious reference to this using different wording
4.2.6 Innovation - Technology
Innovation can be product, process or other, technology relating to building or procurement process
4.2.7 Long Term
Participants did not define long term. 3 year horizons in business are 'normal' so suggest long term, especially in construction, would be seen as more than 10 years
4.2.8 Opportunities
Description used by participants
4.2.9 risk drives change
risk as an enabler of positive sustainable actions
4.2.10 standards
Used in general sense to identify standards, such a BREEAM to ISO and guidance such as PAS
4.2.11 strategic value
Participant description

4.2.12 Business Value
words used by participant - value not defined but often a descriptor of cost saving
4.2.13 Shared Cost-Profit
Participant description of sharing value in the supply network
4.2.14 PFI
Private Finance Initiative as part of a PPP programme of works
4.2.15 Savings
Any form of saving - time, money, materials, biodiversity. However most likely to be cost
5 Network Roles
5.1 Carillion Operations
Internal team - manage operational activity on projects
5.2 Carillion Supplier Performance Team
Manage "My Register" system - review supplier applications and monitor renewals and track potential company financial issues
5.3 Carillion Business Units
Carillion description of sub corporate company unit - i.e. CCS, Services, MENA and Canada
5.4 The Company (Carillion)
The corporate position or role
5.5 Commercial team
Carillion internal team or job family that is broadly associated with Quantity surveying department -
5.6 Carillion Bid Development Team
5.7 Key Suppliers
Carillion have identified their 'key suppliers' based on turnover with the company
5.8 Carillion SC Team
Carillion Supply Chain team manage the procurement and buying of products and services to deliver the commitment to customers.
5.9 Suppliers T1+
Suppliers below Tier 1 (i.e. not directly contracted by Carillion). Note Tier 1 and Tier 1+ can alter roles between projects.
5.10 Work Winning
Carillion phrase for teams who prospect for clients
5.11 professional bodies
Professional bodies such as CIPS or ICE that the procurement teams are familiar with
5.12 Pressure Group (inc NGOs)
some NGOs and organisations are seen as pressure groups - negative connotations with teams. Concern over getting too close and potentially opening up to challenge/lack of trust. Other NGOs are very supportive such as WWF or Hospice movement.
5.13 Specialist Companies
5.14 Suppliers T1
Suppliers directly contracted by Carillion (main contractor)
5.15 Category management
Category management is a function within Carillion supply Chain. Category managers are not buyers, but they are specialists in segmented categories of spend - i.e. curtain, groundworks, M&E.

Carillion Definition:
Carillion's external spend has been analysed and segmented into categories. Each category in turn has been allocated to a supply chain professional to manage with the objective being to deliver the business and functional requirements of reducing cost, improving performance and driving innovation year on year. It is not an approach that is confined to the supply chain

function but requires the active participation of and engagement with stakeholders, function and individuals across the business to make it successful. Category Managers will undertake a strategic sourcing process -(7 steps - Gather Data, Analyse, Source, Negotiate, implement, Transition plan, measure and improve). The category managers will work together with the Head of Service, site teams, and our supplier to deliver the category strategy which will be driven by this souring process. Along with costs capability, cultural fit, flexibility and partnering ability will be evaluated when selecting preferred suppliers" Carillion Intranet pub 2012 Accessed 2017

5.16 Project

An infrastructure or building 'project' on behalf of a client

5.17 sub-contractors

Contractors who work for Carillion on a project. They may sub contract further. It is possible that on smaller jobs they might be a main contractor.

5.18 consultants

Appears to be interchangeable with some of the professional organisations - e.g. consulting engineers.

5.19 Structural engineers

Participant description

5.20 Quantity Surveyors

Participant description - external to Carillion (see also Carillion commercial team)

5.21 Main Contractor

primarily linked to Carillion's role but may be more generic description by client

5.22 manufacturer

Participant description or added as descriptor of manufacturer

5.23 Carillion Sustainability Team

Carillion corporate and Business Unit sustainability staff. Corporate seen as separate to BU but very few staff and all tend to work together.

5.24 Design

Design both intra and inter company. Participants do not differentiate – SC-RH2 saw designers as architects, engineers, internal teams – very generic

5.25 End Users

People who live and/or work or use the structures created - the consumer

5.26 clients

Those who directly pay Carillion to build or manage structures. The construction industry uses Clients, Developers and Investors as separate network descriptors, with different roles. For this code they are not differentiated if they directly contract with Carillion.

5.27 External Expertise

companies or individuals contracted to provide professional expertise not available within Carillion - i.e. engineers, designers, surveyors, legal advice, consultants

5.28 Suppliers managing Environmental issues

examples of how procurement team see suppliers dealing with environmental issues

6 Process

6.1 management of information

all references by interviewees on the how information is disseminated, used and lack of/excess. Responses are both negative and positive.

6.2 Supplier selection criteria

selection criteria for suppliers- both formal (“My Register”), client requirements and less formal - buyer preferences,/values, other team agendas

6.3 Audi/Assessment

Reference to physical or digital audits or supplier assessment

6.4 Product

Materials used to create structures - either temporary for construction use or permeant as part of structure

6.5 Bids

response to contract tenders or other procurement forms from clients

6.6 Early Engagement

ill-defined term used by participants. may refer to multiple network partners but often used in relation to clients and designers. Main focus is failure to engage early in process of structure development leads to inefficiencies, loss of value and failure to maximise potential for sustainable builds

6.7 Exemplar

example by participants where they see sustainability has been done well

6.8 material specification

specification supplied to Tier 1 contractor of the nature of materials that need to be supplied. The specification is frequently content/detail based rather than by outcomes.....although this does occur in some cases

6.9 Target setting

Any form of targets set, used or created noted by participants

6.10 Specification

A formal written document itemising in detail the requirements for a project, materials, timelines etc. This is usually provided by the designer and or engineer but may include direct client information too.

6.11 Boundary Setting

Either a participant comment or interviewer note of how and where participants envisage the boundary up to which they are responsible for sustainability.

6.12 episodic supply

where suppliers are not constantly involved in supplying a company - i.e. they may work on one project for 2-3 years and then not supply for 3-4 years until the next relevant job comes up.

6.13 sustainability in supply chain process

Participant commentary on how sustainability is managed/flows through the supply chain

6.14 Sustainability Tool

Tools identified by participants that they have used or have supported sustainability in procurement

7 Soft systems-

7.1 Values

Encompasses mentions of values, ethics and comments that represent these

7.2 control

participant description

7.3 responsibility

participant comment or example of which network actors should undertake a task or be liable for its delivery

7.4 Transparency

participant comment or example of

7.5 Peer Pressure

specific mention by participants or examples of issues where they have experienced this

7.6 Trust

Identifying where participants saw trust as an issue or benefit

7.7 honesty

participant generated

7.8 influence

examples of influence by different network members on sustainability in the construction of

buildings or infrastructure

7.9 tensions

mention by participants of tension, examples of tensions

7.10 Collaboration

participant comments on collaboration, use of word collaboration and examples of collaboration within the supply network. Can be both negative and positive

7.11 Relationships

specific mention of relationships by participants

7.12 Adversarial

Phrase may be used directly by suppliers or could be the coding of negative relationships, passing of risk to others, lowest price at any cost,

7.13 Knowledge transfer

Knowledge - understanding of or information about a subject that you get by experience or study - being aware of something. Examples or participant comment on transfer of sustainability knowledge in the network

7.14 lifecycle

participant comment or example of lifecycle approach to sustainability

7.15 Internal views on Sustainability

participant views on how sustainability is seen within Carillion by colleagues

7.16 Knowledge of Sustainability

Knowledge - understanding of or information about a subject that you get by experience or study - being aware of something. Sustainability - environmental, economic and social - their interrelated nature and understanding of major issues.

7.17 Understanding Sustainability Impacts

Participant comment or understanding of the impacts of their procurement/company on sustainability issues

7.18 Incorrect knowledge

False news, misunderstanding about sustainability issues

7.19 supplier capacity

Participant comment or examples of positive or negative effect of supplier capacity on sustainability within the supply network

7.20 Perceptions of sustainability

Interviewer coded - examples of participant perceptions of sustainability or their comments on how others see it

Appendix 5: Code list, participants by job role

Code	Job Role	Carillion Team /other	Research Phase
CM-1	Head of Category – MEP	Carillion Category Management	D3, D4, D6, D10
CM-2	Category Manager – MEP	Carillion Category Management	D3, D4, D6, D8, D10
CM-3	Head of Category – Prelims.	Carillion Category Management	D3, D4, D6, D8
CM-4	Head of Category - Groundwork's / External Works / Demolition / Asbestos	Carillion Category Management	D3, D4, D6, D8, D10
CM-5	Head of Category - Building Envelope	Carillion Category Management	D3, D4, D6,
CM-6	Head of Category – Finishes (Construction)	Carillion Category Management	D3, D4, D5, D6, D8, D10
CM-D	Director	Carillion Category Management	D3, D4, D5, D10
D-HD	Head of Design	Carillion Design	D5, D10
HSS-H	Head of Health, Safety and Sustainability	Carillion Health Safety and Sustainability – CCS	D10
HSS-HO	Head of Health and Safety	Carillion Health Safety and Sustainability - CCS	D10
O-AD0	Account Director - Building project	Carillion Operations - CCS	D5
O-BIM	BIM Implementation Manager	Carillion Operations- CCS	D5
O-RBIM	Regional BIM Manager	Carillion Operations - CCS	D5
S-BM	Business Unit (CCS) Sustainability Strategy- monitoring, reporting, leading project sustainability	Carillion Sustainability-CCS	D1, D2, D3, D4, D6, D7, D8, D10
SC-A1	Supplier Accreditation and Monitoring	Carillion Supply Chain -Group	D2,
SC-A2	Supplier accreditation and management	Carillion Supply Chain - Group	D2, D3, D4, D6
SC-D1	Regional Director - Managing National strategy, Supply Chain procurement, multiple projects, client liaison	Carillion Supply Chain- CCS	D2, D3, D4, D6, D10
SC-DB	Supply Chain Director, CCS Board position	Carillion Supply Chain - CCS	D3, D4, D6, D7, D10
SC-JV	Supply Chain Manager - Managing procurement – joint venture	Carillion Supply Chain-CCS	D2, D3, D6

Code	Job Role	Carillion Team /other	Research Phase
S-CM	Group Sustainability Manager - Corporate sustainability, policy, strategy and reporting	Carillion Sustainability-Group	D2, D4, D10
SC-P1	Supply Chain Manager - Leading team on large public-sector project, delivery, client liaison	Carillion Supply Chain-CCS	D2, D3, D4, D6
SC-PM	Programme Manager	Carillion Supply Chain – Group	D10
SC-RM1	Regional Manager - Managing Regional Supply Chain team multiple projects, client liaison (Building)	Carillion Supply Chain- CCS	D2, D3, D4 D6,
SC-RM2	Regional Manager -Managing Regional Supply Chain team multiple projects, client liaison (Building)	Carillion Supply Chain-CCS	D2, D3, D4 D6, D10
SC-RM3	Regional Manager - Managing Regional Supply Chain team multiple projects, client liaison (Infrastructure)	Carillion Supply Chain- CCS	D3, D4, D5, D6, D10
SC-SB	Senior Buyer	Carillion Supply Chain - CCS	D5
S-CSO	Chief Sustainability Officer	Carillion Sustainability- Group	D10
S-I	Professional Head of Sustainability – Infrastructure	Carillion Sustainability- CCS	D7, D10
S-SA	Sustainability Advisor CCS	Carillion Sustainability	D5, D10
S-SAC	Sustainability Advisor – Canada (MENA)	Carillion Sustainability – Canada	D10
SUP- 1	Sustainability Manager, 2x Sales team	Tier 2/3: Manufacturer – Ceramics	D8
SUP-2	Director of Sustainability	Tier 2&3: Manufacturer – Ceramics	D8
SUP-2	Sales team	Tier 2&3: Manufacturer – Ceramics	D8
SUP-3	Head of Sustainability + Key Account Manager	Tier 3: Manufacturer – Plastics	D8
SUP-4	Sustainability Manager and Key Account Manager	Tier 1&2: Wholesaler	D8
SUP-5	Unknown	Tier 2&3: Manufacturer – Cables	D8

Code	Job Role	Carillion Team /other	Research Phase
SUP-6	Unknown	Tier 2&3: Manufacturer - Cables	D8
SUP-7	Sustainability Manager	Tier 1&2: Manufacturer - Cement/Aggregates	D8
SUP-8	UK Head of sustainability and Sustainable Construction Engineer	Tier 1&2: Manufacturer - Cement/Aggregates	D8
SUP- 9	Unknown - no interview	Cable Manufacturer	
SUP-10	Head of Sustainability	Tier 1&2&3: Manufacturer -Paving and Stone	D8
SUP-11	Head of Sustainability	Tier 1&2&3: Manufacturer - Plasterboard	D8
SUP-12	General Manager and Technical Manager	Tier 1&2: Manufacturer Assoc. -Steel	D8
WW-PC	Proposals Co-ordinator	Carillion Work Winning - CCS	D5
WW-PM	Proposals Manager	Carillion Work Winning -CCS	D5

Appendix 6: What do our stakeholders value

Table 31: Supply Chain team assessment: What do our Stakeholders value? (April 2017) (42 participants, 183 comments)

		Carillion Values				Nature of Collaboration			
	Supply Chain Responses	We Care	We deliver	We achieve together	We improve	Relational	Transactional	Indicates collaborative working	sustainability
Suppliers	Payment on time		1				1		
	Correct Score		1				1		
	forward notice of workload			1		1		1	
	commitment (£)			1		1		1	
	improving their business by working with us				1	1		1	
	systems		1				1		
	H&S	1				1			1
	Mutual Trust			1		1		1	
	Honesty			1		1			
	Consistent Carillion approach		1				1		
	Development Opportunity - Legacy				1	1		1	
	Lots of work and opportunity to expand			1		1		1	
	Equality	1				1			1
	Collaboration			1		1		1	
	Engagement			1		1		1	
	Timely payments		1				1		
	Trust			1		1		1	
	Ethics	1				1			1

		Carillion Values				Nature of Collaboration			
	Supply Chain Responses	We Care	We deliver	We achieve together	We improve	Relational	Transactional	Indicates collaborative working	sustainability
Carillion Colleagues	Brand			1		1			
	Image			1		1			
	H&S	1				1			
	Credibility			1		1			
	Security	1				1			
	Opportunity			1		1			
	Welfare	1				1			
	Opportunity			1		1			
	Equality	1				1			1
	Respect	1				1			
	working in a strong team with good opportunities and support			1		1		1	
	feel valued	1				1			
	transparency		1				1		
	Consistency of strategy, process and support		1				1		
	known suppliers			1		1		1	
our clients	Value for Money		1				1		
	no surprises		1				1		
	Programme		1				1		
	customer experience			1		1			
	competitive pricing		1				1		
	reliability		1			1			

		Carillion Values				Nature of Collaboration			
	Supply Chain Responses	We Care	We deliver	We achieve together	We improve	Relational	Transactional	Indicates collaborative working	sustainability
	Cost		1				1		
	Quality		1				1		
	Trust			1		1		1	
	Quality		1				1		
	openness			1		1		1	
	Compliance		1				1		
	Value - capital and life cost		1				1		
	innovation				1		1		
	Defining brand design			1			1		
	no noise' or reputational issue		1				1		
	OTIF (on time in full)			1			1		
	Cheap		1				1		
	value for money		1				1		
	cost certainty		1				1		
	Value for Money		1				1		
	best price		1				1		
	Programme		1				1		
end Users	No defects		1				1		
	Cheap building		1				1		
	Engagement			1		1		1	
	Influence			1		1			
	Value		1				1		
	relevance			1		1			

		Carillion Values				Nature of Collaboration			
	Supply Chain Responses	We Care	We deliver	We achieve together	We improve	Relational	Transactional	Indicates collaborative working	sustainability
	improvement				1		1		
	reliability		1			1			
	Trust			1		1		1	
	cost		1				1		
	finish quickly		1				1		
	quality		1				1		
	quality		1				1		
	ease of maintenance		1				1		
	efficiency of design				1		1		

Appendix 7: Carillion Sustainability Questions: Pilot PQQ and Tender process (2017)

Category	Subcontract enquiry question
environment	Do you have a documented Environmental Management System (EMS)?
environment	Is your EMS certified by a third party to ISO14001:2004 or equivalent? If so please provide copy of the certificate.
environment	Please demonstrate how environmental pollution or nuisance impacts e.g. noise and dust, would be reduced during construction, or considered in the design (if the scope of works includes design)?
environment	Please describe and provide evidence of the Environmental impact for the materials you supply, including sourcing and processing?
environment	Please provide evidence of waste minimisation and resources e.g. recycled content, minimising the use of non-renewable material, diversion of waste to landfill, waste minimisation?
environment	Please provide evidence of energy, carbon and water: embodied (in manufacture), construction phase including transport, and in use (design of permanent works?
social	Please provide evidence of involvement in community investment initiatives? Would you commit to supporting Carillion in local community engagement initiatives and events?
social	Please provide evidence and experience of using local employment and skills training, e.g. apprenticeships and work placements? (Local is defined as the local authority areas in which we are working). How many work placement opportunities would you be able to provide, and what sort of work placements?
social	1. Please provide evidence and experience of monitoring labour standards in the supply chain?
social	Please provide evidence and experience of providing opportunities for local suppliers and SMEs?
social	Please provide evidence of diversity and inclusivity in your workforce?
social	Are you a member of the Infrastructure Supply Chain Sustainability School? If yes please attach your current dashboard. If not, would you commit to joining (it is free of charge) and participating in events if successful in this tender? (We will be pleased to provide details).

Appendix 8: List of Acronyms

Acronym	Description
APRES	Action Programme on Responsible and Ethical Sourcing
ASR	Annual Sustainability Report
BCSA	British Constructional Steelwork Association
BIM	Building Information Modelling
BITC	Business in the Community
BRE	formally the Building Research Establishment
BREEAM	Building Research Establishment Environmental Assessment Method
BSI	British Standards Institute
C&D	construction and demolition
CAQDAS	Computer Assisted Quality Data Analysis
CARES	UK Certification Authority for Reinforcing Steel
CCS	Carillion Construction Services
CECA	Civil Engineering Contractors Association
CEO	Chief Executive Officer
CES	Centre for Environment and Sustainability (University of Surrey)
CIOB	Chartered Institute of Building
CIPS	Chartered Institute of Purchasing and Supply
CIRIA	Construction Industry Research and Information Association
CLC	Construction Leadership Council
CPA	Construction Products Association
CPD	continuous professional development
CRC	Carbon Reduction Commitment
CRF	Corporate Research Forum
CSR	Corporate Social Responsibility
DECC	Department of Energy and Climate Change
DECC	Display Energy Certificates
DfMA	Design for Manufacture and Assembly
EIO-LCA	Environmental Input-Output-Life Cycle Assessment
EMS	Environmental Management System
EPBD	Energy Performance of Buildings Directive
EPC	Energy Performance Certificate
EPD	Environmental Product Declaration
EPSRC	Engineering & Physical Sciences Research Council
ETI	Ethical Trading Initiative
EU-DG	European Union Directorate General
FSC	Forest Stewardship Council
GCB	Green Construction Board
GPN	Global Production Networks
GRI	Global Reporting Initiative
GVC	Global Value Chains
HS&S	Health Safety and Sustainability
HSE	Health Safety and Environment
IBS	Industrialised building systems

Acronym	Description
ICE	Institute of Civil Engineers
IEMA	Institute of Environmental Management
ILO	International Labour Organisation
ISO	International Organisation for Standardization
JCT	Joint Contracts Tribunal
KPI	Key performance indicator
LCA	Life Cycle Assessment
LCC	Life Cycle Costing
LED	Light Emitting Diode
LEED	Leadership in Energy and Environmental Design
llp	Limited Liability Partnership
LSCA	Life Cycle Sustainability Assessment
M&E	Mechanical and Engineering
MENA	Middle East and North Africa
MOD	Ministry of Defence
MPA	Mineral Products Association
NBS	National Building Specification
NEC	New Engineering Contract
NGO	Non Governmental Organisation
NHS	National Health Service
NSMD	non-state market driven
OBIA	Overall Business Impact Assessment
ODA	Olympic Delivery Agency
OECD	Organisation for Economic Co-operation and Development
ONS	Office of National Statistics
ORR	Office of the Rail Regulator
PCR	Product Category Rules
PDS	Practitioner Doctorate in Sustainability (University of Surrey)
PEFC	Programme for Endorsement of Forest Certification
PFI	Private Finance Initiative
PQQ	Pre-Qualification Questionnaire
RIBA	Royal Institute of British Architects
RICS	Royal Institute of Chartered Surveyors
RSPO	Round Table on Sustainable Palm Oil
SCM	Supply chain Management
SCSS	Supply Chain Sustainability School
SDG	Sustainable Development Goal
sLCA	Social Life Cycle Assessment
SME	Small and medium sized enterprises
SPI	Supplier Performance Index (Carillion)
SPSG	Sustainable Procurement Steering Group (Carillion)
SSCM	Sustainable Supply Chain Management
TMO	Temporary Multiple Organisations
UKGBC	UK Green Building Council

Acronym	Description
UN	United Nations
UNEP	United Nations Environmental Programme
USP	Unique Selling Point
WBCSD	World Business Council for Sustainable Development
WRAP	Waste Resource Action Plan
WWF	World Wide Fund for Nature

Appendix 9: Confirmation of Ethics Committee Approval

RESEARCH & INNOVATION SERVICES
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Erica Russell
Centre for Environmental Strategy (CES)
FEPS

University Ethics Committee

03 August 2017

Dear Erica,

UEC ref: UEC_2017_005_FEPS
Study Title: Can main contractor category management create the collaborative basis for a more sustainable construction supply network

On behalf of the Ethics Committee, I am pleased to confirm a favourable ethical opinion for the above research on the basis described in the submitted protocol and supporting documentation.

Date of confirmation of ethical opinion: 3rd August 2017

The final list of documents reviewed by the Committee is as follows:

Document	Version	Date
Ethics Application Form (submitted 3rd Aug 2017)	3	11 July 2017
Research Protocol	3	11 July 2017
Participant Information Sheet	4	31 July 2017
Consent Form	4	31 July 2017
Covering note (Supplier Brief) (submitted 12th July2017)	1	11 July 2017
Brief to Suppliers and questions	2	24 April 2017
Email Introduction to the survey and to ask for participant engagement (recommended by Carillion)	2	04 Jan 2017
Email Introduction to the survey and to ask for participant engagement (potential respondent met at meeting/conference)	2	04 Jan 2017
Insurance Proforma	1	04 Jan 2017
Risk Assessment		04 Jan 2017
Email on 21st June 2017 from researcher with details of the legal agreement in place between the University and Carillion		

This opinion is given on the understanding that you will comply with the University's Ethics Handbook for Teaching and Research and have completed mandatory Health and Safety training provided by the University of Surrey.

If the project includes distribution of a survey or questionnaire to members of the University community, researchers are asked to include a statement advising that the project has been reviewed by the University's Ethics Committee.

If you wish to make any amendments to your protocol, please refer to the Guidance on Amendments which can be found on the Research Integrity and Governance Office webpages.

The Committee will need to be notified of adverse reactions suffered by research participants, and if the study is terminated earlier than expected with reasons. Please be advised that the Ethics Committee is able to audit research to ensure that researchers are abiding by the University requirements and guidelines.

You are asked to note that a further submission to the Ethics Committee will be required in the event that the study is not completed within five years of the above date.

Please inform me when the research has been completed.

Yours sincerely

Julia Hill

Dr Julia Hill
Research Integrity and Governance Co-ordinator

cc Prof Chris France

References

Achilles 2018, , *About Us* [Homepage of Achilles Information Ltd], [Online]. Available: https://www.achilles.com/about-us/our-story/ [2018, 6/15].

Ackoff, R.L. 1974, *Redesigning the Future: A Systems Approach to Societal Problems,* John Wiley, New York.

Acquaye, A.A. & Duffy, A.P. 2010, "Input–output analysis of Irish construction sector greenhouse gas emissions", *Building and the Environment,* vol. 45, pp. 784-791.

Acquisti & Sostenibilità 2014, , *Sustainable Supply Chain Review 2014* [Homepage of Acquisti & Sostenibilità], [Online]. Available: http://www.osservatoriosostenibilita.org/en/the-sscr [2015, 07/07].

ACS Group 2014, *Corporate Responsibility Report of the ACS Group* , ACS Group, Madrid.

Action Sustainability 2016, , *Supply Chain Sustainability School: Modern Slavery* [Homepage of Action Sustainability], [Online]. Available: https://www.supplychainschool.co.uk/default/modern-slavery.aspx [2017, 5/7].

Adetunji I., Price A.D.F. & Fleming P. 2008a, "Achieving sustainability in the construction supply chain", *Proceedings of the Institution of Civil Engineers: Engineering Sustainability,* vol. 161, no. 3, pp. 161-172.

Adetunji I., Price A.D.F. & Fleming P. 2008b, "Achieving sustainability in the construction supply chain", *Proceedings of the Institution of Civil Engineers: Engineering Sustainability,* vol. 161, no. 3, pp. 161-172.

Adetunji, I., Price, A.D.F. & and Fleming, P. 2008, "Achieving Sustainability in the Construction Supply Chain", *Proceedings of the ICE - Engineering Sustainability*Thomas Telford (ICE Publishing), , 2008, pp. 3, 161 - 172.

Ahi, P. & Searcy, C. 2015, "Measuring Social Issues in Sustainable Supply Chains." Measuring Business Excellence 19 (1): 33–45.", *Measuring Business Excellence,* vol. 19, no. 1, pp. 33-45.

Ahi, P. & Searcy, C. 2013, "A comparative literature analysis of definitions for green and sustainable supply chain management", *Journal of Cleaner Production,* vol. 52, pp. 329-341.

Akintan, O.A. & Morledge, R. 2013, "Improving the Collaboration between Main Contractors and Subcontractors within Traditional Construction Procurement ", *Journal of Construction Engineering,* vol. 2013.

Akintoye, A. & McKellar, T.D. 1997, *Electronic data interchange in the UK construction industry.* , The Royal Institution of Chartered Surveyors Research Paper Series 2 (4)., Royal Institution of Chartered Surveyors.

Akintoye, A., McIntosh, G. & Fitzgerald, E. 2000, "A survey of supply chain collaboration and management in the UK construction industry", *European Journal of Purchasing & Supply Management,* vol. 6, no. 3–4, pp. 159-168.

Alder, H. & Gooch, F. 2013, *Ethical and Sustainable Procurement*, Chartered Institute of Packaging and Supply and Traidcraft, London.

Allain, J., Crane, A., LeBaron, G. & Behbahani, L. 2013, *REPORT: Forced Labour's Business Models and Supply Chains. (Forced Labour). Joseph Rowntree Foundation.*, Joseph Rowntree Foundation & Queens University, Belfast.

Alvarez, G., Pilbeam, C. & Wilding, R. 2010, "Nestlé Nespresso AAA sustainable quality program: an investigation into the governance dynamics in a multi-stakeholder supply chain network. ", *Supply Chain Management: An International Journal,* vol. 15, pp. 165-182.

Alwan, Z., Jones, P. & Holgate, P. 2017, "Strategic sustainable development in the UK construction industry, through the Framework of Strategic Sustainable Development", *Journal of Cleaner Production,* vol. 140, no. 1, pp. 349-358.

Anink, D. 1996, *The Handbook of Sustainable Building: Ecological Choice of Materials in Construction and Renovation*
, James and James (Science Publication).

Arcadis BV 2014, *Seamlessly Global, Annual Report 2014*, Arcadis BV, Amsterdam, Netherlands.

Argent llp 2016, *, Sustainability Statement* [Homepage of Argent llp], [Online]. Available: http://www.argentllp.co.uk/sustainability [2016, March 8th].

Argent llp 2015, *, Sustainability: Kings Cross* [Homepage of Argent llp], [Online]. Available: file:///C:/Users/BLK%20User/Downloads/Documents/Downloads/Sustainability_King_s_Cross_i_.pdf [2016, March 8th].

Argote, L. & Ingram, P. 2000, "Transfer: A Basis for Competitive Advantage in Firms. ", *Organizational Behavior and Human Decision Processes,* vol. 82, no. 1, pp. 150-169.

Arlbjørn, S.J., Freytag, V.P. & de Haas, H. 2011, "Service supply chain management: A survey of lean application in the municipal sector", *International Journal of Physical Distribution & Logistics Management,* vol. 41, no. 3, pp. 277-295.

Augiseau, V. & Barles, S. 2017, "Studying construction materials flows and stock: A review", *Resources, Conservation and Recycling,* vol. 123, pp. 153-164.

Balfour Beatty plc 2014, *Sustainability: A colletive responsibility. Our Goals and Metrics: Our Blueprint for Sustainable Business*, Balfour Beatty plc, UK.

BAM 2014, December-last update*, Is BREEAM Outstanding worth it?* [Homepage of BAM], [Online]. Available: http://www.bam.co.uk/media-centre/blog/bamblog/2014/12/12/Is-BREEAM-Outstanding-worth-it [2018, 7/22].

Bankvall, L., Bygballe, L.E., Dubois, A. & Jahre, M. 2010, "Interdependence in supply chains and projects in construction", *Supply Chain Management,* vol. 15, no. 5, pp. 385-393.

Barrett, J. 2019, *The Retrofit Challenge for houseing - What is the plan?*, Speech: Ecobuild Conference edn, London, UK.

Bastl, M., Johnson, M., Lightfoot, H. & Evans, S. 2012, "Buyer-supplier relationships in a servitized environment: An examination with Cannon and Perreault's framework. ", *International Journal of Operations & Production Management,* vol. 32, no. 6, pp. 660-675.

BBC News 2019, 14th March-last update*, Construction company Dawnus 'in administration'* [Homepage of BBC News], [Online]. Available: https://www.bbc.co.uk/news/uk-wales-47567023 [2019, 3/20].

Beach, R., Webster, M. & Campbell, K.M. 2005, "An evaluation of partnership development in the construction industry. ", *International Journal of Project Management,* vol. 23, no. 8, pp. 611-621.

Bennett, A. & Elman, C. 2006, "Qualitative Research: Recent Developments in Case Study Methods ", *Annual Review of Political Science,* vol. 9, no. 1, pp. 455-476.

Benoit-Norris, C., Cavan, D.A. & Norris, G. 2012, "Identifying Social Impacts in Product Supply Chains: Overview and Application of the Social Hotspot Database ", *Sustainability,* vol. 4, no. 9, pp. 1946-1965.

Bergin, R. 2016, *, Ethics and Architecture The art of minimising impacts* [Homepage of APRES], [Online]. Available: http://apres.bre.co.uk/wp-content/uploads/2016/12/Rory-Bergin.pdf [2017, 1/8].

Berry, C. & McCarthy, S. 2011, *Guide to sustainable procurement in construction,* Ist edn, CIRIA, London.

Beske, P., Land, A. & Seuring, S. 2014, "Sustainable Supply Chain Management Practices and Dynamic Capabilities in the Food Industry: A Critical Analysis of the Literature", *International Journal of Production Economics,* vol. 152, pp. 131-143.

BHRSC 2016, *A Wall of Silence: The construction sector's response to migrant rights in Qatar and UEA*, Business and Human Rights Resource Centre, London.

Bilec, M.M., Ries, R.J. & Matthews, H.S. 2010, "Life-Cycle Assessment Modeling of Construction Processes for Buildings ", *Journal of Infrastructure Systems,* vol. 16, no. 3, pp. 199-205.

BIS 2013a, *Industrial Strategy: Industry and Government in Partnership: Construction 2025*, HMSO, London, UK.

BIS 2013b, *Supply Chain Analysis into the Construction Industry: A Report for the Construction Industrial Strategy*, HMSO, London, UK.

BIS 2010a, *Estimating the amount of CO_2 emissions that the construction industry can influence. Supporting material for the Low Carbon Construction IGT Report*, HMSO, Department for Business, Innovation and Skills, London, England.

BIS 2010b, *Low Carbon Construction: Innovation & Growth Team, Final Report*, Department of Business, Innovation and Skills: HM Governement, London, UK.

BIS 2008, *Strategy for Sustainable Construction*, Department for Business, Innovation and Skills, London.

Bishop, D., Felstead, A., Fuller, A., Jewson, N., Unwin, L. & Kakavelakis, K. 2009, "Constructing learning: adversarial and collaborative working in the British construction industry. ", *Journal of Education and Work,* vol. 22, no. 4, pp. 243-260.

Bové, A., D'Herde, D. & Swartz, S. 2017, *, Sustainability's Deepening Imprint.* [Homepage of McKinsey&Company], [Online]. Available: https://www.mckinsey.com/business-functions/sustainability-and-resource-productivity/our-insights/sustainabilitys-deepening-imprint [2018, 5/6].

Bowen, F.E., Cousins, P.D., Lamming, R.C. & Faruk, A.C. 2001, "Horses for courses. Explaning the gap between the theory and practice of green supply", *Greener Management International: The Journal of Corporate Environment Strategy and Practice,* vol. 35 (Autumn 2001), pp. 41-60.

Bowen, F.E., Cousins, P.D., Lamming, R.C. & Farukt, A.C. 2001, "The role of supply management capabilities in green supply.", *Production and Operations Management,* vol. 10, no. 2, pp. 174-189.

BRE 2019, *, What is BREEAM?* [Homepage of Building Research Establishment], [Online]. Available: https://www.breeam.com/ [2019, 2/21].

BRE 2018, *Product Category Rules for Type III Environmental Product Declarations of Construction Products to EN15804+ A1: PN 514 Rev 2.0,* BRE Global Ltd, Watford, England.

BRE Global Ltd 2008, *BRE Environmental & Sustainability Standard BES 6001: ISSUE 1.0: Framework Standard for the Responsible Sourcing of Construction Products*, BRE Global LTd, London.

BREEAM 2015, *, Responsible Sourcing Credits* [Homepage of BREEAM], [Online]. Available: http://www.breeam.com/page.jsp?id=617 [2015, November 5th].

Bresnen, M. & Marshall, N. 2000, "Partnering in construction: a critical review of issues, problems and dilemmas", *Construction Management and Economics,* vol. 18, no. 2, pp. 229-237.

Bringer, J.D., Johnston, L.H. & Brackenridge, C.H. 2006, "Using computer-assisted qualitative data analysis software to develop a grounded theory project.", *Field Methods,* vol. 18, no. 3, pp. 245-266.

Brinkhoff, A. & Thonemann, U.W. 2007, "Perfekte Projekte in der Lieferkette", *Harvard Business Manager,* vol. 7, no. 2007, pp. 6-9.

Briscoe, G. & Dainty, A. 2005, " Construction supply chain integration: an elusive goal?. Supply Chain Management: An International Journal, 10(4), 319–26.", *Supply Chain Management: An International Journal,* vol. 10, no. 4, pp. 319-326.

Briscoe, G., Dainty, A. & Millett, S. 2001, "Construction supply chain partnerships: skills knowledge and attitudinal requirements ", *European Journal of Purchasing & Supply Management,* vol. 7, no. 4, pp. 243-255.

Briscoe, G.H., Dainty, A.R.J., Millett, S.J. & Neale, R.H. 2004, "Client-led strategies for construction supply chain improvement", *Construction Management and Economics,* vol. 22, no. 2, pp. 193-201.

Brockhaus, S., Kersten, W. & Knemeyer, A. 2013, "Where Do We Go From Here? Progressing Sustainability Implementation Efforts Across Supply Chains ", *Journal of Business Logistics,* vol. 34, no. 2, pp. 167-182.

Broft, R., Badi, S.M. & Pryke, S. 2016, "Towards supply chain maturity in construction", *Built Environment Project and Asset Management,* vol. 6, no. 2, pp. 187-204.

Bryant, A. 2009, "Grounded Theory and Pragmatism: The Curious Case of Anselm Stauss

", *Forum Qualitative Sozialforschung / Forum: Qualitative Social Research,* vol. 10, no. 3.

Bryde, D., Broquetas, M. & Volm, J.M. 2013, "The project benefits of building information modelling (BIM)", *International Journal of Project Management,* vol. 31, no. 2013, pp. 971-980.

BSI 2017a, *Construction prequalification questionnaires: PAS 91:2013+A1:2017*, 2nd edn, British Standards Institute, London, UK.

BSI 2017b, , *PAS2080:2016* [Homepage of British Standards Institute], [Online]. Available: https://shop.bsigroup.com/ProductDetail?pid=000000000030323493 [2018, 9/28].

BSI 2013, ***BS EN 15804:2012+A1:2013: Sustainability of construction works. Environmental product declarations. Core rules for the product category of construction products***, British Standards Institute, London.

BSI 2010, *Principles and framework for procuring sustainably - Guide. BS 8903: 2010.*, British Standards, London.

BT Openreach 2015, , *About Us: Environment and Society* [Homepage of BT Openreach], [Online]. Available: http://www.cvf.openreach.co.uk/orpg/home/aboutus/environmentandsociety/csr.do [2016, March 10th].

BuildUK 2017, , *Leading the Construction Industry* [Homepage of Build UK], [Online]. Available: http://builduk.org/ [2017, February 8th].

Caniels, M.C.J. & Gelderman, C.J. 2007, " Power and interdependence in buyer supplier relationships: a purchasing portfolio approach", *Industrial Marketing Management,* vol. 36, no. 2, pp. 219-229.

Carillion 2017, *How we're making tomorrow a better place: Carillion Sustainablity Report 2016*, Carillion plc, Wolverhampton.

Carillion 2015, *Sustainability Report 2014: Our Business*, Carillion, Wolverhampton.

Carillion 2000, *We are making choices: Carillion's environment, community and social report 1999–2000*, Carillion Plc, Wolverhampton.

Carillion plc 2017a, *, Carillion Plc, Group of companies' accounts made up to 31 December 2016* [Homepage of Companies House], [Online]. Available: https://beta.companieshouse.gov.uk/company/03782379/filing-history?page=2 [2018, 4/9].

Carillion plc 2017b, January-last update*, Sustainable Supplier Charter* [Homepage of Carillion plc], [Online]. Available: http://sustainability2016.carillionplc.com/assets/files/sustainable-supplier-charter-jan-2017.pdf [2018, 24.7.18].

Carillion plc 2017c, *Work Winning resources 2017: Sustainability Questions*, Analysis of client PQQ questions 2016-2017 edn, Carillion plc, Wolverhampton.

Carillion plc 2016a, *, A Better Tomorrow: Annual Sustainability Report 2015* [Homepage of Carillion plc], [Online]. Available: http://sustainability2015.carillionplc.com/assets/files/carillion-sr2015-full.pdf (Archived by WebCite® at http://www.webcitation.org/6xBZ8AZCh). [2017, February 5th].

Carillion plc 2016b, *Making tomorrow a better place: Annual Report and Accounts 2015*, Carillion plc, Wolverhampton, UK.

Carillion plc 2016c, *, Our Values* [Homepage of Carillion plc], [Online]. Available: https://www.carillionplc.com/about-us/our-values/ [2017, 6/1].

Carillion plc 2014a, *Collaborative working: Guidance to completing a relationship management plan*, Corporate Guidance edn, Carillion plc, Wolverhampton, UK.

Carillion plc 2014b, *A guide to Sustainable Procurement*, Training Materials edn, Carillion Plc, Wolverhampton, UK.

Carillion plc 2013, *Step Up Programme*, Carillion plc, Wolverhampton, UK.

Carter, C.R. 2005, "Purchasing social responsibility and firm performance: the key mediating roles of organizational learning and supplier performance. ", *International Journal of Physical Distribution & Logistics Management,* vol. 35, no. 3, pp. 177-194.

Carter, C.R. & Jennings, M.M. 2004, "The role of purchasing in corporate social responsibility: a structural equation analysis. ", *Journal of Business Logistics,* vol. 25, no. 1, pp. 145-186.

Carter, C.R. & Liane Easton, P. 2011, "Sustainable supply chain management: evolution and future directions", *International Journal of Physical Distribution & Logistics Management,* vol. 41, no. 1, pp. 46-62.

Carter, C.R., Meschnig, G. & Kaufmann, L. 2015, "Moving to the next level: why our discipline needs more multilevel theorization", *Journal of Supply Chain Management,* vol. 51, no. 4, pp. 94-102.

Carter, C.R. & Rogers, D.S. 2008a, " A framework of sustainable supply chain management: moving toward new theory. ", *International Journal Physical Distribution and Logistics Management,* vol. 38, no. 5, pp. 360-387.

Carter, C.R., Rogers, D.S. & Choi, T.Y. 2015, "Toward the theory of the supply chain", *Journal of Supply Chain Management,* vol. 51, no. 2, pp. 88-97.

Carter, C.R. & Rogers, D.S. 2008b, "A framework of sustainable supply chain management: moving toward new theory", International Journal of Physical Distribution & Logistics Management, Vol. 38 Issue: 5, pp.360-387,", *International Journal of Physical Distribution & Logistics Management,* vol. 38, no. 5, pp. 360-387.

CDP 2018, *, Closing the Gap: Scaling up sustainable supply chains* [Homepage of Climate Disclosure Project], [Online]. Available: https://6fefcbb86e61af1b2fc4-c70d8ead6ced550b4d987d7c03fcdd1d.ssl.cf3.rackcdn.com/cms/reports/documents/000/003/014/original/CDP_Supply_Chain_Report_2018.pdf?1518084325 [2018, 8/21].

Charmaz, K. 2014, *Constructing Grounded Theory,* 2nd edn, Sage Publications Ltd, London, England.

Charmaz, K. 2003, "Grounded theory: Objectivist and constructionist methods." in *The sage handbook of qualitative research*, ed. U. London, 2nd edn, Sage, Thousand Oaks, CA. USA, pp. 249-291.

Charmaz, K. 1995, "'Grounded Theory'" in *Rethinking Methods in Psychology*, eds. J. Smith, R. Harre & L. van Langenhove, 2nd edn, Sage, London, , pp. 27.

Chegut, A., Eichholtz, P., Kok, N. & Quigley, J.M. 2011, "The Value of Green Buildings New Evidence from the United KingdomChegut, A., Eichholtz, P., Kok, N. and Quigley, J.M., 2011. The value of green buildings: new evidence from the United Kingdom. *ERES 2010 proceedings*.", *European Real Estate Sociey Conference 2010*ERES, Milan, Italy, 2010.

Cheng, J.H., Yeh, C.H. & Tu, C.W. 2008, "Trust and knowledge sharing in green supply chains.", *Supply Chain Management: An International Journal,* vol. 13, no. 4, pp. 283-295.

Cheng, J.-., Yeh, C.-. & Tu, C.-. 2008, "Trust and knowledge sharing in green supply chains.", *Supply Chain Management: An International Journal,* vol. 13, no. 4, pp. 283-295.

Cherns, A. & Bryant, D. 1984, "Studying the clients role in construction management", *Construction Management and Economics,* vol. 2, no. 2, pp. 177.

Choi, T.Y., Dooley, K. & Rungthusanstham, M. 2001, "Supply networks and complex adaptive systems: control versus emergence", *Journal of Operations Management,* vol. 19, no. 3, pp. 351-366.

Chopra, S. & Meindl, P. 2013, *Supply Chain Managment: Strategy, Planning and Operation,* 5 edition edn, Pearson Education Ltd, Harlow, England.

Choudhuri, I. 2015, "
Pre-Operational Water of Construction: case study of a commerical complex in Pune, India", *International Journal of Science, Engineering and Technology,* vol. 3, no. 5, pp. 1136-1139.

Christopher, M. 2011, *Logistics & Supply Chain Management,* 4th edn, Pearson UK, London.

Christopher, M. 1992, *Logistics and Supply Chain Management.* , Pitman, London.

Christopher, M. & Ryals, L. 1999, "Supply Chain Strategy: Its Impact on Shareholder Value", *Int Jrnl Logistics Management,* vol. 10, no. 1, pp. 1-10.

CIOB 2010, *Procurement in the Construction Industry*, Chartered Institute of Building, London.

CIPS 2018a, , *Category Management* [Homepage of Chartered Institute of Purchasing and Supply], [Online]. Available: https://www.cips.org/en-GB/knowledge/procurement-topics-and-skills/strategy-policy/category-management/ [2019, 12/1].

CIPS 2018b, , *Collaborative working* [Homepage of Chartered Institute of Purchasing and Supply], [Online]. Available: https://www.cips.org/en/knowledge/procurement-topics-and-skills/efficiency/collaborative-working1/ [2018, 7/8].

CIPS 2015a, , *Procurement* [Homepage of Chartered Institute of Procurement and Supply], [Online]. Available: https://www.cips.org/Knowledge/procurement-glossary/P/ [2015, 6th October].

CIPS 2015b, , *Purchasing* [Homepage of Chartered Institute of Procurement and Supply], [Online]. Available: https://www.cips.org/Knowledge/procurement-glossary/P/ [2015, 6th October].

CIPS 2015c, , *Sourcing* [Homepage of Chartered Institute of Procurement and Supply], [Online]. Available: https://www.cips.org/Knowledge/procurement-glossary/S/ [2015, October, 6th].

CIPS 2015d, , *Sustainable and Ethical Procurment* [Homepage of Chartered Institute of Procurement and Supply], [Online]. Available: www.cips.org/en-GB/Knowledge/Procurement-topics-and-skills/Sustainability/Sustainable-and-Ethical-Procurement/ [2015, October 1st].

CIPS 2012, , *All about CIPS* [Homepage of Chartered Institute of Packaging and Supply], [Online]. Available: https://www.cips.org/Documents/Membership/Branch%20Event%20uploads/About%20CIPS%20May%202012%20FINAL.pdf [2018, 23.7.18].

Ciroth, A. & Eisfeldt, F. 2015, "A new, comprehensive database for social LCA: PSILCA", ILCM, New Delhi, India, September.

Ciroth, A., Finkbeiner, M., Hildenbrand, J., Klöpffer, W., Mazijn, B., Prakash, S., Sonnemann, G., Traverso, M., Ugaya, C.M.L., Valdivia, S. & Vickery-Niederman, G. 2011, *Towards a Life Cycle Sustainability Assessment*, UNEP/SETAC, Paris, France.

CLC 2018, , *Construction Leadership Council: Board* [Homepage of Construction Leadership Council], [Online]. Available: http://www.constructionleadershipcouncil.co.uk/about/ [2018, 9/13].

Clift, R. 2004, " Metrics for supply chain sustainability. " in *Technological choices for sustainability* Springer, Berlin, Heidelberg, pp. 239-253.

Clift, R., Sim, S., King, H., Chenoweth, J.L., Christie, I., Clavreul, J., Mueller, C., Posthuma, L., Boulay, A., Chaplin-Kramer, R., Chatterton, J., DeClerck, F., Druckman, A., France, C., Franco, A., Gerten, D., Goedkoop, M., Hauschild, M.Z., Huijbregts, M.A.J., Koellner, T., Lambin, E.F., Lee, J., Mair, S., Marshall, S., McLachlan, M.I.S., Canals, L.M.i., Mitchell, C., Price, E., Rockström, J., Suckling, J. & Murphy, R. 2017, "The challenges of applying planetary boundaries as a basis for strategic decision-making in companies with global supply chains. *Sustainability*, *9*(2), p.279.", *Sustainability,* vol. 9, no. 2, pp. 1-23.

Clift, R. & Wright, L. 2000, "Relationships Between Environmental Impacts and Added Value Along the Supply Chain", *Technological Forecasting and Social Change,* vol. 65, no. 3, pp. 281-295.

Cole, R. & Kernan, P.C. 1996, "Life cycle energy use in office buildings", vol. 31, no. 4, pp. 307-317.

Committee on Climate Change 2017, *Meeting Carbon Budgets: Closing the policy gap 2017: Report to Parliament*, Committee on Climate Change, London.

Connelly, B.L., Certo, S.T., Ireland, R.D. & Reutzel, C.R. 2011, "Signalling Theory: A Review and Assessement", *Journal of Management,* vol. 37, no. 1, pp. 39-67.

Connelly, B.L. & Ketchen. D.J. Slater, S.F. 2011, "'Toward a Theoretical toolbox' for Sustainablity Research in Marketing", *Journal of the Academy of Marketing Science,* vol. 39, no. 1, pp. 86-100.

Constructing Excellence 2015, , *Demonstrating Excellence An Evolution of the Programme of Demonstrations* [Homepage of Constructing Excellence], [Online]. Available: http://constructingexcellence.org.uk/wp-content/uploads/2015/03/demonstrating_exc.pdf [2018, 9/25].

Construction News 2016, , *CN100 2016: Top 100 Contractors*. Available: https://www.constructionnews.co.uk/analysis/news-analysis/cn100-2016-the-top-100-contractors/10010244.article2/15].

Cook, T.D. & Reichardt, C.S. 1979, *Qualitative and quantitative methods in evaluation.* Sage Publications, Beverly Hills, C.A.

Corder, G.D., Mclellan, B.C., Bangerter, P.J., Van Beers, D. & Green, S.R. 2012, "Engineering-in sustainability through the application of SUSOP", *Chemistry Engineering Research and Design,* vol. 90, no. 1, pp. 98-109.

Cox, A. & Ireland, P. 2002, " Managing construction supply chains: the common sense approach. ", *Engineering, Construction and Architectural Management,* vol. 9, no. 5/6, pp. 409-418.

Cox, A. & Thompson, I. 1997, "Fit for purpose' contractual relations: determining a theoretical framework for construction projects. ", *European Journal of Purchasing and Supply Management,* vol. 3, pp. 127-135.

Cox, R.W. & Wartenbe, M. 2018, "The Politics of Global Value Chains" in *The Political Economy of Robots. International Political Economy Series*, ed. R. Kiggins, 1st edn, Palgrave Macmillan, London, UK, pp. 17-40.

CPA 2012, *A guide to understanding the embodied impacts of construction products*, Construction Products Association, London.

Crawford, R. & Treloar, G. 2005, "An assessment of the energy and water embodied in commercial building construction", *Australian Life Cycle Assessment Conference*Australian Life Cycle Assessment Society, Sydney, N.S.W., Australia, 4th : 2005 : Novotel, Sydney, N.S.W., pp. 1-10.

Creswell, J.W. 2017, " The selection of a research approach" in *Research design: qualitative, quantitative, and mixed methods approaches.* Sage, London, pp. 3-23.

Crone, M. & Roper, S. 2001, "Local learning from multinational plants: knowledge transfers in the supply chain.", *Regional Studies,* vol. 35, no. 6, pp. 535-548.

Crossrail 2018, *, Crossrail: The Learning Legacy* [Homepage of Transport for London], [Online]. Available: https://learninglegacy.crossrail.co.uk/ [2018, 8/16].

Curkovic, S. & Sroufe, R. 2011, "Using ISO 14001 to promote a sustainable supply chain strategy", *Business Strategy and the Environment,* vol. 20, no. 2, pp. 71-93.

Cushman, M., Venters, W., Conford, T. & Mitev, N. 2009, "Understanding sustainability as knowledge practice", *British Academy of Management Conference: Fast-tracking Performance through Partnerships,*LSE Research Online: http://eprints.lse.ac.uk/23324/, London, 9-11 September 2002.

Dadhich, P., Genovese, A., Kumar, N. & Acquaye, A. 2015, "**Developing sustainable supply chains in the UK construction industry: A case study** ", *International Journal of Production Economics,* vol. 164, pp. 271-284.

Dainty, A.R.J., Briscoe, G.H. & Millett, S.J. 2001, "Subcontractor perspectives on supply chain alliances", *Construction Management and Economics,* vol. 19, no. 8, pp. 841-848.

Dallasega, P. & Rauch, E. 2017, "Sustainable Construction Supply Chains through Synchronized Production Planning and Control in Engineer-to-Order Enterprises", *Sustainability,* vol. 9, no. 1888, pp. 1-25.

Davies, R. 2019, 15th March-last update, *Interserve goes into administration after rescue deal rejected* [Homepage of The Guardian], [Online]. Available: https://www.theguardian.com/business/2019/mar/15/interserve-to-go-into-administration-after-shareholders-reject-deal [2019, 3/20].

DDCMS 2018, 5 April 2018-last update, *The Public Services (Social Value) Act 2012, An introductory guide for commissioners and policymakers Version 3.2* [Homepage of Department of Digital, Culture, Media and Sport], [Online]. Available: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/690780/Commissioner_Guidance_V3.8.pdf [2018, 11/26].

De Beuckelaer, A. & Wagner, S.M. 2012, "Small sample surveys: increasing rigor in supply chain management research", *International Journal of Physical Distribution & Logistics Management,* vol. 42, no. 7, pp. 615-639.

De Silva M. & Paris R. 2015, "Delivering Crossrail, UK: A holistic approach to sustainability", *Proceedings of the Institution of Civil Engineers: Engineering Sustainability,* vol. 168, no. 4, pp. 151-158.

DEFRA 2018, October-last update, *UK Statistics on Waste* [Homepage of Department of Environment, Food, and Rural Affairs], [Online]. Available: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/746642/UK_Statistics_on_Waste_statistical_notice_October_2018_FINAL.pdf [2019, 1/28].

DEFRA 2015a, *Digest of Waste and Resource Statistics – 2015 Edition*, DEFRA, London, UK.

DEFRA 2015b, March 2015-last update, *UK Statistics on Waste – 2010 to 2012* [Homepage of Government Statistical Service], [Online]. Available: www.gov.uk/government/uploads/system/uploads/attachment_data/file/416471/UK_Statistical_release_UPDATEv6_19_03_2015.pdf [2015, 10/14].

DEFRA 2013, *London 2012 Olympic and Paralympic Games The Legacy: Sustainable Procurement for Construction Projects A Guide*, Department for Environment, Food and Rural Affairs, London.

DEFRA 2011, *Ethical Procurement Policy Statement*, DEFRA, London.

DEFRA 2006, *Procuring the Future: Sustainable Procurement National Action Plan: Recommendations from the Sustainable Procurement Task Force*, Department for Environment, Food and Rural Affairs, London.

Demaid, A. & Quintas, P. 2006, "Knowledge across cultures in the construction industry: sustainability, innovation and design ", *Technovation,* vol. 26, pp. 603-610.

Demaid, A. & Quintas, P. 2004, "Knowledge cartography in the sustainable environment", *Engineering Management Conference: 2004 IEEE International*IEEE, , October, 2004, pp. Vol 3, 893-897.

Demaid, A. & Quintas, P. 1999, "The design of a networked product by a network of designers", *The Design Journal,* vol. 2, no. 3, pp. 8.

Demarest, M. 1997, " Knowledge management: an introduction", *Long range Planning,* vol. 30, no. 3, pp. 374-385.

Derwent Pencils 2013, *How pencils are made today - Derwent Pencil Factory, Cumbria, UK*, https://www.youtube.com/watch?v=b8Tmz6crROo edn, Derwent Pencils, Cumbria, England.

Deshpande, R. & Webster Jr, F.E. 1989, "Organizational culture and marketing: Defining the research agenda", *Journal of Marketing,* vol. 53, no. 1, pp. 3-15.

DfT 2014, September 2014-last update*, Network Rail Framework Agreement* [Homepage of Department for Transport], [Online]. Available: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/349439/framework-agreement.pdf [2016, 29th March].

Dias, A.C., Lemos, D., Gabarrell, X. & Arroja, L. 2014, "Environmentally extended input-output analysis on a city scale - Application to Aveiro (Portugal)", *Journal of Cleaner Production,* vol. 75, pp. 118-129.

Dike, I.U. & Kapogiannis, G. 2014, "A conceptual model for improving construction supply chain performance. ", *Proceedings of the 30th Annual Association of Researchers in Construction Management* ARCOM, Portsmouth, UK, 2014.

Dolan, T. & Fedele, K.M. 2004, "Strategic Sourcing: Reducing Cost and Supporting Diversity Goals", *89th Annual International Supply Management Conference*Institute for Supply Management, Tempe, USA, April.

Dubey, R., Gunasekaran, A., Childe, S.J., Papadopoulos, T. & Wamba, S.F. 2017, "World class sustainable supply chain management: critical review and further research directions", *The International Journal of Logistics Management,* vol. 28, no. 2, pp. 332-362.

Dubois, A. & Gadde, L.E. 2002, "The construction industry as a loosely coupled system: implications for productivity and innovation", *Construction Management and Economics,* vol. 20, no. 7, pp. 621-631.

Dubois, A. & Gadde, L. 2000, "Supply strategy and network elects purchasing behaviour in the construction industry ", *European Journal of Purchasing & Supply Management,* vol. 5, pp. 207-215.

Dyer, J.H. & Hatch, N.W. 2006, " Relation-specific capabilities and barriers to knowledge transfers: creating advantage through network relationships ", *Strategic Management Journal,* vol. 27, no. 8, pp. 701-719.

Dyer, J.H. & Nobeoka, K. 2000, "Creating and Managing a High-Performance Knowledge-Sharing Network: The Toyota Case", *Strategic Management Journal,* vol. 21, no. 3, pp. 245-367.

Dyer, J.H. & Hatch, N.W. 2004, "Using supplier networks to learn faster", *MIT Sloan Management Review,* vol. 1, pp. 56-64.

E.C Harris LLP 2013, *Supply Chain Analysis into theConstruction Industry: A Report for the Construction Industrial Strategy. BIS Research Paper No. 145*, Department for Business, Innovation and Skills., London.

Eaton, K.J. & Amato, A. 1998, "A Comparative Life Cycle Assessment of Steel and Concrete Framed Office Buildings", *Journal of Constructional Steel Research,* vol. 46, pp. 1-3.

Eccles, R.G. 1981, " The quasifirm in the construction industry. ", *Journal of Economic Behavior & Organization,* vol. 2, no. 4, pp. 335-357.

Edenhofer, O., Pichs-Madruga, R., Sokona, Y., Kadner, S., Minx, J.C., Brunner, S., Agrawala, S., Baiocchi, G., Bashmakov, I.A., Blanco, G., Broome, J., Bruckner, T., Bustamante, M., Clarke, L., Conte Grand, M., Creutzig, F., Cruz-Núñez, X., Dhakal, S., Dubash, N.K., Eickemeier, P., Farahani, E., Fischedick, M., Fleurbaey, M., Gerlagh, R., Gómez-Echeverri, L., Gupta, S., Harnisch, J., Jiang, K., Jotzo, F., Kartha, S., Klasen, S., Kolstad, C., Krey, V., Kunreuther, H., Lucon, O., Masera, O., Mulugetta, Y., Norgaard, R.B., Patt, A., Ravindranath, N.H., Riahi, K., Roy, J., Sagar, A., Schaeffer, R., Schlömer, S., Seto, K.C., Seyboth, K., Sims, R., Smith, P., Somanathan, E., Stavins, R., von Stechow, C., Sterner, T., Sugiyama, T., Suh, S., Ürge-Vorsatz, D., Urama, K., Venables, A., Victor, D.G., Weber, E., Zhou, D. & Zou, J. 2014, "Technical Summary" in *Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* ., eds. O. Edenhofer, R. Pichs-Madruga, Y. Sokona, et al, https://www.ipcc.ch/site/assets/uploads/2018/02/ipcc_wg3_ar5_technical-summary.pdf edn, Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA., pp. 31-107.

Egan, S.J. 1998, *Rethinking Construction: Report of the Construction Task Force to the Deputy Prime Minister, John Prescott, on the scope for improving the quality and efficiency of UK construction.*, DTI, HMSO, London, UK.

EISC Ltd 2012, *Construction Sector Overview in the UK*, EISC Ltd, Southampton.

Eisfeldt, F. 2016, *, Introducing PSILCA 1.0 – A comprehensive and transparent database for Social LC* [Homepage of Green Delta], [Online]. Available: https://www.greendelta.com/wp-content/uploads/2017/03/Presentation_PSILCA_Webinar_April2016.pdf [2018, 4/10].

ELAW 2010, *Guidebook for Evaluating Mining Project EIAs,* 1st edn, Environmental Law Alliance Worldwide, Eugene, Oregan, USA.

Elkington, J. & Fennell, S. 1997, *Shark, Sea Lion or Dolphin?,* March-April edn, Tomorrow.

Ellis, C. 1986, *Fisher Folk: Two communities on Chesapeake Bay,* 1st edn, University Press of Kentucky, Lexington.

EPD International 2016, *, The International EPD© System* [Homepage of EPD International], [Online]. Available: http://www.environdec.com/en/ [2016, 1/14].

Eriksson, P.E. & Laan, A. 2007, "Procurement effects on trust and control in client-contractor relationships", *Engineering, Construction and Architectural Management,* vol. 14, no. 4, pp. 387-399.

Eriksson, P.E. 2008, "Achieving suitable coopetition in buyer-supplier relationships: the case of AstraZeneca.", *Journal of Business to Business Marketing,* vol. 15, no. 4, pp. 425-454.

Eriksson, P.E. 2006, "Procurement and governance management – development of a conceptual procurement model based on different types of control", *Management Revue,* vol. 17, no. 1, pp. 30-49.

ETI 2014, 1.4.14-last update*, Ethical Trading Initiative - Base Code* [Homepage of Ethical Trading Initiative], [Online]. Available: http://www.ethicaltrade.org/sites/default/files/resources/ETI%20Base%20Code%2C%20English.pdf [2015, 12/1].

EU Commission 2010a, *, Buying Social: A Guide to Taking Account of Social Considerations in Public Procurement* [Homepage of EU Commission], [Online]. Available: http://ec.europa.eu/social/main.jsp?langId=en&catId=89&newsId=978 [2015, 10/1].

EU Commission 2010b, 19th May-last update*, DIRECTIVE 2010/31/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 19 May 2010 on the energy performance of buildings (recast)* [Homepage of EU Commission], [Online]. Available: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2010:153:0013:0035:EN:PDF [2016, 1/14].

EU-DG Environment 2015, *, Green and Sustainable Public Procurement* [Homepage of DG Environment], [Online]. Available: http://ec.europa.eu/environment/gpp/versus_en.htm [2015, 10/1].

European Commission 2016, 17/06-last update*, Construction and Demolition Waste* [Homepage of European Commission Environment], [Online]. Available: http://ec.europa.eu/environment/waste/construction_demolition.htm [2018, 3/26].

Fawcett, S.E., Fawcett, A.M., Watson, B.J. & Magnan, G.M. 2012, "Peeking inside the Black Box: Toward and understanding of Suply Chain Collaboratio Dynamics", *Journal of Supply Chain Management,* vol. 48, pp. 44-72.

Fawcett, S.E. & Magnum, G.M. 2002, "The rhetoric and reality of supply chain integration ", *International Journal of Physical Distribution and Logistics Management,* vol. 32, pp. 339-361.

Fearne, A. & Fowler, N. 2006, "Efficiency versus effectiveness in construction supply chains: the dangers of “lean” thinking in isolation", *Supply Chain Management: An International Journal,* vol. 11, no. 4, pp. 283-287.

Fernandez-Solis, J. 2008, "The systematic nature of the construction sector", *Architectural Engineering and Design Management,* vol. 4, pp. 31-46.

Fernie, S., Green, S.D., Weller, S.J. & Newcombe, R. 2003, "Knowledge sharing: context, confusion and controversy", *International Journal of Project Management,* vol. 21, no. 3, pp. 177-187.

Fernie, S. & Tennant, S. 2013, "The non-adoption of supply chain management ", *Construction Management and Economics,* vol. 31, no. 10, pp. 1038-1058.

Finkbeiner, M., Schau, E.M., Lehmann, A. & Traverso, M. 2010, "Towards life cycle sustainability assessment", *Sustainability,* vol. 2, no. 10, pp. 3309-3322.

Ford, N., Barron, M., Davies, J., Drake, N., Edwards, M., Ghumra, S., Hodson, S., Lowres, F., Macé, E., Modarres, P., Russell, E. & Wingfield, A. 2017, *Embodied Carbon: Developing a client brief*, UK Green Building Council, London.

Formentini, M. & Taticchi, P. 2016, "Corporate sustainability approaches and governance mechanisms in sustainable supply chain management ", *Journal of Cleaner Production,* vol. 112, pp. 1920-1933.

Freidberg, S. 2015, "From behind the curtain: talking about values in LCA", *The International Journal of Life Cycle Assessment,* , pp. 1-5.

Frostenson, M. & Prenkert, F. 2015, "Supply chain management when focal firms are complex: a network perspective", *Journal of Cleaner Production,* vol. 107, pp. 85-94.

FSC 2018, , *FSC Members List* [Homepage of Forest Stewardship Council], [Online]. Available: http://memberportal.fsc.org/ [2018, 9/13].

FSC 2017, , *The 10 FSC Principles*. Available: http://www.fsc-uk.org/en-uk/about-fsc/what-is-fsc/fsc-principles [2017, 5/3].

Gereffi, G., Humphrey, J. & Sturgeon, T. 2005, ". The governance of global value chains. ", *Review of International Political Economy,* vol. 12, pp. 78-104.

Gervasio, H., Gervasio, S.L., Dimova, A. & Pinto, A. 2018, "Benchmarking the Life-Cycle Environmental Performance of Buildings ", *Sustainability,* vol. 10, no. 5, pp. 1454.

GFTN 2016, , *GFTN-UK Forest Product Reporting Summary for 2015: Carillion plc*

[Homepage of Green Forest and Trade Network], [Online]. Available: https://carillionplc-uploads-shared.s3-eu-west-1.amazonaws.com/wp-content/uploads/2016/08/1332BJ-carillion-gftn-uk-2015-published-timber-report-original.pdf (Archived by WebCite® at http://www.webcitation.org/6xBY8pzrJ) [2017, 5/3].

Gibbon, P., Bair, J. & Ponte, S. 2008, "Governing Global Value Chains: an introduction", *Economy and Society,* vol. 37, pp. 315-338.

Gibbon, P. & Ponte, S. 2008, "Global value chains: from governance to governmentality? ", *Economy and Society,* vol. 37, pp. 365-392.

Gilbert, N. & Stoneman, P. (eds) 2016, *Researching Social Science*, 4th edn, Sage, London.

Glaser, B.G. 1998, *Doing grounded theory: Issues and discussions. ,* Sociology Press, Mill Valley, CA.

Glaser, B.G. & Strauss, A.L. 2008, *The Discovery of Grounded Theory: Strategies for Qualitative Research,* 3rd edn, Aldine Publishing Company, Hawthorne, NY, USA.

Glass, J. 2014, *The only Way is Ethics*, June edn, CIRIA, London.

Glass, J., Achour, N., Parry, T. & Nicholson, I. 2011a, "The role of responsible sourcing in creating a sustainable construction supply chain", *Management and Innovation for a Sustainable Built Environment MISBE*CIB, Working Commissions, Amsterdam, The Netherlands, June 20-23.

Glass, J., Achour, N., Parry, T. & Nicholson, I. 2011b, "The Role of Responsible Sourcing in Creating a Sustainable Construction Supply-Chain", *Managment and Innovation for a Sustainable Built Environment*Amsterdam, Netherlands, 20-23 June.

Gligor, D.M. & Autry, C.W. 2012, "The role of personal relationships in facilitating supply chain communications: A qualitative study", *The Journal of Supply Chain Management,* vol. 48, no. 1, pp. 24-43.

Gligor, D.M. & Holcomb, M. 2013, "The role of personal relationships in supply chains: An exploration of buyers and suppliers of logistics services", *The International Journal of Logistics Management,* vol. 24, no. 3, pp. 328-355.

Globescan 2015, *The 2015 Sustainability Leaders: A GlobeScan/SustainAbility Survey.*

Gold, S., Seuring, S. & Beske, P. 2010a, "Sustainable supply chain management and inter-organizational resources: a literature review. ", *Corporate Social Responsibility and Environmental Management,* vol. 17, no. 4, pp. 230-245.

Gold, S., Trautrims, A. & Trodd, Z. 2015, "Modern slavery challenges to supply chain management", *Supply Chain Management: An International Journal,* vol. 20, no. 5, pp. 485-494.

Gold, S., Seuring, S. & Beske, P. 2010b, "The constructs of sustainable supply chain management - A content analysis based on published case studies", *Progress in Industrial Ecology,* vol. 7, no. 2, pp. 114-137.

Grant, R.M. & Baden-Fuller, C. 1995, "A knowledge-based theory of inter-firm collaboration ", *Academy of Management Journal,* , pp. 17-21.

Green Construction Board 2018, , *Board Members* [Homepage of Green Construction Board], [Online]. Available: https://www.greenconstructionboard.org/index.php/board [2018, 13/9].

Green, S. 2009, "The evolution of corporate social responsibility in construction: Defining the parameters" in *Corporate Social Responsibility in the Construction Industry*, ed. A.D. Michael Murray, 1st edn, Taylor and Francis, , pp. 13-34.

Green, S.D., Fernie, S. & Weller, S. 2005, "Making sense of supply chain management: a comparative study of aerospace and construction. ", *Construction Management and Economics,* vol. 23, no. 6, pp. 579-593.

GRESB 2016, , *2016 Global Snapshot* [Homepage of GRESB Real Estate], [Online]. Available: https://gresb-public.s3.amazonaws.com/2016/content/2016_Global_Snapshot.pdf [2016, 10/12].

GRI 2015, August-last update, *G4: Sustainability Reporting Guidelines* [Homepage of Global Reporting Initiative], [Online]. Available: https://www.globalreporting.org/resourcelibrary/GRIG4-Part1-Reporting-Principles-and-Standard-Disclosures.pdf [2018, 10/28].

Grover, R. & Froese, T.M. 2016, "Knowledge management in construction using a SocioBIM platform: A case study of AYO smart home project. ", *Procedia Engineering,* vol. 145, pp. 1283-1290.

Häkkinen, T. & Belloni, K. 2011, "Barriers and drivers for sustainable building", *Building Research and Information,* vol. 39, no. 3, pp. 239-255.

Hancock, D. 2018, "Keynote 1: Transforming Construction ", *Centre for Systems Engineering and Innovation 2018 Industry Showcase*Centre for Systems Engineering and Innovation, Imperial College, London, 9/7.

Handfield, R.B. & Nichols, E.L. 1999, *Introduction to Supply Chain Management*, Upper Saddle River: Prentice Hall.

Harland, C.M. 1996, "Supply chain management: relationships, chains and networks", *British Journal of Management,* vol. 7, pp. S63-S80.

Hartmann, A. & Caerteling, J. 2010, "Subcontractor procurement in construction: the interplay of price and trust. ", *Supply Chain Management: An International Journal,* vol. 15, pp. 354-362.

Hassini, E., Surti, C. & Searcy, C. 2012, "A literature review and a case study of sustainable supply chains with a focus on metrics", *International Journal of Production Economics,* vol. 140, no. 1, pp. 69-82.

Hay, L., Duffy, A. & Whitfield, R.I. 2014, "The sustainability cycle and loop: models for a more unified understanding of sustainability", *Journal of Environmental Management,* vol. 133, pp. 232-257.

Healy, G. 2015, "Building resilience to economic risks through responsible sourcing: Turner and Townsend Consulting", *APRES: Managing risk and enhancing reputation through responsible sourcing*Loughborough University, Loughborough, 24th November.

Hendriks, A.J., Hofstee, W.K. & Raad, B.D. 1999, "The five-factor personality inventory (FFPI). ", *Personality and Individual Differences,* vol. 27, no. 2, pp. 307-325.

Henson, S. & Humphrey, J. 2008, "Understanding the complexities of private standards in global Agri-food chains", *The Journal of Development Studies,* vol. 46, no. 9, pp. 1628-1696.

Highways England 2016, January 2016-last update, *Highways England, Operational Metrics Manual* [Homepage of Highways England], [Online]. Available: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/496470/Operational_Metrics_Manual_January_2016.pdf [2016, March 8th].

Highways England 2015, , *Strategic Business Plan 2015-2020* [Homepage of Highways England], [Online]. Available: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/396487/141209_Strategic_Business_Plan_Final.pdf [2016, March 8th].

Hillman, A.J. & Keim, G.D. 2001, "Shareholder value, stakeholder management, and social issues: What's the bottom line?", *Strategic Management Journal,* vol. 22, no. 2, pp. 347-357.

HM Government 2015, November 2015-last update*, Greening Government Commitments Annual report April 2014 to March 2015* [Homepage of DEFRA, UK Government], [Online]. Available: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/487751/ggc-annual-report-2014-2015.pdf [2016, March 22nd].

HM Government 2008, *Strategy for Sustainable Procurement*, BIS, London.

HM Treasury 2013, *Infrastructre Carbon Review*, HM Treasury, London.

Hobbs, G. 2008, *Construction and Resources Roadmap; BRE Report prepared for DEFRA's Business Waste and Resource Efficiency Programme (BREW)* , BRE, Watford, UK.

Hoejmose, S.U., Brammer, S. & Millington, A. 2012, "Green Supply chain management: the role of trust, committment and top management in B2B and B2C markets", *Industrial Marketing Management,* vol. 41, pp. 609-620.

Holt, D. 2004, "Managing the interface between suppliers and organizations for environmental responsibility–an exploration of current practices in the UK ", *Corporate Social Responsibility and Environmental Management,* vol. 11, no. 2, pp. 71-84.

Holtermans, R. & Kok, N. 2018, *International Green Building Adoption Index 2018,* CBRE, Maastricht University.

Hosseinijou, S.A., Mansour, S. & Shirazi, M.A. 2014, "Social life cycle assessment for material selection: A case study of building materials", *International Journal of Life Cycle Assessment,* vol. 19, no. 3, pp. 620-645.

HSE 2018, , *Health and safety statistics for the construction sector in Great Britain* [Homepage of Health and Safety Executive], [Online]. Available: http://www.hse.gov.uk/statistics/industry/construction/index.htm [2018, 11/8].

Hughes, D., Williams, T. & Ren, Z. 2012, "Differing perspectives on collaboration in construction", *Construction Innovation,* vol. 12, no. 3, pp. 355-368.

Humphrey, H. & Schmitz, H. 2001, "Governance in Global Value Chains", *Institute of Development Studies,* vol. 32, no. 3, pp. 19-29.

IBM Corp. 2017, *IBM SPSS Statistics for Windows*, Version 25.0 edn, IBM Corp., Armonk, New York, US.

IBM Corp. 2016, *IBM SPSS Statistics for Windows*, Version 24.0 edn, IBM Corp., Armonk, New York, US.

Ibn-Mohammed, T., Greenough, R., Taylor, S., Ozawa-Meidaa, L. & Acquaye, A.A. 2013, "Operational vs. embodied emissions in buildings—A review of current trends", *Energy and Buildings,* vol. 66, no. 2013, pp. 232-245.

ICE 2015, *Civil Engineering Procedure,* 7th edn, Institute of Civil Engineers, London, UK.

ILO 2017, 9/19-last update*, Global Estimates of Modern Slavery: Forced Labour and Marriage* [Homepage of International Labour Organisation], [Online]. Available: http://www.ilo.org/wcmsp5/groups/public/---dgreports/---dcomm/documents/publication/ [2018, 1/21].

ILO & Walk Free Foundation 2017, *Global Estimates of modern slavery: forced labour and forced marriage*, International Labour Office and Walk Free Foundation, Geneva, Switzerland.

Innovate UK 2015, *, UK's Building performance evaluation project*

[Homepage of Innovate UK], [Online]. Available: https://connect.innovateuk.org/web/building-performance-evaluation/overview [2015, 11.17].

Interserve Plc 2014, *SustainAbilities Progress Update*, Interserve Plc, Reading, UK.

IPCC 2014, *Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Edenhofer, O., R. Pichs-Madruga, Y. Sokona, E. Farahani, S. Kadner, K. Seyboth, A. Adler, I. Baum, S. Brunner, P. Eickemeier, B. Kriemann, J. Savolainen, S. Schlömer, C. von Stechow, T. Zwickel and J.C. Minx (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.*, Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

ISO 2017, Edition 1-last update*, ISO 20400 - Sustainable Procurement* [Homepage of International Standards Organisation], [Online]. Available: https://www.iso.org/publication/PUB100410.html [2018, 9/12].

ISO 2015, *, ISO 14001:2015 - main changes since 2004 edition* [Homepage of International Standards Organisation Technical Committee], [Online]. Available: https://committee.iso.org/sites/tc207sc1/home/projects/published/iso-14001---environmental-manage/main-changes.html [2018, 9/11].

Ive, G. & Murray, A. 2013, *BIS Research Paper Number 118: Trade Credit in the UK construction Industry: An Empirical Analysis of Construction Contractor Financial Positioning and Performance JULY 2013*, BIS, London, UK.

Jay, S., Jones, C., Slinn, P. & Wood, C. 2007, " Environmental impact assessment: Retrospect and prospect", *Environmental impact assessment review,* vol. 27, no. 4, pp. 287-300.

Jorgensesn, A.L. & Knudsen, J.S. 2006, "Sustainable competitiveness in global value chains: how do small Danish firms behave", *Corporate Governance: The international journal of business in society,* vol. 6, no. 4, pp. 449-462.

Joyce, T. 2014, *Knowledge, Belief and Justification*, Royal Institute of Philosophy, London.

Kadefors, A., Bjo¨rlingson, E. & Karlsson, A. 2007, "Procuring service innovations: contractor selection for partnering projects", *International Journal of Project Management,* vol. 25, no. 4, pp. 375-385.

Kalwani, M.U. & Narayandas, N. 1995, "Long-term manufacturer–supplier relationships: do they pay?", *Journal of Marketing,* vol. 59, no. 1, pp. 1-5.

Kats, G., Alevantis, L., Berman, A., Mills, E. & Perlman, J. 2003, *The costs and financial benefits of green buildings.* , A report to California's sustainable building task force, California, USA.

Keir Group Plc 2016, September-last update*, Corporate Responsibility Report 2016; Responsible business, positive outcomes: The Kier approach to sustainable business* [Homepage of Keir Group Plc], [Online]. Available: http://www.kier.co.uk/~/media/Files/K/Kier/Annual%20Reports/annual-reports-2016/download/14102016%20Kier_CR16.pdf [2017, February 14th].

Keir Group Plc 2014, *Together, we make our world work better*, Keir Group Plc, Sandy, UK.

Kersten, W., Allonas, C. & Brockhaus, S.W., N. 2010, "Green Logistics: An innovation for logistics products" in *Innovative PRocess Optimization Methods in Logistics: Emerging Trends, Concepts and Technologies*, eds. W. Kersten & T. Blecker, Erich Schmidt Verlag, GmbH & Co. Ltd, Berlin, pp. 369-386.

Kibert, C. 1999, "Introduction" in *Reshaping the Built Environment: Ecology Ethics and Economics*, ed. C. Kibert, Island Press, Washington DC, , pp. 378.

King, A.P. & Pitt, M.C. 2009, " Supply chain management: A main contractors perspective. " in *Construction Supply Chain Management: Concepts and Case Studies;* , ed. S. Pryke, Wiley-Blackwell, London, UK, pp. 189-192.

Kofoworola, O.F. & Gheewala, S.H. 2009, "Life Cycle Energy Assessment of a Typical Office Building in Thailand", *Energy and Buildings,* vol. 41, no. 10, pp. 1076-1083.

Kogg, B. & Mont, O. 2012, "Environmental and social responsibility in supply chains: The practise of choice and inter-organisational management", *Ecological Economics,* vol. 83, pp. 154-163.

Kogut, B. 1988, "Joint ventures: theoretical and empirical perspectives.", *STrategic Management Journal,* vol. 9, no. 4, pp. 319-332.

Korczynski, M. 1996, " The low-trust route to economic development: Inter-firm relations in the UK engineering construction industry in the 1980s and 1990s. ", *Journal of Management Studies,* vol. 33, no. 787, pp. 808.

Kornelius, L. & Wamelink, J.W.F. 1998, " The virtual corporation: learning from construction", *Supply Chain Management,* vol. 3, no. 4, pp. 193-202.

Koskela, L. 2000, *An exploration towards a production theory and its application to construction*.

Krause, D.R., Vachon, S. & Klassen, R.D. 2009, "Special topic forum on sustainable supply chain management: introduction and reflections on the role of purchasing management", *Journal of Supply Chain Management,* vol. 45, no. 4, pp. 18-25.

Kucukvar, M. & Tatari, O. 2013, "Towards a triple bottom-line sustainability assessment of the U.S. construction industry", *International Journal of Life Cycle Assessment,* vol. 18, no. 5, pp. 958-972.

Kurtz, D.J., Santos, J.L.S. & Varvakis, G. 2012, "Uncovering the Knowledge Flows in Supply Chain Relationships", *iBusiness,* vol. 4, pp. 326-334.

Laing O'Rourke 2014, *Sustainability Report, extract from Laing O'Rourke Annual Review 2014*, Laing O'Rourke, UK.

Latham, S.M. 1994, *Constructing the Team: Joint Review of Procurement and Contractual Arrangements in the United Kingdom Construction Industry*, HMSO, London, UK.

Lave, J. & Wenger, E. 1991, *Situated Learning: Legitimate peripheral participation,* 1st edn, Cambridge University Press, Cambridge, UK.

Layder, D. 1992, *New Strategies in Social Research: An Introduction and Guide,* 1st edn, Polity Press, Cambridge.

Lee, S.-. 2008, "Drivers for the participation of small and medium-sized suppliers in green supply chain initiatives. ", *Supply Chain Management International Journal,* vol. 13, pp. 185-198.

Lepech, M. 2009, 8/14-last update*, Life Cycle Assessment: A scientific way to look at going green.* [Homepage of Stanford University], [Online]. Available: http://slideplayer.com/slide/2316155/ [2016, 2/15].

Levers, M.D. 2013, "Philosophical Paradigms, Grounded Theory, and Perspectives on Emergence

", *Sage Open,* vol. Oct-Dec, pp. 1-6.

Levine, M., Urge-Vorsatz, D., Blok, K., Geng, L., Harvey, D., Land, S., Levermore, G., Mongameli Mehlwana, A., Mirasgedis, S., Novikova, A., Rlling, J. & Yoshino, H. 2007, *2007, Residential and commercial buildings, Climate Change 2007: Mitigation, Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [B. Metz, O.R. Davidson, P.R. Bosch, R. Dave, L.A. Meyer (eds)],* Cambridge University Press, Cambridge, U.K. & New York, NY, U.S.A.

Leximancer 2016, *Leximancer: Text in, Insight out*, Version 4.5: 15th March 2016 edn, Leximancer Pty Ltd, Brisbane, Australia.

Lloyd-Roberts, S. 2014, 8 December 2014-last update*, Qatar 2022: Construction Firms Accused Amid Building Boom* [Homepage of BBC], [Online]. Available: http://www.bbc.co.uk/news/business-30295183 (Archived by WebCite® at http://www.webcitation.org/6xBamEK3H) [2017, 11/9].

Lockamy III, A. & Mccormack, K. 2004, "The development of a supply chain management process maturity model using the concepts of business process engineering", *Supply Chain Management: An International Journal,* vol. 9, pp. 272-278.

Locke, R.M. 2013, *The Promise and Limits of Private Power,* 1st edn, Cambridge University Press, Cambridge, UK.

Lockie, S., Butterss, I., Adams, D., Daniels, R. & Thorne, A. 2004, *Schools for the future: Cost of BREEAM compliance in Schools*, Faithful and Gould, London.

London, K.A. & Kenley, R. 2001, "An industrial organization economic supply chain approach for the construction industry: a review", *Construction Management & Economics,* vol. 19, no. 8, pp. 777-788.

Love, P.E.D., Li, H. & Mandal, P. 1999, "Rework: a sympton of dysfunctional supply chains", *European Journal of Purchasing & Supply Management,* vol. 17, pp. 657-668.

Lozano, R. & Huisingh, D. 2011, "Inter-linking issues and dimensions in sustainability reporting", *Journal of Cleaner Production,* vol. 19, no. 2–3, pp. 99-107.

Lucintel 2017, December-last update*, Growth Opportunities in the Global Construction Industry* [Homepage of Lucintel], [Online]. Available: https://www.lucintel.com/construction-industry-2018-2023.aspx [2018, 2/19].

Luzzini, D., Brandon-Jones, E., Brandon-Jones, A. & Spina, G. 2015, "From sustainability commitment to performance: The role of intra- and inter-firm collaborative capabilities in the upstream supply chain ", *International Journal of Production Economics,* vol. 165, pp. 51-63.

M&S 2015, June-last update*, How we define our Plan A attributes* [Homepage of Marks and Spencer Plc], [Online]. Available: http://corporate.marksandspencer.com/documents/plan-a-our-approach/how-we-define-plana-product-attributes-june2015.pdf [2016, June 1].

Matthews, H.S., Hendrickson, C.T. & Weber, C.L. 2008, "The importance of carbon footprint estimation boundaries.", *Environmental Science and Technology,* vol. 42, no. 16, pp. 5839-5842.

Maunula, A. 2008, *The implementation of building information modelling - a process perspective". Report 23*, Helsinki University of Technology, Finland.

Maystad, J., De Luca, G., Sekeris, P.G. & Ulimengu, J. 2014, "Mineral Resources and Conflicts in DRC: A Case of Ecological Fallacy?", *Oxford Economic Papers,* vol. 66, no. 3, pp. 721-749.

McClelland, J. 2015, *Supply Chain Collaboration is a must-have* , HTTP://RACONTEUR.NET/BUSINESS/SUPPLY-CHAIN-COLLABORATION-IS-A-MUST-HAVE edn, Raconteur.

McClelland, J., Glass, J., Anvuur, A. & Ghumra, S. 2015, *A Manifesto for Ethical Sourcing in the Construction Industry*, University of Loughborough, http://apres.lboro.ac.uk/docs/Manifesto-Ethical-Sourcing.pdf.

McCormack, M., Treloar, G., Palmowski, L. & Crawford, R. 2007, ""Modeling Direct and Indirect Water Requirements of Construction", Build. Res. Inform., Vol 35 (2), 2007, p 156-162.", *Building Research and Information,* vol. 35, no. 2, pp. 156-162.

McDermott, P.M., Khalfan, M.A. & Swan, W. 2004, "An exploration of the relationship between trust and collaborative working in the construction sector", *Construction Information Quarterly,* vol. 6, no. 4, pp. 140-146.

McKolsky, B. 2014, *, Collaboration: The next buzzword?* [Homepage of Architecture Now], [Online]. Available: http://architecturenow.co.nz/articles/collaboration-the-next-buzzword/ [2018, 9/4].

Mefford, R.N. 2011, "The Economic Value of a Sustainable Supply Chain", *Business and Society Review,* vol. 116, no. 1, pp. 109-143.

Meng, J., Chen, G.Q., Shao, L., Li, J.S., Tang, H.S., Hayat, T., Alsaedi, A. & Alsaadi, F. 2014, ""Virtual Water Accounting for Building: Case Study of E-town, Beijing", Journal of Cleaner Production, Issue 68, 2014, p 7-15.", *Journal of Cleaner Production,* , no. 68, pp. 7-15.

Mentzer, J.T., DeWitt, W., Keebler, J.S., Min, S., Nix, N.W., Smith, C.D. & Zacharia, Z.G. 2001, "Defining supply chain management", *Journal of Business Logistics,* vol. 22, no. 2, pp. 1-25.

Mentzer, J.T., Foggin, J.H. & Golicic, S.L. 2000, "Collaboration: the enablers, impediments, and benefits.", *Supply Chain Management Review,* vol. 5, no. 6, pp. 52-58.

MOD 2015, 26th August 2016-last update*, Sustainable MOD Strategy Waste Management 2015-2025* [Homepage of Ministry of Defence], [Online]. Available: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/502047/20150826_MOD_WasteStrategy_2015_-_2025.pdf [2016, 21st March].

MOD 2013, 21st June 2013-last update*, Defence Infrastructure Organisation, Estate and Sustainable Development* [Homepage of Ministry of Defence], [Online]. Available: https://www.gov.uk/guidance/defence-infrastructure-organisation-estate-and-sustainable-development [2016, 30th March].

MOD 2011, 27th May 2011-last update*, Sustainable Development Strategy: A sub-strategy of the strategy for Defence 2011-2030* [Homepage of Ministry of Defence, UK Government], [Online]. Available: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/27615/20110527SDStrategyPUBLISHED.pdf [2016, 16th March].

Mollenkopf, D., Stolze, H., Tate, W.L. & Ueltschy, M. 2010, "Green Lean and Global Supply Chains", *International Journal of Physical Distribution & Logistics Management,* vol. 40, no. 1/2, pp. 14-41.

Morledge, R., Knight, A. & Grada, M. 2009, "The concept and development of supply chain management in the UK construction industry" in *Construction Supply Chain Management: Concepts and Case Studies,* ed. S. Pryke, Wiley-Blackwell, Oxford, pp. 23-38.

MPA 2015, , *Summary Sustainable Development Report 2015: Progress and momentum . . . a continuing commitment* [Homepage of Mineral Products Association], [Online]. Available: http://www.mineralproducts.org/sustainability/pdfs/MPA_SD_Report_2015.pdf [2017, February 6th].

Murguía, D.I., Bringezu, S. & Schaldach, R. 2016, "Global direct pressures on biodiversity by large-scale metal mining: spatial distribution and implications for conservation", *Journal of Environmental Management,* vol. 180, pp. 409-420.

Murphy, B. 2015, , ***Environmental Product Declarations (EPDs): Type III labels to ISO 14025*** [Homepage of Greenspec], [Online]. Available: http://www.greenspec.co.uk/epds-type-iii-labels-to-iso-14025/ [2015, 27/11].

Murphy, D.F. & Bendell, J. 1998, "Do-It Yourself or Do-It together? The Implementation of Sustainable Timber Purchasing Policies by DIY Retailers in the UK" in *Greener Purchasing: Opportunities and Innovations*, ed. T. Russel, Greenleaf Publishing, Sheffield, pp. 118-134.

Murray, M., Langford, D., Hardcastle, C. & Tookey, J. 1999, "Organisational design" in *Procurement Systems: A Guide to Best Practice in Construction*, eds. S. Rowlinson & P. McDermott, E. & F.N. Spon edn, London, , pp. 83-118.

Network Rail 2015, 25th March-last update*, Control Period 5 Delivery Plan* [Homepage of Network Rail], [Online]. Available: http://www.networkrail.co.uk/publications/delivery-plans/control-period-5/cp5-delivery-plan/ [2016, 29th March].

New, S. 2015, "Modern Slavery and the Supply Chain: The Limits of Corporate Social Responsiblity?", *Supply Chain Management: An International Journal,* vol. 20, no. 6, pp. 697-707.

Newcombe, R. 2003, "From client to project stakeholders: a stakeholder mapping approach", *Construction Management & Economics,* vol. 21, pp. 841-848.

Ng, S.T., Rose, T.M., Mak, M. & Chen, S.E. 2002, "Problematic issues associated with project partnering: the contractor perspective.", *International Journal of Project Management,* vol. 20, pp. 437-449.

Nicholson, I., King, E., Edwards, P., Upstill-Goddard, J. & Seghal, S. 2017, *Minimising risk through responsible sourcing. A handbook for the construction industry (C767D)* , CIRIA, London, UK.

Nystrom, J. 2007, *Partnering: definition, theory and evaluation,* , Unpublished PhD Thesis, edn, Royal Institute of Technology (KTH): https://www.diva-portal.org/smash/get/diva2:11936/FULLTEXT01.pdf, Stockholm Sweden.

Oakdene Hollins 2011, March 2011-last update, *Further Benefits of Business Resource Efficiency* [Homepage of Oakdene Hollins], [Online]. Available: http://randd.defra.gov.uk/Default.aspx?Menu=Menu&Module=More&Location=None&Completed=2&ProjectID=16943 [2015, 10/14].

OECD 2013, 4th July 2014-last update, *Material Resources, Productivity and the Environment: Green Growth Report Series* [Homepage of OECD], [Online]. Available: http://www.oecd.org/greengrowth/MATERIAL%20RESOURCES,%20PRODUCTIVITY%20AND%20THE%20ENVIRONMENT_key%20findings.pdf [2015, 10/14].

Office of Road and Rail 2015, , *Highways Monitor Six month review of Highways England's performance April – September 2015* [Homepage of Office of Road and Rail], [Online]. Available: http://orr.gov.uk/__data/assets/pdf_file/0003/19956/six-month-review-of-highways-england-performance-december-2015-print.pdf [2016, March 8th].

ONS 2017, *Construction statistics: Number 18, 2017 edition*, Office for National Statistics, London.

ORR 2014, 1st April 2014-last update, *Final Determination of Network Rail's Outputs and Funding for 2014-2019* [Homepage of Office of Rail and Road], [Online]. Available: http://orr.gov.uk/publications/reports/final-determination [2016, 29th March].

Ove Arup and Partners Ltd, The Climate Centre & WRAP 2013, *Low Carbon Routemap for the UK Built Environment*, Green Construction Board, London.

Owen, R., Amor, R., Dickinson, J., Prins, M. & Kiviniemi, A. 2013, *Integrated Design & Delivery Solutions (IDDS)*, International Council for Research and Innovation in Building and Construction, Rotterdam.

Oxford Economics 2015, *Global Construction 2030*, Oxford Economics, Oxford, UK.

Pagell, M., Wu, Z. & Wasserman, M.E. 2010, "Thinking differently about purchasing portfolios: an assessment of sustainable sourcing", *Journal of Supply Chain Management,* vol. 46, pp. 57-73.

Palmer, J. & Armitage, P. 2014, *Building Performance Evaluation Programme: Early Findings from Non-Domestic Projects*, Innovate UK.

Park, N.K., Mezias, J.M. & Song, J. 2004, "A resource-based view of strategic alliances and firm value in the electronic marketplace.", *Journal of Management,* vol. 30, no. 1, pp. 7-27.

Parker, J. 2012, *The Value of BREEAM*, BSRIA, London.

Patel, A.B. & Desai, T.N. 2018, "A systematic review and meta-analysis of recent developments in sustainable supply chain management", *International Journal of Logistics Research and Applications,* , no. DOI: 10.1080/13675567.2018.1534946.

Patigonia 2014, *Environmental and Social Initiatives 2014*, Patigonia.

Paulrai, M.A., Chenc, I.J. & Blome, C. 2017, "Motives and performance outcomes of sustainable supply chain management practices: A multi-theoretical perspective", *Journal of Business Ethics,* vol. 145, no. 2, pp. 239-258.

Paulraj, A. 2011, "Understanding the relationships between internal resources and capabilities, sustainable supply management and organisational sustainability. ", *Journal of Supply Chain Management,* vol. 47, no. 1, pp. 19-37.

Peab AB 2014, *Sustainability Report 2014*, Peab AB, Forslov, Norway.

Picton, D. 2016, 7/11/2016-last update, ***Nations United: presenting the business case for sustainability in Geneva*** [Homepage of Edie.net], [Online]. Available: https://www.edie.net/blog/Nations-United-presenting-the-business-case-for-sustainability-in-Geneva/6098138 [2018, 6/7].

Pinkse, J. & Kolke, A. 2010, "Challenges and trade-offs in corporate innovation for climate change", *Business and Society Review,* vol. 38, no. 4, pp. 547-580.

Porter, M.E. & Kramer, M.R. 2006, "Strategy & Society ", *Harvard BusinessReview,* vol. December, pp. 78-92.

Power, D. 2005, "Supply chain management integration and implementation: a literature review", *Supply Chain Management: An International Journal,* vol. 10, no. 4, pp. 252-263.

Prahalad, C.K. & Hamel, G. 1990, "The Core Competancies of the Corporation", *Harvard Business Review,* vol. 68, no. 3, pp. 79-91.

Preuss, L. 2005, " Rhetoric and reality of corporate greening: a view from the supply chain management function. ", *Business Strategy and the Environment,* vol. 14, pp. 123-139.

Pries, F., Doree, A., Van Der Veen, B. & Vrijhoef, R. 2004, " 2004. The role of leaders' paradigm in construction industry change. *Construction Management and Economics*, *22*(1), pp.7-10.", *Construction Management and Economics,* vol. 22, no. 1, pp. 7-10.

Pryke, S. 2012, *Social Network Analysis in Construction*.

Pullman, M.E., Maloni, M.J. & Carter, C.R. 2009, "Food for thought: Social versus environmental sustainability practices and performance outcomes", *Journal of Supply Chain Management,* vol. 45, no. 4, pp. 38-54.

Pusha, R.R. & Mathew, M. 2010, "Integrative and collaborative behaviour of software product-development teams. "Team Performance and Management", 16(7/8), 434- 450.", *Team Performance and Management,* vol. 16, no. 7/8, pp. 434-450.

QSR International 2015, *NVivo 11, released 2015*, 11th edn, QSR International Pty Ltd, Melbourne, Australia.

Quintas, P. 2002, " Implications of the division of knowledge for innovation in networks" in *Alliances, Networks and Partnersips in the Innovation Process*, eds. J.D.L. Mothe & A.N. Link, Klewer, Boston, MA, , pp. 135-162.

Ramström, J. 2008, "Inter-organizational meets inter-personal: An exploratory study of social capital processes in relationships between Northern European and ethnic Chinese firms", *Industrial Marketing Management,* vol. 37, no. 5, pp. 502-512.

Rao, P. 2002, "Greening the supply chain: a new initiative from South East Asia", *International Journal of Operations and Production Management,* vol. 22, no. 6, pp. 632-655.

Reagans, R. & McEvily, B. 2003, "Network Structure and Knowledge Transfer: The Effects of Cohesion and Range", *Aministrative Science Quarterly,* vol. 48, no. 2, pp. 240-267.

Reefke, H. & Sundaram, D. 2017, "Key themes and research opportunities in sustainable supply chain management – identification and evaluation ", *Omega (United Kingdom),* vol. 66, pp. 195-211.

Reuter, C., Foerstl, K., Hartmann, E. & Blome, C. 2010, "Sustainable global supplier management: The role of dynamic capabilities in achieving competitive advantage", *Journal of Supply Chain Management,* vol. 46, no. 2, pp. 45-63.

Rex, E. & Baumann, H. 2008, "Implications of an Interpretive Understanding of LCA Practice", *Business Strategy and the Environment,* vol. 17, pp. 420-430.

Rhodes, C. 2015, *Briefing Paper: 6 October 2015. Construction Industry: statistics and policy*, 01432nd edn, The House Of Commons Library, London, UK.

RIBAJ 2014, *, RIBA Intelligence: Success begins at home* [Homepage of Royal Institute of British Architects], [Online]. Available: https://www.ribaj.com/intelligence/success-begins-at-home [2018, 5/25].

Ribbink, D. & Grimm, C.M. 2014, "The impact of cultural differences on buyer–supplier negotiations: An experimental study", *Journal of Operations Management,* vol. 32, no. 3, pp. 114-126.

Richards, L. & Richards, T.J. 1987, "Qualitative data analysis: Can computers do it?", *Australian and New Zealand Journal of Sociology,* vol. 23, pp. 23-35.

RICS 2018, *Changing priorities in investor decision-making: the sustainability agenda*, Royal Institute of Chartered Surveyors, London.

RICS 2017, *, **UK Construction and Infrastructure Market Survey Qtr 3 2017*** [Homepage of Royal Institute of Chartered Surveyors], [Online]. Available: https://www.rics.org/globalassets/rics-website/media/knowledge/research/market-surveys/uk-construction-and-infrastructure-survey-q3-2017-rics.pdf [2017, 11/23].

RICS 2014, *RICS Professional Guidance, Global Methodology to calculate embodied carbon 1st edition*, Royal Institution of Chartered Surveyors, Parliament Square, London, SW1P 3AD, UK.

RICS 2007, *Survey of Building Contracts in Use During 2007*, The Royal Institution of Chartered Surveyors, London, UK.

Rittel, H.J.W. & Webber, M.M. 1973, "Dilemmas in a General Theory of Planning ", *Policy Sciences,* vol. 4, pp. 155-169.

Roodman, D.M., Lenssen, N.K. & Peterson, J.A. 1995, *A building revolution: how ecology and health concerns are transforming construction* , Worldwatch Institute., Washington, DC, USA.

RSPO 2018, , *How we work* [Homepage of Roundtable on Sustainable Palm Oil], [Online]. Available: https://www.rspo.org/about/how-we-work [2018, 9/20].

Saad, M., Jones, M. & James, P. 2002, "A review of the progress towards the adoption of supply chain management (SCM) relationships in construction", *European Journal of Purchasing & Supply Management,* vol. 8, no. 3, pp. 173-183.

Sandelowski, M. 1995, " Qualitative analysis: What it is and how to begin.", *Res Nur Health,* vol. 18, pp. 371-375.

Sarkis, J., Zhu, Q. & Lai, K.H. 2011, "An organizational theoretic review of gSave Referencereen supply chain management literature", *International Journal of Production Economics,* vol. 130, no. 1, pp. 1-15.

Saunders L.W., Kliener, B.M., McCoy, A.P., Lingard, H., Mills, T., Bismas, N. & Wakefiled, R. 2015, "The effect of early supplier engagement on social sustainability outcomes in project-based supply chains ", *Journal of Purchasing & Supply Management* *http://www.refworks.com/refworks2/default.aspx?r=references|MainLayout::init&lang=en#,* vol. 21, pp. 285-295.

Schmidt, C., Foerstl, K. & Schaltenbrand, B. 2017, "The supply chain position paradox: Green practices and firm performance. ", *Journal of Supply Chain Management,* vol. 53, pp. 3-25.

Schnieder, L. & Wallenburg, S.M. 2012, "Implementing sustainable sourcing—Does purchasing need to change? ", *Journal of Purchasing & Supply Management,* vol. 18, pp. 243-257.

Scholman, H.S.A. 1997, *Uitbesteding door Hoofdaannemers (Subcontracting by main contractors)*, Economisch Instituut voor de Bouwnijverheid, Amsterdam.

Schorsch, T., Wallenburg, C.M. & Wieland, A. 2017, "The human factor in SCM: introducing a meta-theory of behavioral supply chain management.", *International Journal of Physical Distribution & Logistics Management,* vol. 47, no. 4, pp. 238-262.

Schouton, G. & Gasbergen, P. 2011, "Creating legitamacy in global private governance: The case of case of the Roundtable on Sustainable Palm Oil", *Ecological Economics,* vol. 70, no. 11, pp. 1891-1899.

Scott, R.W. 2008, *Institutions and organizations: Ideas and Interests,* 3rd edn, Sage Publications, Los Angeles, C.A.

SCSS 2018a, August 2018-last update*, Supply Chain Sustainability School Board Members* [Homepage of Supply Chain Sustainability School], [Online]. Available: https://www.supplychainschool.co.uk/default/about-the-school/board-and-governance/board-members.aspx [2018, 9/13].

SCSS 2018b, , *Supply Chain Sustainability School: About* [Homepage of Supply Chain Sustainability School], [Online]. Available: https://www.supplychainschool.co.uk/default/about-the-school.aspx [2018, 6/13].

SDU 2016, , ***Sustainability Reporting Template 2015/16 (March 2016 update)*** [Homepage of Sustainable Development Unit - NHS England], [Online]. Available: http://www.sduhealth.org.uk/search/resources.aspx?q=Reporting+template&zoom_query=Reporting+template [2016, March 3].

Seagar, A. 2007, 2/28-last update*, Construction sector rises to challenge of building eco-friendly homes of the future* [Homepage of The Guardian], [Online]. Available: https://www.theguardian.com/business/2007/feb/28/communities.society [2018, 8/22].

Segerstedt, A. & Olofsson, T. 2010, "Supply chains in the construction industry", *Supply Chain Management,* vol. 15, no. 5, pp. 347-353.

Seuring, S. & Muller, M. 2008a, "From a literature review to a conceptual framework for susainable supply chain managment", *Journal of Cleaner Production,* vol. 16, pp. 1699-1710.

Seuring, S. & Muller, M. 2008b, "From a literature review to a conceptual framework for sustainable supply chain management.", *Journal of Cleaner Production,* vol. 16, pp. 1699-1710.

Seuring, S. & Müller, M. 2008, "Core Issues in Sustainable Supply Chain Management – a Delphi Study", *Business Strategy and the Environment,* vol. 17, no. 8, pp. 455-466.

Seuring, S. 2013, "A review of modeling approaches for sustainable supply chain management", *Decision Support Systems,* vol. 54, no. 4, pp. 1513-1520.

Sharfman, M.P., Ellington, R.T. & Meo, M. 1997, "The future of green issues in business: life-cycle oriented environmental management", *Business Horizons,* vol. 40, no. 3, pp. 13-22.

Sharfman, M.P., Shaft, T.M. & Anex Jr, R.P. 2009, "The road to cooperative supply-chain environmental management: trust and uncertainty among pro-active firms. ", *Business Strategy and the Environment,* vol. 18, no. 1, pp. 1-13.

Sharma, S. & Henriques, I. 2005, "Stakeholder influences on sustainability practices in the Canadian forest products industry", *Strategic Management Journal,* vol. 26, no. 2, pp. 159-180.

Shelbourn, M.A., Bouchlaghem, D.M., Chimay, J.A., Malik, M.K.K., Carillo, P.M. & Glass, J. 2006, "Managing Knowledge in the Context of Sustainable Construction", *ITcon,* vol. 11, pp. 57.

Sherratt, F. 2016, *Unpacking Construction Site Safety,* John Wiley and Sons, Chichester.

Simatupang, T.M. & Sridharan, R. 2002, "The collaborative supply chain. ", *The International Journal of Logistics Management,* vol. 13, no. 1, pp. 15-30.

Simpson, D.F. & Power, D.J. 2005, " Use the supply relationship to develop lean and green suppliers. ", *Supply Chain Management: An International Journal,* vol. 10, no. 1, pp. 60-68.

Sinclair, D., Beck, S. & Tait, A. 2013, *RIBA Outline Plan of Work, 2013: An Overview*, Royal Institute of British Architects, London.

Singh, J. 2005, "Collaborative Networks as Determinants of Knowledge Diffusion Patterns ", *Management Science,* vol. 51, no. 5, pp. 756-770.

Singh, V., Gu, N. & Wang, X. 2011, " A theoretical framework of a BIM-based multi- disciplinary collaboration platform", *Automation in Construction,* vol. 20, no. 2011, pp. 134-144.

Sisco, C., Chorn, B., Pruzan-Jorgensen, P.M., Househam, A. & Bombis, E. 2015, *Supply Chain Sustainability - A Practical Guide for Continuous Improvement: Second Edition.* , UN Global Compact Office and BSR.

Sivesind, K.H. 1999, "Structured, qualitative comparison", *Quality and Quantity,* vol. 4, pp. 361-380.

Skanska 2016, *, Annual Report 2015; We build for a better society: Extract of Annual Report 2015* [Homepage of Skanska], [Online]. Available: http://group.skanska.com/494c5b/globalassets/sustainability/reporting--publications/sustainability-reporting/skanska-sustainability-review-2015.pdf [2017, 13th February].

Skanska AB 2014, *Sustainability Review 2014, Extract of Annual Report 2014*, Skanska AB, Stockholm, Sweden.

Skitmore, M. & Smyth, H. 2009, " Marketing and pricing strategy" in *Construction Supply Chain Management: Concepts and Case Studies*, ed. S. Pryke, Wiley-Blackwell, Oxford, pp. 92-111.

Smirnov, A. & Chandra, C. 2000, "Ontology-based knowledge management for co-operative supply chain configuration", *AAAI Spring Symposium "Bringing knowledge to business Processes*AAAI Press, Stanford, California, 2000, pp. 85.

Smith, R.A., Kersey, J.R. & Griffiths, P.J. 2003, *The Construction Industry Mass Balance: resource use, wastes and emissions (revised)*, Viridis.

Sorenson, O., Rivkin, J. & Fleming, L. 2006, "Complexity, Networks and Knowledge Flow", *Research Policy,* vol. 35, no. 7, pp. 994-1017.

Sotiriadou, P., Brouwers, J. & Andrew, L. 2014, "Choosing a qualitative data analysis tool: A comparison of NVivo and Leximancer", *Annals of Leisure Research,* vol. 17, no. 2, pp. 218-234.

Sourani, A. & Sohail, M. 2011, "Barriers to addressing sustainable construction in public procurement strategies", *Proceedings of the Institution of Civil Engineers: Engineering Sustainability,* vol. 164, no. 4, pp. 229-237.

Spence, L. & Bourlakis, M. 2009, "The evolution from coroporate social responsibility to supply chain responsibility: the case of Waitrose", *Supply Chain Management,* vol. 14, no. 4, pp. 291-302.

Spender, J.C. 1996, "Making knowledge the basis of a dynamic theory of the firm", *Strategic Management Journal,* vol. 17, pp. 45-62.

Steele, K., Hurst, T. & Giesekam, J. 2015, *Green Construction Board Low Carbon Routemap for the Built Environment 2015 Routemap Progress: Technical Report*, ARUP, London.

Stern, N. 2006, *Stern Review on the economics of climate change*, HM Treasury, London.

Stevens, G.C. & Johnson, M. 2016, "Integrating the Supply Chain … 25 years on", *Physical Distribution and Logistics Management,* vol. 46, no. 1, pp. 19-42.

Stewart, T.A. 1997, *Intellectual Capital: The New Wealth of Organisations,* 1st edn, Doubleday Dell Publishing Group, New York, NY.

Stinchcombe, A. 1959, "Bureaucratic and craft administration of production", *Administrative Science Quarterly,* vol. 4, pp. 168-187.

Strauss, A.L. & Corbin, J. 1998, *Basics of qualitative research: Techniques and procedures for developinggrounded theory ,* 2nd edn, Sage, Thousand Oaks, CA.

Suprapto, M., Bakker, H.L., Mooi, H.G. & Hertogh, M.J. 2016, "How do contract types and incentives matter to project performance?", *International Journal of Project Management,* vol. 34, no. 6, pp. 1071-1087.

SurveyMonkey 2016, *SurveyMonkey: Surveys online*, SurveyMonkey Inc., San Mateo, California, USA.

Sweett, C. 2007, *Putting a Price on Sustainability*, BRE Trust, Watford, UK.

Taticchi, P., Garengo, P., Nudurupati, S.S., Tonelli, F. & Pasqualino, R. 2015, "A review of decision-support tools and performance measurement and sustainable supply chain management", *International Journal of Production Research,* vol. 53, no. 21, pp. 6473-6494.

Temple, N. & Wigglesworth, C. 2014, *Communities Count: The Four Steps of Unlocking Social Value*, Social Enterprise UK, London, UK.

Tennant, S. & Fernie, S. 2012, "An emergent form of client-led supply chain governance in UK construction: Clans ", *International Journal of Construction Supply Chain Management,* vol. 2, no. 1, pp. 1-16.

Tennant, S. & Fernie, S. 2011a, " Extended construction supply chain management: relationships, rewards and risks", *Management and Innovation for a Sustainable Built Environment I*CIB, Amsterdam, The Netherlands, 20-23 June.

Tennant, S. & Fernie, S. 2011b, "An alternative form of supply chain governance: Construction clans", *Association of Researchers in Construction Management, ARCOM 2011 - Proceedings of the 27th Annual Conference*, pp. 475.

Tennant, S., Fernie, S. & Murray, M. 2014, "The Myths of Best Practice through the Lens of Construction Supply Chain Management", *30th Annual Conference and Annual General*

*Meeting*Strathprints Institutional Repository, Plymouth, 1st September 2014- 3rd September 2014.

The Economist 2018, 1/18-last update*, Where did Carillion go wrong?* [Homepage of The Economist], [Online]. Available: https://www.economist.com/britain/2018/01/18/where-did-carillion-go-wrong [2018, 1/20].

The European Parliament and the Council of the European Union 2017, *Regulation (EU) 2017/821 of the European Parliament and of the Council of 17 May 2017 laying down supply chain due diligence obligations for Union importers of tin, tantalum and tungsten, their ores, and gold originating from conflict-affected and high-risk areas*, Regulation edn, European Union, Brussels, Belgium. https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=OJ:L:2017:130:FULL&from=EN.

Thompson, I., Cox, A. & Anderson, L. 1998, " Contracting strategies for the project environment. ", *European Journal of Purchasing and Supply Management,* vol. 4, pp. 31-41.

Thormork, C. 2006, "The effect of material choice on the total energy need and recycling potential of a building", *Building and Environment,* vol. 41, no. 8, pp. 1019-1026.

Thornburg, R. 2012, "Informed Grounded Theory", *Scandinavian Journal of Educational Research,* vol. 55, no. 1, pp. 1-17.

Tokar, T. 2010, "Behavioural research in logistics and supply chain management", *The International Journal of Logistics Management,* vol. 21, no. 1, pp. 89-103.

Tommelein, D. & Ballard, G. 1998, "Coordinating specialists", *Journal of Construction Engineering and Management (ASEC),* , pp. 1-11.

Touboulic, A., Matthews, L. & Marques, L. 2018, "In the road to carbon reduction in a food supply network: a compex adaptive systems perspective", *Supply Chain Management: An International Journal,* .

Touboulic, A. & Walker, H. 2015, "Love me, love me not: A nuanced view on collaboration in sustainable supply chains ", *Journal of Purchasing & Supply Management,* vol. 21, pp. 178-191.

Tsoukas, H. 2003, "Do we really understand Tacit knowledge?" in *The Blackwell Handbook of Organisational Knowledge*, eds. M. Easterby-Smith & M.A. Lyles, Blackwell, London, , pp. 410.

Turban, E., McLean, E. & Wetherbe, J. 2005, *Information Technology for Management,* 5th ed edn, Wiley, New York.

Tutt, D., Dainty, A., Gibb, A. & Pink, S. 2011, *Migrant construction workers and health and safety communication*, CITB - Construction Skills, King's Lynn.

Udom, K. 2013, 10/1-last update*, Improving collaborative construction contracts* [Homepage of National Building Specifcation], [Online]. Available:

https://www.thenbs.com/knowledge/improving-collaborative-construction- contracts [2018, 8/29].

UK CARES 2016, *The CARES Sustainable Constructional Steel Scheme Summary Report 2015/16*, CARES, England.

UK Government 2018a, *A Green Future: DEFRA - Our 25 Year Plan to Improve the Environment*, 1st edn, UK Government, London.

UK Government 2018b, July 2018-last update*, Industrial Strategy: Construction Sector Deal* [Homepage of UK Government], [Online]. Available: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/731871/construction-sector-deal-print-single.pdf [2018, 9/12].

UK Government 2018c, 26 March-last update*, Public procurement policy: Directives, regulations, policies and guidance relating to the procurement of supplies, services and works for the public sector. Procurement policies in support of enterprise and growth.* [Homepage of UK Government], [Online]. Available: https://www.gov.uk/guidance/public-sector-procurement-policy [2018, 8/13].

UK Government 2017a, *Industrial Strategy: Building a Britain fit for the future*, UK Government, London, UK.

UK Government 2017b, *UK Annual Report on Modern Slavery October 2017*, HM Government, London.

UK Government 2016a, *The Carbon Budget Order 2016: No.785*, Statutory Instrument edn, United Kingdom, London.

UK Government 2016b, 18 November-last update*, UK ratifies the Paris Agreement* [Homepage of UK Government], [Online]. Available: https://www.gov.uk/government/news/uk-ratifies-the-paris-agreement [2018, 1/3].

UK Government 2015a, *, The Construction (Design and Management) Regulations 2015* [Homepage of Uk Government], [Online]. Available: http://www.legislation.gov.uk/uksi/2015/51/contents/made [2016, 1/16].

UK Government 2015b, *, UK Modern Slavery Act* [Homepage of UK Government], [Online]. Available: http://www.legislation.gov.uk/ukpga/2015/30/contents/enacted [2016, 4/3].

UK Government 2013, *Construction 2025*, UK Government, London.

UK Government 2012a, *Public Services (Social Value) Act 2012*, Act of Parliament edn, UK, London, UK.

UK Government 2012b, *Public Services (Social Value) Act 2012*, Act of Parliament edn, UK, London.

UK Government 2011, *Government Construction Strategy*, Cabinet Office, UK Government, London, UK.

UK Government 2008a, 22 November 2018-last update, *Climate Change Act 2008* [Homepage of UK Government], [Online]. Available: https://www.legislation.gov.uk/ukpga/2008/27/contents [2018, 11/29].

UK Government 2008b, *Strategy for sustainable construction:* , Department for Business, Enterprise and Regulatory Reform, UK Government, London.

UK Government 2006, *Review of Sustainable Construction October 2006*, Department of Trade and Industry (DTI), London, UK.

UK Government 1974, , *The Health and Safety at Work etc Act* [Homepage of UK Government], [Online]. Available: http://www.legislation.gov.uk/ukpga/1974/37/contents [2018, 11/3].

UKCG 2009, *Construction in the UK Economy The Benefits of Investment*, UK Green Building Council, London, UK.

UKGBC 2018a, , *Members Directory* [Homepage of UK Green Building Council], [Online]. Available: https://www.ukgbc.org/members-directory/ [2018, 9/13].

UKGBC 2018b, , *Who we are.* [Homepage of UK Green Building Council], [Online]. Available: https://www.ukgbc.org/about-us/ [2018, 2/24].

UKGBC 2015, 18th August 2015-last update, *UK Green Building Council Case Study - Kings Cross* [Homepage of UK Green Building Council], [Online]. Available: http://www.ukgbc.org/sites/default/files/Kings%20Cross%20Development%20Case%20Study_0.pdf [2016, March 8th].

Ullrich, C.A. 2014, "Chapter 2, Introduction to Supply Chain Management" in *Issues in Supply Chain Scheduling and Contracting,* 1st edn, Gabler Verlag, Wiesbaden, pp. 5-14.

UNEP 2015, , *Sustainable Procurement* [Homepage of United Nations Environmental programme], [Online]. Available: http://www.unep.org/resourceefficiency/Consumption/SustainableProcurement/WhatisSustainablePublicProcurement/tabid/101245/Default.aspx [2015, October 1st].

UNEP 2014, *Greening the Building Supply Chain*, United Nations Environment Programme, Division of Technology, Industry and Economics, Sustainable Buildings and Climate Initiative, Paris, France.

UNEP 2009a, *Buildings and Climate Change: Summary for Decision Makers*, United Nations Environmental Programme: Sustainable Buildings and Climate Initiative, Paris, France.

UNEP 2009b, *UNEP: Guidelines for Social Life Cycle Assessment of Products* , 1st edn, UNEP/SETAC, Paris.

Unilever 2014, *Unilever Sustainable Living Plan: Scaling for Impact, Summary of Progress 2014*.

United Nations 2017, *UN Procurement, Practitioner's Handbook*, October 2017 edn, United Nations High Level Committee on Management Procurement Network, Switzerland.

United Nations 2009, *Sustainable Procurement as defined by the HLCM PN Global Reporting Initiative (High Level Committee on Management Procurement Network, Practice Note: Vienna, 2009)*, United Nations Systems, Vienna.

UNSD 2017, , *Global Indicator Framework for the Sustainable Development Goals and Targets of the 2030 Agenda for Sustainable Development, Global Indicator Framework A RES 71 313 Annex, Statistical Commission Pertaining to the 2030 Agenda for Sustainable Development*
[Homepage of United Nations], [Online]. Available: https://unstats.un.org/sdgs/indicators/Global%20Indicator%20Framework_A.RES.71.313% 20Annex.pdf (accessed on 8 November 2017). (Archived by WebCite® at http://www.webcitation.org/6xBbEFjMi). [2017, 11/8].

Unseen UK 2017, *Modern Slavery Helpline: Annual Report* , Unseen UK, Bristol, UK.

Upstill-Goddard, J., Glass, J., Dainty, A.R.J. & Nicholson, I. 2015, "Analysis of responsible sourcing performance in BES 6001 certificates", *Proceedings of the Institution of Civil Engineers: Engineering Sustainability,* vol. 168, no. 2, pp. 71-81.

Upstill-Goddard, J., Glass, J., Dainty, A.R.J. & Nicholson, I. 2012, "Integrating responsible sourcing in the construction supply chain", , pp. 1311.

Usdiken, B., Szen, Z. & Enbiyaog˙lu, H. 1988, "Strategies and boundaries: subcontracting in construction. ", *Strategic Management Journal,* vol. 9, no. 6, pp. 633-637.

USGBC 2015, 23rd February-last update*, Green Building Facts* [Homepage of US Green Building Council], [Online]. Available: http://www.usgbc.org/articles/green-building-facts [2016, 1/8].

Vachon, S. & Klassen, R.D. 2008, " Environmental management and manufacturing performance: The role of collaboration in the supply chain.", *International Journal of Production Economics,* vol. 111, no. 2, pp. 299-315.

Venters, W., Cushman, M. & Cornford, T. 2002, *Creating knowledge for sustainability: Using SSM for describing knowledge environments and conceptualising technological interventions.* , Department of Information Systems, London School of Economics, London, UK.

VERBI Software 2015, *MAXQDA Software programme*, MAXQDA for Windows 11.1.1 B edn, VERBI Software, Berlin.

Verboom, J., Alkemade, R., Klijn, J., Metzger, M.J. & Reijnen, R. 2007, " Combining biodiversity modeling with political and economic development scenarios for 25 EU countries Author links open overlay panel ", *Ecological Economics,* vol. 62, no. 2, pp. 267-276.

Vrijhoef, R. & Koskela, L.". 2000, "The four roles of supply chain management in construction ", *European Journal of Purchasing & Supply Management,* vol. 6, pp. 169-178.

Vurro, C., Russo, A. & Perrrini, F. 2009, "Shaping sustainable value chains: Network determinants of supply chain governance models", *Journal of Business Ethics,* vol. 90, pp. 607-621.

Waheed, Z. & Fernie, S. 2010, "Understanding Knowledge Sharing Through Organisational Networks", *W070-Special Track 18th CIB World Building Congress*International Council for Research and Innovation in Building and Construction (CIB), Salford, UK, May, pp. 158.

Walk Free Foundation 2016, *The Global Slavery Index 2016*, The Minderoo Foundation Pty Lt, Australia.

WBCSD 2016, *, The business case for the use of life cycle metrics in construction and real estate* [Homepage of World Business Council for Sustainable Development], [Online]. Available: file:///C:/Users/User/Downloads/wbcsd_Life%20Cycle%20Environment_final%20(2).pdf [2018, 2/11].

WGBC 2018, November-last update*, World Green Building Trends 2018 SmartMarket Report: Europe* [Homepage of World Green Building Council], [Online]. Available: https://www.worldgbc.org/sites/default/files/SMR0918_Europe_25Nov18.pdf [2018, 12/3].

Williamson, O.E. 2008, "Outsourcing: Transaction Cost Economics and Supply Chain Management", *Journal of Supply Chain Management,* vol. 44, no. 2, pp. 5-16.

Williamson, O.E. 1991, "Comparative Economic Organization: The Analysis of Discrete Structural Alternatives", *Administrative Science Quarterly,* vol. 36: June, pp. 269-296.

Willmott Dixon 2014, *It's what we do: Sustainable Development Review 2014*, Willmott Dixon, UK.

Wolf, C. & Seuring, S. 2010, "Environmental Impacts as Buying Criteria for Third Party Logistical Services ", *International Journal of Physical Distribution & Logistics Management,* vol. 40, no. 1/2, pp. 84-102.

Wolf, J. 2011, "Sustainable Supply Chain Management Integration: A Qualitative Analysis of the German Manufacturing Industry", *Journal of Business Ethics,* vol. 102, pp. 221-235.

WRAP 2012, *Case Study: Direct and Indirect Water Use at Heathrow Terminal 2B*, WRAP, Banbury, England.

WRAP 2007, *Current Practices and Future Potential in Modern Methods of Construction, Ref WAS003-001, 2007.* , WRAP, Banbury.

WRI & WBCSD 2004, *Greenhouse Gas Protocol: Corporate Accounting and Reporting Standard* , 1st edn, World Resources Institute and World Business Council for Sustainable Development, USA.

Xie, G. 2016, "Cooperative Strategies for Sustainability in a Decentralized Supply Chain With Competing Suppliers", *Journal of Cleaner Production,* vol. 113, pp. 807-821.

Yates, A. 2003, *Sustainable buildings: benefits for investors and developers*, BRE, London.

Yin, R.K. 2009, *Case Study Research: Design and Methods,* 1st edn, SAGE Publications Ltd, London.

Zacharia, Z.G., Nix, N.W. & Lusch, R.F. 2011, "Capabilities that enhance outcomes of an episodic supply chain collaboration", *Journal of Operations Management,* vol. 29, no. 6, pp. 591-603.

Zhou, L. & Lowe, D.J. 2003, "Economic Challenge of Sustainable Construction", *Proceedings of the RICS Construcgtion and Building Research Conference*, ed. D. Proverbs, School of Engineering and the Built Environment, University of Wolverhampton, Wolverhampton, UK, September 2003, pp. 113.