Collaboration between construction firms and the supply chain for the implementation of innovation strategies

by

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Abstract

Collaborative innovation strategizing between a construction contractor firm and its supply chain

The construction industry in the UK is one of the major employers, involving many different firms and professional bodies, and it comprises of a wide range of products, services and technologies. Nonetheless, for many decades the industry has suffered several structural challenges, such as low investments in R&D and innovation, fragmentation of supply, and a lack of collaboration. In order to find solutions to these issues, the Government has implemented an Industrial Strategy, which aims to foster supply chain integration, by enhancing investment in innovation. Another specific purpose is to implement Building Information Modelling (BIM), in order to reach more efficiency and sustainability, predictable delivery of buildings, and off-site manufacturing.

Scholars have also argued that the construction industry is considered slow to innovate and characterised by a sense of "backwardness" (e.g. Woudhuysen & Ableу 2004). The implementation of innovative technology can lead to innovative behaviour, to increased integration and efficiency among actors, and simplified design work. Concerning the greater importance placed on supply chains by the industry and the Government, scholars in supply chain management (SCM) emphasise how supply chain integration can solve fragmentation and foster collaboration and innovation.

The aim of the thesis is to understand how a British construction firm collaborates with its suppliers in order to implement innovation strategies. The research is driven by the interest to deepen the analysis of how collaboration and strategizing with the supply chain takes place, and how innovation is managed by the firms involved. Specifically, the research question aims to understand whether the early engagement of the supply chain during projects when innovation is implemented leads to effective collaboration and empowerment.

The empirics are analysed through a novel theoretical approach, which draws on Strategy-as-Practice (SaP) as a general theoretical framework and applies Actor-Network Theory (ANT) to analyse the data. It adopts a research methodology comprising of targeted

ethnographies, in-depth interviews, and document analysis. The reason to adopt this theoretical approach lies in the fact of focusing on the role of actors, both human (e.g. the firms involved), and non-human (e.g. technology) in shaping strategy during particular organisational settings, such as meetings, workshops, or other events. The focus is on how the actor-network, involving the contractor and the supply chain, is built, and how collaborative innovation strategizing (CIS) is shaped by multiple networks and objects, and fluid technology.

Concerning the theoretical contribution, more research is needed to understand the specific role of BIM in supply chain collaboration, and BIM theorisation regarding its fluidity in shaping collaboration and innovation. The flat ontology mobilised here differs from previous SaP studies within the construction industry by refusing to scale strategizing into hierarchies of local practices and structural context and thus being more open about which actors, and places and times, make a difference to the strategizing process. Moreover, strategizing and ANT has few empirical applications in the literature, including SaP research, and is to the best of my knowledge an entirely novel approach in construction.

Concerning the methodological contribution, these novel theoretical approaches are developed here in combination with an ethnographic research to investigate collaboration and the implementation of innovation within specific places and times. Analysing these settings with ANT, within a SaP frame, it was possible to develop interesting insights into how power fluctuates among the actors, and how non-human actors influence collaboration and strategizing. An additional moment ("pre-interessement") has been added to Callon's model of translation which has been used to analyse the building of the actor-network, and how the network builder uses particular ways to converge the suppliers' interests into the network.

The thesis also contributes by providing a "bottom-up", or lived, perspective of how strategy is shaped, and has emphasised the importance of the relationships among heterogeneous actors for collaboration and strategizing. Moreover, the analysis of BIM as a fluid technology allows the elaboration of multiple definitions, practices and meanings of collaboration. The nuanced exploration of collaboration remains rare especially in the BIM literature where the meaning of collaboration is often simplified and presumed as a BIM outcome. Finally, concerning the contribution to industry, the research has emphasised how the integration of the supply chain can be enhanced through long-term relationships and

trust building, such as through a decreased number of selected supplier firms to collaborate with, and regular meetings and workshops with the supply chain. Furthermore, BIM has shown to be an object which fosters collaboration and innovation across supply chain, but it has to be implemented once the actors involved have a solid knowledge of the software, otherwise effective collaboration can be hampered.

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List of abbreviations

AC = architects

AEC = Architecture, Engineering, Construction

ANT = Actor-Network Theory

BIM = Building Information Modelling

BREEAM = Building Research Establishment Environmental Assessment Method

CIS = Collaborative Innovation Strategizing

CITB = Construction Industry Training Board

CLC = Construction Leadership Council

CSCS = Construction Skills Certification Scheme

GSFC = light gauge still frame company

IFC = Industry Foundation Classes

ISIC = International Standard Industrial Classification of all Economics Activities

ISO = International Organization for Standardization

KR = single-supplier for roofing, insulation, infrastructure and structural waterproofing

PEFC = Programme for the Endorsement of Forest Certification

PQQ = Pre-Qualification Questionnaire

PVC = Polyvinyl Chloride

RC = roofing company

RN = single-supplier for suspended ceilings and acoustics

SaP = Strategy-as-Practice

SCM = Supply Chain Management

SIC = Standard Industrial Classification

SHT = Standard House Type project

SP = school project

STS = Science and Technology Studies

TCC = construction contractor company

TFC = timber frame company

TPEs = Thermoplastic Elastomer

VET = Vocation Education and Training

Chapter 1

Introduction

This research project aims to focus on collaborative innovation strategizing (CIS) between a British construction firm and its supply chain in different organisational settings and involving BIM and other objects which influence their collaborative activities. Hence, innovation is not only the main theoretical focus of the research, but becomes an empirical means to understand collaboration. Moreover, the thesis draws on Strategy-as-Practice (SaP) as the general approach to study these strategizing processes, and it then engages Actor-Network Theory (ANT) to deepen the theoretical analysis. In particular, the first theoretical perspective gives a broad theoretical framework to understand strategy as made by actors (e.g. suppliers, managers, architects, etc.), whereas the second theoretical perspective aims to give a micro- and flatter analysis of collaboration and innovation with a particular focus on technology, such as Building Information Modelling (BIM) and its changing role in different settings. This chapter is structured in three main parts: the first aims to give a brief introduction to the context and the background of the construction industry, focusing in particular on the UK Government's industrial strategies. The second part aims to justify the importance of conducting this research both for the industry and academia and illustrate the plan to investigate the argument. The last section will describe the structure of the thesis.

1.1 Background and Government's strategy in the construction industry

The construction industry in the UK is a major employer and had a turnover of around £370 billion in 2016, adding a 9% of the total value of the UK economy (HM Government 2018). However, the industry has often been said to have been held back by several structural issues. In the recent decades, the UK Government has pushed its policies towards the enhancement of the construction and housing sector, in order to respond to the increasing market needs and competition. Moreover, the UK Government has sought to actively respond to critical issues which have been highlighted by Farmer's review (Farmer 2016): low productivity, low predictability (concerning time, cost, and quality), structural

fragmentation (e.g. lack of supply chain integration, high volume of SMEs, high levels of self-employment), leadership fragmentation (e.g. lack of interdependence between the industry and clients, general fragmentation of the industry's main representatives), financial fragility, dysfunctional training funding, workforce size (e.g. ageing workforce, and low levels of entrants), lack of collaboration and improvement culture, lack of R&D and investment in innovation (despite the implementation of BIM in the industry, there is still a large scale gap concerning its actual adoption), and poor industry image (e.g. public perception of poor job security, working conditions and health and safety). Farmer (2016) suggests that the construction industry, its end clients (both private and public), and the Government should work together as strategic initiators for a long-term structural change of the industry.

Some of the recommendations highlighted by Farmer (2016) thus include: investments in skills and technology, developing new business models, reviewing and reforming the Construction Industry Training Board (CITB) to develop training opportunities and attract new entrants into the industry, to develop programme of R&D and innovation to deliver productivity improvements especially in housing, supporting training course developments (e.g. BIM and digitalisation). Moreover, the Government should also intervene to ensure further education, tax and employment policies to establish and maintain skills, and should stimulate innovation the housing sector through pre-manufactured solutions.

The Government has developed an industrial strategy to find solutions to all these issues, notably with the Industrial Strategy "Construction 2025" which has been taken forwards by the Construction Leadership Council (CLC) (HM Government 2013). Central to this policy is a partnership between the Government and construction industry to deliver a set of change aspirations by 2025. This vision can be summarised in five main points: "people", "smart", "sustainable", "growth", and "leadership"[1]. Set against the forecast of 70% growth of the construction market by 2025, the strategy aims to lower costs of construction and building assets, halve the time of the delivery of buildings, halve the

[1] "People" aims to build career opportunities for a diverse workforce by retain and developing skills to increase demand in construction and respond to changes, as well as reinvigorating the perceived image of the industry. "Smart" aims to invest in digital design, BIM, and research and innovation. "Sustainable" aims to improve energy performance of existing building stock, and to invest in low-carbon solutions. "Growth" aims to expand the construction industry's global export markets. Finally, "Leadership" refers to the Construction Leadership Council (CLC) which will focus on delivering this strategy, linking industry and Government commitments (HM Government 2013).

greenhouse gas emissions of buildings, and halve the trade gap between total exports and total imports for construction products and materials.

The Strategy highlights through a SWOT analysis the strength and weaknesses of the UK construction industry. The strengths identified include: construction as a key sector in the UK economy contributing to 7% of UK's value added; economic significance of construction for other businesses; the large construction supply chain (supporting employment and diverse economic activity); worldwide recognised design skills (e.g. Building Research Establishment Environmental Assessment Method – BREEAM); low entry costs and low capital promoting competition. The weaknesses found encompass: low vertical integration of supply chains with high reliance on sub-contracting; low levels of innovation and R&D investment; lack of collaboration and limited knowledge sharing across multiple projects; high construction costs (HM Government 2013).

In particular, as a response to the low level of innovation and technology investment and uptake in the industry, the "smart" point of the Strategy aims to invest in smart construction and digital designs, enhance research and innovation, and implement BIM which has become mandatory for all procured Government contracts from 2016. BIM implementation is mandated to allow the construction of more sustainable and efficient buildings in a shorter time span, including facilitating increased off-site manufacturing. Moreover, the Government aims to foster supply chains by pushing them to invest in technology and workforce and facilitating their access to finance and payment practices.

The newest Industrial Strategy – Construction Sector Deal (HM Government 2018) builds on Construction 2025 and highlights five key areas for policies: ideas, people, infrastructure, business environment, and places[2]. In particular, the framework aims to deliver: 33% reduction in the cost of construction, 50% reduction of the time to deliver a new build, 50% reduction in green gas emissions in buildings, and 50% reduction in the trade gap between total exports and imports of construction products and materials. In order to meet these goals, three strategic areas must be developed: digital techniques to be

[2] The area of "Ideas" refers to more investments in R&D. In particular, the construction sector will contribute with £430m joint investment with the government in new technology and techniques. The area "People" involves the creation of jobs, as well as attracting, training, and retaining skilled workforce (e.g. increased number of apprenticeships in construction). The area "Infrastructure" projects to invest around £600bn of public and private investment in infrastructure over 10 years, particularly for housing. Finally, the area "Business Environment" refers to more sustainable practices, higher levels of collaboration and supply chain integration.

implemented with the involvement of the supply chain, off-site manufacturing, and whole life asset performance.

As the Industrial Strategy makes clear, the construction sector is also characterised by a high level of subcontracting and fragmentation. In particular, fragmentation is likely to be caused by a high presence of self-employment and many small and micro businesses (BIS 2013). One of the most important structural changes in the industry was indeed the increasingly reliance on subcontracting (starting from the 1970s), which was mostly due to the increased number of listed private contractors relying on specialist trades. According to Green (2011), subcontracting represented an advantage for contractors because they could rely on specialists and do not worry about providing continuity of work. Harvey (2003) used the term "flexibilization" indicating the downsizing of firms and the outsourcing of functions. In particular, the surge of subcontracting was facilitated by client diversification, technological complexity and an increasingly competitive environment. Hence, larger contractors started to rely on subcontractors, whereas many smaller firms reinvented themselves into specialist subcontractors. As a result construction work started to be organised by an "extended chain of vertical subcontracting" in which the main contractors focused on managing and coordinating subcontractors (Green 2011).

Hence, fragmentation of the industry is typified by short-term relationships among firms and suppliers, working from project to project. This short-termism may hinder the establishment of long-term collaboration, supply chain integration, innovation, and knowledge sharing. One of the ways to overcome short-termism and lack of integration is the acknowledgement by construction firms of the importance of building strong and trustworthy relationships with the supply chain and establishing common goals to reach business success for all parties. This means trying to define and develop a "collaborative advantage" which is reciprocal and comprises integration, flexibility, efficiency and innovation. The benefits of supply chain collaboration have been emphasised both by authors in the academic field, and also by the Government, as discussed above.

Even though there has been a push in recent years towards collaborative and trustworthy relationships with the supply chain, and more generally towards more efficient and innovative practices, construction firms in the UK still find it hard to accomplish all these improvements. A reason can be the fact that investing a lot of money and time in innovative collaboration practices may not be financially possible, particularly for small businesses.

Moreover, there still are many cultural barriers involved in changing products, materials, or processes in order to innovate. Therefore, it is important to acknowledge the advantages of implementing collaborative practices and innovation for all the actors involved. For example, collaboration itself can lead to innovative ideas and efficiency since different actors can share their expertise. The Government's recent Industrial Strategy may also give a big push towards change in the industry.

These weaknesses also affect the development of training processes which are rather low, and which can hinder innovation and projects practices. Other issues which can slow down growth are reported skills shortages in the sector: 53% of employers in the construction contracting sector reported such shortages in professional occupations (BIS 2013). Other factors may slow down growth and innovation as Clarke, Winch and Brockmann (Clarke et al. 2013) discussed. These include low skilled labour, which is not rewarded the way it should in the UK construction sector and fragmentation in construction trade unions leading to a weak collective agreement. In particular, they argue that construction workers in the UK are not rewarded (by the Construction Skills Certification Scheme – CSCS) for their personal competencies or occupational qualifications to allow them work on site, but for their performance output to be attached to a particular task.

Hence, for example, bricklaying is based on narrow trade skills. Moreover, there is no interest in the construction trade unions to define construction occupations according to different qualification levels. An opposite example of bricklaying is given by Germany, where bricklaying can be described as a qualified occupation, under a VET (Vocation Education and Training) system with a focus on building occupation capacity, and on autonomy of workers in building practices, such as planning, controlling, coordinating, evaluating, and being flexible to changing needs in the sector (Brockmann et al. 2008). Therefore, they denounce the loss of occupational capacity in the UK which does not respond well to the changing construction sector due to social and economic conditions, and technological innovation.

Concerning the general housing sector, a main problem facing the UK is the inability of the housing market to keep up with the increasingly high demand for houses. Moreover, from the financial crisis which started in 2007, house prices have started to surge and this has led to inequality and social and economic issues (Keohane & Broughton 2013). In particular, according to household projections between 2011 and 2021, an extra 2.7 million new houses should be needed by 2021 (CBI 2013). The constraints of increasing the

availability of housing stock are caused by the lack of available land to build on, both due to physical scarcity and planning restrictions. Barker (2004) argues that a more efficient use of land can be achieved by building houses at higher densities. Finding additional land for development may take place on accessible open land or on already intensively built land. Clearly, the former solution would bring higher cost on society, whereas the last solution would have smaller costs (Barker 2004). One often cited response to this issue has been the introduction of BIM and the standardisation of buildings (e.g. residential, commercial, etc.). Indeed, the reduction of time and costs due to standardisation of components allows to produce more quickly in order to respond to the increased demand.

The 2008 financial crisis also seriously hit the capacity of the sector to meet long-term demand, due to the lack of mortgage and development finance and lost labour and skill capacity, resulting in some of the lowest levels of housing completion registered after the Second World War. Unfortunately, this issue is predicted to become even more dangerous when considering the demographic growth expected by 2030. This means an increase of 20% of the number of households (Office for National Statistics 2013). According to Barker's (2004) review, the UK should develop a more flexible housing market to obtain higher level of competitiveness and economic and social stability by giving more importance to the private rented sector and a better balance of housing tenures. Indeed, the creation of more diverse housing supply can help to reduce economic volatility which can also benefit the social well-being.

To sum up, the main challenges which have been identified in this section are: fragmentation, short-termism, low levels of innovation and R&D investments, lack of collaboration and integration of the construction supply chains, low skilled labour, lack of training opportunities and rewards, and an acute need for innovation.

1.2 Reasons to conduct this research, research aim and research question

The aim of this research is to understand how a large construction firm collaborates with their suppliers in order to foster innovation strategies in different organisational settings. In order to address this, it explores a series of overlapping challenges facing the construction industry in the UK, such as the need to be more innovative, to collaborate and integrate the supply chains in developing and implementing innovative processes and products, and to

implement BIM. Hence, it will try to address the research gaps which will be highlighted in the chapter.

What is interesting about the partnership between the selected contractor and its supply chain, in the light of recent Government policies, is the way in which the contractor pushed towards innovating and engaging with a smaller number of trusted suppliers in the long-term across multiple projects. This allowed them to innovate by implementing technological products with the support of their suppliers (e.g. BIM, off-site construction, standardisation of products, uptake of innovative materials), and by enhancing collaborative practices and processes within their supply chain (e.g. through the use of BIM and early engagement of suppliers in projects). The agreements they established with some selected suppliers also help in this thesis to explore trust and integration between firm and supply chain and the development of shared goals and profits.

The main research question is: does the early engagement of supply chains around innovative technologies and practices foster effective suppliers' collaboration and empowerment within the firm's innovation strategizing? Hence, the main themes emerging from this research question are: innovation and collaboration. The units of analysis involved are: the contractor and its supply chain, which includes different firms of different sizes and expertise (e.g. timber frame, steel frame, plumbing, roofing, etc.). Other sub-questions can be elaborated from this main research question, but they will be discussed, together with more specific objectives, at the end of chapter 3, once the literature review will be presented and the theoretical approach will be justified.

This case study involves an exploration of firms which were already changing their practices in order to respond to the increasingly competitive market and before and during the launch of the Government's recent industrial strategy for construction. The research is therefore driven by a desire to understand more deeply the implementation and outcomes of collaboration and strategizing among construction firms which are working together while delivering innovative processes and technologies. In particular, the focus on BIM and its implementation and learning process across the supply chain can lead to interesting insights into how an innovation is managed, used, and how it influences the way in which the firms collaborate and strategize. Indeed, as I will discuss in the analysis, technology and objects can also be considered "actors" (in terms of ANT) which have a role in shaping collaboration and strategizing. The project will also address some gaps in academic

literature regarding innovation, strategizing and supply chain management, with a particular theoretical approach which will be more carefully discussed in chapter 3.

This theoretical framework will be combined with an ethnographic approach concerning participant observations during specific meetings and events. The idea of "following the actors" as they conduct a design meeting, or participate to workshops makes it possible to observe the action as it unfolds, thus providing some insights into collaboration and strategizing which would have been hidden from the researcher if they were not present in the field. This type of research method has interested me because I was able to be present and feel part of the group of people working inside of a firm. Moreover, ethnographic research within the construction industry involving the supply chain and collaborative innovation is not often researched in the literature. It may also give some interesting insights to practitioners from an external point of view. For example, interviews with both the contractor and the suppliers can reveal a wider range of opinions on specific topics (e.g. innovation implementation, collaboration), and observations can make the researcher catch some particular interactions or reactions which would have not been noticed otherwise.

Therefore, in the light of the main challenges in the industry which have been elaborated above, this project focuses on a series of overlapping industry challenges: implementing innovation (particularly BIM) integrating the supply chain and fostering collaboration. The project can thus provide interesting insights to inform on-going attempts to change the industry to meet these challenges, including the UK Government's recent industrial strategy.

1.3 Structure of the thesis

The thesis comprises of seven chapters: introduction (1), literature review (2), theoretical approach (3), methodology (4), two chapters of analysis and discussion (5 & 6), concluding discussion chapter (7). The present chapter, which is the introduction, aims to present the context of the research, with a focus on the Government's policies towards the construction sector, and the reasons to conduct this project. Chapter 2 comprises the literature review of previous studies and theories which will be discussed throughout this research. The importance of this chapter is to highlight the gaps in literature and highlighting the research

questions. The following chapter (3) consequently follows the literature review since it presents the theoretical approach which is used to analysis the data for this research. The discussion of the theoretical approach will be introduced by a literature review of the main theories to be considered, and my specific theoretical approach to analyse the data. Chapter 4 will discuss about the methodology of this study, particularly about ethnography and reflexivity.

Chapters 5 and 6 focus on the empirical analysis and discussion. Chapter 5 covers the analysis of the building of the actor-network following Callon's (1986) translation model by highlighting the benefits and limitations of the model itself according to my data. These limitations will find an answer in chapter 6 which covers the "post-ANT" concepts of multiplicity and fluidity which have not being considered in Callon's model, and which deepen my analysis and discussion in order to answer the research question. Chapter 7 aims to give a theoretical reflection with a focus on my contribution to theory, methodology and collaboration studies. It comprises some final discussion about collaboration, technology, and power. It also includes the conclusion of the thesis: it responds to my research questions, contributions to practitioners, and highlights the limitations of this research by suggesting also future directions for research.

Finally, this research is based on collaboration with real companies and participants. However, for confidentiality reasons the actual names of companies and participants involved in the research have been anonymised.

Chapter 2

Literature review

2.1 Introduction to the literature review

The aim of this chapter is to give the reader an overview of the main theories arising from the construction and innovation literature which will cover the two main themes emerging from this research: collaboration and innovation. The introduction chapter has discussed the UK construction industry through industrial reports and academic papers, in order to highlight the industry's characteristics and challenges that the Government and the industry are facing. It is very important to have a general understanding of the industry as whole, and a more specific understanding of the sub-sectors with which my research is engaged, so that it will be easier to identify the innovative processes and technology within the firm which has been chosen as the case study for this research, and also to know the context in which it operates. The theories about collaborative innovation and supply chain management will then identify important contributions and gaps in literature.

The chapter is structured into four main sections: firstly, a discussion about the level of innovation and technological uptake in the industry will be developed since it represents one of the principal challenges to be addressed by apparently "conservative" British construction firms and is the focus of this thesis. Secondly, having introduced the concept of innovation and technology in the previous section, innovation is defined, and theories that explain various aspects of innovation are discussed. A more specific analysis of innovative technology within the industry will then be followed, with reference to BIM and a deeper discussion about collaboration (such as BIM's capacity to improve collaboration). Thirdly, the literature on supply chain management and power dynamics are reviewed. Moreover, this section examines the diffusion of collaboration in construction in different organisational settings, particularly involving the supply chain during strategizing activities. These settings include, for example, the role of strategic meetings which will be discussed later in the chapter.

2.2 Definition of the construction industry and innovation in the UK

The construction sector is a large, complex, and key area of the UK economy and it comprises of a wide range of products, services and technologies. According to the International Standard Industrial Classification of all Economics Activities (ISIC), the term "general construction" is "the construction of entire dwellings, office buildings, stores and other public and utility buildings, farm buildings etc., or the construction of civil engineering works such as motorways, streets, bridges, tunnels, railways, airfields, harbours and other water projects, irrigation systems, sewerage systems, industrial facilities, pipelines and electric lines, sports facilities etc" (Part Three –F). Hence, the construction sector comprises of different types of industries. In particular, the "construction of buildings" includes "general construction of buildings of all kinds. It includes new work, repair, additions and alterations, the erection of prefabricated buildings or structures on the site and also construction of temporary nature. Included is the construction of entire dwellings, office buildings, stores and other public and utility buildings, farm buildings, etc" (United Nations 2008).

2.2.1 Definition of innovation and drivers and barriers for innovation diffusion

Before assessing more carefully the level of innovative uptake in construction, and the innovation challenge that is the focus of this research, it is important to define innovation. The following definitions can be applied to all industries, but they define specific aspects of the meaning of innovation which can be applied to construction as well. Innovation can be defined as: "(…) change that is valuable to somebody, that is the result of purposive human action, that exploits new ideas and knowledge, and that is achieved through a rational, managed procedure" (Kreiner 2015, p. 30-31). Tidd and Bessant (2013) suggest another interesting definition for innovation which "entails searching for new ideas, selecting the good ones, implementing them and capturing the value in the market".

Hence, novelty is achieved through a process of selected means and procedures. Finally, another definition of successful innovation is: "the effective generation and implementation of a new idea, which enhances overall organizational performance" (Sexton & Barrett 2003, p. 626). Moreover, *innovation* can be distinguished from *invention*. *Invention* refers to a design or physical manifestation which is novel to what already exists,

and it can be employed in practice, or not, whereas *innovation* includes both the invention and its application (Gambatese & Hallowell 2011; Slaughter 1998). Innovation can also be considered the principal source of economic growth (Mokyr 2005) and a source of employment opportunities and skills. It can also provide favourable outcomes for realising environmental benefits, such as through the implementation of low carbon technologies and efficient building (Foxon et al. 2005). Innovation, both as a new process or as a new product within an organisation, can help to reduce costs, improve quality and safety, increase market share and increase the technical feasibility of projects (Madewell 1986; Slaughter 1998).

In this study, innovation refers both to innovative practices, such as collaborative strategizing, supply chain agreements and standardisation processes, and to the implementation of innovative products and technologies, such as BIM. Even though implementing innovation is undoubtedly a means to improve performance, it is also challenging, especially due to the fragmentation of the construction industry. As Dainty et al. (2017) argue, the introduction of BIM within the UK construction context is seen as revolutionizing construction practice through efficiency and integration of project delivery both by the Government promoting it, and within the academic literature. Nonetheless, the context in which it must be implemented is important and it may influence its declared benefits. Indeed, SMEs may lack the capacity to invest in technological innovations, thus they might need a specific strategy to adopt BIM.

Concerning the housebuilding industry, there has been an increasing interest in so-called “modern methods of construction”, such as the manufacturing of housing components off-site. Nonetheless, the popular perception is that the industry is still not very innovative in the uptake of new technology (Goodier & Gibb 2007). However, there are some authors arguing that innovation is actually happening through project networks, involving multiple actors, whereas policy makers find it difficult to promote technological uptake and cooperation (Whyte & Sexton 2011). Other authors (Barrett et al. 2007) argue that the definition of innovation might not be very clear when discussing the level of innovation in construction. They argue that the visibility of innovation in construction should depend on the type of innovation, which could be: sector-level, business-level, and project-level. Sector-level innovation is very visible and can lead to radical or step change, such as through regulations and standards, and dominant construction clients. Business-level

innovation can lead to radical or incremental change and comes from research and development activities, and from general organisational development (e.g. enhanced supply chain arrangements, business processes or practices, etc.). Finally, project-level innovation is usually incremental, but has the biggest impact on the sector. It results from design teams cooperating towards novel design solutions based on tacit knowledge.

As discussed, the construction industry is usually considered slow to innovate, particularly concerning its abilities to adopt innovative processes and the acquisition of innovative products from other industries. The UK report "Industrial Strategy for Construction" (BIS 2013) also argues that around two-thirds of construction contracting companies fail to innovate. Thus, many authors refer to the construction sector in terms of its "backwardness" (e.g. Woudhuysen & Abley 2004, Nicolini et al. 2001, Gann 2000, Winch 1998), and the fact of being a low tech sector. Indeed, the complexity of the construction process negatively impacts innovative processes because multiple levels of actors (e.g. the selection of an internal network of actors, and an external network including clients, sub-contractors, and material suppliers) and interactions make it difficult to engage different types of knowledge. Hence, knowledge sharing and transfer are complicated in passing from one project to another and may also represent a risk in threatening existing practices (Bygballe & Ingemansson 2014).

The difficulty of coordination and cooperation between independent organisations within a temporary project are often said to be barriers to innovation and cause the fragmentation of the industry (Slaughter 1998). Moreover, these complex interactions within the supply chain and among different projects may also present barriers to collaboration in terms of inadequate information sharing. Collaboration is in fact information driven and it is directly influenced by human behaviour. Indeed, as Fawcett's (2008) survey study demonstrates, a lot of people in construction organisations are suspicious of changes and prefer to stick with usual practices. Moreover, the fact that skills are rigidly demarcated along traditional trade lines means that people may not easily embrace new technologies or processes. Indeed, innovation uptake may be slowed down by the long process of re-skilling employees.

Moreover, systemic problems may hamper the diffusion of innovations. These include, for example, lack of stable institutions, difficulty of communications among different actors within the system, and lack of knowledge and capabilities of policy makers

and entrepreneurs (Negro et al. 2012). Hence the problem of the innovation process in the UK is not the lack of investments, but rather the slow pace of change. Winch (2003) argues that cross-sectoral comparisons concerning the performance (in productivity trends, or R&D expenditure) of the construction industry is biased due to the international Standard Industrial Classification (SIC). Indeed, in this classification the construction value chain is systematically different compared to other industries (e.g. motor vehicles): construction comprises of four value chains, such as design (A), manufacture (B), distribution (C), and maintenance (D), whereas the motor vehicle industry comprises only two (A and B). Furthermore, product innovation is excluded from the analysis since it is included in the design phase, which is attributed to architectural and engineering consulting firms, which are allocated to the SIC group Other Business Service, and not construction.

Other barriers to innovation in construction include: unbalanced government rules and regulations, inability to manage risk, lack of training and education, short-term financial client orientation, looking for the lowest bidder, limited budgets, and inappropriate contracts (Barrett et al. 2007). Despite such barriers, it seems construction does occur as it is found the use of novel materials, new business models, new building designs; this suggests creative problem solving and local innovation is present (Orstavik et al. 2015). As Harty (2008) argues, construction innovation is firstly a response to external needs, such as those of the client; secondly innovation usually originates from external firms, instead of being developed within the construction firm; thirdly, innovation can originate from problem-solving activities within the actors who are involved in a construction project.

One of the main drivers of innovation in construction is client requirements: the client can in fact encourage project's participants to develop particular strategies to deal with unpredictable change (Gann & Salter 2000), and also foster innovation by providing high standards of work. Other drivers include, for example, the level of competition, government regulations, environmental sustainability, long-term relationships, demonstrable cost and value (Ozorhon et al. 2015; Barrett et al. 2007). Moreover, the development of supply chains, which include long-term relationships and integration in the supply chain, trust, coordination, open communication, joint problem-solving, and cultural alignment, can also lead to innovative solutions (Frödell 2011).

R&D investments which include training and organisational change are essential to innovate and grow. However, the construction industry in many countries, and in the UK

too, is rather low in terms of R&D expenditure, while few construction firms take advantage of innovation programs made by governments (Seaden & Manseau 2001; Miozzo & Dewick 2002). Although R&D expenditures are low, construction firms do find ways to evolve their working practices due to the competitiveness of the market and key performance indicators (KPIs) actually show improvements from year to year (e.g. partnering innovation). It is indeed interesting to highlight that the construction industry uses products and services from other sectors which show high level of expenditures in R&D, such as machinery and equipment, technical testing and analysis, and telecommunications (Barrett et al. 2007).

Innovation in the industry is not always profit-driven, but it is influenced by a panoply of "institutional contingencies", such as national policies, government regulations, construction standards, market and financial conditions and the public opinion for the environment (Dale 2007; Lizarralde et al. 2015). Hence firms need to find ways to adapt their procedures and technologies according to these external pressures. This process might not be easily implemented due to the high number of firms and actors involved in construction projects, and the low levels of innovation and flexibility to change. Construction firms rarely innovate in isolation, but in collaboration with other firms, customers or suppliers, and in cooperation with innovation partners such as universities (Hauser 2010). Such processes could be challenging as the sector is also characterised by high levels of sub-contracting, self-employment and a proliferation of many small and micro businesses (BIS 2013). Hence, investing in the integration of supply chains and inter-firm collaboration would positively impact on the implementation of innovation.

Firms must harness the innovative capabilities of numerous actors and firms, many of which might be loosely coupled to the production effort. The term "loosely coupled system" (Weick 1976) refers to the idea that different organisational entities have their own function within a wider industrial context, but each of these entities are interconnected by couplings which could be tight, or loose (Dorée & Holmen 2004). Loose couplings could potentially foster novel solutions because of the involvement of many actors from different contexts, but at the same time may prevent innovation diffusion because of the structure of construction projects (e.g. difficulties in promoting learning, decentralisation, and short-term relationships). Hence loose couplings seem to favour short-term productivity and hamper innovation (Dubois & Gadde 2002). This complexity might go some way to explaining why the industry is often seen as slow to innovate (Goodier & Gibb 2007).

However, Dubois and Gadde's (2002) view about tight and loose couplings is contested by some authors, such as Dorée and Holmen (2004). They argue that an overall tightening of all sorts of couplings is not required to reach technological innovation, and it may even increase costs and hamper learning. With their case study they suggest that when the contractor wants to develop a new technology some tight and loose couplings of different types with the supply chain are necessary. Hence, they emphasise the importance of intra-firm inter-project couplings for the implementation of technological innovation, even though there is a no clear technology development strategy from the contractor.

Government regulations are sometimes seen as an obstacle to technological innovation in firms, but sometimes they play a very important role in making firms more easily adopt new practices and use important information. Indeed, the UK housing sector is deeply influenced by these. For example, public sector social housing has seen many new regulatory standards concerning the use of sustainable materials and new technologies, as well as new buildings which have to comply with strict energy and emissions regulations. Although energy regulations are implemented, the real diffusion process of renewable energy technologies has been slow compared to policy targets. A reason for this is the fact that radical innovations take time to establish because they have to radically change the system (Dodgson et al. 2008).

Hence, it has been deeply discussed the challenges within the construction industry, particularly those which represent barriers to the implementation and diffusion of innovation. At the same time, some suggestions concerning the way in which the industry could be more innovative have been highlighted, such as through collaborative activities involving different organisations, tight or loose couplings, Government policies, and R&D and training investments. The next section aims to analyse previous studies found in the literature concerning some aspects of innovation, such as innovation diffusion and knowledge sharing. These two concepts are very important in order to implement a long-term innovation strategy which can travel among different projects and organisations.

2.2.2 Previous studies on innovation diffusion and knowledge sharing within networks

The construction innovation literature argues that traditional measurements of innovation do not fit the construction sector. For example, these measures do not consider innovation in organisational processes, which are actually very important in construction as they

include integration, interactions, and contracting arrangements (Slaughter 2000; Winch 2003). However, the potential to improve the rate of innovation is high when the industry's inter-organisation is considered (Bygballe & Ingemansson 2014). Indeed, an extensive literature emphasises how innovations success is created by investing and sharing resources, knowledge, and risks, and developing open communication with suppliers (Soosay et al. 2008; Frankel et al. 2002).

Within the built environment, issues on innovation adoption and diffusion involve the presence of different actors and interests. For example, science and technology studies (STS) have highlighted the role of networks, actors and the concept of *unbounded innovation* (Harty 2005; Harty 2008), whereas institutional scholars have shifted the focus to *collective action* (Whyte & Sexton 2011). In particular, Harty (2008) argues that when innovation goes beyond the control boundaries of its implementer, then the concept of *relative boundedness* should be used. Within the construction context, boundedness is significant in the "attempts to reconfigure sequences and practices of inter-organizational project work" (p.1033). Hence, in this unbounded context, the alignment of multiple actors and interests is necessary in order to successfully innovate.

Whyte and Sexton (2011) discuss innovation in the built environment starting from some previous studies on economics and management of innovation to propose new directions for research through an institutional view. They argue that in the "post-Schumpeterian literature" the focus is on government policies and firm-level innovation, particularly in manufacturing firms. At the firm level, the aim is to understand how to profit from innovation (Teece 1986), whereas at the policy level innovation is considered positive for economic growth. Moreover, within the post-Schumpeterian literature, innovation studies concern complex interaction between diverse actors and interests in an institutional context. Innovation management has come to contribute to other streams of research involving innovation and technology, such as the sociology of technology, diffusion of innovation, institutional innovation, etc. They finally highlight that the emerging literature on innovation is increasingly considering the "meso-level" in order to connect global and local practices, and discussing the role of stakeholders and technology. Even though this research adopts a flat ontology, the fact there is an emerging innovation literature which considers the importance of the meso-level (e.g. middle managers) is also emphasised in this thesis when different actor-networks may influence CIS.

The construction industry relies heavily on co-developing innovation with the other participants in the projects (e.g. designers, sub-contractors, clients, suppliers) and mainly innovates at the project level (NESTA 2012). Moreover, there is a lack of research concerning inter-organisational innovation which also emphases the importance of network relationships. An example of inter-organisational innovation can be found in the case study by Ozorhon et al. (2014) in which they emphasise the importance of integration between project participants to facilitate knowledge sharing and the adoption of innovation. For example, the establishment of partnering agreements with suppliers enables the innovation to flow. In such an environment characterised by diversity of actors and interests, networks play an important role. This concept has been discussed in the construction literature, for example through Winch's (1998b) model of innovation diffusion which depicts the importance of the "superstructure" (clients, and professional institutions) in encouraging the diffusion of innovation by putting pressure on the supply chain partners.

According to the "agency-structure perspective", within the innovation diffusion literature, actors are shaped by the surrounding setting and institutional forces, but at the same time, the setting and institutions are influenced by actors (Pettigrew 1997). Indeed, Larsen (2011) argues that it is important to understand networks in order to evaluate how innovation diffuses within a particular context. By understanding these networks, it is possible to gain insights into part of actors' contextual setting, their first contact with the innovation and their opinions. Hence, context can shape how actors interpret and discuss about innovation diffusion, even though, through an agency-structure perspective, the actors themselves can also influence contextual settings and institutional forces. This perspective offers a multi-layered view of innovation diffusion through understanding of the interplay between actors and settings/institutions. Hence innovation is formed and changed over time by a dynamic network of actors in which they communicate.

Moreover, Larsen (2015) draws on the social network analysis (SNA) and develops a map to emphasise the importance of actors external to the firm in diffusing innovation within the construction sector. The map shows the network of firms engaged in innovation: this representation emphasises again the fact that a firm does not innovate in isolation, but innovation is often generated by external firms and collaboration with them, and then innovation diffusion occurs throughout this network of firms. This network is described as an "outward-looking network" in which all the stakeholders, such as contractors, suppliers,

consultants, and the client, play an important role in the innovation process. The involvement of many organisations assumes that communication and knowledge sharing have to be carefully implemented in order to lead to a successful collaboration and innovation. There is a recognised link between innovation and knowledge sharing between different actors, but the process of sharing can be problematic because it is across professional and organisational boundaries (Kimble et al. 2010). The management of knowledge plays a central role in the construction process because it involves "recurrent activities embedded in economies of scale (p. 590)" (Styhre & Gluch 2010). However, "the lack of standard work processes (p. 50)" represents the most important impediment towards knowledge management (Carillo et al. 2004).

Construction firms have tried to solve the issue of knowledge sharing and transfer by using "platforms" which are tools for standardising technical solutions and practices and can take the form of boundary objects. For example, a study by Sthyre and Gluch (2010) concerning a Scandinavian construction company (SCC) identifies different types of platforms which act as flexible boundary objects with the aim to integrate know-how, and resources to be used without imposing a strict model. These platforms can take the form of an Intranet system to store, share, and distribute knowledge, but most knowledge sharing still occurs through personal networks and open communication. Platforms can therefore capture and formalise knowledge without having to count on social capital which can be very costly and inefficient in terms of establishing and maintaining relationships (Bresnen et al. 2005; Styhre & Gluch 2010). The concept of boundary objects, introduced by Star and Griesemer (1989) will be discussed in the following chapter.

Finally, looking beyond the construction literature, Carlile (2004) argues about the management of knowledge across boundaries in settings where innovation is implemented. He develops an integrative framework (see Figure 2.1) by considering three different approaches in organisation and product development theory. The bottom level refers to a syntactic boundary of transferring of knowledge. When a novelty arises, the simple transfer of knowledge can become problematic because the current lexicon within the group setting is no longer sufficient to represent the differences now present. The second level refers to the semantic boundary (referring to meaning) of translating knowledge and it arises when novelty makes differences and dependencies unclear. As a result, actors must develop common meanings in order to address interpretative differences across boundaries. The top

level is the pragmatic boundary of transformation of knowledge and it occurs when the novelty generates different actors' interests. When interests are in conflict, the knowledge generated in one domain can have a negative impact on another. Hence, domain-specific knowledge and common knowledge may need to be transformed to effectively share and assess knowledge at the boundary.

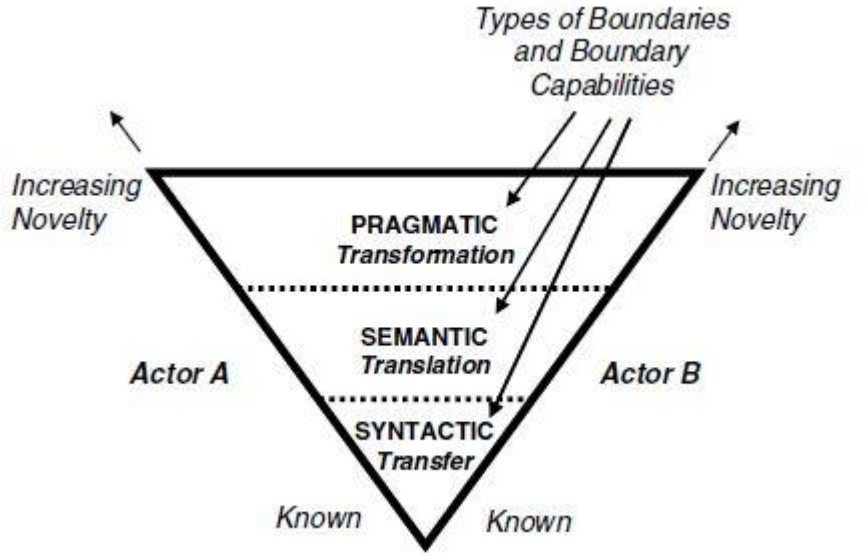

Figure 2.1 Carlile's framework on managing knowledge across boundaries.

Such general frameworks can be adaptable to the construction industry, such as during the design process while using innovative software, such as BIM in a heterogeneous environment. For example, in the syntactic boundary actors may spend time to understand the model's requirements and a common lexicon needs to be established to share and assess each other's knowledge (e.g. BIM terms, regulations, codes, etc.). In the semantic boundary actors may discuss different design preferences and requirements due to their different expertise and use of different software. In this case BIM may have a semantic capacity to translate this into common meanings showed through a 3D model. Finally, in the pragmatic boundary actors have finally found a way to adequately transform and share knowledge through collaboration, negotiations, and opinion sharing of the design model. Hence, the framework represents an example of how knowledge sharing and communication is shaped among different actors in a particular context when an innovative technology is implemented.

2.2.3 Previous studies and theoretical streams on technological innovation and BIM

The implementation of innovation can refer to a technology, or a particular process. The implementation of an innovative technology (e.g. software, new material) is important to understand since it may influence the way in which actors work together. From the late 20th century until recently, technological change was understood as intrinsic to economic systems, in particular capitalist economies. Numerous studies drew upon Schumpeter's (1942) process of *creative destruction* of industries: industrial change happens through waves of creative destruction, meaning that the process incessantly revolutionise the economic structure within, destroying the old one, and incessantly creating a new one. The "post-Schumpeterian literature" focused more on the firm-level innovation and government policy, particularly in large multidivisional manufacturing firms, following a linear model of innovation, in which innovation is seen positively for economy growth. Within this literature, more recent studies have focused on the diversity of user involvement in complex innovation in the built environment (Whyte & Sexton 2011).

It has been emphasised that innovation and knowledge can travel through inter-organisational boundaries. This process can begin and extend the implementation of technological innovation, such as new software, a new building material, or a new product. Moreover, the technology itself can lead to innovative behaviour and working habits among the actors involved in a project. Indeed, as Whyte and Hartmann (2017) argue, digital building information is *transformative* and often unpredictable since it changes the interactions of actors with the built environment and with each other, and their roles and responsibilities. For example, drawing on the theoretical stream of sociology of technology, Schweber and Harty (2010) explore socio-technical networks to examine the development of American and British reinforced concrete industry. In the case studies presented, "BSLink", which is a building services system package producing 3D models, seems at first a stable artefact. However, different uses and interests by different actors lead to different outcomes, thereby attesting to the interpretative flexibility of the "tool". Hence, technology impacts differently on the context in which it is implemented, but at the same time technology can be affected by that context, for example, through norms, company's identity, and actors' behaviour.

One technology which profoundly influences how a project is planned, designed and produced, and which is becoming more and more common within construction in the UK, is

BIM (Bygballe & Ingemansson 2014). This software has seen a rise in its implementation across firms in the UK thanks to a Government's regulation (Cabinet Office 2011) to promote digital innovation and increase efficiency in the construction sector. BIM can be defined as "a domain of loosely coupled information technology (IT) systems for generating (authoring tools), controlling (model checking tools), and managing (planning tools) building information flows intra- and inter-organizationally, based on principles of information systems' interoperability" (Papadonikolaki & Wamelink 2017, p. 3) The implementation of BIM aims to develop 3D models as well as digitalise all project and asset information, documentation and data. Therefore, the introduction of BIM throughout the sector means to embed digital best practice in projects and all businesses related to them in order to become and remain competitive in the market (Shibeika & Harty 2015). This technological innovation may seem to challenge the fragmentation of the industry by enhancing collaboration and coordination against the involvement of many different spheres of influence and power dynamics among actors within a project.

The adoption and implementation of BIM can be driven by private-public partnerships (e.g. client-demand, or demand from partnering structures for asset delivery), and by legislation. It has found difficulty until now to extend beyond the specific project and the temporary coalitions of actors. However, the development of supply chain management and integration across construction firms has allowed to spread the innovation to all tiers through procurement strategies (Papadonikolaki & Wamelink 2017). The organisations still have to routinize these practices in the long-term, that is, transferring them into a new network of actors within a new project and so on (Linderoth 2010). However, such issue may be solved with the development of supply chain agreements and early involvement of a trusted supply chain.

There are several recent papers which highlight the performance of BIM, both in terms of time saving, and simplification of working practices, and its effect on collaboration. For example, Park and Lee (2017) compare two mechanical, electrical and plumbing (MEP) projects which differ from their BIM implementation. In the first project, called "BIM-assisted coordination", the designs are first drawn in 2D, and then converted into 3D BIM models. In the second project, called "BIM-led coordination", 3D models are generated directly by all trades who afterwards develop the 2D drawings. The authors argue that the second projects results to be much more time- and quality-efficient, and it also shows a

greater level of integration among different actors (Whyte & Hartmann 2017). Regarding the impact of BIM on collaboration, Cidik et al. (2017) prove BIM's ability to systematise and simplify design work, but they realise that it leads only to collaborative working practices to maintain and update models without crossing boundaries between the participants' disciplines. Hence, they argue that BIM can allow greater simplification and organisation of the project design, but without any integration between disciplines (e.g. MEP, structure engineering, architects, etc.). Poirer et al. (2017) also argue about the impact of BIM on collaboration within architecture, engineering, and construction (AEC): BIM seems to reshape actors' cognitive determinants which influence the events patterns and outcomes of collaboration.

The implementation of BIM seems quite beneficial for organisations, however there may be some cases in which its implementation is not so beneficial. For example, BIM might minimise architectural variety and the role of architects as designers. Indeed, the standardisation and the aim to reduce costs of models, processes, and materials resulting from BIM negatively impacts on the architects' technical skills and creativity, even though communication between building partners is facilitated. The result is that the architects may even feel "marginalised" from the project (Moran et al. 2016). Another issue that may affect some firms is that some of them might not receive enough funding to undertake the process of implementing BIM, as Dainty et al. (2017) discuss: political BIM agendas might not encourage innovation across all businesses since SMEs may not obtain the investments for adopting BIM, such as the cost for the software licence, or training of the employees in order to respond to requirements of state-mandated projects. Hence, BIM can divide as much as integrate.

Hence, it has been discussed the importance of integration with external actors (e.g. supply chain, clients, sub-contractors) to develop innovation strategies and implement new technologies, or processes, through inter-organisational boundaries. Knowledge sharing among different organisations and across multiple projects is also essential to diffuse innovation and implement it. This process can also influence the actors' working habits and collaboration, as it has been argued above with the implementation of BIM. Moreover, there is a need in the construction literature concerning innovation and, in particular, innovation technology to consider the connections among the actors (e.g. within actor-networks) to develop CIS. This means focusing on the variety of actors and their activities

and interactions in specific settings where innovation has to be implemented and strategic tasks have to be satisfied and produced.

2.3 Supply chain management and collaboration

In order to assess more deeply the aspects of integration and collaboration which have been generally discussed in the previous sections referring to the supply chains, the supply chain management literature (SCM) and collaboration studies within the construction context may allow to understand the active role of supply chain development and suppliers' integration and collaboration in order to implement innovation. In the construction sector, SCM is becoming increasingly important to solve fragmentation and foster competitiveness. SCM defines "an integrative philosophy to manage the total flow of a distribution channel from suppliers to the ultimate users" (Cooper et al. 1997, p. 1-14). Moreover, SCM can be considered an evolutionary and cumulative innovation (Saad et al. 2002) and it is a more recent term compared to partnering, which can be defined as "a strategic arrangement whereby a contractor is engaged in a series of projects with the aim of lowering costs and improving efficiency" (Dainty et al. 2001, p. 841; Harris & McCaffer 2001).

Since the 1990s there has been an increasing interest to develop supply chain theories and to enhance coordination (Segerstedt & Olofsson 2010). The Egan Report was published from an initiative of the UK government in order to emphasise ways to improve the construction sector's performance and to create more value for customers. The Report outlines some key features of SCM, such as: acquisition of suppliers through value based sourcing, maximisation of innovation, learning and efficiency, development of suppliers and management of workload to improve suppliers' and firm's performance (Egan 1998). These characteristics highlight very important aspects of managing a supply chain, such as managing relationships with suppliers that is pivotal to establish trust and gaining access to resources. In particular, the development and use of a particular resource combination influence the dynamic efficiency of firms, therefore their productivity (Araujo et al. 1999). Moreover, developing trustworthy relationships with the supply chain is also essential to improve collaboration and foster innovation, as will be discussed in the next section.

The supply chain theoretically implies a linear process but, in practice, there is limited linearity because of the presence of many different actors (e.g. clients, consultants,

contractors and suppliers) forming linkages of knowledge transfer, information, and contractual relationships (Pryke 2009). This widespread fragmentation throughout the construction sector has led to difficulties in establishing collaborative relationships within the supply chain. Although collaborative advantage is widely acknowledged in literature (Cao & Zhang 2010), there are some factors which may prevent or make it harder to develop collaborative supply chains, such as short-term project orientations, lack of communication, or different organisational visions. Nonetheless, establishing collaborative relationships with suppliers may lead to positive outcomes to all parties, such as the implementation of innovative processes, products, and materials, and increased performance.

Although relationship management of the supply chain is very difficult to be reached and sustained, business success and innovation can only be achieved through the enhancement of the inter-organisational performance and collaboration (Soosay et al. 2008). Hence firms are starting to improve their supply chains (e.g. through long-term relationships, integration, trust) in order to ensure business success and competitive advantage. Nowadays, still few construction firms can develop proactive supply chain management because of the difficulties in building trust and long-term relationships across projects. In fact, SCM represents the most resource intensive requirement for buyers and suppliers, even if it is the most advantageous approach for both (Cox 2004). Moreover, power may create issues in the relationship; it is demonstrated that SCM works best when there is a dominance of buyers over suppliers, or there is an interdependence of power between them. This means that firms adopting this approach have regular and standardised demand from suppliers and have low switching costs (Cox 2004; Soosay et al. 2008). All these issues will be discussed in the following chapter.

2.3.1 Collaborative advantage and collaborative innovation

SCM, which includes supply chain integration and relationship management, is directly linked to the development of collaboration. Collaboration can be defined as inter-organisational relationships in which the parties share information, resources, implement joint problem-solving, and share mutual goals (Soosay et al. 2008). Collaboration exists when open communication, trust, and shared risk and rewards are developed and it implies cooperation (Hogarth-Scott 1999; Soosay et al. 2008). When the actors within the supply chain establish joint knowledge creation and joint innovation, it is easier to develop

collaborative advantage. “Collaborative advantage” refers to the synergistic and reciprocal outcome of collaborative activities (Vangen & Huxham 2003) and resides across the boundaries of a firm. It comprises the following sub-dimensions: process efficiency, flexibility, business synergy, quality, and innovation. Process efficiency is a measure of success and a factor of the ability of the firm to make profits (e.g. inventory turnover and operating costs). Business synergy refers to the extent to which supply chain partners combine complemented resources to obtain spill-over benefits. Studies also confirm that supply chain collaborative advantage directly improves firm’s performance (Cao & Zhang 2010).

The research literature suggests a clear link between collaboration and innovation in the supply chains. Indeed as Corsten and Felde (2005) argue, the collaboration of suppliers leads to positive effects for the buyer: the suppliers can contribute to the firm innovation by introducing their R&D and therefore by absorbing some of the firm’s R&D costs, and they can also transfer knowledge and ideas for creating better products, or processes (Soosay et al. 2008). Skippari et al. (2017) also agree with this, arguing that information sharing may lead to a wider exposure to new ideas, technology and opportunities which can prepare the firm in a changing situation. One of the key challenges for implementing collaborative innovation is effectively engaging all the diversity of actors into the innovation process, foster inter-organisational relationships, and guide actors’ interests towards a common goal (Henneberg et al. 2010). Hence, since innovation within the supply chain usually occurs between buyer and seller, suppliers’ involvement and network connections becomes pivotal to implement innovative processes (Roy et al. 2004).

Concerning information and knowledge sharing with the supply chain to implement innovation, Soosay et al. (2008) presented a study of continuous innovation within ten logistics firms which practiced standardised operations with most customers and suppliers. All these firms, apart from one, shared knowledge with customers and suppliers to various extents as each of them had their own strategy of information sharing. They highlight that sharing knowledge and information develops innovation capabilities since firms and supply chain can learn from each other. Collaboration of these firms with their supply chain resulted in incremental and radical innovations, along for some with improved customer service, reduced costs, improved strategic focus, and quality improvements (Soosay et al. 2008).

When analysing collaboration within the supply chain, different collaboration strategies can be identified: horizontal, vertical, and lateral integrations (Barratt 2004; Simatupang & Sridharan 2002). Horizontal integration occurs when organisations at the same level of the supply chain manufacture similar products and decide to share resources, such as warehouse space, or manufacturing capacity. It is thereby possible to reduce logistics, administrative, and fixed costs, and improve market access. Vertical integration involves the integration between organisations at different levels of the supply chain (e.g. between the producer and the distributor). Finally, lateral collaboration combines horizontal and vertical integration concerning their benefits and sharing capabilities.

The development of collaboration strategies also allows the pursuit of innovative solutions. Indeed, strategic alliances can foster technological innovation by complementing resources of actors at the same level of the chain (horizontal integration) or gaining knowledge from actors downstream or upstream of the supply chain (vertical integration). An example of vertical integration and innovation could be, for example, the implementation of an innovative technology, such as BIM, which has started to be spread across different levels of the supply chain, thus becoming also a means of collaboration.

2.3.2 The implementation of BIM as a collaborative object

Technology has a role in collaborative organisational settings, such as meetings and workshops in shaping collaborative innovation and also the strategizing of project's participants. It can be argued that BIM has changed deeply the way in which actors work during construction projects. Indeed, BIM improves project performance (Bryde et al. 2013), affects collaboration and coordination (Dossick & Neff 2010), and also impacts organisational structure. Its implementation in collaborative settings can also change the actors' roles (Sebastian 2011). Papadonikolaki et al. (2016) propose an analysis of BIM and SCM, and their effect on collaboration throughout different case studies. The application of BIM for all case studies concerns: 3D representations, design coordination, clash detection, and quantity take-off. The analysis has found three levels of BIM-based collaboration: ad-hoc, linear, and distributed.

"Ad-hoc BIM collaboration" is observed in one case study in which the contractor is the only responsible for coordinating the actors' BIM models, and 2D drawings are frequently exchanged since very few actors know how to use BIM. In this case, BIM is

implemented only by one actor (e.g. the contractor, or an external consultant), thus the process of collaboration induced by the software itself is slowed down. “Linear BIM collaboration” is observed in two case studies in which most actors know how to use BIM, apart from some suppliers. In these contexts, the contractor has separate BIM sessions with each actor, after which the information is sent to the others. Therefore, the contractor has to invest some time to train these suppliers, otherwise BIM cannot be fully implemented (e.g. information sharing and collaboration are slowed down).

Finally, “distributed BIM collaboration”, observed in other two cases, involves the coordination of activities and it is obtained through pre-schedule joint BIM meetings. In this case, building information is more evenly shared among the actors. In all these situations, the implementation of BIM has influenced the SC partnerships. Having more or less BIM-prepared partners leads to mutual help through training sessions among the actors. Moreover, the SCM practices are influenced by the physical BIM collaboration, such as through joint meetings concerning BIM with all partners involved. Hence, from this study is possible to understand how the implementation of BIM within a project, involving partners with different BIM knowledge levels, can influence supply chain practices, and vice versa. It is a way of framing the very different types of collaboration and power dynamics that can emerge through BIM-enabled collaboration.

2.3.3 The importance of supply chain integration and trust

Hence, it has been discussed how collaboration strategy is based on the integration of the supply chains, and how BIM can also enhance supply chain’s collaboration and integration. Supply chain integration means inter-organisational integration of systems, processes and actors, and it also implies building closer relationships among actors of the supply chain (Porter 2005). However, adversarial and disjointed relationships within the construction industry make difficult to implement integration and hence to improve supply chain performance (Fearne & Fowler 2006). One solution would be that construction supply chains improve their information exchange and communication through early involvement of the actors. Moreover, building closer relationships is directly linked to reaching integration; this means building trust and mutual understanding (Bankvall et al. 2010). Empirical studies prove that the benefits of supply chain integration can be obtained only if there are trustworthy and close relationships between supply chain partners. In this way,

partners can understand each other's businesses better, and can help each other to improve supply chain processes, and innovate. The synergy between SCM and IT (e.g. BIM), can lead to SC integration, which involves strategies, such as risk and reward sharing, joint inter-firm operations, IT investments, and early involvement of the supply chain (Papadonikolaki & Wamelink 2017).

Trust, which can be defined as shared values and vision, and strong long-term relationships, is fundamental to develop long-term strategies and innovation, and thus to implement integration strategies. Indeed, it can be argued that trust is a critical factor of supply chain relationships and it is founded on role performance, cultural alignment, and interaction frequency (McAllister 1995). However, it is very difficult to build and maintain. Indeed trust is recognised by managers as one of the top factor of high-performing supply chains, but very few of them have actually built relational trust with partners (Fawcett et al. 2012). One of the reasons for this common phenomenon is that trust takes a lot of time to be built and the fragmentation and short-termism of construction projects do not foster such outcome. However, as this study will show, the introduction of supply chain agreements may enhance trust in supply chains since they provide a secure way to recognise suppliers' capability to contribute to decision-making and strategies and aims to build long-term relationships. In particular, trust can also contribute to the capability to innovate, to achieving cross-functional coordination and supply chain responsiveness, and integration (Eng 2006; Panayides & Venus Lun 2009; Yeung et al. 2008).

Based on a study by Pidduck (2006), previous mutual experience between firm and suppliers engenders trust. It is argued that if supplier's reputation is considered too low or too high, it could be damaging for the buying firm as a low reputation for the supplier would mean low quality, and too high could make supplier take too much control over the relationship. This study therefore highlights that the relationship between buyer and supplier is founded on power dynamics which may have positive or even negative effects. It is therefore important, in studying this collaborative context, that power is balanced between the two parties depending on the tasks to undertake, and that issues of power between the two parties are also considered. For example, attraction (e.g. similar interests and values) between buyer and supplier, communication and information flow, joint problem solving, and formalization of the supplier's selection process would work as prerequisite for a trustworthy relationship (Frödell 2011). If these factors are established,

then it is possible to develop long-term collaborative innovation strategies which would be beneficial for both parties. Nonetheless, power dynamics are inevitably part of buyer's and supplier's relationship, and power's evenly distribution fluctuates between them.

2.3.4 The role of power in buyer-supplier relationships

Three different schools of thoughts can be identified in defining power. Firstly, the SCM literature considers power as a property of organisations, and its premise is that the interdependence of organisations within the supply chain may influence buyer-seller relationships (Cox et al. 2001; Meehan & Wright 2012). However, since the chain dynamics consider only tangible and economic factors and do not consider social and relational influences on power, power itself is attributed to organisations (Blau 1964; Homans 1958). Secondly, Social Exchange Theory attributes power to rational organisations where relationships are based on a comparative cost-benefit analysis. In this case, power is an attribute of an individual (Zemanek & Pride 1996) who is at the centre of the buying and are the focus for business-to-business marketing strategies (Webster & Wind 1972). Finally, power as property of actor's relationships: individuals interact differently according to different kind of situations based on the power sources available (Meehan & Wright 2012).

Power asymmetry in the supply chain represents an important topic for research as differences of power among partners are almost inevitable. However, their presence does not necessary lead to conflicts, but can increase risks for the "weaker" party, who can feel more vulnerable as they may not possess enough influence over the "stronger" partner. It can therefore become necessary to explore how win-win situations may foster collaborative activities (Nyaga et al. 2013). The benefits of the "win-win" negotiations are also articulated in Japanese long-term collaborative sourcing approaches in the automotive sector called *lean thinking* (Womack et al. 1990; Womack & Jones 1996). Other authors (e.g. Christopher 2000; Naylor et al. 1999; Cox & Townsend 1998; Fisher 1997) argue that this type of approach might not always be appropriate for buyers because of the uncertainty and volatility of the market which leads to variable demand and supply. Therefore they emphasise the need to operate and respond with an *agile and responsive* approach (Cox 2004).

As Cox (2004) highlights, there is an epistemological problem between the "lean" and "agile" approach: in the lean approach, the market factors (high volume and high

standardised demand and supply) and the type of sector (e.g. car industry) are completely different from other types of industries, such as construction, in which demand and supply vary significantly making an agile approach more appropriate for buyers who must behave differently according to the circumstances of the market. Green (2011), for example, emphasises how flexibility became the “dominant doctrine” in the UK construction sector (e.g. from the 1980s) as a response to competitive pressure and diversification of client demands. This led to increase in subcontracting, thus more power of the contractor, who does not have to provide subcontractors with continuity of work, thus minimising non-productive time and fixed labour costs. Nonetheless, as it has been discussed previously, in the last few years there has been a push towards integration of supply chain, and establishment of long-term relationships with a fewer number of subcontractors and suppliers, who also gained more power in the working relationships.

The concept of dependency is linked to that of power and occupies a vast space in the literature of the supply chain. Power-dependency can be identified in two dimensions: power imbalance or asymmetric interdependence, and joint interdependence or symmetric interdependence (Casciaro & Piskorski 2005; Yilmaz et al. 2005). Various studies suggest that asymmetric power relationships (power imbalances) are drivers of buyer-supplier relationships and SCM: indeed, suppliers’ dependence facilitates supplier adaptation and collaboration towards socially responsible conditions and standards established by buyers. On the contrary, when suppliers have the power over buyers, their practices cannot be influenced by buyers. In this case buyer’s power cannot lead to SCM and long-term relationships with suppliers. Finally, joint dependence relationships create a sense of common purpose, and it is therefore positively associated with SCM (Hoejmose et al. 2013).

All this discussion refers to a traditional view of power as a property that is owned. However, some theoretical approaches, such as ANT, look at power in a relational way, not as something to be owned. Foucault (1980), for example, considers power as an effect of knowledge dependent on the actors’ discourses. In particular, he conceptualises power and discourse, in which power circulates, is not centralised, and it is not coming from top to bottom as a chain, but it is "deployed and exercised through a net-like organization (p.98)", in which power relations pervade all levels of social existence. He also argues that power is "productive" and thus creates forms of knowledge and discourse. Moreover, Foucault

(1980) does not focus on the general strategies of power, but focuses on the *micro-physics of power*, which look at the localised mechanism of power circulation (Leghissa et al. 2016).

Hence, this thesis will assume that power is not a possession of actors, but it is relational and fluctuates among actors, who may be human and non-human. Therefore, power refers to *relations* of power, spheres of influence, and how actors generate networks of associations, which become part of a process of translation, as it will be discussed in the analysis and discussion chapters (Michael 2017).

2.4 Addressing the research gaps

This section aims to highlight the research gaps emerging from the discussion of this chapter and will help to understand why this research has been conducted. This section is closely linked with the last section of Chapter 3 as the theoretical approach is also introduced. Despite previous studies having considered many different factors that influence the spread of innovative products, or processes affecting organisations, there is still lack of research concerning the study of project-specific factors influencing contextual innovation and co-innovation throughout the construction context. In particular, the indicators of innovation and their impact in the construction specific projects need to be addressed (Gambatese & Hallowell 2011).

Moreover, there is also a need for further research on BIM and its impact on collaboration with a focus on the individuals involved and the different organisational settings in which BIM is encountered, developed and implemented. Indeed, previous BIM studies have mainly addressed the structural and process aspects that enable BIM-driven collaboration within an organisation (Poirier et al. 2017). This research will have a focus on the role of actors as participants involved in different projects and thus will address this gap together with a targeted ethnographic approach which will allow a micro-analysis of collaborative innovation.

Concerning the research gaps emerging from the SCM and collaboration literature, Saad et al. (2002) argue that most studies emphasise the buyer-seller relationship within the manufacturing sector, whereas the construction industry itself is seldom explored. Moreover, construction research has been mainly focused on the relationships between contractor and client (Edum-Fotwe et al. 2001; Bresnen & Marshall 2000), and has not

considered in depth the relationship downstream, such as between contractor and supplier (Jones & Saad 1998). Bankvall et al. (2010) also agree on this by arguing that, even though there are many studies which focus on SCM, little attention has been placed on the relationships between contractors and their sub-contractors and material suppliers.

Furthermore, the combination of innovation and collaboration within the supply chain of construction industry still represents a very important topic both for research, both for the industry itself. The need to broaden innovative processes and products in order to translate collaborative advantage between organisations into competitive advantage for the sectors, and to integrate supply chains in order to respond to the Government's Industrial Strategy and become more efficient, give further justification to undertake this study. In doing so, the role of technology as integrational glue between different organisations is highlighted and it is critically evaluated in terms of its effects on CIS.

2.5 Conclusion

The aim of this chapter is to discuss the broad literature around the main themes of innovation and collaboration within construction supply chains. The chapter firstly provides a general analysis of the construction industry in the UK because it is important to understand the context in which this research is conducted, such as the industry's current challenges and future goals, according to the Industrial Strategy. In this section, emphasis is given to explore the concept of innovation and the significance of innovation in construction. The overview of the uptake of innovations in the UK construction industry highlights the significant barrier of sector fragmentation on developing greater innovation.

The following section concerns the innovation literature and explores previous studies of innovation diffusion, and the important role of knowledge sharing across networks. The reason to discuss knowledge and networks is that they provide interesting insights into issues within the construction industry, and the ways in which they can overcome the challenge of fragmentation. The section concludes with the discussion of previous studies about technological innovation, such as BIM, which also represents a pivotal topic of this study as its implementation in different organisational settings will be carefully discussed, and a novel theorisation will be developed.

The second part of the chapter concerns a discussion about SCM and collaboration with the supply chain. Integration and trust are discussed here as essential concepts of SCM to increase supply chain performance and collaboration. Emerging from this, the important role of power between buyer and supplier is presented with reference to literature. Power dynamics among parties can influence the way in which actors collaborate and do strategizing and may also be influenced by the technology involved. Finally, the research gaps found in literature are highlighted, and, together with chapter 3, will address the reason to develop my theoretical approach.

Chapter 3

Theoretical approach

3.1 Introduction to the theoretical approach

The previous chapter evaluated the collaborative innovation and supply chain literature in the construction industry. Reviewing those previous studies provided a clear analysis of the construction industry and its challenges, such as fragmentation, sub-contracting, and the slow pace of innovation. It has been also highlighted that the construction industry has been lagging behind other industries in terms of innovation, even though in recent years there have been some changes and improvements, such as a greater involvement of the supply chain in decision-making and innovation strategies (e.g. thanks to increased supply chain integration, collaborative activities, trust building).

This chapter aims to continue the discussion with an emphasis on the theoretical aspects which will help to answer the main research question, that is: does the early engagement of supply chains around innovative technologies and practices foster effective suppliers' collaboration and empowerment with the firm's innovation strategizing? It will therefore be explained why my theoretical approach (a SaP-informed ANT study) can help to understand collaboration and innovative practices, and how it will fill the gaps in literature. Hence, this chapter will review extant work, highlight main theoretical concepts which will be used throughout the analysis and discussion, and then will explain my theoretical approach which will answer the gaps encountered. Focusing on how actors (including the supply chain) collaborate in different organisational settings through an ethnographic study can reveal a novel micro-analysis which is often overlooked in innovation studies.

The main aim of this chapter is to introduce the theoretical approach used to analyse the data and to outline the main theories of SaP and ANT by reviewing previous studies and theories for both of them. The reason to consider SaP lies in the importance placed on the actors and their micro-practices in shaping strategy in different organisational settings. Moreover, SaP draws out attention to how strategies are things that firms, and the actors therein, *do* rather than they have. In fact, in order to comprehend the early collaborative engagement of supply chains to foster innovative strategizing within the firm, it is important

to understand both what strategies are developed, and how they are implemented. This perspective will therefore contribute to the analysis of collaborative strategizing when different actors are involved, and actor-networks are built. Since this research considers actors playing a pivotal role in particular strategizing activities where collaboration among different parties takes place, SaP does provide a theoretical lens towards actors' everyday activities in shaping strategy. ANT is also relevant to understand *pluralistic* contexts, which are characterised by variety of actors, both human and non-human (e.g. technology). Hence, the approach will allow to highlight the role of technology in shaping strategizing, and the type of relationships among the actors. According to ANT, these contexts are characterised by diffused power and networks where more than one strategy is developed (Denis et al. 2007).

The term "pluralistic contexts" (or organisational settings) in this research refers to the physical places inside an organisation, in which a diversity of actors is present. While a more detailed definition of these contexts will be in the next section, these contexts refer to settings where strategy is done, including: (i) formal meetings, (ii) workshops, and (iii) conferences. In this thesis these are organisational settings where strategizing takes place between the constructor and the suppliers. These settings are characterised by heterogeneity (in relation to the diversity of organisations present, their interests, and the actors involved) and by social relations among these actors (e.g. the relationship between the contractor and the mandated supplier, or between the architect and the suppliers). The last section will be pivotal in understanding my theoretical approach which will combine SaP with ANT as a method to study collaborative strategizing and innovation in the supply chain.

The following sections will cover: firstly, a review of the main points of interests regarding SaP literature, such as its origin, the main theoretical perspectives therein, and the role of "strategic episodes" as settings for strategizing. Secondly, it will review ANT research, such as the origins of "classical" ANT, with a particular focus on Callon's (1986) translation model to understand the building of networks, the role of boundary objects in networks, and the concepts of multiplicity and fluidity arising from "post-ANT" (Michael 2017) theories. Lastly, the decision to combine these two perspectives will be explained by highlighting the limitations of the previous theoretical approaches. This will enable me to build a conceptual framework that will frame my analysis and discussion, based on network

building (following Callon's model of translation), multiplicity and fluidity. Finally, the aim, research questions and objectives will be presented.

3.2 Review of SaP literature

In order to analyse the micro-practices of the actors in the process of strategizing, a literature review of SaP will enable a broader understanding of this theoretical perspective. The origins of the SaP literature can be traced to the study of strategy in various organisational contexts, which began to establish a stable identity at the beginning of 2000s (Vaara & Whittington 2012). From the 1970s onwards, the term "strategy" started to grow and to be studied. "Strategy" was then dominated by a belief that it was something that organisation *had* and the focus largely became the firm taking a one-off decision to implement strategy (Johnson et al. 2007). Following this position, strategy was conventionally considered as a property of organisations.

Instead SaP can be seen as an approach which aims to *"*humanize management and organization research*"* (Jarzabkowski et al. 2007, p. 1); this is because SaP is concerned with strategy as an activity *within* an organisation, involving interactions of people. Strategy is thereby analysed as it evolves and as it is made by individuals. This perspective can have various benefits, such as the possibility to assess what managers *actually do* to manage strategies and relationships with suppliers, instead of focusing on what they *should do*. In this way, top-down strategies can be contrasted against "bottom-up" strategies, wherein seeming "non-strategists", such as middle managers, or the supply chain, can be explored as pivotal to strategizing.

In this approach there are practices which refer to what people actually do for strategizing. These last practices can be referred to as *"*praxis*"*, which is the *"*concrete, unfolding activity as it takes place*"* and it is guided by practices (Suddaby et al. 2013, p. 332). "Practices" instead refer to "shared routines or behaviour, including traditions, norms and procedures for thinking, acting and using things" (Reckwitz 2002, p. 249-251). The term *"*practitioners*"* refers to the strategy's actors who perform the strategic activity and carry its practices according to their personal interpretation and experience (Whittington 2006). Apart from taking into consideration the importance of everyday activity, SaP also emphasises the emotional dynamics and their role in influencing interpretation (Suddaby et

al. 2013). For example, Liu and Maitlis (2014) investigate emotions in strategic conversations and analyse how emotional dynamics shape strategizing of a top-management team. Hence, they argue that emotions influence issues to discuss and decisions to make which then affect strategizing processes.

Therefore, the SaP theoretical lens links *praxis* and *practices*, that is, it allows consideration of both the micro and the macro level. This can generate interesting considerations as this broader spectrum of analysis can lead to examinations of the surprising effects of strategy practices within local praxes. Acknowledging these results is important to reframe or innovate strategy practices, such as by talking into account the lens of different actors (e.g. managers, suppliers, etc.) during particular activities (e.g. meetings, workshops, etc.).

The following sections will more deeply discuss the link between macro and micro practices in order to better understand the importance of the relation between the different levels of the organisation in how strategies are done. The following sections will also highlight some different theoretical perspectives within the SaP literature which propose different interpretations of this micro-macro linkage. Finally, some previous studies within the construction industry drawing on SaP, and a discussion on organisational settings, such as meetings and workshops, will close the section. These settings are important to consider since they represent contexts in which strategizing takes place, and thus actors collaborate and together shape strategies coming from the top of the organisation.

3.2.1 Linking macro to micro practices

SaP not only goes “beneath” the organisation process to examine what happens inside the organisation on a daily basis, but it also goes “beyond” to identify how strategic practices originate in the broader business context (Molloy & Whittington 2005). And crucially, this environment is characterised by a plurality of actors. As such, SaP considers all members’ roles within and beyond the single organisation, not only the work of senior/chief executives as in traditional strategy research where analytical focus assumes strategies can easily cascade through an organisation. Instead SaP assumes that even external actors, such as consultants, architects, suppliers can play an important role in shaping strategy within the organisation which is surrounded by this network of different actors and organisations. SaP recognizes these senior people’s activities are always reliant on the wider context of

institutionalised and organisational practices. Actors engage with this context and implement their strategic activities. These kinds of practices include, for example, strategic planning, tools and techniques for strategic analysis, agenda-driven behaviour in meetings or boards, etc.

Hence, SaP does not only focus on the micro-level of a particular context, it also links macro and micro practices of strategizing in order to understand how strategy is not only disseminated and implemented, but also how it is "appropriated, translated and transformed" (Sage et al. 2012, p. 222) by people, artefacts, or events. Therefore, SaP can inform a meso-level analysis in strategizing to explain how these practices are translated and transformed in a particular everyday context (Jarzabkowski et al. 2007; Sage et al. 2012). This "activity-based view" of micro-phenomena concerns "what people do in relation to strategy and how it is influenced by and influences their organizational and institutional context" (Johnson et al. 2007, p. 7). Along with other practice-based organisational studies (e.g. Hardy & Thomas 2014, Maitlis & Lawrence 2003), SaP emphasises the relations of power shaped among the actors, or "strategists", involved.

For example, Sage et al.'s (2012) paper provides an interesting SaP analysis of the enactment of lean strategizing in the construction industry by exploring the meso-level between CEO's lean construction strategies and their actual translation and transformation on site by managers. Lean strategizing is shown to develop different values in different settings, leading to multiple meanings of lean strategy (e.g. the CEO understands it as more diffused power, and more collaboration between different managerial levels, while on-site lean was translated into more peer control and arguably less meaningful collaboration). In this thesis BIM and collaboration do also have different meanings according to the way they are enacted by the actor-networks. Moreover, the role of middle managers (from different organisations) is also emphasised as direct actors within the strategizing activities.

Outside construction, Tidström & Rajala's (2016) study draws on SaP to analyse coopetition, which is defined as "…a paradoxical relationship between two or more actors simultaneously involved in cooperative and competitive interactions, regardless of whether their relationship is horizontal or vertical" (Bengtsson & Kock 1999, p. 182), between organisations from a multilevel perspective. Hence, they consider praxis and practices on coopetition aiming to understand how they are interrelated on micro, meso, and macro levels. The case study they present involves a large multinational company and its supplier

within the manufacturing industry. They argue that coopetition strategy is constructed over time across macro, meso, and micro levels which are formed by interrelated activities. The macro level refers to the network between the organisations; the meso level refers to the relational (e.g. type of dialogue among the individuals) and organisational (e.g. routines and strategies) level; the micro level refers to the team and individual level. Their findings reveal the importance of praxis and practices intended as activities coopetition strategy and their role in influencing a coopetitive business relationship. Moreover, they highlight how individual praxis (micro) both influences and is influenced by praxis and practice on higher levels (meso and macro).

3.2.2 Overview of SaP theoretical perspectives

Having introduced the main characteristics of SaP, a general overview of different theoretical perspective within SaP is beneficial as these approaches are influenced by different strands of practice theory (Suddaby et al. 2013). Seidl and Whittington (2014) propose an interesting and clear overview of different theoretical practice perspectives in SaP which offer a theorization by linking local praxis to larger practices. This review results in identifying six significant theoretical SaP perspectives which include: Foucauldian perspective (Foucault 1980; 1984), Giddensian structuration theory (Giddens 1984), Archer's (Archer 1982; 1995) critical realism, narratology, Bourdieusian perspective (Bourdieu 1977; 1990; 1998), and Wittgenstein's (1951) language game concept. Figure 3.1 below summarises them in a diagram which offers a clear overview of these SaP perspectives by positioning them along two axes: the vertical axis indicates the tendency of theories towards a taller or flatter ontology, whereas the horizontal axis indicates their main empirical focus.

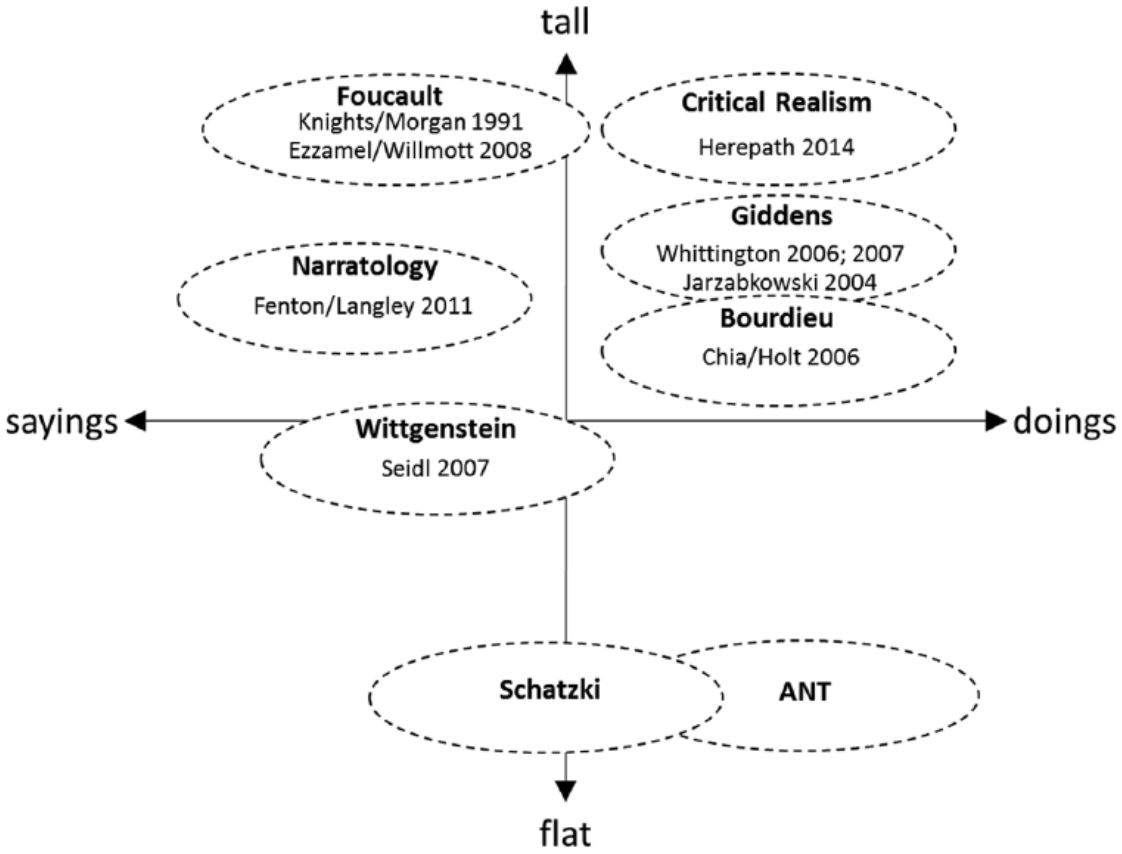

Figure 3.1 Diagram of theoretical perspective in SaP research (Seidl & Whittington 2014).

The Foucauldian perspective focuses on an historical and macro-level analysis of discourse, particularly identifying *"*the power effects of the strategy discourse*"* (Seidl & Whittington 2014, p. 1409). In Figure 3.1 it is placed on the top left of the diagram as it is characterised by a tall ontology and it is more concerned with "sayings", that is to say, discourse analysis. Another theoretical perspective characterised by a tall ontology is critical realism (top right) in which a clear distinction between macro-structures and micro-activities is highlighted as identifying two separate entities (see e.g. Herepath 2014). These two perspectives focus on the macro-structures and offer analyses which, in the first case, do not consider the micro-activities and praxis in shaping strategy, and, in the second case, target the social world to understand the complexities of structures which cause facts and events. Hence, the Foucauldian perspective, being a tall ontology, does not provide a focus on praxis in terms of activities and collaborative strategizing among actors; whereas, according to Herepath (2014), critical realism does not assume any linkage between macro and micro. However, this research will analyse how macro practices and micro activities connect, for example, how innovation strategies coming from the top management of the construction firm are

translated and shaped in different settings through collaboration between the firm and the supply chain.

Narratology aims to analyse narratives, such as the micro-stories of managers or other actors as they interact during daily working activities aimed at making strategy (Fenton & Langley 2011). This theoretical perspective is positioned in the higher part of the diagram as micro and macro narratives *"*get layered on the top of each other*"* (Seidl & Whittington 2014, p. 1411). Indeed, people's stories can be influenced by institutionalised macro-strategy drawn by the organisation's vision (Deuten & Rip 2000). Below this perspective, Seidl positions Wittgenstein and language theories.

Seidl (2007) draws on Wittgenstein and argues that strategy should be considered as "a network or ecology of different language games regulating the proper use of strategy language" (p. 209). In this context, the link between the local and the social is found in the "structural coupling between different language games" (Seidl & Whittington 2014, p. 1412). This perspective is strictly concerned with communication and text analysis. Hence, narratology mainly concerns narrations, that is, an analysis based on a story coming from, for example, people's interviews, whereas Wittgenstein's language theory is strictly focused on text analysis. These theories would not benefit the analysis of this research since, for example, the material role of technology in influencing strategizing is not considered.

The interest in strategy as discourse has increased in recent years, and an increasing number of researches are focused on the linguistic nature of strategizing and the ways in which language shapes strategy. SaP has been linked to studies which examine different forms of interactions "through a discursive lens". This research highlights that strategists make important use of discourse through narrative, rhetoric, and metaphor, or through discursive activities such as justifying, legitimating and naturalising (Vaara & Tienari 2002; Hardy & Thomas 2014) when they are strategizing. Silverman (1997) highlights the importance of recording events as it is the only mean to understand how people are shaping the setting through their conversation. This analysis can also establish "linkages" between micro (e.g. human interaction, conversations, etc.) and macro (e.g. social structures, markets, etc.).

Seidl and Whittington (2014) locate the Bourdieusian perspective and Giddensian structuration theory in the middle-top right of the diagram. According to the first perspective, strategists' dispositions ("*habitus*") to develop strategies are influenced by the

cultural and social environment in which they are embedded. Micro (the individual) and macro (the society) appear to be "flattened" (Chia & MacKay 2007). Giddensian theory emphasises the role of "management practices-in-use" (Jarzabkowski 2004). Since strategists reflectively deploy, in their micro-activities, strategizing practices, such as particular techniques and tools, it can be argued that the macro-level influences activities on the micro-level, and at the same time, local praxis modifies practice on the macro level. For example, Jarzabkowski and Seidl (2008) considered strategy meetings as social practices which have the power to influence the strategy activities within an organisation.

The main advantages of the taller ontologies lie in the fact that a clear macro-theory can explore power and causality and increase the significance of local praxis, enabling SaP analyses to make a broader critique considering more sites with similar structures. The interconnection between macro and micro is important to contextualise practices in praxis and praxis in practices. Indeed, in this study, the interconnections between top-down strategies and strategizing in a specific everyday setting is important to grasp as collaborative activities are shaped directly by actors.

Flatter ontologies represent networks of actors who can be both humans and non-humans. In this group, Seidl and Whittington (2014) locate ANT and Schatzki's (2002) interpretation of practice theory. The focus is on different empirical sites where activities are enacted. By looking at Seidl's diagram, ANT is placed more in the "doings" because of the consideration on non-humans, whereas Schatzki's is placed right in the middle between "doings" and "sayings". Hence, a SaP perspective, following a flatter ontology, should focus on the actors and analyse what they "do" together in different contexts (Seidl & Whittington 2014).

Therefore, my theoretical approach combining SaP and ANT would mean that a strong focus would be given to the actors (human and non-human) as the main *actants* of collaborative strategizing in interconnected networks. In order to answer the research questions whose purpose is to analyse the collaborative context in which the organisations collaborate with technology, the aim is to follow the actors in different organisational settings where collaboration and implementation of innovation unfold. This can give a perspective from the bottom of an organisation of how strategy is built directly from the actors. Being this research based in the construction industry, a review of previous studies in this context drawing on SaP is required.

3.2.3 Previous studies drawing on SaP within the construction industry

There are not many previous studies within the construction industry using a SaP perspective, particularly when they combine an ethnographic research method. These studies focus on themes such as different levels' strategizing in organisations, and the exercise of managerial power and discourse. Sage et al. (2012) draw on SaP and ethnography to discuss the diffusion of lean construction focusing on how strategy is enacted. SaP allows for the analysis of the "meso level" of lean strategizing between the corporate intentions of the CEO, and the managerial practice on site. The authors argue how lean strategizing gets "transformative value in different settings", hence developing new discourses which influence the project and the company too.

Koch et al. (2015) also focuses on lean production processes in two project-based organisations in Denmark and UK through a SaP perspective. In this study, lean production appears as a strategic change within the organisation, in Denmark it is initiated bottom-up from a project manager's decision, whereas in the UK it is imposed top-down. They argue the importance of middle managers' role as strategy practitioners to mediate and translate the strategic intent into operations. Middle managers also have the delicate role of mediating between strategy practice and the main actors who have power to enact them. For example, in the UK organisation, the middle managers' praxis is used to apply managerial tools (e.g. reinterpreting and operationalise lean strategy through meetings, workshops) to enable communication and hierarchical relations.

In his doctoral thesis, Löwstedt (2015) analyses a Swedish construction company drawing on SaP, particularly Bourdieu and narratology. The reason to adopt this perspective is to consider strategy a socially constructed activity within an organisational and cultural context. Hence, much attention is put on the actors involved in the organisation and how strategy is enacted. In order to do so, he uses an ethnographic study, focused observations and interviews. He interpretatively argues how strategizing encompasses both micro and macro levels of the organisation, thus the managers are the producers and consumers of their strategy. However, even though the firm's managers are part of this strategizing discourse, proactive strategizing, such as strategy plans and workshops, is minimised; whereas short-term building projects receive the major focus. This strong identification and focus as "construction workers" can eventually hinder knowledge sharing and innovation.

McCabe's (2009) paper does not take place within a proper construction context, rather in a mutual building society, but gives a discussion about power dynamics from different organisational levels through a strategic change, producing contradiction, ambiguity and inequality. He highlights concepts such as plurality and micro-strategizing, and he conducts interviews and document analysis in order to understand how power is executed in situations of strategic change. From the interviews he realises that strategic discourse creates ambiguity and contradiction between the CEO and the senior/middle managers. As the CEO talks to the employees about the future strategy of the organisation, power seems to be absent as CEO's presentation portrays him as "man of the people" while at the same time he is supposed to make decisions and, thus, exercise power on the employees. In order to motivate his tough decisions (e.g. reducing employees) he uses sensitivity to make everyone feel part of one team aiming to reach costs savings and more efficiency. However, ambiguity leads the employees' implementation of the CEO's strategy with different results and some managers use resistance to slow change. McCabe (2009) thus highlights that power coming from management can have limitations and can also lead to resistance from other actors.

Laine and Vaara (2007) consider how subjectivity is influenced by discourses and practices of strategic development inside an engineering consulting group. Using participant observations, target interviews and document analysis, they try to understand how actors make sense of different discourses and practices concerning organisational strategizing. These different kinds of subjectivities result in empowering or disempowering effects which can mobilise specific discourses leading to corporate management control, or organisational resistance. Hence, they argue how corporate management impose a top-down discourse, which aims to reorganise decision-making, and promote new objectives. This discourse is interpreted as a way to gain control and reflects the hierarchical power coming from top managers. Even though this discourse aims to legitimate the strategic initiatives for change, it also creates resistance within many middle managers. Indeed, they create their own discourses of resistance to corporate management and thus their subjectivity is reshaped as "strategic actors". The authors also argue how project engineers create their own discourse to distant themselves form the "imposed" top-down discourse of organisational change. Their discourse is based on their expertise and experience with more concrete business issues compared to "abstract strategic rhetoric".

Hence, all these previous studies highlight the roles of other organisational actors, apart from the top-strategist management, in discursive strategizing. Middle managers are not only the translators of corporate strategies but can actually resist and develop their own discourses to shape strategies. This is an important concept which will be emphasised in this thesis and it is part of the SaP literature. However, McCabe (2009), and Laine and Vaara (2007) draw upon discourse analysis and power relationships which can be positioned in the Foucauldian perspective (top left of Figure 3.1), and therefore their theoretical approach has a different perspective, in terms of the ontological level, compared to this thesis in which a flatter ontology with ANT is adopted. Indeed, this research focuses on the "doings" of actors and their impact on strategizing. Finally, Löwstedt's argument is positioned in the Bourdieusian perspective and narratology, and it focuses on the cultural and social aspect of context. The beneficial and distinctive contribution of an ANT approach would provide an understanding of strategizing by focusing on the "doing" of human actors and technology as both influencing power dynamics and collaboration. Indeed technology, but also specific organisational settings, such as meetings, may have an important role in shaping the actors' CIS.

As it will be discussed in the next section, organisational settings, where meetings, workshops, or other events are carried out, represent an interesting context to analyse collaboration among actors. Following the ANT and SaP approach, it is possible to follow the actors as they are implementing specific activities and interactions, and how technology is differently used and influences CIS.

3.2.4 Meetings as settings to implement collaborative strategizing

Due to the importance of organisational settings as places where collaboration and strategizing are developed around particular innovation, some previous studies, within the organisation studies and SaP literature, discuss meetings which are typically perceived as tools for accomplishing specific tasks, such as decisions (Simon 1997). Other more recent studies have shifted the attention to the role of meetings as "routinized social practices" which stabilise the wider social system in which they are in (Peck et al. 2004). Meetings can also be defined ethnomethodologically as discursive constructs, in which the micro-techniques are analysed, such as turn-taking in speaking, and reference to an agenda. From these concepts, another definition of meetings can be outlined: "meetings are planned

gatherings of three or more people who assemble for a purpose that is ostensibly related to some aspects of organisational or group function" (Jarzabkowski & Seidl 2008).

Meetings are considered "episodic" because they involve a particular group of people in a specific time and space (Schwartzman 1989; Boden 2004; Boden 2005). The concept of "strategic episodes" has been developed as a framework to analyse meetings within the strategy-as-practice (SaP) literature which will be discussed in the next chapter. The reason to use this concept in the context of this research lies in the fact that organisational settings, such as meetings and workshops, do represent events of collaborative strategizing involving groups of people (e.g. the contractor, suppliers, sub-contractors, architects). The term "episodes" concerns the characteristic of events of being formed by a beginning and a pre-defined end which becomes the reference point for all the other activities within the meetings. Beginning and ending thus refers to two points of temporary structural change. Organisational members can, in fact, change their daily routines and propose variations of the existing strategy. This can lead to destabilizing effects if the internal dynamics of an organisation are considered. However, meetings can also stabilise organisational strategy through recurrence, meaning that they can influence wider institutionalization processes across the organisations (Jarzabkowski & Seidl 2008; Johnson et al. 2010; Suddaby et al. 2013).

Some authors argue that strategic episodes are more or less ritualised. They believe that rituals are important in social structuring and explaining behavioural dynamics, thus they are relevant to understand strategy workshops. Participating in a strategy workshop is characterised by restricted access and defined by Bell (1992) as "privileged". Participants distant themselves from daily activities and engage, temporarily, in this privileged environment where a sort of "liturgy" is carried out. They certify that it is evident that most management of the workshop is accomplished before or after the episode. However, they argue that workshops are still important because they provide a collective engagement and emotional commitment among participants. Finally, from their research results, the translation of possible strategic outcomes, agreed within workshops, into practice can also become problematic. For example, participants of workshops may establish commitments which eventually do not extend into organisational outcomes (Johnson et al. 2010).

According to Hodgkinson's (2006) interviews and surveys of different organisations, strategic workshops are part of a formal strategy development process in organisations and

are directly linked to strategic planning systems. Nonetheless, the link between formal planning system and strategy workshops is not always effective because workshops are usually useful to motivate and emphasise the understanding of strategy (e.g. Johnson et al. 2010). However, they need to be followed by an implementation plan and good communication throughout the organisation in order to obtain tangible strategic outcomes. The surveys conducted by Hodgkinson et al. (2006) also reveal that workshops are similar to "forums" for debate and there is little information gathering and analysis prior to them. Therefore, strategic workshops may or may not be effective within the wider organisational strategy, thus they need to translate into clear objectives, and communication among the participants is important. These meetings and workshops are characterised by multiple participants and objects, thus heterogeneous relations occur. ANT particularly focuses on these relations, aiming to understand how they form and are shaped in actor-networks, as it will be discussed in the following section.

3.3 Review of ANT literature

The purpose of this section is to highlight the main themes emerging from the ANT literature. These themes, such as actor-network, multiplicity, and fluidity, are important to comprehend how actors collaborate and strategize. ANT "describes the enactment of materially and discursively heterogeneous relations that produce and reshuffle all kinds of actors including objects, subjects, human beings, machines (…)" (Law 2008, p. 1). This approach started to be developed in Paris between 1978 and 1982 within Science and Technology Studies (STS), an interdisciplinary field strongly influenced by sociology, philosophy and history. ANT is often not defined as a theory, rather it tells stories about relations among actors, and how they are assembled to form networks (Law 2008) that are aligned together to produce actors that can cohere and circulate (e.g. technologies, ideas, texts, practices). These relations are not just *social* relations, but comprise human and non-human actions and actors and how these networks endure and remain stable throughout time (Latour 1994). ANT approaches are particularly interested to understand the result of the combination between human and non-human actors (*actants*) according to their position in the network, and the power that comes out from these relations (Greenhalgh & Stones 2010). Therefore, in order to understand this approach, it is necessary to

comprehend how the networks of human and non-human work in practice, through case studies (Law 2008). These terms, such as human and non-human actors, actor-network, relations, were introduced in the "classical" ANT, which will be now discussed.

3.3.1 Heterogeneity and translation in "classical" ANT

In this study the term "classical" ANT is proposed to refer to studies mainly undertaken during the 1980s. During that period, ANT is used as a critical tool to understand the world as *heterogeneous* and *relational*. According to *material semiotics*, which refers to the study of how actors (human and non-human) and arrangements (organisations, inequalities) are produced, the world is materially diverse and heterogeneous. Law and Singleton (2014) argue that, in order to understand the world, it is necessary to understand how practices generated within particular material combinations. Hence, for example, to understand foot-and-mouth disease, it is necessary to look at its materials and how they have been "practiced" in different locations. The heterogeneity of networks means that they comprise of human and non-human. Indeed, a key theme central to ANT is the role of non-human, as Latour (1991) explains "We are never faced with objects or social relations, we are faced with chains which are associations of humans and nonhumans" (p.110). ANT therefore proposes that any object, including a technological artefact like a car or telephone, results from the association of human and non-human actors.

Some key elements of ANT, such as translation and enrolment of actors, emerged from "Laboratory Life" by Latour and Woolgar (1979). In this study, the authors put emphasis on the "social" and the "technical" as resources for the scientists in laboratories to construct their arguments, texts, and experiments, which must be accepted as true by society. The scientists are embedded in different networks (e.g. policy makers, regulators, other scientists), and they must orient towards them in order to get their findings accepted and thus make science circulate in the society. In order to do so, the scientists must "enrol" the other people in society by "translating" their interests into the scientists' arguments. This process is examined and discussed by Latour's case study of Pasteur's work on microbes. In this study, the interests of the "outsiders" (e.g. farmers, scientists, hygienists, etc.) for the experiments result from Pasteur's work in enrolling them: Pasteur translated the microbes of the anthrax disease into his laboratory. By doing so, he also translated along

farmers' interests and made them realise that the laboratory experiment is the only way to solve the anthrax problem (Michael 2017).

Hence, Pasteur was able to analyse the disease by reproducing in the micro-scale what other actors, such as hygienists, were studying on the macro-scale in farms and herds. After the experiments in laboratory, Pasteur also implemented the field trial which reinforced even more the interests of farmers and other actors, such as veterinary scientists, hygienists, and medics (Latour 1983; 1988). An important point made is that science creates a link between macro and micro: science can use the micro to reshape the macro, and it looks at the macro to consequently affect the micro. Moreover, following Latour's case study, it seems that a micro-analysis is the most appropriate to understand the shifts between macro and micro as Pasteur's lab experiment influenced the whole society (Michael 2017).

The concept of *translation* has been clearly defined in "Unscrewing the big Leviathan" by Callon and Latour (1981): "By translation we understand all the negotiations, intrigues, calculations, acts of persuasion and violence, thanks to which an actor or force takes, or causes to be conferred on itself, authority to speak or act on behalf of another actor or force" (Callon & Latour 1981, p. 279). For such translation to be successful, different meanings must be made mutually compatible and "obvious" (or *black boxed*) to the others' wills in order to enrol a network of actors. This heterogeneous network recalls Callon's (1986) principle of *generalized symmetry* according to which the different elements of a network are analysed using the same analytic tools (Denis et al. 2007; Michael 2017).

The concepts of *translation* and *blackboxing* will be applied to this study's analysis, following Callon, since they are useful to understand how a network is built (e.g. through shared interests and negotiations), and how actors are eventually enrolled. Therefore, this process allows to understand how actors collaborate to respond to strategic objectives and shape them through innovative strategizing. The process of translation in the construction of an actor-network has been discussed in more detail in one of Callon's main studies and it is introduced in the next section to help elaborate why some key ANT concepts will inform the theoretical approach taken in this thesis.

3.3.2 Callon's model of translation and network building

Callon's early ANT studies discuss the process of how scientists and engineers build their networks to allow technologies and ideas to cohere and circulate. One of the most important studies to take into consideration is that of the fishing community of St Brieuc Bay (Callon 1986). The case study and the "model of translation" presented will be carefully reviewed as it is central to the analysis of this research. In particular, the different phases of translation will help to understand the construction of the actor-network and all the actors involved. Before reviewing his study, it is relevant to highlight Callon's premise at the beginning of his paper. He argues that social scientists and engineers are actively engaged in changing society and that science and technology cannot be purely defined by sociology and the sociological study of social forces and actors (e.g. power, class). The study starts from scientists and representatives of the fishing community gathered in a conference aiming to increase the production of scallops by farming them. Three researchers discovered a technique to farm the scallops after a journey to Japan which increased the stocks of the crustaceans. Such technique could have been an advantage if implemented because of the dwindling stock of scallops in France due to their intensive exploitation.

Callon (1986) analyses the construction of this network and the production of knowledge through four moments of translation. These are: *problematisation* in which translators try to define the problem and an "obligatory passage point" needed to solve it; *interessement* in which translators draw together actors' interests in order to follow the project; *enrolment* in which the main actors are assigned roles and alliances are built; *mobilisation* in which "the actor-network extends beyond the initial group" (Denis et al. 2007). In the problematisation phase, the researchers determine the set of actors by defining their identities and making them an *obligatory passage point* in the network of relationships. Hence, three actors are identified: the scallops (*Pecten Maximus*) which are represented as potentially "farmable", the fishermen of St Brieuc Bay which are interested in restocking the bay with scallops, and the scientific colleagues who agree to the researchers' project. Therefore, the researchers themselves and their experiment will become an obligatory passage point which the fishermen have to pass through in order to actualise their "translated interests" (Michael 2017). This is discussed in the following steps of the model. Indeed, in the interessement phase the researchers try to stabilise and consolidate the identity of the other actors by building devices to be placed among them

(*interessement devices*). These devices are, for example, the towline and the collectors used to anchor the scallops' larvae, whereas for the fishermen, the devices are texts and conversations to understand the reasons to follow the researchers' project. If the role of the interessement devices is successful, then problematisation's validity is confirmed (Callon 1986).

Nonetheless, the interessement devices do not assure that alliances are built, and actors are enrolled. In order to achieve enrolment of actors, it is necessary to conduct negotiations. As Callon (1986) argues, the scallops can get enrolled, if they are willing to anchor to the collectors. However, the researchers have first to negotiate with the scallops and all the "enemy forces" which can affect the larvae's anchorage. These enemies include, for example, currents (as an obstacle to anchorage), and parasites, whereas the negotiations with the scallops comprise of the choice of material used for the collectors, as it is observed that some materials can hinder, or slow down the process of anchorage, but there as some cases in which larvae attach themselves. This proof of the anchorage of a limited number of larvae is finally judged as sufficient by the scientific colleagues who thereby are enrolled. The fishermen, on the contrary, do not participate in the negotiations and get enrolled without any resistance.

In the last phase of mobilisation, Callon (1986) argues that the fact that only a limited number of larvae anchor to the collectors means that only a small proportion of scallops represent the whole population and thus the anchorage is taken for sure by the researchers. Regarding the fishermen and the scientific community, only a few representatives did actually go through the process of enrolment. A perfect symmetry is represented: "a series of intermediaries and equivalences are put in place which lead to the designation of the spokesman" (p. 13). In this context, the three researchers have become representative of the scallops, the fishermen, and the scientific community and they must work at keeping these actors' interests enrolled in the network by publishing and presenting scientific papers at conferences. In this way, the actors are "displaced" and "mobilised" (Callon 1986). In effect, a new actor, a farmed scallop, appears to have been created and can now circulate in France and perhaps beyond.

However, this network, formed by stabilising consensus and alliances, can be contested at any time. In fact, Callon's (1986) case study shows how that the repeated experiment results in a failure. The number of farmed larvae is not sufficient to decide on

the future success of the project. Indeed, the larvae refuse to anchor to the collectors in the following years, meaning that the anchorage at the time of the first experiment was maybe just accidental. The researchers are therefore "betrayed". The fishermen also failed to follow their roles by fishing the scallops without respecting the commitments agreed by their representatives regarding the long-term sustainability of the scallops' farming. In this way, the identities of the actors change and also the scientific colleagues become sceptical (Callon 1986; Michael 2017b).

Callon's (1986) model of translation, as depicted in the scallops' study, is beneficial to this thesis because it can be used in this research to analyse how the network between the contractor and the supply chain is built, how these actors, both human and non-human (e.g. BIM and other objects implemented within the network) build these relations, and contribute in stabilising and circulating a specific (collaborative) innovation. In effect, aiming towards the implementation of the network builder's strategy. In particular, the four different phases of the model can be recognised in the process where the actor builder, who may, for example, be a director in a construction contractor firm, creates the premises and the environment to attract external organisations' interests (e.g. supplier firms) and "enrol" them by providing benefits for both parties. Even though this model would help to describe network building and collaboration, there are some limitations within this line of analysis, particularly regarding the role of technology in influencing the actors' collaborative activities and interactions. An empirical analysis of the model and its limitations will be offered within the empirical analysis of this study.

3.3.3 Boundary objects

As it has just been mentioned, the concept of technology in Callon's (1986) study is limited in some respects. Given the focus of this research is on how strategies can enable technological innovations in construction and housebuilding it is important to elaborate these limitations and how they will be overcome through the integration of related ANT concepts into the theoretical approach. That is, the research approach must go beyond analysing the effects of "interessement devices" as argued by Callon (1986). For example, technology such as BIM can act as an actor within the network and actively influence collaboration among human actors. While Callon (1986) considers technologies as somewhat utilitarian interessement devices wherein the network builder attracts the

interests of other actors, these tools, or processes, can also have wider, less predictable, effects across a series of actors. The fact that an actor-network comprises of both human and non-human actors makes possible the consideration of technological artefacts to possess more active roles within and between networks of actors.

One way to address this issue is to consider technologies as *boundary objects* that can be interpreted differently by different groups and can therefore connect different "social worlds". These social worlds are divergent in terms of their discourse and practice, however, boundary objects make possible the communication and cooperation between them (Denis et al. 2007; Michael 2017c). Boundary objects were first defined by Star and Griesemer (1989) in a study of Berkeley Museum of Vertebrate Zoology as: "(…) objects that are both plastic enough to adapt to local needs and the constraints of the several parties employing them, yet robust enough to maintain a common identity across sites (…) They have different meanings in different social worlds but their structure is common enough to more than one world to make them recognizable, a means of translation" (p. 393).

The concept of boundary objects has been applied in different contexts, including construction, to understand how knowledge is shared and created across boundaries of practice among specialist groups. Indeed, an actor-network can bring together different communities of practice (e.g. contractors, suppliers, architects, consultants) in project-based settings. In this context, knowledge can be shared through boundary objects which can therefore actively facilitate communication issues within projects (Sage et al. 2010). Indeed, when a network brings together different organisations, it is necessary that actors also share information and knowledge in order to collaborate in the long-term and implement innovation.

Various engineering-based and managerial tools and techniques have been explored as acting as boundary objects, such as engineering sketches and drawings. Their visual representation "allow for the manipulation of tacit knowledge between individuals" (Henderson 1991, p. 450). Also Sage et al. (2010) analysed the role of a project management tool, a "Project File", which worked as a boundary object mediating flexible knowledge between actor networks and even empowering practitioners, and shaping power within the organisation. Other studies have used management systems and practices as boundary objects, involving technologies such as Enterprise Resource Planning (ERP) information systems (Pawlowski & Robey 2004), and also social events, such as conferences and

workshops. In this last study, boundary objects act as "common information spaces" enabling interactions and coordination without shared goals (Bartel & Garud 2003).

In Star and Griesemer's (1989) study of the Berkeley Museum of Vertebrate Zoology, they develop the concept of boundary objects to analyse the flow of specimens and information from different social worlds, such as collectors and trappers, to the museum (Michael 2017). The museum's director used "taught and enforced methods standardization" (Bresnen 2010, p. 617) in collecting and categorizing specimens and used various objects (boundary objects) to improve the integration of all the specialist communities involved in the project. These boundary objects included, for example: repositories acting as shared resources through libraries, ideal types which are abstracted and adaptable such as atlas and "species", standardised forms as method of communication across different groups, and coincident boundaries producing a common referent, such as the state of California (Bresnen 2010). For example, the state of California was represented through maps which shared borders, but it was interpreted differently by the different social worlds: for collectors, maps showed representations of roads and camp sites, whereas for professional biologists, it represented "life zones". Hence, the common referent of "California" worked as a point of cooperation (Michael 2017).

From this study, it is therefore possible to understand how boundary objects can have different effects since they can be interpreted differently by the actors involved. For example, the implementation of BIM can assume different meanings for the contractor and for the suppliers. As such, this technology may have a much more active influence over the process of CIS if it was understood, with Callon (1986), purely as an interessement device. However, more recent ANT studies suggest the role of objects within a network is not limited to their function as predictable blackboxes, stabilizing interessement devices, or integrative boundary objects. This later body of ANT scholarship is discussed now to understand how such objects can also construct new, multiple, realities, by circulating as multiplicities and fluids.

3.3.4 Multiplicity and fluidity

ANT research in 1990s, and onwards, shows an "ontological turn" in STS towards a focus on how reality is made or enacted. Therefore, ontology is placed in relation to practice and the multiplicity of these practices is argued. According to Mol (1999), reality is "done and

enacted rather than observed" (p. 77), thus it is affected by various tools throughout the diversity of practices. Each activity enacts a different object, therefore different realities. The implication of this is that reality is multiple. This is explained in Mol's (2002) study "The body multiple" which describes diagnostic and treatment practices for lower limb atherosclerosis. She argues that atherosclerosis is differently enacted in different places in the hospital. For example, in surgery it is represented as a pain in walking, in radiography it is represented by an X-ray photo of semi-blocked blood vessels, or in the ultrasound department it is in the form of Doppler readings. These differences can be mutually exclusive since each of them implies a different action, which depends on various objects and technologies (Law 2008; Michael 2017d). According to material-semiotics, Mol (2002) argues that each of these practices creates its own material reality. Hence more than one actor-networks can be identified and the way they are related together is a practical matter (Law 2008).

The different enactments of atherosclerosis within a hospital can be coordinated and generate a single disease (e.g. when the surgeon collaborates with the pathologist), or they can remain separate from each other (e.g. in the vascular surgery department). Therefore, multiplicity of practices generates multiplicity of realities, which more or less cohere (Michael 2017). This concept of multiplicity will be useful when considering the presence of multiple actor-networks (e.g. suppliers, sub-contractors, consultants, etc.) within a contractor firm developing a collaborative innovation strategy (e.g. lean construction), and how it involves different actors, has different strategic goals, and lead to different strategic outcomes. Nonetheless, all these networks may be connected among each other.

Law and Singleton (2014) discuss multiplicity through the foot-and-mouth disease. They argue that the disease is "different things in different practices" (p. 384) because it is performed differently in different sites. Foot-and-mouth disease as a "natural" reality is not only just seen and interpreted by vets, virologists and epidemiologists in a different way, but it is a different thing in those different science fields. Indeed, vets look for symptoms on the body of the animals, whereas in laboratories the disease is a virus. For the epidemiologists, it is again different as it is something that diffuses through the population within which it can spread. Therefore, foot-and-mouth disease is a *multiple reality* produced in different meanings given to it, different tools that study it, and different concerns on it. The way in which these different realities relate to each other is considered by Law and Singleton

(2014). They argue that since laboratories need blood samples, then these samples mostly come from the vets. If virologists find the antibodies, then the two practices line up by making a combined reality.

The types of relations and associations emerging have an important role in identifying the non-human, which can vary according to the nexus of relations. For example, concerning the map of California's (as discussed in the previous sub-section) meaning, it is both common to the different social worlds of the study, both specific for each of them. It is common in the sense that the map shows a shared attachment to "California", but it implies divergent understandings according to the professions. The role of associations in shaping the non-human has been discussed by Mol and Law (1994; 2004) concerning anaemia and hypoglycaemia. They are both characterised by *fixity* and *fluidity* as they are manifested in multiple ways. For example, hypoglycaemia is enacted through biomedical practices, but also through domestic, labouring and aesthetic activities, thus it is a process comprising of many associations and networks within the hypoglycaemic body. In this situation, the body "is full of tensions" (e.g. between the interests of different organs), but keeps its integrity (Mol & Law 2004, p. 57; Michael 2017). Latour (1992) makes an interesting argument regarding technological artefacts which go beyond the designers' intentions: the scripts embodied in this technology are multiple and reflect different networks (Michael 2017). Thus it is also becomes possible to talk of *fluid technology* (de Laet & Mol 2000).

In this study by de Laet and Mol (2000), the Zimbabwe bush pump is described as an example of fluid technology with fluid boundaries. The authors present a different number of manifestations of the pump, such as: "a water-producing device, defined by the mechanics that make it work as a pump", or "a type of hydraulics that produces water in specific quantities and from particular sources", or "a sanitation device" (Law 2002, p. 98). Being a network, manuals, measurements and tests, and even the village community who set up the pump need to be included in the pump's constitution. The boundaries of the pump are fluid and also the elements which make it work: some elements, such as some bolts are unnecessary, leather seals are replaced with bits of old tyre. Fluidity can be observed also if the pump is considered as a device to supply clean water: in this case, the level of micro-organisms depends on who is using the pump, or it may be that there is no facility to measure the contamination of water. Therefore, the pump does not have a fixed structure and it changes shape, thus it is a "mutable mobile" (Law 2002). As Law (2008)

argues, objects can reconfigure themselves, and the different created realities are loosely associated.

All these recent ANT influenced concepts will be useful to discuss how technology, such as BIM, changes shape in different organisational settings (e.g. meetings, workshops). In these different contexts, the technology can be considered fluid and creates multiple realities. Indeed, BIM can be defined in different manners according to where and by whom it is implemented. Moreover its implementation may lead to unexpected outcomes concerning the way in which the actors collaborate. This analysis about technology will address the research gap which has been highlighted in Chapter 2, that is, the lack of theorisation on BIM and its influence on collaboration from the perspective of the actors involved. Moreover, it will also contribute to the lack of project-specific factors influencing contextual innovation in construction.

3.3.5 Previous studies using ANT within the construction industry

The main concepts and authors of ANT have been discussed, now the main studies drawing on ANT within the construction context will be highlighted. Construction provides an interesting example to analyse multiple actor-networks, due to the presence of many organisations and technology in projects. In literature, they are mainly focused on the implementation of innovation (e.g. Harty 2008), the adoption of BIM (e.g. Linderoth 2010), and in general to understand projects (e.g. Sage et al. 2011). Harty (2008) draws on ANT and the concept of *relative unbounded innovation* by arguing that ANT is the right approach to "follow and trace the dynamics of implementation, wherever they might lead" (p. 1033). Indeed, ANT concerns how people and objects come together to form a network and how they are held together, or disassociated and reconstituted. Moreover, ANT considers the continual transformations of actors, artefacts and practices occurring through interaction, while also tracing associations, thus innovation, as they occur.

Harty (2008) argues that, for example, in the first phase actors involved in the project are resistant to change, that is passing from 2D-based to 3D-based design practices. Indeed, this process is seen as discontinuous with the existing ways of working. However, the presence of wider associations from outside the project makes the process more relatively unbounded. Hence, the innovation process is "intersected with robust and pre-existing associations that extended outside the domain of the project" (p. 1038). In fact, it is

impossible to isolate the project from wider influences, which many times contrast with the project's aims, and therefore resulting in resistance to implementation. Finally, a standard document, works as a mediator between actors within and outside the project, and it enforces relative boundedness of the process. This study reveals that the collaboration of multiple organisations within a single project is influenced by multiple actors, who may also firstly resist to innovative changes (e.g. BIM, or new software). Moreover, technology can extend beyond a single project and influence collaborative strategizing in different ways.

Linderoth (2010) sees the adoption and use of BIM as the "inter-linkage" of actors forming a construction project, taking as a case study a major Swedish construction company. He first discusses why actors using BIM get enrolled in the network, then he redefines the roles and relationships created by BIM, and finally he analyses the consequences of using BIM as a cooperative tool in context. For example, the author highlights that it is the company itself that decided to implement BIM in all projects. Therefore, BIM becomes an "obligatory passage point" for all actors involved, who will see their roles redefined by the software, or by their interactions using the software. This leads to increased transparency and improved collaboration. In the wider context, the importance placed on time and action in projects leads to the adoption of new technologies, such as BIM, to reach immediate benefits, even though some actors (e.g. site managers) have to be convinced by others of these benefits.

Tryggestad et al. (2010) draw on ANT to analyse the connections between objects and knowledge in construction projects. In particular, they focus on the ANT concepts of goal translation, trials of strengths, and circulating objects. They regard objects, such as artistic sketches, drawings, photos and models of a skyscraper project, as mediators, which are transformative. They argue that construction design is a collective activity producing and distributing knowledge, and that design is a flexible process in which trials of strengths have to be implemented to solve tensions which these tools create among the stakeholders, who have different design ambitions, but also mobilise different objects. Hence, these objects progressively become part of the design process and transform its outcomes.

Sage et al. (2011) emphasise the role of objects in achieving social order and transformation during projects. The focus of ANT in understanding how non-human (materiality) can shape human activities and knowledge is central to this study. The authors use an historical case study of the Skye road bridge project to develop an ANT perspective

on project complexities. In order to do so, they follow Callon's (1986) model of translation (problematisation, interessement, enrolment, and mobilisation). The reason to highlight this study lies in having adopted Callon's model to discuss the construction of the actor-network. Moreover, it emphasises the role of non-human (e.g. technology) to influence actors' activities which is an important justification, as discussed in the previous section, for engaging SaP and ANT. In the problematisation phase of the case study, the government tries to define the identities of the actors involved in the project.

In the interessement phase, the actors define their identities through the relations with each other through negotiations (e.g. between the contractor and the conservationists), and then alignment of interests thank to the "Eurasian otter" working as a boundary object. In the enrolment phase new actors and relations are introduced forming new actor-networks for the toll-bridge and protests. In the last phase, it is argued that the project is successfully mobilised by the construction and design contractor's actor-network, and the conservationist actor-network. However, the mobilisation is not successful within the actor-network of the toll-bridge as it cannot enrol the local population. Hence, this study is interesting to understand how actors' relations and interests are built and mobilised following the translation process of Callon, even though the process eventually fails (Sage et al. 2011).

Lingard et al. (2012) also apply ANT to give a theoretical analysis of design decision-making, that is Construction Hazard Prevention through Design (CHPtD), on the occupational health and safety (OHS) of construction workers. They focus on the interactions between human actors and non-human artefacts. They highlight the importance of "unpacking" design decision-making, which is black boxed, to understand the heterogeneity of actors and interests involved. Hence, the professional responsibility for CHPtD is informed not by a single point actor (as it may be understood from a punctualised actor-network), but by socio-material interactions which shape decision-making. They also argue the role of the external actors in shaping decisions and influencing construction workers' experience of OHS. Hence, they highlight how construction projects present a *relatively unbounded* (see Harty 2008) context.

London & Pablo (2017) draw on ANT approach to study collaboration in industrialised building (IB) housing construction. They mobilise some ANT concepts, such as prime mover and translation, generalised symmetry, convergence, stabilisation, and multiplicity, to

explore collaboration in a novel way. Hence, they argue that through an ANT approach it is possible to identify multiple prime movers within collaboration and overlapping actor-networks. Moreover, the importance placed both on humans and non-humans allows to have a more complete understanding of collaboration as it can be shaped by both actors. They also highlight the role of convergence as contradictory ideas coming from the actors within the networks can lead to innovation and thus a different level of collaboration. They emphasise the concept of destabilisation in IB contexts where disruptive technologies, introduced by the prime mover, can lead to a destabilization of the network. Finally, they highlight how IB contexts are characterised by multiplicity as the actors enrolled in one network are simultaneously members of other projects, and their own organisation, thus they have multiple constituencies and commitments. This means that actants enrolled in multiple networks are in a constant state of tensions which can create innovation.

3.4 My theoretical approach: A SaP-informed ANT study

The previous sections have provided a concise literature review about SaP and ANT, with a focus on explaining the benefits and limitations of these theories to elaborate the theoretical approach that will inform empirical analysis in this thesis. Some previous studies drawing on SaP and ANT within the construction industry have also been discussed in order to have a broader understanding of how some theories have been analysed in the context specific to this research. Hence, the reason to introduce these reviews is to more clearly outline my theoretical contribution which combines some aspects of SaP with some aspects of ANT. Drawing on these two perspectives allows an analysis of strategizing that attends to the everyday practices and actors who are directly involved in different organisational settings.

It is also important to emphasise how SaP gives a strong focus on the actors as *actants* shaping strategy within a process (rather than the content of a strategy), whereas ANT's focus is on the *relationships,* including networks, among these actors that construct strategies. As ANT explains, these relationships may change according to the context in which they are implemented, and the actors that already exist in that context, such as the Eurasian otter in Sage et al's (2011) study, and thus may influence the actors' strategizing. Hence, the combination of these two approaches is complementary to each other and

especially well-suited to address the research question because it allows to examine CIS from the perspective of the actors. This perspective helps to understand how suppliers really contribute to CIS by observing their interactions and activities with the contractor, and technology (e.g. BIM).

3.4.1 Limitations and contribution of SaP and ANT for this research

Many studies of strategic decision-making have only focused on the implementation of strategy by top managers, or strategists (e.g. Hambrick & Mason 1984, Papadakis et al. 1998, Wiersema & Bantel 1992), while SaP perspective has given a broader analysis by considering also actors who are in the middle or at the bottom of the hierarchy within the organisation as main contributors for the formulation of strategy. Nonetheless, as McCabe (2009) criticizes, SaP literature tends to consider power as a possession of managers, whereas it can also come from other actors of the organisation, and managers may not even "possess" power. Hence, research should also consider the extent of the supply chain's integration and the need to widen the strategizing network under analysis by considering external actors (e.g. suppliers, sub-contractors, consultants, etc.) as direct participants in strategizing and innovation. Therefore, even though some previous studies have already examined inter-firm strategizing (e.g. Sage et al. 2010, Tidström & Rajala 2016), there is still a gap in the literature concerning inter-firm collaboration around supply chain CIS in organisational settings and analysed through ethnography.

Moreover, there is still lack of research which combines SaP with flat ontologies, such as ANT, within the construction industry. In this context, a flat approach would benefit such analysis by tracing the linkages between different sites and actors since it focuses on the role of human and non-human actors as the main *actants* of strategizing and collaboration. This is important in this context because technologies, such as BIM, can influence the way in which actors collaborate and strategize according to the way in which they are used. Indeed, as discussed in Chapter 2, digital building information is transformative and unpredictable influencing the interactions of actors, and their roles and responsibilities (Whyte & Hartmann 2017). Moreover, strategizing and the implementation of innovation may occur during normal meeting and workshops involving actors who are not top strategists, but are rather middle managers, architects, technicians, installers, etc.

Moreover, drawing on ANT perspective towards the "distinction" between macro and micro organisational levels, this thesis will highlight that macro is not distinct from the micro. According to Denis et al. (2007), ANT lies between macro and micro, meaning that networks may have both a local and a broader scope. Hence, it is possible to simultaneously consider different levels of analysis spanning from micro to macro. Latour (2005) offers a subtler take on these distinctions and argues that ANT suggests that the macro is equal to the micro: macro is no longer a wider context in which the micro is enclosed, but it is *added* to it and it is connected to many other contexts. Hence, he puts importance on *connections* which create a flat scenario, and shape structures. In this way, there are no jumps from micro to macro, but rather, following these connections in a flat approach allows for an understanding of how networks are formed as being more or less encompassing on the extent of their connections. This thesis draws on Latour's (2005) consideration of a flat landscapes and connections, especially to understand how certain networks and strategizing endure, and become more powerful, or "contextual", among actors.

However, some structuralist authors, such as Greenhalgh & Stones (2010), argue that a limitation of ANT is its flat ontology. This means that "structure" is not "*a pre-existing layer*", therefore the causality of social structures is not considered in the analysis. Moreover, black boxes cannot provide a stable set of relations since they are stable only in one precise moment but can change at any time. Although unpredictability characterises these dynamic relations, considering a flat landscape characterised by connections between actors can provide some interesting insights regarding particular events which can change the normal course of actions. For example, the complexities of activities and interactions between construction firms and suppliers represent an interesting platform from which to analyse how a network is built and the role of technology (e.g. BIM) in shaping CIS.

Hence, even though there are some limitations and challenges in the adoption of SaP and ANT, drawing on SaP to analyse the strategizing activities by different actors within the organisation, and applying ANT to focus the attention on the micro analysis of actors (both human and non-human) would benefit in terms of a more detailed examination of strategizing based on real observed facts and interactions, in order to answer the main research question looking at the collaborative strategizing of construction firms and suppliers. Indeed, it is possible to study how a strategy is enacted since its existence is made real by the network of human and non-human gathered in a specific context. Moreover, the

fact that there are gaps in literature within construction about strategizing studies on the micro-level where innovation also plays a critical role to shape strategic decisions makes way to this research. Coupling strategizing with collaboration among different actors can also lead to some insights drawing on ANT and an ethnographic approach. Indeed, observing events occurring can portrait different scenarios compared to what it would have been expected.

Moreover, ANT is relevant in a context of pluralism. Pluralistic contexts are characterised by diffused power and networks of human and non-human actors. Their existence supports the creation of a strategy. ANT suggests that strategy can only be created within a particular network. Therefore, in a pluralistic context, there is no one single strategist, but many actors are in the process of developing strategy as "an active node in a multifaceted constantly shifting network" (Denis et al. 2007, p. 208) which is able to satisfy multiple interests. This can be observed in different organisational settings where different actors are collaborating, such as in the construction context: there are different forms of strategizing according to the actors' interests and this creates different realities. This application of an ANT perspective seems well suited where there are loosely coupled actors, hence power is diffused, and many different objects (e.g. strategic plans, architectural models, documents, software) are mobilised (Denis et al. 2007). Therefore, in considering the plurality of actors the thesis can sheds light on inter-firm collaboration which is becoming increasingly important in the construction industry.

Therefore, an ANT approach would help to understand how, even though different power dynamics and fragmentations within the construction industry (e.g. between projects, and concerning innovation transfer through projects) are present, networks are built, actors (such as the contractor and the suppliers, technology, etc.) are connected and established through networking, and strategizing takes place. In this way, it is possible to identify a strategy that is shaped differently by different actors as its existence is made real by the actors' network (Denis et al. 2007). Strategizing thereby becomes a "translation process", drawing on Callon's (1986) model. Moreover, the use of technology, such as BIM, can also have the power to influence strategizing and interactions among actors, and even be reshaped in different contexts, recalling the concept of "fluid technology" as a mutable mobile (de Laet & Mol 2000; Law 2008), as will be discussed in depth in the analysis chapter. The empirical application of an ANT perspective in pluralistic organisational contexts is still

rare when it deals with the implementation of collaboration and strategizing, particularly within the construction context (Denis et al. 2007).

3.5 My objectives and research questions

Now that previous studies of innovation, supply chain and collaboration within construction, the two theoretical approaches (SaP and ANT), and research gaps have been reviewed, I will re-state my research aim in order to understand in more detail my research questions and objectives. The aim of this study is to understand how a large construction firm collaborates with its supply chain in order to foster innovation strategies in different organisational settings. The objectives of this thesis are specified:

1. To conduct an extensive literature review, which has been done in the previous chapter regarding the themes of collaboration, innovation, and supply chain management, and in this chapter by discussing theoretical concepts linked to my theoretical approach (SaP and ANT);
2. To identify a suitable case study within the UK construction sector, such as a construction firm that is innovative. The innovation is informed by the firm's goals to integrate its supply chain, to implement BIM, and to develop new processes and products;
3. To identify projects involving innovations (e.g. processes and technology) and analyse their implementation in different organisational settings involving the supply chain;
4. To develop the methodology to understand multi-sited collaboration. Hence, to conduct in-depth interviews with the firm and suppliers, and targeted ethnographies during meetings, workshops, and other events involving suppliers, in order to understand how they collaborate, strategize, and manage innovations, especially BIM;
5. To develop, apply, and evaluate a theoretical framework which draws on SaP and ANT in order to theorise the role of technology, such as BIM, and the actor-network's dynamics.

From the main research question (does the early engagement of supply chains around innovative technologies and practices foster effective suppliers' collaboration and empowerment with the firm's innovation strategizing?), other sub-questions can be identified which will help to outline the analysis of my thesis. Firstly, what is the firm's strategy to engage with the supply chain? How are actor-networks built? These two research questions aim to have a clear vision of the contractor's main strategy regarding

supply chain management and integration. Moreover, it links to the actor-network perspective, particularly with Callon's model of translation (and its limitations), to understand how the actor-network, involving the firm and the suppliers, is created and transformed.

Secondly, what is the role of innovative technologies (e.g. BIM) and practices (e.g. supply chain agreements, workshops, meetings) in shaping collaboration between the firm and suppliers? Do they assume different characteristics in different contexts? The identification of different innovations and the discussion about their impact on collaboration among the actors directly involved is central to this research. Indeed, innovations can impact differently on the actors based on the context in which they are implemented. This can have different effects on the collaborative and strategizing activities. The theoretical concepts emerging from these research questions, and which will be carefully discussed in the analysis chapter, are multiplicity and fluidity. In particular, the concept of fluidity and multiplicity connects with ANT literature and their discussion will allow to extend the argument about network building drawing on Callon's (1986) model of translation. Moreover, these concepts will help to investigate how BIM and other objects used by the actors may change characteristics and shape actions differently in different settings.

These analysis chapters and chapter 7 will also discuss: how is collaboration implemented in different contexts? What are the power dynamics arising from different organisational settings (e.g. meetings, workshops)? This last group of questions focus on the different collaborative activities made by the actors and the way in which power dynamics arise from interactions and strategizing. The way in which power emerges from one actor to another can in fact influence how strategizing is implemented. This part is consequently linked to the previous two; power dynamics may shape how a network is built by forming new connections among the actors (and vice versa), and fluidity of objects can also affect collaboration, thus power dynamics.

Chapter 4

Methodology

4.1 Introduction to the methodology

This chapter aims to outline the case study's methodology and to discuss the process of data collection and analysis with a focus on ethics and the reasons which led to the decision to employ specific research methods. The chapter will introduce the study context (the construction contractor firm and its supply chain) and introduce the culture, future strategies, and main projects of the construction firm. These empirical details are beneficial to explain the reasons to selecting this organisation and introduce important features of one of the main actors in the study. The chapter will also justify my methodology, in relation to the theoretical approach and the research questions, while also discussing the research methods that will be adopted. In particular, it will outline the reasons to adopt short ethnographies, in-depth interviews, and document analysis and how these methods are applied and combined in this study.

The chapter is structured as follows: the case study central to this research will be analysed. The construction firm's culture, strategies, and supply chain development will be discussed in order to better understand the type of organisation and its relationship with the supply chain and why this firm was selected. Then, a presentation of the research methods will be provided. In this section a discussion about the ethnographic approach, the reason to adopt it, and some reflexive comments will be made. Other methods, such as in-depth interviews and document analysis also represent an important part of the data collection and analysis process, thus their implementation will also be discussed. Finally, a section about the ethics will conclude the chapter as they represent an important issue to consider whenever people are involved in a research project. Indeed, ethical considerations around anonymity and participants' attitudes towards the study will also be explained.

4.1.2 Justifying the methodology in relation to the theoretical approach

In Chapter 3 previous studies about SaP and ANT were reviewed, with a focus on construction and on some main theoretical concepts. My theoretical approach has also

been discussed, and the reasons to draw on SaP and ANT to this research have been highlighted. Hence, my theoretical approach aims to focus on the actors, or *actants*, during collaborative and strategizing activities, and on the relationships among them. ANT might suggest, for example, that networks of actors collaborating in different organisational settings (e.g. contractor firm, suppliers, sub-contractors) are connected to each other to form a larger, more extensive, actor-network, perhaps led by the contractor. It is important to understand how these networks collaborate within and together in order to reach the main network's strategic goals. Furthermore, by focusing on a case study which involves a lot of different organisations (e.g. contractor firm, suppliers, sub-contractors), it is possible to explore how the connections and relationships work among this team of actors and how they collaborate, in order to answer the research question exploring the implementation of technology and power dynamics which influence actors' strategizing.

As discussed in Chapter 3, the theoretical approach proposed has a flat ontology focusing on the actors, and their relationships, as they influence CIS. An ethnographic method of analysis can also contribute to this flat ontology and the purpose of "following the actor" as emphasised by SaP and ANT. In this research, short targeted ethnographies characterised by observation and informal talks with the actors are particularly beneficial in order to grasp the actual feeling and opinions of the actors in a specific moment, and to deeply understand the relations among human and non-human actors. Indeed, Latour (1987) argues that technology has to be studied in action in order to grasp the dynamics of interaction, hence highlighting the concept of relational materiality (Law 1999) according to which actors assume their attributes according to these relations. Hence, a combined SaP and ANT approach do fit this ethnographic analysis since they both aim to "follow the actors" and focus on the micro-interactions between them.

Moreover, observing how the actors interact among each other and with technology within a specific setting provided a deep understanding of their relationships and power dynamics. Both SaP and ANT pay a particular attention to the "actor" as those who "do" strategy (*praxis*) and may mediate a top-down collaborative innovation strategy implementation. ANT's approach considers non-human actors who possess agency and therefore can shape strategizing and collaboration in some contexts. Hence, it becomes possible to analyse the role of technology, its implementation, and the way in which it changes characteristics and outcomes in different settings.

4.2 Presentation of the case study

In discussing my methodology, it is important to introduce and justify the selected case study. The study considers two different projects led by the contractor with their supply chain, and other organisational settings, such as workshops, conferences, and relationship meetings involving the mandated suppliers. The selection of these specific settings to analyse strategizing and collaboration within the network of actors is justified by the theoretical approach and the research questions which I aim to answer. As previously discussed, a combined SaP and ANT approach can provide a framework to observe collaboration as it occurs by focusing on the actors. Hence, it would be possible to answer the main research question (does the early engagement of supply chains around innovative technologies and practices foster effective suppliers' collaboration and empowerment within the firm's innovation strategizing?), and sub-questions[3] by analysing the activities and interactions happening within these settings, and the relationships between the contractor and the suppliers. Observing these contexts would also provide insights into the role of technology: how it is implemented by the actors, and how it influences their collaboration and strategizing.

This research project focuses on one case study, a large privately-owned UK contractor which has reached £1bn turnover and employs 3,500 people across the UK. The firm delivers residential constructions and developments, public and commercial projects, private rental developments, interior design, and other services such as improving houses' efficiency. This project will focus on analysing the private residential business and the contracting of education developments with a focus on the supply chain. These two branches of the organisation will be part of two different projects which will be analysed through various short ethnographies during meetings and workshops. The core values of the company are: innovation, partnership, sustainability, and people. According to their official website, the company considers itself to be innovative as it invests over £1m each year in

[3] What is the firm's strategy to engage with the supply chain? How are actor-networks built? What is the role of innovative technologies (e.g. BIM) and practices (e.g. supply chain agreements, workshops, meetings) in shaping collaboration between the firm and suppliers? Do they assume different characteristics in different contexts? How is collaboration implemented in different contexts? What are the power dynamics arising from different organisational settings (e.g. meetings, workshops)? See section 3.5.

research and development, and it is one of the first to offer standardised solutions to the market of schools, leisure developments, and care homes.

The value “partnership” reflects its willingness to build long-term relationships with the supply chain which should even “reflect” the company, and with customers. This value does suggest the firm’s dedication towards fostering the relationships with the suppliers, and this is something which can be understood by the types of interactions and activities that they share with them, such as conferences, workshops, and “supply chain agreements”. “Sustainability” is a very broad term which, in this case, refers to preserving the environment (e.g. through waste reduction, reducing of carbon footprint, adopting best practices, and procuring resources sustainably). The company has also an in-house sustainability consultancy which looks for delivering low carbon and sustainable built environment. Finally, the value “people” refers to the firm’s willingness to care about its employees and the community. Indeed, the firm invest a lot on trainings and apprenticeships, and on health and safety measures for the employees, as it was possible to ascertain from various research interviews and their official website.

Hence, it appears clear the dedication and commitment of the firm beyond construction of buildings, such as the interest towards sustainability and building strong relationships with the supply chain. Indeed, the firm aims to build trustworthy and long-term relationships with the supply chain, and to reduce the number of suppliers as a response to increased efficiency and sustainability. To reach this, the firm has implemented supply chain agreements which regulate the partnership between the contractor and the supplier firm which has been carefully selected by the contractor after a period of contacts, factory visits, and tests. Moreover, these agreements foster the implementation of innovations and processes leading to more sustainable supply chains.

4.2.1 Why choose this company

The selection of this company is due to the fact that the construction firm aims to implement innovative processes and technology and develop its supply chain in terms of closer relationship, sustainability and collaboration. Hence, the case study represents a suitable example in order to answer the research questions due to the level of innovation, supply chain involvement and collaboration. In particular, the firm can be considered innovative in the UK industry for many reasons. First of all, it is undertaking an innovative

process of standardisation leading to the development of products (e.g. residential houses, schools, leisure centres, etc.) in which branding, and marketing strategy are strongly emphasised. The aim is to sell branded and standardised products with clients' customisation. Indeed, offering this marketing strategy in the UK construction industry is quite innovative. The firm is in the process of shifting from offering processes, thus being a contractor, which responds to the client's needs, to offering products which can be customised. This is innovative for a contractor, who can therefore have more control over the production, strategy, market, etc.

Moreover, the firm has decided to implement BIM throughout the whole organisation and supply chain, even though its implementation started from public funded projects (e.g. for schools), and continued in the firm's private business, such as the residential housing. The innovation of BIM represents a way to improve many phases of the building process, such as the design of models, which are more detailed and according to the increasing level of the software can be in 3D, 4D, 5D. Moreover, logistics and fabrication are also enhanced by BIM. Linked to the implementation of BIM is the standardisation process and off-site construction. Indeed, the firm has been developing product and material simplifications to be adopted, including its suppliers, and has moved much construction work off-site, that means, pre-fabricating components. Furthermore, BIM also allows companies to engage earlier with their suppliers from the design process, and thus to build stronger relationships with them.

Secondly, both the introduction of the supply chain agreements and the attempt to imbue closer relationships with suppliers represents another aspect of innovation. In fact, even though many construction firms in the UK find it difficult to develop trust and long-term relationship with the suppliers, this firm has attempted to produce a solution to the benefit of all parties. The agreements set up the regulations of their partnership and thus provide guarantees to protect both interests. Finally, the degree of BIM implementation in the firm also influences the way in which the firm collaborate with the suppliers. In fact, its use can encourage a collaborative way of working among the actors involved (e.g. during meetings to discuss the architectural models). Hence, as well as being innovative, the firm also provides a rich case study to look at how collaboration with the supply chain takes place, and how strategizing activities are implemented when innovative processes and technologies, with the potential to reshape collaborative relations, such as BIM, are present.

4.2.2 Access to the firm

Since this PhD research is part of a wider academic project, involving Loughborough University and University of Reading and funded by the Economic and Social Research Council (ESRC), the first access to the firm has come from this source. It allowed me to participate firstly in the standard housing project "exercise" meetings using BIM. From this opportunity, I was able to introduce myself to various managers and other roles within the contractor firm and also to the supplier firms. In particular, I was given notice of all the main supply chain meetings, workshops, and conferences which were scheduled for the following months. Hence, through email and informal talks with some of the contractor's managers, and the Product Director, I was able to keep and expand my contacts within the firm and outside (e.g. with suppliers).

4.2.3 Challenges in conducting an ethnographic study inside an organisation

There are many advantages of conducting ethnography and observation research. These include, for example: the directedness of watching practices as they unfold, having a more holistic view of the phenomenon under study, while interviews may require indirect means for assessing information, and revealing multifaceted aspects of group behaviour. However, there are also some challenges to be faced with, such as a sustained access to the subjects of the study and building trust with participants. These issues influence also the large amount of time to be spent in order to progress to the following stages and to gather all the information needed (Cooper et al. 2004). Therefore, the researcher must have good time and organisation management to handle and complete all the processes involved, which not all may be predetermined.

Moreover, in the case of a non-participant observation which only involves observing the context without being part of it, the researcher must possess very good skills to notice and interpret language, feelings, activities, and objects. In this study, even though the ethnography had some participative moments, long periods of time were spent only observing the meeting, or the workshop, hence body language, and feelings were considered important too. In general, observation may also be influenced when popular images and beliefs counteract against the description and understanding of the phenomenon under study.

One of the main challenges has been reaching the complete access to the firm, and, particularly, keeping contact with the firm. Even though obtaining access has been facilitated by being part of a specific research group, I still experienced some issues in finding the right case study to focus on, and which would have given me the right information to analyse through SaP and ANT lenses. However, having the access to participate in meetings and workshops proved to be the right context in which apply ethnography and follow the actors during CIS (e.g. how they collaborated through technology such as BIM, and implemented innovation strategies in specific settings). I also had some issues in keeping contact with the people inside the firm. Attending various meetings with the same (or almost the same) participants and conducting interviews helped me to get recognised by some people in different settings. This made me feel more part of the group which I was with and made me feel more comfortable to informally interact with some people and minimize the tendency for others to behave differently with me.

Another challenge was being able to follow all the technical discussion during meetings. Since many different participants were present and the dialogue was very technical, I sometimes struggled to understand everything since many abbreviations were used, and they sometimes referred to situations in which I was not present, thus I did not completely understand what was being said. However, video and audio recordings really helped in the analysis phase to listen to the meeting as many times as necessary. I could also ask to the direct participants to fill some gaps of the discussion, for example during formal interviews or informal conversation. Although I experienced some challenges during my data collection, the ethnographic research allowed me to get an inner look inside the firm, and participating in meetings and workshops facilitated the understanding of collaboration and interactions with the supply chain in a way in which it would have not been possible otherwise. Moreover, it helped me to familiarise with the construction environment and with all the roles involved in a project, particularly with the aim of following the actors and the way in which they interact with each other and with technology. Hence, this research method which is linked to a SaP perspective and an “ANT method” because it is focused on the actors, their relationships, and the way in which they do strategy, resulted beneficial for answer my research questions.

4.3 Presentation of the projects and pluralistic contexts

After the presentation of the organisation, it is important to discuss the projects in which I was involved, and thus the organisational settings, or pluralistic contexts (due to the presence of different organisations), where CIS takes places.

4.3.1 Defining the pluralistic context under study

It is important to clarify what the term "pluralistic context" means since it will be central to this research. They are organisational settings which refer to physical places inside an organisation and the different actors found within. These different contexts are linked together by processes of collaboration and strategizing among actors, including both human and non-human. Hence, they represent the places in which CIS takes place, and the dynamics of the actor-network can be analysed. For example, among the organisational settings under study, there will be project design meetings in which design managers, BIM managers and other professional roles of the contractor firm will lead the meeting with the supply chain (e.g. sub-contractors and architects). This setting is identified as the context in which the actors collaborate and strategize together as BIM is implemented, and the main purpose is to elaborate the architectural models and discuss on-site issues. Another organisational setting is the relationship meeting involving one person from the contractor firm and other one or two people from the mandated supplier firm. This other context can be identified as the quarterly meetings to manage the partnering relationship between the two firms and it is placed in a small room in the main Purchasing office of the contractor, and it is a rather informal talk between the actors, even though a pretty strict schedule of topics is followed.

Other organisational settings include the supply chain conference, and other workshops. Regarding the sub-regional supply chain conference, it can be identified as a strategic event which aims to build trust and closer relationship with the supply chain. According to the regional divisions of the business, it is held in different sites across the UK and it is a rather formal event in which suppliers' awards are also distributed. However, the conference usually ends with a social night in which the context becomes more informal and helps to build closer relationships. Concerning workshops, there are different types, some are more technical, such as design workshops (e.g. regarding BIM), while others are held for

different purposes (e.g. more formal workshops during conferences, or in strategic event for specific products). They are identified as being based on communications and opinion sharing and involving more suppliers' firms. It can also be considered as a learning platform both for the contractor both for the suppliers. I will now explore these settings more in depth.

4.3.2 Standardised housing project (SHT)

The first project is part of the residential part of the construction firm, and it aims to model standardised housing through the implementation of BIM. This project was ethnographically followed for this study during a period of three months and a total of five meetings and workshops were observed. The project was actually an exercise started by the contractor to spread the implementation of BIM both within the organisation, and to the supply chain, and enhance collaborative working. This exercise can be considered an innovation in terms of collaborative decision-making and use of BIM to get to a standardisation of design and processes, but it also represented a learning process for the suppliers. The meetings' aim was to engage suppliers with the BIM learning process and understand the level of detail of BIM by looking at the 3D architectural model (Revit) and the suppliers' models (e.g. timber frame, steel frame and roofing). The purpose of the project is to develop standardised house models with standard components, which possess fixed specifications, fixed design, and fixed cost in order to create a "repeatable product" to apply quickly in other designs.

The meetings were very intense in terms of actions and decisions to make regarding the modelling phases of the houses, and they represented an interesting setting to observe how a diversity of people (e.g. suppliers, architects, BIM managers) collaborates. As the timber frame supplier and the roofing supplier were still in the initial stage of learning how to use BIM, the Revit model was designed by an architect coming from an external firm. As the suppliers presented their 2D-CAD models with other pieces of software, the aim was to translate those models into Revit with the help of the architect's and the firm's expertise. It was therefore necessary to find a process to get these different programmes mutually compatible in order to transfer the information required from the suppliers to the architectural model. The involvement of technology (non-human actors) to understand how collaboration and strategizing combine together theoretically links to an ANT perspective and will be analysed in the next chapter.

The meeting was video- and audio-recorded as part of a targeted ethnography in order to being able to analyse it afterwards as many times as necessary. The video camera was placed at the rear of the room so that it caught all people sitting around the table and the screen where all the models were projected (Figure 4.1).

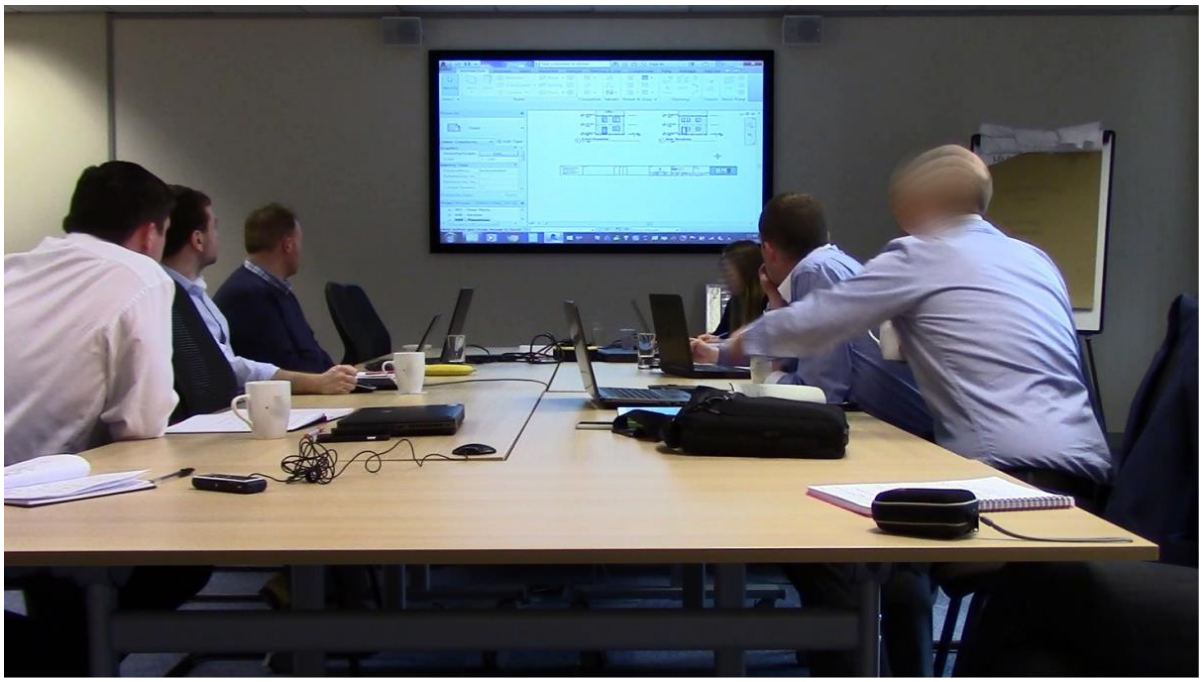

Figure 4.1 Participants sitting around the table and discussing while looking at the screen as caught on video camera.

4.3.3 Standardised school project (SP)

The other project concerns the development of schools through BIM and standardised components. Even though the occasions to observe meetings for this project were limited compared to the first one, it was possible to participate in two design meetings gathering BIM and design managers, suppliers (e.g. M&E) and structural engineers, and conduct some interviews inside the construction firm and with some suppliers. One of the meetings aimed to outline the lessons learned on site. The Design Manager was indeed following a very long and thick list of observations made on site and they discussed about what it worked, what it should be changed, and what new standard processes/products should be introduced for the next projects.

This project can be considered one of the most innovative paths launched by this construction firm and it offers: cost-efficient solutions to the increasing demand of school

around the UK with a fixed cost, and fast and on-time delivery thanks to standardised components, off-site construction and a strong supply chain. The process is similar to the SHT, but it is actually a joint venture between the firm and a public-sector organisation, hence it combines public sector know-how with private expertise, whereas the housing project is developed directly by the private contractor.

4.3.4 Relationship meetings

Relationship meetings are part of the normal meeting schedule between the contractor and the mandated supplier. They are held approximately every three months and the purpose is to discuss some points of interest for their partnership (e.g. quality, sustainability, product development, innovation, general relationship). Hence, they represent a good-practice method to build stronger relationship, to discuss any kind of issue that the supplier is experiencing, to do problem-solving, and to review what it has been done to include the supplier company into the business. The observation of two of these meetings, with two different suppliers, allowed to get a real sense of the way the firm and suppliers manage their relationship and collaborate towards reaching mutual goals, as declared in the supply chain agreements. The meetings involved one “mediator” from the firm and one or two people from the supplier company. Therefore, the discussion resulted to be rather informal and relaxed.

4.3.5 Workshops and supply chain conference

The supply chain conference is an annual event which is organised in different region in the UK involving the mandated suppliers. It is an all-day event and its purpose is to build stronger relationship and to recognise the work done as a team with pictures and videos of the developed projects and with the distribution of awards. It is also a chance to highlight the values that they share and the future strategies. The firm used different visual technologies to communicate its values and main facts to the suppliers. For example, a PowerPoint presentation was used to share some main concepts regarding the firm’s strategy. Moreover, some videos and pictures, which were taken directly on construction sites, helped to engage and motivate suppliers even more by showing tangible outputs resulting from the joint work.

The second part of the conference involved four different workshops, each to discuss about four different topics: people (community), BIM, supply chain, and products. For example, the supply chain workshop emphasised the importance of proactive relationship, feedback on pre-construction, and performance. They represented an occasion to debate on some aspects of the working practices and highlight some issues. Therefore, the workshops provided another example of the contractor's willingness of collaborating and improving the relationship with the supply chain. Figure 4.2 and 4.3 below show the gatherings of suppliers for these workshops.

Figure 4.2 Suppliers gathered in the "Supply Chain" workshop.

Figure 4.3 Suppliers gathered in different workshops according to the topic to be discussed (during the supply chain conference).

Another all-day event workshop was also attended and concerned the discussion about doors as standard components of buildings. Hence, the workshop was attended by door manufacturers and installers, and by all the different regional offices of the contractor firm. The event comprised of a PowerPoint presentation, general discussion about some topics around the tables of participants, and some interactive group discussions. The workshop was also a social event which created an informal place to interact with other companies and bond even more with the contractor. A more detailed analysis of all these events, which represent very interesting settings for collaboration, innovation, and relationship building, will be presented in Chapter 5.

4.4 The process of data collection and analysis

This section aims to present and discuss the reasons to adopt the research methods which have been chosen for this study, and how the data has been organised and analysed.

Moreover, some personal considerations about the process of data collection will be discussed. The research uses a qualitative approach for collecting data. Targeted ethnographies in meetings and workshops between suppliers and firms were conducted, as well as in-depth interviews with managers from the firms and the supply chain. Looking retrospectively on how the ethnography has been conducted may lead to novel perspectives about actors' interactions and activities, but at the same time this process can cover some challenges for the researcher which will be discussed in the next section. In-depth interviews and document analysis have also their limitations, but they still provide some very interesting insights into the case study as they complete the information gathered through ethnographies.

4.4.1 Conducting ethnography and observation research

Before exploring my experience of conducting ethnography, it is important to first highlight some aspects of this research method in literature. Qualitative research methods can be classified into three roots, representing different ways of knowing: experiencing, enquiring, and examining. These categories develop into non-participant observation, participant observation, interviews, and archival techniques (Wolcott 1992). Ethnography may be considered as a theory for conducting research, rather than a practical guide on which techniques and tools to employ. Indeed it includes several research methods, such as participant observation, in-depth interviews, and conversations (O'Reilly 2012).

These methods enable the researcher to get an inner look of the field. For this reason, it could be argued that ethnography is more holistic than quantitative methods because the researcher obtains closer and richer knowledge of world as it is lived not as it is presumed to be by scholars. Hence, as previously discussed, ethnography is well suited to ANT approach concerned to follow the actors and observe their actions as they occur in a particular time and setting. However, trust needs to be established, and continually renegotiated, between the ethnographer and the actors under study (Brewer 2000). Trust helps the ethnographer to be part of the context and to openly communicate with people who may feel more open and secure in relating to an "external" person.

Ethnography refers to any qualitative research, usually involving participant observation, presenting an in-depth analysis of an everyday context. There is not a unique definition of ethnography since the term is very variable and contested. For example,

Hammersley and Atkinson (2007) focus their definition on the actions of the ethnographer and the type of data collection gathered: “ethnography usually involves the ethnographer participating (…) in people’s daily lives for an extended period of time” (p. 3) watching, listening and asking questions. On the other hand, Fetterman (2010) emphasises more on the value of ethnography as an “ambitious journey” which aims to tell and then interpret “credible, rigorous, and authentic stories from the perspective of local people” (p. 1). Ethnography has its roots in the scientific anthropology of exotic cultures during the 1920s (e.g. Mead’s research in Samoa). The ethnographer’s analysis was then purposefully detached from the subject under study to suggest a level of scientific objectivity in ethnographic accounts. However, this static and descriptive approach changed in the following decades towards a balance between subjectivity and objectivity (Clifford & Marcus 1986).

An important consideration, arising from the first ethnography studies of foreign cultures, is that of the deep distinction between ethnography and a mere travel description: “the traveller just passes through, whereas the ethnographer lives with the group under study”. This highlights the importance of the interpretation of the ethnographer. What they see and listen to in the field needs to be interpreted through his/her lens, establishing the boundary of the research (Clifford & Marcus 1986). Conducting ethnography is thus a practice-based approach to studying social reality, and is commensurate with the combined theoretical approaches of SaP and ANT. This practice-based view allows an analysis of social interactions, and interactions with non-human actors too. An issue arising from this consideration is that the researcher may become too involved in the study, hence changing the natural setting and the quality of the research (Robson 2011).

This can be offset, for example, through the researcher’s reflexivity of the social dynamics of the context under study. When the ethnographer wrote down what he/she observed, reflexivity becomes important to give meaning to the data. Hence reflexivity works as a bridge between interpretation and the writing of the text, and it requires a critical attitude. Reflexivity represents a factor of discussion among ethnographers. On the one hand, it can be argued that reflexivity is a problem, because partial knowledge is presented through research and thus the legitimation of data is biased. On the other hand, reflexivity represents a solution because it explicates the partial nature of the data, whose legitimation and representation can be improved (Brewer 2000).

Ethnographers have a constructivist approach concerning human social action: they believe that the social world is constructed by people's interpretation and the actions based on these interpretations (Hammersley 1992). This constructivist view is also shared by SaP and ANT which imply a study of the social world in which the single individual understands reality through the surroundings and his/her behaviour, thus reality is a product of human beings interacting with the world. In this context, the aim of the researcher is cultural interpretation which requires creativity, imagination, and skills of the ethnographer, but also being able to assess and balance between plausibility and credibility (Hammersley 1990). Moreover, due to the long period of engagement between the researcher and the people under study, ethical issues arise at all stages of ethnography. For example, the ethnographer has to protect the wellbeing, autonomy, safety, and dignity of all people being studied (Iphofen 2015), and also he/she should try to stay impartial. This means, for example, that the researcher should stay as detached as possible with his/her personal opinions and preferences.

An ethnographic study thus implements observation as the main research method towards the "object" of interest. Observation may be employed in an exploratory phase where some initial data are gathered as precursor to the study, or as a supportive method which complement data taken by interviews. The observer's role changes according to the extent of participation in that particular context. For example, the "participant observer" becomes a member inside the observed group and establishes a role; in this case, the design is flexible and unstructured since it usually includes conversations. On the other hand, the "pure observer" usually uses a fixed design and structured method of analysis.

Four different participant observers can be identified: the "complete observer", the "participant as observer" (the researcher takes part in the activities and can ask question to the group), the "marginal participant" (largely passive, but accepted in the group), and the "observer as participant" (the researcher does not take part in any activity, but his/her status is known to the group). Finally, non-participant observation means being inside a particular context, but the researcher does not participate, but only tries to listen and understand the context (Robson 2011). In this study, I was a "participant as observer" during meetings, conferences, and workshops. This condition allowed me to be involved in some if the organisation's activities and interact with the actors who were present. The

presence of the researcher was known by the actors involved, and it did not seem to strongly influence the way in which the events or the activities were occurring. This type of observation revealed to be useful both to observe the event from an external perspective, and to informally talk to some participants. More formal and specific questions were then asked through longer interviews.

It is important for a qualitative researcher to develop a trustworthy study which responds to four criteria which have been proposed in literature: credibility, transferability, dependability, and confirmability. Credibility aims to understand how congruent are the findings with reality and, in order to accomplish this criterion, the researcher has to employ different tactics, such as well-established research methods, triangulation, iterative questioning, and frequent debriefing sessions (Merriam 1998; Shenton 2004). Transferability relates to the extent that the research can be transferred to the real world. Some authors suggest that it is responsibility of the research to provide enough description of the context around the fieldwork and to establish the boundaries to enable the transfer by the reader (Lincoln & Guba 1985; Firestone 1993). Finally, dependability relates to the capability of performing the required functions in different times, whereas confirmability has to assure that the work's findings results from the experiences of informants, rather than from the researcher (Shenton 2004).

Hence, observation methods represent a fundamental part of qualitative research. Observing a particular context where people work or live normally enables the researcher to analyse information and behaviours that would not be highlighted during interviews. Hence, it is possible to follow the actor when action occurs and analyse the strategizing activities in a specific time and space, as it demanded by the combination of SaP and ANT. Nonetheless, the observer must be skilled and usually the information gathered in the fieldwork through observation alone needs to be complemented with other methods of analysis, such as interviews or documentary analysis, to obtain a holistic picture. Despite its benefits, some criticisms still persist, particularly by positivists who criticise the existence of multiple interpretations of reality. These observational methods are therefore useful for my research in order to capture the often less considered, perhaps mundane, strategizing behaviours and practices within an organisation's meeting or workshop involving different participants, and which might be taken for granted or not viewed as significant by actors in an interview.

4.4.2 “Targeted ethnography” inside the organisation

This research will use an ethnographic approach for collecting data, and it will comprise of short ethnographies, or “targeted ethnographies”, in different organisational settings with the support of audio and video recordings. The use of targeted ethnographies represents a method of data collection which requires short periods of fieldwork (e.g. weeks or months), even though it is a "data intensive" process (Knoblauch 2005) in which a lot of different data collection techniques should be used. In particular, the support of audio- and video-recording of activities helps to extend the ethnography beyond the actual encounter (Pink & Morgan 2013). It is thereby possible to collect and analyse lots of data without being present for long periods on field. For this study, being able to record meetings allowed me to listen to the discussion as many times as necessary, and thus to elaborate a richer analysis than using field notes alone. Moreover, it allowed me to spend more time in the field to observe interactions with technologies and innovations rather than just taking detailed notes of conversation. This is particularly important for an ANT-SAP approach to exploring strategizing where “doings” or following the actors that influence the action (Latour, 2005), are emphasised over “sayings” (see Figure 3.1 by Seidl and Wittington’s diagram about tall and flat ontologies).

Observing a particular event, such as a meeting, also allows the researcher to be present when unplanned events occur. Therefore, it is possible to analyse the micro-dynamics of interaction of actors, the type of activities conducted, the setting where the event is taking place, and any change or issue that may arise in that precise moment. It also allows to focus on the language used, the body language (e.g. hand gestures, facial gestures, bodily comportment position), and the responsibilities of the actors involved. Hence, ethnography conducted inside the firm can offer an inner look in the organisation and its everyday routines. Moreover, it is also possible to have informal conversations with employees, and thus widen the views of the actors and the knowledge of the organisation. Hence, an ethnographic approach allows a deeper insight of the organisation compared to information coming only from face-to-face interviews or surveys with employees, managers, or directors who may, in attempt to manage impressions, depict only the “positive” side of collaborative innovation strategy implementation.

Being an external observer may also represent an opportunity to interpret actors' *praxis* (as discussed in Chapter 3, the term from SaP concerns the actual everyday activities

of actors, or *practitioners* in SaP terms, in strategizing) and organisations' practices in a different and novel way compared to the actors directly involved. Collaborative innovation and power asymmetries may also be understood through the ANT concept of *translation* during study. For example, the process of making decisions on technical aspects of the project may become a learning process for actors, helping enrol them in support of a strategy, and lead to the development and circulation of innovative strategies. Nonetheless, in-depth interviews are still important to understand how the firm is organised, including specific processes concerning the relationships with the suppliers is intended to be managed, and to obtain a subjective and deeper understandings of the actors in terms of their views concerning supply chain relationships, values, and approach to innovation.

In a study by Hartmann (2013), ethnography, which includes observations and informal talks, served as a way to reveal micro-cultural aspects which were embedded in everyday practices within the project team. Such approach enabled the researcher to understand collaborative relationships between two parties as a process of learning involving the project team and the researcher. An ethnographic method may thus also reveal some interesting aspects of the relationships between the contractor and the supply chain, and it will highlight how collaboration and innovation, which are aimed for in their vision and strategies, are implemented. Hence, ANT would be a lens to analyse these relationships which form the network of actors, and with SaP I would focus on the actors' everyday *praxis* that encompass collaborative innovation strategizing. For all these reasons, an ethnographic approach is the most appropriate method of data collection for this study.

4.4.3 In-depth interviews and document analysis

In-depth interviews and document analysis aim to integrate and complete the ethnographic study. In-depth interviews are useful to get a detailed point of view from some actors who may also be involved during the event observed through the ethnography. Hence, they contribute to the ethnographic field notes by allowing the questioning of main issues arising during the observations, and the views and feelings of actors on those issues. A total of ten semi-structured interviews were conducted of about one to two hours each with the main people involved in the analysed projects. Regarding the SHT project, the interviews were made with two mandated suppliers (one was the Business Development Manager and the

other was Sales Director), the architect, the Design Coordinator, and the Head of BIM of the firm.

Another interview was then jointly conducted with the Purchasing Manager and the Product Manager, who work in the Purchasing office of the firm and are in direct contact with the supply chain in terms of selecting the right suppliers, set up the supply chain agreements, and engaging with them throughout the working relationship. Two other interviews were conducted with the Product Director responsible for innovation and improvement (John) in different time periods (one in 2016, another in 2017). Moreover, since he was the main contact with the firm, other meetings were held with him to discuss about the research project and other topics. Another interview was held with the Product Manager for the school projects, and with one of the mandated suppliers for suspended ceilings in the schools. See Table 4.1 for a detailed summary of these interviews. The topics covered ranged from basic information, such as personal and professional background, to general views about innovation and the industry, the implementation of BIM, collaboration taking place in the projects, relationship management, and the role of innovation within the supply chain.

Interviewees (Name and/or job title)	**Where and when**	**Duration**	**Company**	**Description of Role/Relationship with TCC**	**Position in the supply chain**
John – Product Director	Skype, Spring 2016	01:09:00	TCC	Product and Innovation Director	Contractor
Sales Director	Skype, Spring 2016	00:50:13	TFC	Sub-contractor, supplier of timber frame	"Category A" supplier (mandated supplier)
Product Manager (for SP)	Skype, Spring 2016	01:36:27	TCC	Product Manager for the school projects, managing	Contractor

				innovation and mandated suppliers' design meetings	
Architect (for SHT)	At AC, Spring 2016	01:06:29	AC	Architect, external consultant for Revit	External consultant leading the implementation of Revit with the suppliers
Design Coordinator (SHT)	At TCC, Summer 2016	01:02:28	TCC	Coordinating the standard housing project and the different actors involved	Contractor
Business Development Manager	At RC, Summer 2016	00:40:58	RC	Sub-contractor, supplier for timber roofing engineering	"Category A" supplier (mandated supplier)
Purchasing team	At TCC, Summer 2016	01:12:39	TCC	Purchasing Manager and Product Manager involved in the selection of suppliers and managing relationships	Contractor
Head of BIM	At TCC, Summer 2016	02:05:35	TCC	Head of BIM involved with the training programme	Contractor

				within TCC and suppliers	
Key Account Manager	Skype, Winter 2017	00:30:28	RN	Supplier for suspended ceilings	"Category A" supplier (mandated supplier)
John – Product Director	Skype, Winter 2017	00:39:20	TCC	Product and Innovation Director	Contractor

Table 4.1 List of interviews with additional information.

These interviews were very important to highlight the role of the interviewee, his/her thoughts about the projects, the relationship with the other participants, to understand the other companies which were involved and their goals, interests and culture, and some challenges that they encounter in their working practices and relationship building with other partners. Such interviews are also important within the SaP-ANT approach that I am using, because they permit a deeper analysis of the actors. This can help getting further information about the characteristics and dynamics of the actor-networks and can also reveal the actors' perceptions of technology (non-human actors).

In general, in-depth interviews are essential to increase the understanding of the ethnographic study and vice versa. However, it was observed that, during interviews, the participants were all trying to depict the positive aspects of the partnering agreement and the collaborative process. Indeed, the fact of interviewing suppliers, who have signed a partnering agreement with the contract, probably affected the way in which they answered the questions regarding their thoughts about the relationships with the contractor. Hence, in this case, it was useful and interesting to compare what has been said in the interviews with what it has been observed during meetings and workshops, particularly when more actors (e.g. multiple supplier firms, architects) were present.

Document analysis also played an important role by providing some background information regarding the firm's culture, strategies, and supply chain management and

development processes. These documents include the official website of the construction firm and embedded information (e.g. annual reports, videos, descriptions of products and processes), the "supply chain agreements" as they are disclosed to the suppliers, other documents which were distributed during meetings (e.g. agendas, meeting minutes, project plans), and documentary information about BIM. This analysis was also useful to better understand some aspects of the company, such as the roles of the people involved in the projects under study, the projects themselves, and the details of the rules of the partnering agreements with the supply chain. These documents assume an important role in ANT as objects which establish the shared agenda's goals and interests. Hence, the non-human actors affect the social dynamics within the actor-network and can thus influence CIS.

4.4.4. Bringing the dataset together in line with my theoretical approach

Analysing all these different dataset (observation, interviews, and documents) around my SaP-informed ANT approach was different. Concerning observation data, which means field notes, photos and videos, as I will explain in section 4.4.6, I identified some main themes which emerged during meetings, workshops, or conference. This helped me to analyse a huge amount of data. However, observation data also included notes concerning the actors' feelings, expressions, and voice tone, as well as analyse their activities and discussion which arose in these contexts. Hence, within an ANT and SaP perspective, this assumes importance since it shows the "doings" of the actors and focuses on their relationships and interactions with technology. This dataset also informed my analysis after a process in which I wrote down my thoughts on what I observed as a way to extend the field notes. This writing phase allows to link the observation notes to theory as a "pre-analysis" process.

Interviews represent another huge set of data which aimed to understand the actors' point of view around some themes which I wanted to explore, and which also were observed during ethnography. In this case, the dataset informed the theoretical approach as it provided the background context to understand how the actor-networks were created, and how the relationships between TCC and the supply chain formed and developed through the partnership agreement. Documents also represented the background information needed to understand the characteristics of TCC and its supply chain. Also, documents coming from the observed meetings and workshops worked as objects influencing the actors' collaboration and strategizing, as it is discussed in Chapter 6.

Therefore, they assume importance under an ANT lens since they are non-human actors directly shaping CIS and relationships among the human actors.

4.4.5 Ethical issues and reflexivity

Ethical issues for conducting qualitative research involving people and firms are very important to consider. The first ethical issue to consider was to make sure that all the people involved in the case study agreed to participate. In fact, it is important that all the actors involved in my data collection process knew that the topics and activities occurring in meetings, workshops, and interviews were used for research. In order to do so, all the people interviewed and observed were asked to complete an "Informed Consent Form" which was linked to a "Participant Information Sheet" to agree on participating.

The first form was a tick box which asked whether the research study was clearly explained, whether the potential participant wanted to be part of it or not (with the choice to withdrawal from it at any time), and that all the information was going to be strictly confidential and anonymised. Hence, since confidential information will be used, it is necessary to anonymise data (e.g. name of the participants, companies' names). The anonymised names have been created by using imagination names, or the first letters of the type of organisation (e.g. timber frame company has become TFC), or project (e.g. school project has become SP). This form had to be completed after reading the Participant Information Sheet, whose aim is to explain what the research is about, the researchers involved, and the type of research methods to be implemented. Moreover, a broader confidentiality agreement has been signed by the construction firm (the contractor) since the research project will partly explore its structure and commercial interests.

A second ethical issue to consider, and which was part of conducting an ethnographic method, was whether the actors, who knew they were being observed by an external person (myself, the researcher), felt different and less able to express their normal thoughts and behaviours during meetings. The risks would have been to alter the normal execution of the meeting, or workshop, leading to different actors' interactions and collaborative strategizing. Moreover, video and audio recording were also used, and some still photographs were taken. Although all this data was anonymised, its collection may still have caused some participants to not completely behave normally. My approach to this challenge was to be as open as possible about the research study, and to not interrupt the

normal execution of the meetings and other events, unless asked directly to do so (e.g. when we were asked if we understood some technical aspects that they were discussing, or just some questions). During relationship meetings, which involved only one person from the contractor, and one or two persons from the suppliers, this issue could have been emphasised even more. The observations were not recorded for confidential reasons, but I was present in the meeting room and taking notes of what was happening. The suppliers agreed on my presence and trusted the contractor's decision to have me there. Some of them also showed interest in the research and asked further questions about it.

A solution to the potential risk of distracting, or influencing actors' behaviour, and altering the normal execution of the collaborative activities, was to combine the interviews with ethnography (also with audio and video recording), in order to obtain a more holistic understandings of what is actually happening within a meeting room, or other events with the supply chain. During a formal interview the respondents may feel more conscious about what to reply, and they could positively emphasise some aspects of the firm, or of the relationship with the supply chain, which may not be completely correspondent to events elsewhere. Hence, with this solution is possible to observe the feelings of the actors, their interactions, and the decisions made as they occur.

Another ethical issue which could influence the research is gender and native language. Being a young non-English female conducting a research study within the British construction industry, which is mainly a male and middle-aged dominated sector, does not seem easy. Particularly during ethnography, some gender issues may be more frequent, because of the presence of most male actors during fieldwork. I personally felt a bit insecure at the beginning of the fieldwork because of my decision to research a context in which I never worked and being a foreign environment. This made me feel as an "outsider" in the first period of fieldwork and I worried this would compromise my analysis and findings as I could find it difficult to gain trust of others.

Most ethnographic research still assumes that trust is more easily gained by the researcher if he or she is similar to the group members. This factor may explain the predominance of male researchers in ethnographic studies of members of male-dominated groups (Bucerius 2013). Nonetheless, ethnographers in fields such as anthropology have demonstrated that a high level of dissimilarity between researcher and research participants has a rich potential for developing novel understandings of the field (Powdermaker 1966).

Bucerius (2013) highlights that "being an outsider is not a liability one must overcome, because achieving status as an outsider trusted with "inside knowledge" may provide the ethnographer with a different perspective and different data than that potentially afforded by insider status" (p.2). The "inside knowledge" she cites helped her in her study to get closer to the target group as she was able to start conversation and a relationship by discussing some topics which interested the group. In my research, the interest for my research studies and my personal background (e.g. being an Italian studying abroad) worked as "inside knowledge" to start conversation with some actors during fieldwork (e.g. during workshops, or the conference).

I would also highlight the fact that being a young woman involved in these male-dominated events could have arouse curiosity of some of the participants who then started conversation with me, whereas it could have restrained others from talking to me. Hence, my gender and identity influenced the way in which I collected data, but not inevitably in a negative way. As Thomas (2017) in his study of male researcher within a women-dominated context argues: "My differentiated body and performance did not necessarily hinder the study, but, in fact, played a role in ensuring access, developing relationships, and collecting data" (p. 9).

Moreover, the fact of being involved in design meetings, and strategic and training events, softened this ethical issue, which could have been more emphasised if the research was mainly conducted on construction sites. Indeed, if I were on a construction site, mostly all of workers would have been males (e.g. technicians, bricklayers, and other type of construction workers), making my presence stand out in such context. Since I conducted ethnographies in the managerial side of the firm, sometimes I was not the only woman on fieldwork since there were some women working in administrative and managerial roles inside the organisation.

Finally, another ethical factor to consider would be the fact that my main access to the organisation and project was the Product Director ("gatekeeper") who was the main proponent of the innovation strategy and BIM. Hence, it might be the case to question whether the fact of such strong point of access contributed to influence the behaviour and consideration of the other actors (e.g. other managers inside the contractor firm, and inside some supplier firms) towards my research. I do believe that, being the Product Director the gatekeeper to accessing his firm, influenced in some ways how the other actors responded

to my presence and agreed on having me observing their normal activities with the suppliers. The suppliers themselves could have felt even more hesitant, even though they knew about anonymization and what the research was about, but they showed to fully trust on the Product Director's decision. Nonetheless, I noticed how some of them were more talkative and open to me, whereas others did not want to disclose more information apart from what it should have been discussed in the meeting, or workshop. Finally, some meetings, or events were off-limits for me because of sensitive information.

4.4.6 Coding with NVivo and SaP-ANT analysis

All the collected data, such as observation notes, interview transcriptions, video and audio recordings, pictures, documents, and website links, was coded with Nvivo 10 (*http://www.qsrinternational.com/*). The reason to choose this software is that it allows a large amount of qualitative data to be organised, and analysed by using "nodes" which help to connect different forms of data when they have a theme in common, or when they include some information which needs to be emphasised in the analysis. The term *code* in qualitative analysis usually refers to "a word or short phrase that symbolically assigns a summative, salient, essence-capturing, and/or evocative attribute for a portion of language-based or visual data. The data can consist of interview transcripts, participant observation field notes, journals, documents, literature, artifacts, photographs, video, websites, e-mail correspondence, and so on" (Saldana 2016, p. 3). An important characteristic of coding is that is allows to link data and ideas: "It leads you from the data to the idea, and from the idea to all the data pertaining to that idea" (Richards & Morse 2007, p. 137). Hence, the purpose of coding is to organise and group data into categories which share some characteristics.

During the coding session of my data, I identified a list of patterns which stood out from interviews, videos, field notes, and documents. First of all, I identified the main themes of my research: collaboration and innovation. The theme "collaboration" was very broad, but it represented the main theme of this study, hence I aimed to gather all the information of collaborative activities and interactions of actors. For example, I analysed the text of transcriptions and videos of meetings, workshops, and conferences with the supply chain, looking for points of discussion, the level of the actors' involvement, and thoughts on collaboration from participants during interviews (e.g. how the contractor aimed to involve

the supply chain in collaborative activities, how much influence the suppliers had over those activities to influence strategizing, and also some of the suppliers' thoughts about having these kind of collaborative working practices with the contractor). The theme "innovation" was also very broad, and it gathered information about change within the organisation, such as the introduction of innovative practices, or products which are part of the contractor's main innovation strategy of increased collaboration and involvement of the supply chain.

From these two main patterns, I linked more codes which fell below both collaboration and innovation, and which emerged from my data. They can be called "simultaneous coding" since two or more codes are applied to a single datum (Saldaña 2016). For example, under the theme of collaboration, I coded "BIM", "power", and "relationship with the supply chain". I decided to add the code BIM as it is very important in order to answer the research questions concerning the collaboration with the supply chain, and, in this case, it related to how BIM was implemented collaboratively, and how it influenced collaboration among the actors. Another sub-theme emerging from BIM came from the analysis of data and referred to "technical issues with BIM and other software". Indeed, during meetings it was possible to notice how the use of BIM was tough for some suppliers (because it was a new software for them), and how the communication between BIM and other software had to be improved.

Regarding the "power" code, it was a theme which I purposefully looked for from the data, because it is linked to my research question aiming to understand how suppliers' and objects' involvement really influenced CIS. This theme aimed to gather all information, and actions, which emphasised the actors' power dynamics which have been observed during ethnography, or which have been highlighted during interviews. The concept of power dynamics assumes importance both in SaP and ANT, and may come both from human and non-human actors, who can influence strategizing. Finally, the code "relationship with the supply chain" aimed to highlight the relationship management between the contractor and the supply chain, and the values that they shared.

Concerning the code "innovation", other codes fell under it, such as: "BIM", "supply chain agreements", "school project", and "standardisation". BIM was also coded underneath "innovation" because in this case it referred to BIM as an innovation strategy within the organisation and an innovation for the supply chain. The code "supply chain agreements" aimed to gather all the information about the contract, and how it influenced

the contractor's and supply chain's relationship since it represented an innovation inside the organisations. The code "school project" represented the most innovative project led by the firm for a longer period of time, and I wanted to keep it separate from the main SHT project which I followed more carefully. Finally, "standardisation" was linked to the interviews in order to understand how the contractor's main strategy was understood by the actors and its outcomes in practice. Hence, other codes falling below this were: off-site construction, and standardised products and branding.

Another code was "objects" which referred to all the technology and specific objects used during the organisational settings under study, and which were implemented through social relations by the contractor and suppliers. The reason to have this code was to understand how these objects (e.g. BIM, other software, documents, PowerPoint presentations, and the standardised products, such as schools and house types) influenced CIS. This code was created through the data analysis, because data revealed the importance of these objects during ethnography. Moreover, they acted as main actors for the implementation of innovation strategizing and did have a role in influencing the actors' behaviours and collaboration as it happened through their use.

During the collection and analysis of all this data, reflexivity was also important. Indeed, having gathered a huge amount of data through ethnographic research meant that the main analysis of data was made after the actual data collection and through a long process of reading notes, listening to audios, and watching videos. The process was further facilitated by transcriptions which were mainly produced by an external transcription company, and the fact of being able to read, listen and watch data as many times as needed. The coding process which I described above was used for videos too. Videos' transcription of SHT actually represented a huge amount of data since the meetings were usually at least two hours long. I was not allowed to record other meetings and workshops, but in that case pictures and notes helped me through coding and analysis.

The theoretical lenses through which data was analysed came from an inductive reasoning: from some observations of events (e.g. the SHT meetings), I induced how CIS may happen between a contractor and its suppliers. This was analysed through SaP and ANT theoretical approach. Hence, from the ethnographic data, I understood that a SaP and ANT lens would help me comprehend how actors collaborated in specific contexts, and thus how strategy was shaped by them as their interactions and activities occurred. Moreover, being

the concept of “actor”, both human and non-human, central to ANT and SaP, I focused my analysis on them and their role through collaboration and ethnography.

An ethnographic research leads directly to an ANT perspective which is based on flat ontologies, thus on “doings” of actors. Moreover, ethnography and ANT helped to understand how the relations of those actors were developed and transformed in specific contexts. Also, technology assumed, in this case, an essential role as main actors of collaborative innovation strategizing, and they were used differently and became different things in different settings. SaP perspective was also important to this analysis being its focus also on actors and their “doings” aiming to shape strategy. Hence, through ethnography and SaP, it was possible to highlight the strategic activities as they occurred in a normal everyday context (e.g. meetings).

4.5 Conclusion

In this chapter the methodology and the research methods of this study have been discussed and justified. First of all, the case study firm (TCC) was presented since it is necessary to understand the organisation’s characteristics before discussing my findings and the reasons for choosing this company. Moreover, the TCC’s projects and organisational settings which will be considered for this study have been described and will be fully discussed in the next chapter. Then, previous literature about ethnography and observation research was examined. Since ethnography represents one of the main research methods of this research, it was first useful to understand its origin, characteristics, previous studies, justify its commensurability with my SAP-ANT approach and research questions, and also potential challenges.

Challenges and benefits of doing ethnography were also reflexively discussed together with an evaluation of some key ethical issues arising from my study and strategies to mitigate these concerns. Use of other data collection methods, within the ethnographic approach, such as in-depth interviews and document analysis, were also presented and justified. Finally, the analysis of data was explained, and justified, including description of how data has been organised in the NVivo software, and how and why this software package has been used for data analysis.

The next chapters will analyse and discuss data by applying my theoretical approach and aiming to answer the main research question and sub-questions. Therefore, the first focus will be on the building of the main actor-network drawing on Callon's model of translation (Chapter 5), thus answering the research sub-questions "what is the firm's strategy to engage with the supply chain? How are actor-networks built?". This analysis will discuss the role and interactions of both human (e.g. actors involved in the SHT project) and non-human actors (e.g. technology such as the architectural software, documents, PowerPoint). Chapter 6 will deepen the analysis of the actor-network by addressing the role of non-human actors in shaping CIS, gleaning from post-ANT. This will answer other sub-questions: "What is the role of innovative technologies (e.g. BIM) and practices (e.g. supply chain agreements, workshops, meetings) in shaping collaboration between the firm and suppliers? Do they assume different characteristics in different contexts?".

Finally, in Chapter 7, the discussion about the results from data about collaborative innovation strategizing, with a focus on power relation will answer the sub-questions: how is collaboration implemented in different contexts? What are the power dynamics arising from different organisational settings (e.g. meetings, workshops)? Therefore, the main research question will be answered ("does the early engagement of supply chains around innovative technologies and practices foster effective suppliers' collaboration and empowerment within the firm's innovation strategizing?"), and the contribution of the theoretical approach and the whole thesis.

Chapter 5

Building the actor-network according to Callon (1986)

5.1 Introduction to Analysis Part One

This first section of the analysis chapter aims to examine the building of a collaborative innovation strategy in TCC firm through the creation of an actor-network starting from the case study and drawing on Callon's (1986) model of translation as discussed in Chapter 3. The term "actor-network" identifies the firm's strategy of implementing innovative and efficient processes through collaboration. Consistent with Callon (1986), four different moments of translation will be identified and in which the network builder attracts, interests, and enrols actors inside this actor-network through various *interessement devices*. These actors can be both human and non-human as will be discussed in the chapter.

The reason to apply this model for discussion is that it provides a clear structure to explain the various stages throughout which the CIS actor-network is built and is functioning. Hence, it helps to understand the context and the motivations for the creation of the actor-network, as well as how the actors involved are connected through this strategy, and aligned through shared interests, goals and outcomes in this strategizing process. Another reason to draw on Callon's (1986) model is that the paper encompasses the classical ANT studies (e.g. Callon & Latour 1981, Callon & Law 1982, Latour 1984, etc.) and provides the terminology in the actor-network building (e.g. *actors, problematization, identities/interests, translation, obligatory passage point, associations*, *human and non-human*, etc.). Moreover, the paper has a significance in literature with a high number of citations.

This first part of the analysis answers two main research questions: What is the firm's strategy to engage with the supply chain? How is the actor-network built? I also revealed who the network builders are. The chapter is structured as follows: since Callon's (1986) study of scallops has already being discussed in Chapter 3, there will not be a section to describe this study. Rather, the data will be directly analysed according to Callon's (1986) model of translation, hence there will be a discussion about how his model can be used to understand the data. The argument will be divided into four phases which represent the

four moments of translation. Finally, the benefits and some limitations of applying this model will be discussed. The benefits will clarify what the applied model can reveal about my data, whereas the limitations can be twofold. On the one hand, there are limitations which have been highlighted in the literature by different authors. On the other hand, there are limitations which arise directly by applying the model to my data and which will be addressed in the next chapter where the concepts such as multiplicity and fluidity will be discussed as mitigating the limitations of Callon's (1986) model. In the last section, a brief summary of the first part of analysis of the chapter will highlight the main points discussed and how it answers some of the research questions.

5.2 The stages of the building of the actor-network

Within my study of TCC, the builder of the CIS actor-network can be identified as John, the Product Director responsible for Innovation and Improvement, including also the development of new products and services, and strategic procurement. He is also the director responsible for the standard schools' project, which provides pre-designed buildings across education and leisure market sectors. The term "pre-designed" means that the projects are standardised (using specific standardised components) before selling it to the customers who can still customise them. The process of standardisation does cover many parts of TCC's business, such as for example, the relationship with the supply chain: the supply chain agreements can be considered a way to simplify and standardise the bid process and the working relationships for present and future projects with suppliers.

Importantly, John's CIS actor-network also exists alongside other actor-networks which all work towards the implementation of John's main strategy, but are not reducible to it (i.e. their serve commensurate but separate goals) and are all connected among each other. These actor-networks are: the CEO board network, the Purchasing team network (including the supply chain events), SHT network, and SP network. The CEO board network, for example, represents the TCC main long-term vision and strategy, and thus John aims to follow this strategy and implement it within other strategies such as the collaborative innovation. While some other actor-networks, such as the SHT network, provide a model, and set of techniques, available elsewhere in the firm, for how to extend the collaborative innovation actor-network for new areas of the business such as housebuilding.

The building of the actor-network to construct the CIS by TCC to include its supply chain can be analysed using Callon's (1986) four moments of translation. In this way, it is possible to understand how John developed this strategy that assembled, or "translated" (Callon 1986) the supply chain's interests. Callon's (1986) four phases of translation are: *problematization* in which translators try to define the problem and an *obligatory passage point* is needed to solve it; *interessement* in which translators draw together actors' interests in order to follow the project; *enrolment* in which the main actors are assigned roles and alliances are built; *mobilisation* in which the actor-network extends its size (Denis et al. 2007).

5.2.1 The moment of problematization

Callon starts the discussion of this phase with a question of the researchers who returned from the journey to Japan to study Japanese larvae: "is this experience transposable to France and, more particularly, to the Bay of St. Brieuc?" (Callon 1986, p. 6). Hence, they question themselves whether French larvae, which are different from the Japanese ones, can actually behave, grow, and respond to the collectors the same way as what they experienced in Japan. In order to start answering these questions, the researchers determined a set of actors whose identities became an obligatory passage point in the building network.

From my data analysis, one main actor-network can be identified, and this network is aiming towards implementing the CIS. The central component of this strategy can be defined as "pre-designed products" which is directly linked to the implementation of BIM and the supply chain agreements. This is because the outcome of BIM implementation, which aims to standardise the design and building process, and the development of supply chain agreements, thus working with fewer supplier firms at earlier stages of the design process, leads to houses, or schools which can be considered manufactured from an assemblage of pre-design products. The development of this strategy with the SP project of standardised schools, is a big innovation inside the firm over the last few years and it is proven to be successful. John's innovative strategy of pre-designed products is explained as:

> I suppose it's just the concept, the notion that you can develop a product to generate a demand rather than develop a response to a demand. It's just different because it's a

> risk. You might develop it up and you might not get anything and that is a risk but it's also that you can develop a product up that you can commit to price on and time on and specification on and it can work. It can work for clients but also as well it can make the margin, if it's set up right, that we want to make in terms of profit. And I genuinely think that it's only been limited in terms of the amount that we've done, SP has probably opened more internal eyes than it has external eyes. It's shown that these supply chain agreements can work and that actually there are benefits to that and in quite a short space of time (…) So it's gone from probably me two years ago metaphorically fighting every single surveyor on every single SP job who thought they could buy a better product to now, a couple of years later, being in the position where we are probably mandating those same suppliers for the whole organisation which I think is a massive, massive change (Product Director- 2016).

Moreover, when he was asked about the biggest innovations within this strategy, he first highlighted the certainty of time scale and cost. Then he also discussed:

> Our commitment to our partners, in terms of our supply chain partners, so unlike most buildings, we don't tender on a job by job basis for the components, we have strategic deals for all our major components, like windows, doors, and everything else. Uhm, that is pretty radical... and it is radical for construction, it is not really radical for anyone else, I mean, (....) these things are pretty common things everywhere else, but are pretty radical in the construction industry which is so far behind. Then the main (second innovation) is the use of BIM, A) to invest the money to get it fully designed at risk before even having a client (…) B) the way we are starting to try new digital marketing in terms of visualisation and augmented reality, it is certainly something we are starting to move on (Product Director – 2017).

A key part of John's strategy of innovation and standardisation is the implementation of BIM which also represents, as cited above, one of the main innovations within the business. The mandated introduction of BIM in the construction sector has come from the 2011 Government's Construction Strategy which aimed to reduce the cost of public sector assets

of 20% by 2016. In order to do so, construction suppliers are required to work with BIM Level 2 for centrally procured government projects. In particular, they are required to have fully collaborative 3D BIM, meaning that all information, documentation and data should be digital and can easily be shared and work upon collaboratively. Hence, the government push towards BIM can be considered a central part of the problematization of the CIS actor-network. From government projects, the implementation of BIM can extend to commercial projects. Indeed, as part of the firm's corporate strategy, the implementation of BIM concerned the development of standard school projects from which made the firm obtained a great success and became very competitive in the school construction market. This success was translated into the residential business of the company in order to successfully develop the housebuilding business which lacked innovation even more. Introducing BIM into the residential development of the firm represents an even stronger innovation since the residential sector is still behind of BIM applications.

There are many benefits of introducing BIM into the business, including a better level of information across different levels of the project. For example, the design models, which are in 3D, allow the actors to change and understand the model directly during meetings and remotely. Hence, it encourages a collaborative and coordinated way of working which is also part of John's strategy of enhancing and involving the supply chain.
In the SHT project, the Project Manager highlighted how BIM encouraged communication among participants in the design phase both during meetings, both remotely:

> The more people that have got involved, everyone has said how useful it has been, because the house design is very simple. All the discussion has been around the process and the formatting and how it works. In design management, I always like to be copied in on email conversations so I can sit and see conversations and issues being discussed and reviewed between consultants. That's my window into the design management process. Allied with that, we have regular sit downs round the table to make it all work so that's how I manage design. In BIM you also have got the online collaboration which is Buzzsaw as we sit at the moment, it now might be BIM 360 but it is an online portal where all that information gets uploaded, reviewed, uploaded, reviewed till it's right and shared (Project Manager – 2016).

Following Callon's theory of network building, the network is created by one actor (the "network builder"). In this case study, the main network builder is John because he has been the actor developing and pushing this collaborative innovation strategy through. He has been managing other offices and the supply chain in terms of relationship building and marketing. His presence acts a guide for suppliers inside the firm and can be evidenced throughout interviews with suppliers. Indeed, one of the suppliers involved in the standard housing project said:

> John got close very early, he was involved in all the interviews with ourselves and other contractors and John always kept this under his own wing so he's run alongside us for quite a while. So, in terms of continuity, John's always been there and helped us along in terms of information or introducing us to other people within the organisation. (…) if there's ever an issue, I'm always available, John's always available and we speak a couple of times a week as well (Sales Director of TFC – 2016).

If Callon's (1986) problematization in his study of scallops tried to answer the questions of "how can we make scallops anchor?", then the question that John aimed to answer could be interpreted as: "how can we implement more collaborative and innovative processes by introducing BIM and integrating the supply chain around the BIM model?" In particular, the network builder aimed to attract the actors' interests to pass through obligatory passage points. The suppliers must be willing to share change in their process. These include: build long-term partnerships with the contractor and being involved in the early stages of projects; being part of a learning process of BIM in order to implement Government's requirements (with the help of the contractor and external consultants); innovate which lead to continuous improvement to gain competitive advantage (it is required by the supply chain agreements). Therefore, in order to achieve such change, they must share an answer to the previous question, and recognise the importance of building an alliance with the firm. Regarding BIM and its competitive advantage, and the importance of signing single-supplier agreements, John explains:

> So the thought process was if we take the fledgling product that we've got and we design it around the technologies, we design it around BIM, we can generate a market

> and (a) provide a differentiator to TCC, (b) it helps our clients, most importantly and (c) it provides pipeline to the offsite people. (…) the idea being that doing these strategic single supplier agreements gives us enough of a carrot to make it worthwhile them innovating. There's something tangible. If we only said we really want you to innovate but actually we'll only give you ten units a year, they might innovate for their own reasons but they're not going to share it with us. We need to give them something properly to get their teeth into. So it's a valuable enough relationship for both parties (Product Director – 2016).

Hence, John hypothesises the interests and identities of the actors (the suppliers) in the collaborative partnership established through the single-supplier agreements, just like Callon (1986) discussed about the interests and identities of the actors developing from one single question ("does the Pecten maximus anchor?").

Since BIM needed to be implemented within the firm in its public projects, hence throughout its mandated suppliers, a huge investment has been made inside the firm to build a network of BIM experts throughout all the regional offices. According to the firm's corporate strategy, and how it has been emphasised during interviews, the introduction of BIM was aimed to stimulate innovation, and improve efficiency and profitability. In particular, BIM can encourage innovation since it has led to innovative practices, such as collaborative working environments during design and relationship meetings and workshops. Indeed, the major involvement of the supply chain in these events can lead to more trust and open communication, and thus to shared innovative ideas.

Moreover, BIM itself represented an innovation both for the firm and the suppliers, particularly for housing development. Hence, even though the implementation of BIM has been mandated by the government, the BIM strategy inside the firm was to go beyond the mandate in order to develop all three main businesses (construction, housing, interiors) and be ready for the required change. This decision to extend the use of BIM is due to the successful results, in terms of time and cost savings and competitive advantage, obtained in the SP project of schools.

Although these changes inside the firm represented a huge investment, John's mandated suppliers also needed to invest a lot of money to integrate BIM. Most of the suppliers who were involved in the design projects had only a limited comprehension of

BIM, particularly Revit[4], which is used to develop the architectural models. Along with the implementation of BIM, standardisation processes and off-site construction contributed to reaching more efficiency inside the organisation. This strategy has affected the relationships with the suppliers and the development of the supply chain agreements are part of this strategy. In this situation, a set of actors are determined, and their identities become an *obligatory passage point* in the network of relationships that are built (Callon 1986). The actors who have been identified by the CIS network are both humans and non-humans. Humans comprise of external actors such as the mandated suppliers, architects, and other consultants, and internal actors such as BIM managers, engineers, directors, and the purchasing team. Non-human actors also are part of the network and are represented by four main groups: technological objects such as software BIM (e.g. REVIT), Buzzsaw/BIM 360 Glue; official documents such as the supply chain agreements, BIM documentations and regulations (e.g. BIM execution plan); architectural models both in REVIT and CAD; Power Point presentations during workshops and conferences.

Until now it has been discussed the hypothetical identities and interests of the actors through John's strategy and following Callon's problematization phase. The table below summarises the actors' identities and hypothetical interests as they have been identified by John.

		Who	**Identity**	**Interests**
Human actors	**Internal actors**	Central Purchasing Team (Purchasing Manager, Product Manager, Purchasing Coordinator)	Responsible for implementing John's strategy; suppliers' selectors and suppliers' relationship managers	- to select the best suppliers for the firm through a strict selection process; - to build strong relationships with them; - to keep daily contact with suppliers and solve any issues with them; - to sign the supply chain agreements; - to organise events to

[4] Revit is a BIM software, part of Autodesk, and it is an intelligent model-based process used to plan, design, construct and manage buildings and infrastructure. It supports a collaborative design process, in which project participants can share information, models, and annotations. It also imports, exports and links data with other common formats, such as IFC (Industry Foundation Classes). Information obtained from: https://www.autodesk.com/products/revit/overview#

				foster suppliers' involvement and trust; - to conduct quarterly relationship meetings with suppliers.
		BIM/Project Manager for Standard House Type (SHT) project	Leader of the SHT exercise	- to lead and schedule meetings every month with all participants; - to follow a strict schedule of meetings and workshops from BIM Level 2 to Level 4; - to foster collaboration by exploring the design process, software implementation and any other issue.
		SP Product Manager	Manager of the SP school range product, standardised components to be built on site and adapted according to clients	- to manage standardised components for schools; - to adapt these components according to clients' and sites' needs; - to collaborate with the other regional offices; - to respond to clients' requirements.
		Head of BIM	Responsible to implement BIM in the firm and in the SHT project	- to implement a constant level of BIM in design processes; - to train and develop employees within the firm so that they understand how to manage BIM processes.
	External actors	GSFC	Single-supplier for light gauge steel frame in SHT project	- to design light steel frame models in the housing exercise and other projects; - to develop BIM capabilities; - to keep strategic deals with TCC (supply chain agreements).
		TFC	Single-supplier for timber frame in SHT project	- to design timber frame models in the housing exercise and other projects;

				- to develop BIM capabilities; - to keep strategic deals with TCC (supply chain agreements).
		RC	Designer manufacturer and supplier of roof truss for TCC: recommended by TFC and GSFC for housing project	- to develop BIM capabilities (they never used BIM before); - to keep up with innovation;
		AC – Architects	3D BIM designer of standard houses; leading the architectural model development; external consultants	- to implement BIM level 2 (they have never done it before); - learning process: collaborating with sub-contractors and using BIM; - to enhance co-ordination.
		RN	Single supplier for suspended ceilings and acoustics	- to partner with TCC in different projects; - to innovate; - to suggest innovative and best components.
		KR	Single supplier for roofing, insulation, infrastructure and structural waterproofing)	- to partner with TCC in different projects; - to innovate; - to suggest innovative and best components.

Table 5.1 List of the actors within the CIS actor-network and their interests.

Focusing more carefully on these actors, the Purchasing team plays an important role in selecting the suppliers and developing their interests. For this reason, John's responsibility of choosing the right suppliers has been transferred to the Purchasing team. He particularly emphasised the change occurred to the purchasing team and the supply chain managers concerning the relationships with the supply chain:

> They've gone from just making sure that we keep on friendly terms with supply chain partners and making sure that we have enough people of the right calibre, partners of

> the right calibre, dealing with problems if we have things, to actually now that database stuff being done a lot more by our local supply chain people and the people in the centre of the business looking at strategic agreements and partner approaches and different things as well which has been quite a sea change (Product Director – 2016) .

Based on the interview with the central Purchasing Team, their main responsibilities are:

> (…) administering those agreements (supply chain agreements), making sure they're in place all signed up and then collecting the associated fees that go with that. The other people in the team are predominantly involved with that kind of administration collection process resolving any invoice disputes, so it maintains the correct type of relationship (Product Manager – 2016).

Their tasks also concern assessing the suppliers to enter the supply chain agreement with questionnaires (PQQ) and pricing exercise. Thus, the process is rather specific and structured in order to identify companies which are as similar to TCC as possible in terms of characteristics, vision, innovation level, and long-term goals:

> So in terms of when we've got to a partnered supply that we'll use on every scheme, the exercise generally starts with a PQQ (Pre-Qualification Questionnaire) of some description. It depends on how many suppliers. (…) So it's a big exercise and what you might do is send out 150/200 question PQQ to 80 companies because I've then got to review all that information when it comes back. So we picked out the high level things that were really important to us, like the PEFCs (Programme for the Endorsement of Forest Certification), ISOs (International Organization for Standardization) and things that we felt were really important to the business, did a short PQQ and managed to whittle it down to 25 from these first 15 questions. Once we'd done that, we then sent a full PQQ with all of the questions and a pricing exercise out to all the companies. We then score the companies on their PQQ answers, applying weightings to certain things that we feel are important to the business and again the pricing exercise, we do a comparison to give out a score. It's generally weighted 50:50, 50% on the PQQ, 50% on price because equally they're as important to us. We felt we could always get cheaper,

> can always buy cheaper. I could do the exercise again tomorrow and find something cheaper but not necessarily the right product (Product Manager – 2016).

In order to do so, a vetting process which includes, for example, the level of innovation, pricing offers, and interviews, is developed. TCC also plans site visits to the suppliers' factories in order to obtain a more detailed understanding of the companies and the costs involved:

> It's got to be all about the right company as we said earlier. Then generally the process, this is very brief, takes about three months. When we get down to the final few, we generally narrow it down to the final two or three companies on most products and then we will go out and visit them. We have meetings with them to discuss their offerings, pick up any queries, visit their factory. We like to go to their factory to see for ourselves what their capacity's like, what their professionalism's like. Myself and J. write a business case, a proposal and it goes through various stages of approval through the business (…) Once we've received their comments, made any changes, it then goes out to all of our supply chain personnel through housing construction interiors so all supply chain managers and co-ordinators, they all get copies. They get two weeks and they're meant to liaise with their supply chain partners so their works [part of their] subcontractors to actually say we're going to be using only "that company" ceilings going forward. They'll be speaking to all their ceiling installers saying 'what does this mean to you?', are you happy with this, checking that the proposal's right for everyone. Once we've got through them, it then goes on to our managing directors, to the board meetings and then it gets signed off (Product Manager – 2016).

The aim is to only select suppliers that have a proven traced record in working well for the firm. The intention of implementing BIM represents another important requirement that John is looking for once they are deciding which company to sign the supply chain agreement with. The fact that the potential supplier has not implemented BIM yet, or the BIM process is just at the beginning, is not a reason to reject the company as long as they agree to undertake the BIM learning process.

> I think it's not a case of you're not on a BIM journey so therefore we won't work with you. If it's someone we've had a long-term relationship with, it's a case of on your BIM journey, how do we get you on our journey with us because we want to help you so we can carry on using you. And if they turn round and blatantly no, we're not prepared to even look at it, then that's probably where it all goes wrong. But it's not a case of you're in or you're out (Purchasing Manager – 2016).

Regarding innovation, John is both looking for suppliers who are willing to innovate, but at the same time innovation is a prerequisite in the agreement to be implemented. When John was asked how much push there is for suppliers to innovate, he replied:

> (…) a lot I would answer. In the framework agreements that we enter into with the mandated suppliers, there is actually an obligation to them to innovate (…) They [the mandated suppliers] would come to us with new products that might be appropriate, things like more efficient solar panels, or magnetic blaster (…) So, to be honest with you, there are so many innovations out there, it is just to make sure you pick the right ones that would be beneficial to you and the customers (Product Director – 2017).

Significantly, the problematization of the CIS actor-network does not follow Callon's (1986) model where the network builders seek to impose hypothesised interests and identities on actors that they then seek to enrol. In this case it is possible to identify an additional moment of translation (e.g. "pre-interessement") to add to Callon's. It is located between problematization and interessement. Indeed, John is not limited to hypothesising the interests and identities of actors (as happens during Callon's problematization) but filters them through the supply chain surveys and agreements. He tries to more reflexively and actively select certain identities and interests among a pool of possible actors (i.e. suppliers) rather than impose pre-defined identities and interests on actors. Indeed, the PQQs and the exercises are standardised and structured in order to identify more easily the shared interests for the future partnership. Eventually, only the actors who match these prerequisites are allowed to be considered for enrolment to the CIS actor-network. Hence, PQQs, pricing exercises, and following site visits of TCC to the supplier firms are used by TCC to select and identify the interests they are looking for, and at the same time are used by

suppliers to enhance their competitiveness and highlight their identities to establish this collaboration.

Relationships play an important role in the selection of the suppliers. Previous collaborations and trust are important factors to consider, but also the strategic decision to implement BIM has influenced the way in which John and his Purchasing team are acting and selecting the mandated suppliers:

> I suppose it's affected us to the extent that we're more aware of the people that we're partnering with, forming agreements with, where are they on the BIM journey. Obviously if they've no plans to go down that route, they're probably not the company for us going forward so from a procurement role, we are assessing our supply chain on where they are with BIM (Purchasing Manager – 2016).

The relationship is quite beneficial for both parties. The suppliers are willing to start a learning process of BIM which is facilitated by the firm itself, while John and the Purchasing team try to select the best supplier firms to work with based on their BIM journey, with the purpose of shaping their working practices. Suppliers can feel empowered by learning and implementing BIM as it makes them feel that they can gain competitive advantage in the market and makes them more efficient.

> (…) design things in BIM, it means it sets us apart from our competitors (…) It's changed the way that we do things. We're finding that it's probably going to be a faster way of drawing things from our point of view, putting them through BIM (…) it has been a learning curve. We see it as a very good learning curve for us with very positive outcomes (Sales Director, TFC – 2016).

Hence, John aims to filter actors' interests in order to implement his strategy of collaborative BIM and standardisation. All actors have their interests and goals, such as the willingness to innovate, to implement more efficient processes in terms of time and costs, long-term relationships, and competitive advantage. All these interests are going to be satisfied when they form alliances with each other, as Callon (1986) argued: "the problematization describes a system of alliances, or associations, between entities, thereby

defining the identity and what they want" (p. 8). Such alliances are therefore needed in order to reach John's and the suppliers' strategy and goals.

5.2.2 The moment of interessement

According to Callon (1986), interessement is "the group of actions by which an entity (…) attempts to impose and stabilize the identity of the other actors it defines through its problematization" (p. 8). The cited "entity" would be John who speaks for the firm's strategy which is represented by another actor-network formed by the CEO and the organisation board. However, in this case, as discussed previously, this hypothetical definition of identities and interests is not imposed, instead John filters the actors' interests and identities through the supply chain surveys. Hence, John is looking for these interests directly, instead of testing that the identities and interests comply with the problematization.

Different devices and *trials of strength* are used to enrol these actors. These devices aim to get the actors in the network "interested". However, the moment of interessement is not just about getting the suppliers interested in the network, but it is also about how John stabilises and maintains the identities and interests, that he selects and looks for, within the collaboration. Surveys, questionnaires, and site visits to the supplier firms can thus work as filters for selecting the suppliers. Therefore, John is implementing particular devices to get the actors involved in the firm's strategy and goals. The interessement devices which can be identified within the actor-network are: BIM, the SHT project as a *trial of strength* of the actor-network, the supply chain agreements, and particular events such as workshops, or hot desking.

Firstly, BIM/Revit influences the way in which suppliers and the firm collaborate and design projects by sharing information. It also constitutes an efficient working technology and a learning process for the suppliers which can improve their market competitiveness. However, John recognised that there is an issue of suppliers using different software and thus slowing down the design process and clash detection:

> The difference is that their software that they use … and actually the offsite manufacturers use CAD/CAM software to make the panels so they've been further ahead of the curve. The only difference is that a lot of them use their own bespoke

> software. So when we talk about them moving up in terms of their BIM capability, it's switching from their manufacturer specific software to maybe Revit, to something that will enable us to clash detect their element earlier in the process than their software. We can still do it with their software but it comes a lot later on in the process and arguably negates (…) If they were working on Revit, that would be done consistently at the same time. It's just more co-ordinated and then a clash detection is where you take the architect's model, the engineer's model, the M & E model, TFC's model. You overlay them in three dimensions on top of one another and see if there's any elements that are in the same spatial place that shouldn't be. And that's a clash. (…) part of the journey for us is to help them adopt software that will help us as a team do it the best way possible (Product Director – 2016).

The implementation of BIM in architectural modelling is thus beneficial for both parties (e.g. increases their competitive advantage, cuts time and costs, delivery time is more certain, information is shared and flows better) and its purpose is to smooth the process of development of the final architectural model in Revit. In order to do so, John's network offers an easy access, or shortcut, to learning BIM which is guided by the Head of BIM inside TCC. This shortcut can be considered an interessement device.

As Latour (1987) argues, there are four ways to translate, or enrol the interests of actors in an actor-network. The first one, "I want what you want" (p. 108) aims to tailor the object in order to attract people's explicit interests, such as through trust, increased collaboration and integration, long-term relationships, and fostering of innovation which have been emphasised by the contractor. The second translation, "I want it, why don't you?" (p. 111) make people mobilised by our interests following us rather than the contrary. This has been discussed here by the learning process of BIM, and the establishment of the supply chain agreements which imply various benefits for the actors in the network. In the third translation "if you just make a short detour…", (p. 111) the actors are offered a guide through a shortcut, such as the possibility for the supply chain to learn how to use BIM and being involved in innovative projects in the long-term.

As Latour (1987) explains, "this community of interests is the result of a difficult and tense negotiation that may break down at any point. In particular, it is based on a sort of implicit contract: there should be a return to the main road, and the detour should be

short" (p. 112). Hence, the length of this detour is the result of negotiations. Finally, the fourth translation "reshuffling interests and goals" (p. 113) highlights the importance of that the actors' goals are explicit. This is represented in this study by the regular relationship meetings and workshops between the firm and the single suppliers who are able to express their goals and issues within the network.

Undertaking a learning process for BIM also leads to enhanced collaboration and the possibility to be involved from the early stages of a project, which can help the supply chain to feel more involved, particularly during the design phase, and thus it empowers them in terms of their contribution to the project, leading more easily to innovative outcomes. This can be done by increasing the amount of time spent by the actors using e-mails, or phone, as well as an online platform, such as Buzzsaw.

> In BIM you also have got the online collaboration which is Buzzsaw as we sit at the moment, it now might be BIM 360 but it is an online portal where all that information gets uploaded, reviewed, uploaded, reviewed till it's right and shared. That's been a good learning process, rather than architects bringing a laptop and putting the 2D CAD on the wall or bringing a paper copy to get a penult (Project Manager – 2016).

Furthermore, John has emphasised even more the importance of the time spent beyond the actual meeting as a collaborative practice through the means of different online technologies:

> I'd like to think the meetings should be about progress reports rather than doing stuff. The doing stuff should take place between meetings so I'd like to think that they're embodied in each other's offices for meetings and what have you and that they're working in as collaborative a way as they can do, through whatever medium they need to. It could be a conference call, video conferencing, online demonstration of the BIM, whatever they need to (Product Director – 2016).

He also highlighted the contribution to develop an online information resource for BIM which can be used by all the supply chain:

> (…) we've got a portal where our suppliers can go on and our architects can go on and get our BIM families, our MBS clauses, our standard details, all the buy in agreements that we want to use. And because that's our yellow book and design manual, because there's a lot of content, so that we [meta tag?] that content so that you go on, you might say what sector you're working in and what type of building. You could say a leisure centre, I'm going to build a swimming pool. It'll only push through the content that's relevant to you. It's not going to swamp you with a load of stuff that relates to housing, isn't that good. So all the tacit knowledge that we've got, it will push you through all the technical advice, it will push you through lessons learned, it will push you through our quality alerts, things to look out for. So when you start the job, you've got the best chance of finishing it without any problems as opposed to that kind of accidental collaboration (…) (Product Director – 2016).

Hence, BIM works as an interessement device for suppliers who can develop innovation inside their firms, increase their market competitiveness, and enhance their relationships with TCC. For all these reasons the suppliers get interested in the actor-network, and remain interested for a long-time thanks to the BIM learning process which is supported by TCC.

Secondly, the SHT project can be argued as being a *trial of strength*. This *trial of strength* reveals which connections in the network are solid and which are not and any interests of actors that are contradictory to the problematization. This means that each entity revealed in the problematization, can agree on becoming part of the actor-network, or can refuse by showing their identities and interests in another way. In the SHT exercise there were some issues in combining the sub-contractors' design models into a Revit architectural model, which was managed by the architect. These issues were the difficulty of different software to communicate effectively with Revit (e.g. different file formats, convertibility issues, different naming conventions, and wrong coordinates when different formats were merged).

For example, the clash detection exercise, which was implemented through Autodesk 360 Glue, eventually revealed that the final architectural model did not really match perfectly with the other models (e.g. timber frame, roofing, etc.), as it can be seen from Figure 5.1.

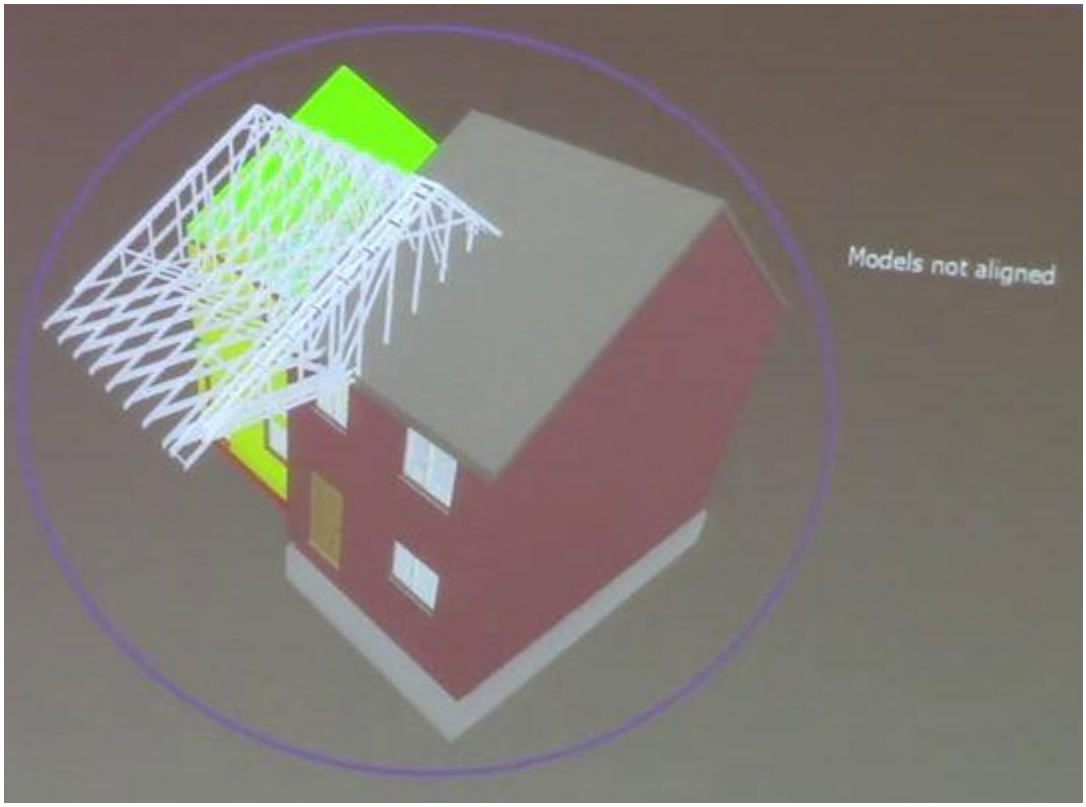

Figure 5.1 The models clearly do not align after running the clash detection.

The clash detection's purpose was actually to highlight any design issues after merging all the suppliers' models. Hence, it was a way to have a clear representation of how collaboration was developing, and if there were communication and technical problems. This image showed that the implementation of BIM/Revit and a collaborative style of meetings did not lead to the desired outcomes, even though the perceptions of the actors involved throughout the meetings seemed favourable because the succession of the design meetings was smooth in terms of the level of details added. Moreover, the actors showed interests in implementing the new software and collaborate throughout the meetings.

The exercise continued after this challenging moment, in which it was evident how collaboration and communication did not work out in practice, and all the actors were quite frustrated during the clash detection exercise. Since it was only an exercise, it was probably expected to be difficult and some mistakes might have happened, particularly because of the innovation for the suppliers' firms. Nonetheless, the exercise continued throughout the following months and so the collaboration which eventually led to positive results, such as the launch of the standardised house types. This particular case represented a *trial of strength* since it challenged the relations of the actor-network and the collaboration among

them. In fact, the suppliers and architects worked through the hard work of understanding the issues that they encountered with the software and embraced the innovative technology as a way of working together, through collaborative meetings. Spokesperson of each of the organisations involved (suppliers' firms, architects' firm, and TCC) worked as the main responsible for maintaining the actor-networks' relations and to collaboratively work towards the outcome. The difficulty that they encountered was that most communication happened remotely, and therefore it resulted in more complicated interaction and information sharing which was passing through BIM. This was an innovation for all the project's participants.

Thirdly, the supply chain agreements can also be considered interessement devices since they get the suppliers "interested" because of the benefits included, such as preferential working relationships, access to projects, and learning opportunities. The agreements are initially signed for a period of two years which can be extended into more years by mutual agreement between the parties. The agreement lists various suppliers' obligations, such as the appointment of a Supplier Representative, and the attendance to quarterly and annual review meetings whose schedules are carefully decided by the contractor. The agreements are an innovation introduced by John in the last years:

> We only signed the first of the mandated agreements I think in November (2015) but we've got seven now (Spring 2016). We've got another four going through the system, they cover a big bulk of the work that we do and so that's a huge change, that and the drive towards offsite. These things are starting to coalesce (Product Director – 2016).

These innovative agreements involve contractors and sub-contractors and represent a rather recent innovation within the housing business of the firm:

> It's a brand new thing for TCC Homes. It's the first two supply chain agreements we've got with framework contractors. The whole wider supply chain we've got a system in the office called Cat. A approved so what we tend to do is get our favoured subcontractors Cat. A approved. Cat A approved basically means we get preferential rates off of those subcontractors because we're giving them regular work. (…) they're

> sole so if it's timber frame, there's only one Cat. A approved. There might be four of them. If it's lightweight steel frame, GSFC are our sole provider. (…) They've got exclusivity, they're not competing against anyone so it's negotiated work, hence why we can get a good rate off them, we're giving them work and they're not competing against someone else. Our Cat. A approved subcontractors we might have five or six M & E companies and five or six plaster boarders and five or six roofers. So when we get a tender in the office, we would send out the tender to those five or six (Project Manager - 2016).

These agreements have completely changed the characteristics of the firm's supply chain and the relationship with them, and they have introduced an innovative process inside the firm comprising all the supply chain.

> The standardisation work Kevin's doing which we've now been doing for two years is effectively all new because up until that point, we had quite a wide supply chain (…) it is very much about aligning ourselves with somebody, working with them, they understand us, we understand them, building that interdependence (…) As we've said, it's about narrowing down our supply chain, having a fewer number of companies we're dealing with you can build these relationships with. We are seeing in our team our supply chain effectively reducing. There are targets to reduce our works partners particularly in the construction industry by 10% per year until we reach a point where we're achieving zero defects at handover. So we are trying to really flush out now who are the people we want to work with, who is on the same page as us (Purchasing Manager – 2016).

Hence, the reduction of the members of the supply chain means reducing costs, sharing information, and fostering relationships. In fact, the agreements can lead to benefits in terms of cost reductions, as the Product Manager explained:

> (…) we're hoping with the more standardisation we're doing, the more we can push through that actually we can keep the costs as they are or even bring them down because if we're buying smaller amounts of products they can increase … we've seen it

> with one of our partners who said we're manufacturing far more of these products now than we were last year so therefore we can afford to make them a bit cheaper and we'll pass that saving on to you. So actually there's more of a reduction and our costs coming down (Product Manager – 2016).

Moreover, information sharing can also be an advantageous way to collaborate and it represents a way to build stronger relations among the actors involved in the supply chain (e.g. manufacturers, sub-contractors, installers).

> We try to bridge the gap so as our department, we send information out to our manufacturers, our goods partners on a weekly basis saying these are the sites that are coming on, these are the subcontractors that have picked up orders. So if you were a manufacturer of plasterboard, for example, you can look down that sheet and say there's 20 plastering orders been placed last week and that's who the orders went to. I'll pick up the phone and contact those people and say can we supply you with your … hopefully they've been involved earlier on and followed it through but we provide them with all that information to help them try and win work to try and bridge that gap. So we do try and [knit them] over wherever we can (Product Manager - 2016).

Furthermore, relationships are strengthened leading to trust-building for long-term collaboration. It has also been emphasised the importance of sharing the same values and a similar vision in order to establish a strong relationship and better collaborate in projects:

> (…) if you're talking about aligning businesses and sharing values, in talking to TFC's [timber] engineering when we did for the PQQ process and interviews and went to visit them, they talked the same language as TCC. You walked in their offices, they could have had TCC logos everywhere, they had the same sort of straplines and the same sort of things like coasters. It was very much very lined up (Product Manager – 2016).

The importance of relationship building and sharing resources is at the base of John's main strategy. He discussed also that there should be a situation in which the suppliers should feel part of the same business as John's and it is worthwhile for them to invest in innovative

processes and products in order to benefit within their own business, but most importantly within the CIS actor-network.

> (…) if you take the three-year deals that we've done, it's not just about cost. It's about what they do during that three years. (…) if we don't prove that we've improved our business and we've improved their business, we won't get the next one and that's it, the idea being that doing these strategic single supplier agreements gives us enough of a carrot to make it worthwhile them innovating. There's something tangible. If we only said we really want you to innovate but actually we'll only give you ten units a year, they might innovate for their own reasons but they're not going to share it with us. We need to give them something properly to get their teeth into. So it's a valuable enough relationship for both parties (Product Director – 2016).

Considering the supply chain's point of view, the single supplier emphasised the benefits of having these agreements in place and building stronger connections with John's network:

> In a normal building project, you have a client who decides how they want to have the building built, then an architectural designer who will engage the services of the main contractors to price it. Within the design, there will be elements that the client wants to keep and there will be elements which they client isn't really bother about. It offers the opportunity to what is called "value engineering" each individual package. And if it falls correctly, it gives you the opportunity to save money. With the TCC agreement, they have already value engineered the project to begin with. So, when an architect says I want to put suspended ceiling in it, TCC would say put RN on it. The price is already agreed, we understand the product, therefore the efficiency comes from specifying the right product the first time (...) There is a large element of trust which TCC has placed on manufacturers such as RN. So we are giving the right advice consistently. There have been times when we have almost cost ourselves money; we value engineered our own projects and that is because the company ethos is to become a trusted advisor (National Account Manager of suspended ceiling and acoustic solutions, single-supplier – 2017).

Therefore, a supply chain agreement represented an interessement device because it provided with a list of benefits for both parties in the long-term. In particular, suppliers signing these agreements do recognise the lead of TCC in the learning process of BIM and innovation, as long as they put effort into implementing BIM inside their firms and within TCC's projects. Also, this effort would be worth it in the longer period, such as through enhanced innovation, efficiency and market competitiveness.

Fourthly, the fact the John schedules workshops and other training events throughout the year also function as an interessement device for the suppliers in the CIS actor-network. Workshops and supply chain conferences are important scheduled events throughout the year and represent an occasion to build stronger relationship and empowering the supply chain. The supply chain conference is held once a year in different regions around the UK and gathers the mandated suppliers according to their regional offices. The conference is a formal event organised by TCC to discuss present and future strategies together with the supply chain, networking, and suppliers' awards are delivered.

Visual technologies are often used, such as Power Point presentations for sharing and highlighting some main information and concepts to strengthen strategic goals and vision with the suppliers. Indeed, the conference started with a video ("Why Simon Sinek – Start with why. How great leaders inspire action") which explained how businesses need to develop their identity, their strategy to inspire people to "feel part of the business' identity" and therefore buy the products. It was emphasised how "people are interested not in *what* you do, but *why* you do it". Hence, TCC wanted to highlight the fact that it is first important to know the internal customers (all the employees as part of the business, therefore also the supply chain) before the external customers. It is therefore a message towards the suppliers about *shared identity* and *stronger relationship* to motivate and engage them within the business.

Therefore, the identities and interests filtered by John in the problematization empower the suppliers who can feel part of the business. Hence this example represented a way in which, following Latour's (Latour 1987) concept of translating interests, the contractor aimed to attract the suppliers' interests, make them deeply understand the reasons behind their relationships towards shared goals, making suppliers take a *detour* by offering them support to learn and implement BIM, and finally, making their interests heard, such as through relationship meetings and workshops.

The Power Point presentation during the supply chain conference continued with important highlights about the 5-year strategy which included also slogans, such as "Creating thriving communities". The term "communities" refers to consultants, suppliers, and everybody who is influenced by TCC's business. Moreover, some videos and pictures, which were taken directly on construction sites, helped to motivate and commit suppliers even more by showing tangible outputs resulting from collaborating with them. The importance of BIM was also emphasised by explaining the reasons to implement BIM and the fact that BIM involves *collaborative* working with 3D models. In this case again the filtered interests of implementing collaboration between the supply chain and the firm have been consolidated with the suppliers.

Concerning workshops, two types can be identified in my data: design workshops (e.g. during the SHT exercise), but also strategic workshops. The term "strategic workshops" refers to events in which the supply chain is involved to discuss about a particular topic. For example, the supply chain conference's workshop represented a proactive and collaborative platform to discuss some issues that suppliers were having with the firm, but it also represented an example of desire for control for both parties. On the one hand, the suppliers were raising concerns and issues about some main topics and wanted to receive feedback from TCC and create an opportunity for problem-solving. On the other hand, the contractor's aim of such event is to strengthen relationships with the supply chain and to receive feedback from their "allies" in order to understand what needs to be changed and decide whether more training is needed.

Hence, in this case, the workshop becomes a *symmetrically reflexive interessement device* as it is beneficial both for the suppliers, and for the firm itself since it provides feedback which is useful for the network builder. This situation distances itself from Callon's (1986) model in which the interessement devices did not show symmetry and reflexivity, but rather their purpose is to asymmetrically extend the network builder's interests on other actors. According to Callon (1986), "for the case of the scallops (like the fishermen and the scientific colleagues), the interessement is founded on a certain interpretation of what the yet to be enrolled actors are and what as well as what entities these actors are associated with" (p. 10). Hence, in this research, the symmetry and reflexivity of interessement devices reflects the fact that suppliers are enrolled into the actor-network through much more negotiations, instead of through an impositional top-down manner.

This sense of engagement and importance placed on the relationship with the supplier has particularly impressed one of them who said in an interview:

> I was very impressed with the passion that the company was looking to achieve growth and they were honest they can't do it without the support of others, including ourselves (…) We take the partnership with TCC very seriously. If there is anything we can do to help them we will, but at the same time we are a business and can't give everything they want, but we try to. The key to our successes is that we engage with projects early in the design process. So we have got a good understanding of the projects (National Account Manager of suspended ceiling and acoustic solutions, single-supplier – 2017).

Finally, as part of John's strategy to attract and build on suppliers' interests and keep them empowered through their collaboration, training days are organised by the Purchasing team for the supply chain to attend and they may concern technical training, such as online training for BIM, but also hot-desking. In summer of 2016 the firm was just starting this process of BIM training both within the firm, and with the supply chain.

> So what the idea is that supply chain go to what we call the conference or a meeting to be introduced to BIM so they have like a very basic sort of 'bronze training'. This is BIM, this is why they're doing it, this is why we're doing it, this is what we expect of you. If you feel like you can't do that then consultancy know, the industry know the product is out there and know how to write a road map for you to be able to get to the standard that we need you to be at and that's in essence what the plan is. So then they would employ a consultant for a day. They'd go through their business, how they function, what software they use and then write a roadmap of progression. So then we would then know which companies are actually trying to better themselves and we've partnered with a couple of companies over the last sort of 18 months that John may have mentioned to you, TFC (Head of BIM – 2016).

These learning and training opportunities also work as interessement devices since they provide the suppliers with opportunities to enhance their competencies and working relationships, as well as make their voices heard. Being able to obtain these improvements

enables the suppliers to build and maintain their interests and then be enrolled in the actor-network. Moreover, the fact that TCC keep asking the suppliers how these events are developing and whether they are satisfied by them is also a way to filter the suppliers' interests in order to provide with the best possible opportunities. Therefore, trainings work just like workshops as places where suppliers can express their identities and interests, responding to the symmetrical reflexive interessement devices, which have been discussed previously. Furthermore, the interessement devices which have been discussed in this section are seamlessly aligned. This means that they are enacted together and work together towards the implementation of the CIS actor-network.

5.2.3 The moment of enrolment

As long as the phase of interessement is successful, then it is possible to talk of *enrolment*. When the actors get interested and alliances are built among the actors within the actor-network, then these actors are enrolled. This does not always happen. However, in this particular research study, it is possible to identify the enrolment of some suppliers, who become "mandated suppliers" by signing to the supply chain agreements and starting their collaboration with the network-builder, John. According to Callon (1986), "to describe enrolment is thus to describe the group of multilateral negotiations, trials of strength and tricks that accompany the interessement and enable them to succeed" (p. 10). Once the negotiations are solved and the actors assume their role in the actor-network, then it is possible to establish their enrolment.

Following Callon's (1986) argument, these negotiations may be hindered, or slowed down by "enemy forces" which, in the construction industry could be identified by the easy access to other jobs in the industry driven partly by a shortage of skilled employees and due to low entry barriers in the market. Low barriers to entry in the construction industry are evinced by the presence of many small and specialised businesses, often established by former employees of larger companies. Therefore, the firm needs to negotiate with its suppliers in order to offer more benefits compared to other companies. This has been partly done by John through the supply chain agreements. The mandated suppliers can thus take a lot of advantages, such as learning opportunities (e.g. BIM), special bid conditions, stronger relationship with TCC, increased efficiency and reduced costs.

> (…) for the supply chain partners like GSFC and TFC's, in that supply chain agreement we've got design rates so if we get a job in, we're sitting down with a client, we think we might want timber frame. We'll go and get TFC's for a couple of weeks and do some drawings. We've got an agreement with them so that's part of that process (Project Manager SHT – 2016).

These sorts of negotiations continue throughout the working relationship between the suppliers and the firm. In fact, it was observed that during the quarterly relationship meetings and in workshops, both the suppliers and the firm were collaborating and relying on each other's support in order to solve issues or improve some difficult situations. For example, during the supply chain conference's workshop, in reviewing the suppliers' feedback concerning the relationship between them and the firm, the suppliers highlighted the need to have a constant point of contact with TCC. Hence, TCC responded by enrolling Relationship Managers in seven trades (M&E, groundworks, steelwork, roofing, courtain & walling, dry lining & ceiling, brickwork) in order to establish a regular dialogue.

However, at the same time, during the conference's workshop, TCC highlighted the importance of suppliers coming to meetings with the Relationship Manager well prepared in order to create a two-way process in which both supplier and Relationship Managers communicate and agree on goals and agenda. Moreover, suppliers also asked for having regular feedback from TCC which responded by conducting a performance reviews in pre-construction. Hence, listening to the mandated suppliers' requests and issues, and providing quick solutions to their feedback is the way in which John keeps suppliers consolidated within the network, as in Callon's in which the researchers' purpose is to make the larvae to anchor. In order to do so, they negotiate with the scallops in order to increase the level of interessement.

These negotiations can also be observed during relationship meetings between the supplier and the person within TCC responsible for keep contact with the supply chain (e.g. Purchasing Manager, Purchasing Coordinator). In one of the observed relationship meetings, the supplier, a roofing and insulation company, complained about the fact of having a hard time with TCC's working partners who are the installers of a specific material. The roofing supplier wanted to replace the insulation material of a museum's roof with TPEs (thermoplastic elastomer) and had a quite hard discussion with the installers (TCC's

partners) who considered TPE not the right solution. TCC Purchasing Manager then looked up the differences between those two materials considered (PVC – polyvinyl chloride and TPE) and suggested to the supplier that they sell the material better to the installers: it is important that they highlight the reasons why PVC would not be the best solution for them and for the client, and thus explain why TPE would be the right choice.

The negotiations eventually lead to the definitions of the actors' roles within the network. On the one hand, John believes that by implementing CIS and supply chain agreements founded on trust, open communication, and innovative processes, it is possible to enhance the shared outcomes.

> We've gotta stay closer to feel for longer basically, so if we get closer, much much closer to fewer people because we are using the same people times and times again, then we can build long-lasting relationships and benefits for both parties, and that's what we want (Product Director – 2017).

On the other hand, the mandated suppliers do trust John's strategy and are persuaded by collaboration and continuity of collaboration with future projects, closer relationships, and learning opportunities.

> We feel as if we've been invited to the table as one of the family, very much open book on costs. If we can work out different ways of doing things and it costs a little bit more money, we just tell them that and if they can see the benefits, then that will go ahead (…) It's just a case of we're probably a lot more open and honest with TCC because of who they are and the links that we have. Because there's agreement in place, we've got nothing to hide. I don't know, you're dealing with the same people and at the end of the day, we just want to create an environment that's easy for us and easy for them and by doing it this way, we think that's the end goal and we will get there (Sales Director of timber frame single-supplier – 2016).

Moreover, their technical expertise and opinions are taken into great consideration, for example, during design meetings and relationship meetings. This helps to build trustworthy and reliable relationships and collaborative strategizing where decisions are made.

> (…) if there is a problem with something, let's say a design problem, we just sit round the table and talk about it really. Everybody has some input. It's very open, everybody's very honest and if somebody sees a way of getting over that problem, then we all just agree round the table, yes that's what you do, we'll design it that way (Sales Director of timber frame single-supplier – 2016).

Therefore, there are different ways in which the actors are enrolled: attracting them with shared values, willingness to build long-term relationship, offering occasions for learning and training, empowerment, consent by signing the supply chain agreements. All the techniques, such as shared values, long-term relationships, learning and empowerment are implemented once the suppliers sign the supply chain agreements. Hence, these agreements lead to a lot of benefits for both parties, even though some obligations are also required from the suppliers, as discussed before. These techniques have proved to be beneficial in the industry in terms of increased collaboration. Roles are thus defined and distributed: mandated suppliers are persuaded by learning opportunities, long-term relationship throughout projects, and collaboration; architects as external consultants also are persuaded by collaborative design meetings as innovative way of working with sub-contractors, and the possibility to implement BIM and reach higher level of details in the architectural model; clients are also attracted by the fact of obtaining a pre-designed product in shorter and pre-determined timeframe, and with the possibility of customisation.

5.2.4 The moment of mobilisation

In this stage, the role of spokespersons constructs and identifies the actors, who are the participants in the actor-network under study. These spokesmen represent wider entities in particular situations. The actor-network that I have been discussing is a collaborative innovation strategy that involves the use of BIM standardised products, coupled to a collaborative supply chain. John is identified as the spokesperson for this actor-network, and the problematization that he identifies is "how can we implement more collaborative and innovative processes by introducing BIM and integrating the supply chain?". Hence, he highlights the importance of implementing standardisation and collaboration with the supply chain. This means that the suppliers should be involved earlier in the design process

and collaborate with TCC through BIM which represents an innovation for both parties, and aims to standardise design of models and the final products (e.g. schools and residential buildings). From the interviews made with the supply chain, it appears that they trust him, and they identify with this image of the contractor, TCC, they are partnering with as depicted by John. This is manifest in the way John always built close relationships with the suppliers in order to develop mutual trust in the long-term.

> John got close very early, he was involved in all the interviews with ourselves and other contractors and John always kept this under his own wing so he's run alongside us for quite a while. So in terms of continuity, John's always been there and helped us along in terms of information or introducing us to other people within the organisation (Sales Director of TFC – 2016).

> (…) we would go out to visit their factories, or you know I have been to Berlin to see trader exhibitions that were exhibiting there with new products as well (Product Director – 2017).

In this sense, the CIS actor-network becomes stabilised and John becomes its spokesperson. However, the other actors of the actor-network do also have spokespersons. For example, the spokesmen of the mandated suppliers would be the one or two people directly involved in the relationship meetings, or in workshops. They are there to represent their firm. The Purchasing Team (e.g. Purchasing Manager, Product Manager, etc.) who are directly involved with selecting and managing the supply chain, also speak on behalf of John and their purpose is to implement its strategy. Other spokespersons within TCC are the Relationship Managers, whose role is to deal with the suppliers to maintain good relationships, still representing John.

All these spokesmen, who were at first displaced, become reassembled in different organisational settings (relationship meetings, workshops, conferences), as Callon (1986) discussed about the mobilisation of "silent actors" (scallops, fishermen and specialists) into the conference room. The suppliers do believe that CIS, including BIM learning can lead to a lot of benefits, such as a more competitive position in the market, enhanced innovation, and

better relationship with John and the firm. Hence, "the enrolment is transformed into active support" (p. 15).

> It has been a learning curve. We see it as a very good learning curve for us with very positive outcomes (…) it's raised our profile as a company, it's turned us into a more technically able business (Sales Director of TFC – 2016).

> It's not something we've done before but it is very beneficial. Once this is in place, all the information's there and it just becomes a [call off?] exercise for us so we know that the customer only wants this house type so we know the house type is this material and we can just manufacture it straight away, improves our processes (Business Development Manager of RC – 2016).

Callon (1986) argues that this network of relationships, formed by consensus and alliances (and therefore the representativity of the spokesmen), can be contested any time.

5.2.5 Implications for collaboration during the building of the actor-network

Understanding how John has built the CIS actor-network to implement the main firm's strategy of innovation and collaboration is important to analyse how collaboration and power dynamics have been influenced among the actors in order to answer the research question[5]. How has collaboration between the contractor and the supply chain changed during the moments of problematization and interessement? First of all, actor-networking, that is sociology of translation, always concerns the transformation of the actors involved, and it is about making equivalent and shifting (Law 2007). In this study, the supply chain agreements have changed the relationship and the partnership agreements between the contractor and the supplier firm. Once the Purchasing team has found the right supplier to partner with, a special long-term relationship is established between them, and this relationship is regulated by the agreement itself with duties and benefits for both parties. The relationship which TCC aims to establish with the mandated suppliers is very open and collaborative (e.g. concerns the early involvement of the supply chain during projects, long-

[5] Does the early engagement of supply chains around innovative technologies and practices foster effective suppliers' collaboration and empowerment within the firm's innovation strategizing?

term relationships with them, open communication and mutual problem-solving), and it is nourished by regular relationship meetings, workshops, and phone calls.

The decision for establishing these long-term partnering with some suppliers has been deeply researched by the contractor, in particular by the Purchasing team. Indeed, as it was discussed in the moment of interessement, John's strategy is to filter the suppliers' interests through surveys and questionnaires in order to choose the best partners in terms of capabilities and shared values (e.g. the level of innovation and the willingness to innovate, the type of products or services offered, their expertise, and their strategic vision). This process has been defined as an additional moment of translation to Callon's model, a "pre-interessement" phase.

Hence, John and the Purchasing team have the power to lead this decision. Although the contractor had the leading role in choosing the suppliers to partner with, the selected suppliers were then put in a position in which they are empowered by the supply chain agreements and the relationship formed with TCC. In particular, entering into these agreements allowed the mandated suppliers to become part of many learning opportunities, such as with BIM and become involved in new and innovative projects (e.g. SHT). In all these occasions they had the opportunity to express their opinions, expertise, problem-solving, and at the same time to count on TCC for support and active collaboration. This process of empowerment will be discussed more specifically in the next chapter.

Secondly, BIM had a great influence on the relationships and roles inside the projects. Indeed, one of the sub-questions of this thesis is to analyse the role of technology (non-human actors), such as BIM, in influencing collaborative activities and interactions among the human actors. Moreover, the implementation of technology also shapes the power dynamics within the group of actors. It can be argued that BIM emphasised the power of TCC as the main contractor because their demand of using BIM in projects have the power to actually change the way of suppliers' way of working: some sub-contractors may be too weak in terms of capacity to invest, and internal expertise to be their own driving force for an extensive and integrated implementation of BIM in construction projects.

Because of the problematization of BIM within the CIS actor-network, new roles and competencies are expected from the actors, such as an increased need of collaboration. Hence, all of the design processes become more transparent (e.g. because of easily shared

information) and all of the models need to be accessible to everyone, in particular to the design manager (e.g. the Project Manager in the SHT project) in order to keep control of the leading role in the design process (Linderoth 2010). Nonetheless, the example of the SHT clash detection that I discussed above (see paragraph 5.2.2 and figure 5.1) depicts how collaboration may not happen so easily through BIM when the actors are not completely familiar with the software which has a completely different way of working compared to others (e.g. AutoCAD). The difficulties in understanding all the elements of how BIM works, the different technical names, and the different way of managing collaboration and information may challenge the actors. Moreover, as Linderoth's (2010) interviews based study with construction managers suggest, in projects regulated by partnering agreements, the implementation of BIM is due to contractual relations in order to make BIM an obligatory passage point. Moreover, BIM adoption can be facilitated by a collaborative environment which is emphasised by the contractual relations, and a greater power of the contractor who can effectively require the extended use of BIM.

During the enrolment phase, in which alliances are eventually built, the suppliers become "Category A" mandated suppliers after signing the supply chain agreements with TCC. In this phase John's aim is to maintain the interests of the suppliers through continuous negotiations. Hence, suppliers are offered various benefits through this partnership, such as learning opportunities, increased competitiveness, long-term relationship and support from TCC, and special bid conditions for future projects. John's strategy is indeed to create a long-term trustworthy relationship which is transferred from project to project. Hence, collaboration with the supply chain is fostered and power dynamics are shared in different ways between them. This strategy represents a strong factor for the collaboration of these actors.

Open communication, in terms of sharing of information and opinions, also becomes an important factor of their relationship, such as during the relationship meetings. In particular, as through the interessement phase, the moment in which the actors meet and start to negotiate and collaborate, some spokespersons are present and they represent TCC, or the supplier firms in specific settings. It has been discussed how the met consensus and alliances can be contested at any time, such as through the SHT exercise which represented a *trial of strength* of the network. Although the design meetings seemed to provide regular improvements with BIM and the Revit model, the clash detection eventually highlighted the

technical issues of the whole model. The software revealed its limits in terms of collaboration among the actors who, at the same time, trusted the software too much and did not focused properly on communication. Also, the fact of having tight schedule of meetings in which the level of detail should have increased regularly has led the sub-contractors behind in terms of learning of BIM, and the possibility of improving communication through its online platform.

It has been emphasised in literature (e.g. Linderoth 2010; Andersen et al. 2004; Dubois & Gadde 2002; Slaughter 1998) how the disruptive nature of construction projects and of supply chains is a big challenge in terms of re-establishing network for continuous collaboration and innovation, and in particular for re-establishing the network around BIM in future projects. The supply chain agreements developed by TCC aim to solve this issue by calling for long-term collaboration and innovation with a fewer and more trusted number of supplier firms. The establishment of these agreements in previous years for the SP project have shown that this intention was actually implemented, and some suppliers who TCC have worked with in the past are actually part of new projects at the moment. This kind of collaboration thus made possible the development of standardised products, such as pre-designed schools which can be personalised by customers. These products represent the main innovation within TCC who worked with fewer suppliers and sub-contractors, and developed their marketing strategy, such as branding in order to emphasise the fact that they are offering a product (schools).

5.3 Strengths and limitations of Callon's model for this study

Callon's (1986) model of translation has been used to understand how the actor-network was built. Hence, it provided some good starting points for the analysis of data, but also some limitations were found. One of the benefits of using Callon's model is the clear identification of the actors and their interests in order to set the foundation for future alliances and building of the actor-network. Hence, focusing on the actors to understand their identities and interests, and how collaboration is shaped is central to my research question. A further strength is the emphasis on the role of the interessement devices, such as non-human objects and processes, to filter the suppliers' interests and identities in order to respond to the problematization identified by John. The role of non-human actors, such

as technology, is part of my sub-research question, in order to examine how they shape CIS. However, according to the available data, the identification of these interessement devices (e.g. BIM, supply chain agreements) is not as simple as described by Callon because BIM can be "different things in different practices" (p. 384) thus it performs differently in different practices (Law & Singleton 2014). Each of these practices creates its own material reality; hence multiple actor-networks can be identified, such as John's actor-network (CIS actor-network), SHT project actor-network, and SP actor-network. Understanding these multiple realities allows to have a clearer picture of how CIS is implemented in different contexts, but still aiming towards John's main strategy. Moreover, BIM can act as fluid object since it changes characteristics in different contexts, and it is defined differently according to the actors involved. Hence, the object can be considered fluid and can create multiple realities. These concepts will be discussed in the next chapter.

Another limitation is that Callon (1986) makes a top-down model as is evidenced in his concept of interessment as the imposition of stable, hypothesised, interests and identities on actors to be enrolled. On the contrary, my data show that the relationships between John's firm and suppliers are not top-down, instead they are collaborative and open. It is in this case, that I argued the existence of a "pre-interessement" phase in which John filters and reflexively select the interests and identities of the suppliers. Most of the events organised by the firm (e.g. workshops, quarterly relationship meetings, hot-desking) provides suppliers a place to contribute, to give opinions, to discuss, to problem-solving with their own input. Interesting is also the fact that the quarterly relationship meetings, and all the events organised by the firm are prescribed on the supply chain agreements, as a "top-down rule" from John. Indeed, he aims to establish identities and interests on actors and test the actors' commitment during specific practices (e.g. in the SHT exercise, or other workshops) to assess the translation process of their interests. Nonetheless, in practice, these meetings and events are not as formal as it might be expected, but are actually quite informal, and open communication and collaboration is present. Moreover, they work as a reflexive form of interessement because they work as a feedback for both John and the suppliers. In this way, John can obtain important information regarding actors' interests and better understand how to keep them enrolled.

5.4 Conclusion

This chapter aimed to understand how the CIS actor-network is built and is extended within TCC. In order to do so, it follows Callon's (1986) model of translation because it provides a rich analysis of how actors involved are related together around this strategy and how their identities and interests are transformed and translated according to the network builder's purpose. Moreover, the clear distinction of the phases of this process (problematization, interessement, enrolment, and mobilisation) helped to analyse in more details each step of the translation.

The key findings of this chapter concern the fact that in the problematization phase, the actors' interests and identities were not hypothesised as top-down imposed process, as in Callon's (1986), but were filtered by John through surveys and questionnaires in a "pre-interessement" phase. In the interessement phase I argued how John offered a shortcut to learning BIM to the suppliers, such as through training and workshops. Moreover, this shortcut enhanced collaboration and involvement of the supply chain, making them feel more empowered within the actor-network. Hence, meetings and workshops worked as symmetrically reflexive interessement devices, since suppliers can make their interests heard. Such symmetry and reflexivity means that the actors are enrolled in to the CIS actor-network through more negotiations and equity, compared to Callon's (1986).

In the enrolment phase, continued negotiations allowed the definition of the actors' roles within the actor-network. These negotiations occurred during relationship meetings, and workshops, as well as through the supply chain agreements which provided a lot of benefits for the suppliers. Furthermore, these agreements allowed to maintain the interests of the suppliers in an industry where there are low barriers to entry and skills shortages. Finally, in the mobilisation John is identified as the actor-network's spokesperson who obtained the trust from the suppliers. This was evident in the way in which they spoke about John and his closeness to establish their relationships and agreements. Mobilisation emphasises all the displacements of the actors, and their reassemblance in one place thanks to the designation of the spokesperson and their transformations.

The next analysis and discussion chapter aims to answer the sub-research question about the role of technology in shaping CIS in different contexts. Hence, how technology is implemented in the actor-networks, and how it creates multiple realities will be discussed.

Chapter 6

"After ANT": Multiple actor-networks and fluid objects

6.1 Introduction to Analysis Part Two

This chapter aims to respond to the limitations of the ANT analysis encountered in the previous chapter. The analysis with Callon's (1986) model has highlighted some limitations, such as the fact that the network's connections between actors are not imposed top-down, as Callon (1986) argues, but are more symmetrical as the relationship among actors in my case study is largely collaborative and open. My analysis also suggests that there is more than one single actor-network in my case study (e.g. CEO and organisational board, purchasing team, SHT, and SP). More recent ANT thinking suggests that perhaps, therefore, multiple realities (e.g. BIM, collaborative settings) are present (Latour 2005; Law 2008). Moreover, the interessement devices are not only "tools" used by the network builder to impose and stabilise identities on the other actors, but they may change characteristics and influence in different ways the context in which they are present by going beyond the network builder's intentions, or their initial purpose.

To address these issues, the chapter will now engage, and develop, the concepts of multiplicity and fluidity, from "ANT and after thinking" (Law 1999). These concepts have different meanings, but they are related. Indeed, as discussed in chapter 3, multiplicity assumes that reality is "done and enacted rather than observed" (Mol 1999, p. 77), thus it is constructed by various objects throughout the diversity of practices. This can be observed in different meetings, workshops and events. Each activity enacts a different object, therefore different realities, as these objects assume multiple forms of reality. It thus implicates that reality is multiple. The example of atherosclerosis by Mol (2002) shows how this disease is enacted in different settings in a hospital (e.g. by a pathologist through the microscope, or by a doctor with the patient's leg). The concept of fluidity assumes that the object can manifest differently, such as the pump in de Laet and Mol's (2000) study. Fluidity can also be identified according to who uses the object and the fluid purposes of its use. Hence, the object is not fixed, but changes shape and creates different realities, as it varies its

associations in different contexts. The transformation of the object can create multiple realities. In this way, the two concepts of multiplicity and fluidity are related.

The chapter will try to fully answer the following sub-research questions (which was partly analysed in Chapter 5): what is the role of innovative technologies and objects (e.g. BIM, Power Point presentations, architectural models, videos, etc.) and practices (e.g. supply chain agreements, workshops, meetings) in shaping collaboration and strategizing between the firm and suppliers? Do they enact different realities of collaboration in different contexts? How? The chapter is structured in the following way: firstly, in order to respond to the limitations of the previous chapter, where the multiplicity of actor-networks and actors was downplayed, an examination of the different actor-networks and the connections among them will be discussed. Understanding these actor-network means having a clear description of the settings and the associations where objects are differently enacted.

Secondly, although a single actor-network can have different objects, a single object (e.g. BIM) in multiple networks can enact multiple realities and have different effects on collaborative innovation. It is important to identify such mediating objects and understand their role within the CIS actor-network. Moreover, these objects can assume different characteristics in different settings, where the CIS actor-network is extended (e.g. workshops, conferences, meetings), leading to different outcomes in terms of collaboration innovation strategizing. Hence, the concept of fluidity and fluid technology will be introduced and discussed, particularly with a reference to BIM, in order to analyse the role of these objects in multiple realities.

6.2 Multiple networks and multiple realities

Within the analysis of the construction of the CIS actor-network, it is possible to identify multiple actor-networks which are interrelated and connected with each other. As previously discussed, John's actor-network aims to implement innovative pre-designed products and standardisation processes, and to introduce BIM throughout the whole business and the supply chain. This actor-network is included in a corporate strategy actor-network inside TCC comprising of the CEO and the organisational board. In turn, from John's network, other actor-networks can be identified according to my data: the Purchasing team,

the SHT project, and the SP project. All these actor-networks respond to the main TCC's corporate strategy which John promotes and delegates to the other teams (see Figure 6.1).

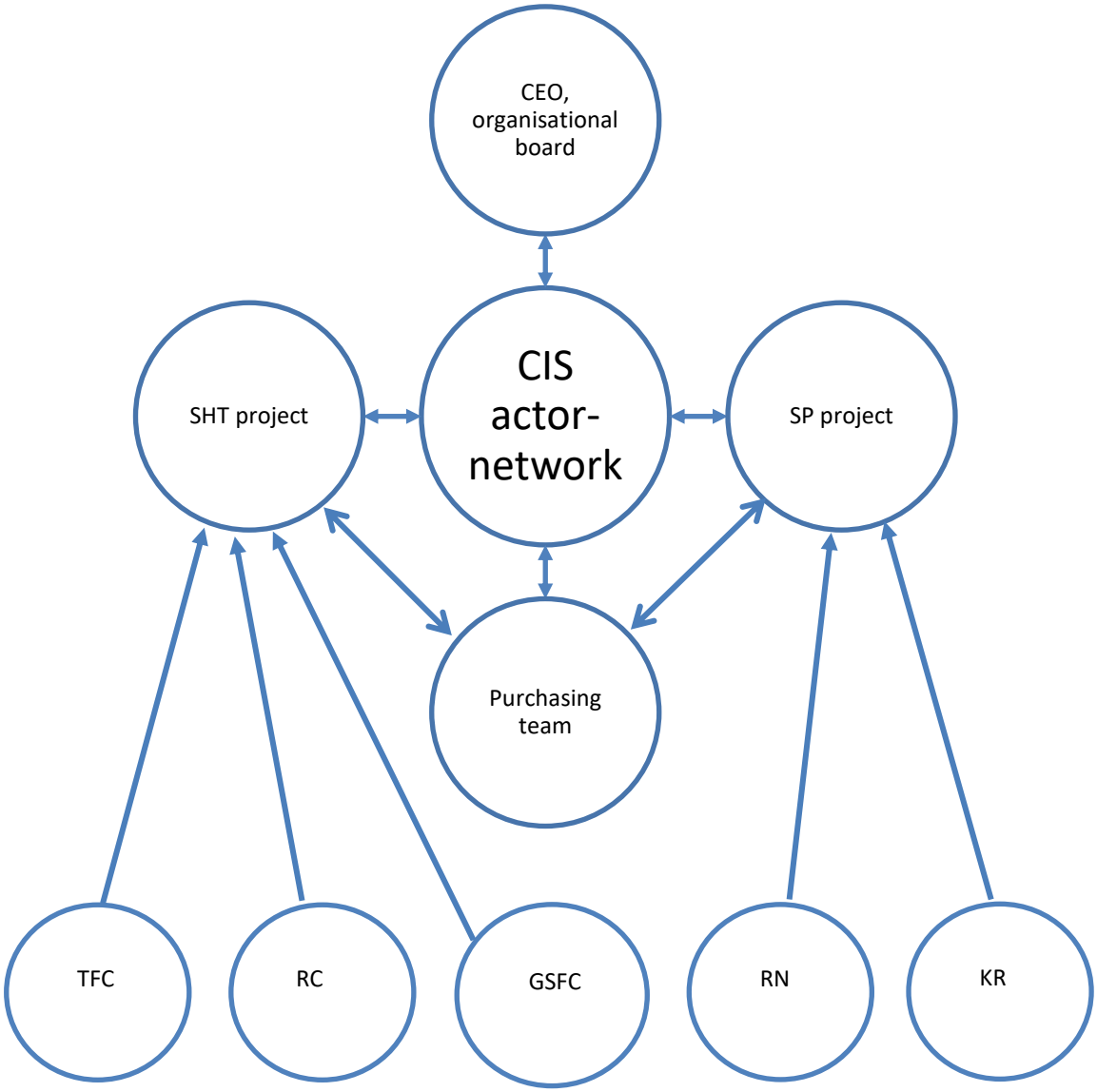

Figure 6.1 How the actor-networks are connected with each other. "Category A" suppliers below the Puchasing team are linked to the project which they are part of.

The diagram depicts how the different actor-networks communicate and collaborate with CIS actor-network being at the centre of this situation. CIS actor-network is actively engaged with the Purchasing team actor-network. The object created by this actor-network is the strategy of establishing the supply chain agreements and building relationships with the

mandated suppliers. The other actor-networks which are actively engaged with CIS actor-network are the SHT project, the SP project, and the CEO organisational board. The SHT actor-network creates standardised houses with BIM and collaborative design meetings. The SP actor-network's object is to develop standardised schools with BIM. The CEO and organisational board actor-network creates the object of TCC's main strategic vision which John shares and tries to implement across the organisation and the supply chain. Below there are "Category A" suppliers, some of them directly involved in the SHT actor-network, and others in the SP actor-network.

The actor-networks are inter-connected and create hierarchical scales. However, according to ANT researchers (who are following the actors on the ground "like an ant"), macro does not represent a wider or larger site in which the micro is embedded, but it represents another equally local, micro place, "which is connected to many others through some medium transporting specific types of traces" (Latour 2005, p. 176). This means that the landscape remains flat, which does not mean that the organization is flat and that hierarchies do not exist. The relations among these actors and "centres of calculations" create those hierarchies.

6.2.1 Purchasing team actor-network

The Purchasing team network is directly connected to the CIS actor-network since it aims to construct part of his strategy, namely to find the right supply chain partner, implement the supply chain agreements, and enhance the relationship with the mandated suppliers, such as through relationship meetings, workshops, trainings, and conferences. It can be defined as an actor-network because it is formed by an array of heterogeneous actors, both human (e.g. Purchasing Manager, Product Manager, administrative roles), and non-human (e.g. questionnaires, trainings, workshops). This actor-network creates the basis for the suppliers' active involvement in the partnership with TCC, such as the submission of surveys and questionnaires to the suppliers, site visits, training workshops, and regular contact with them. Hence, the main role of this actor-network is supporting the pre-interessement phase described in Chapter 5. The Purchasing team's main responsibilities were discussed during the interview:

> (…) with our Category A supply chain partners, we've got trading agreements which are based around spend (…) so a big part of what we do in our team is administering those agreements, making sure they're in place all signed up and then collecting the associated fees that go with that. The other people in the team are predominantly involved with that kind of administration collection process resolving any invoice disputes, that type of thing so it maintains the correct type of relationship. Then they get involved to an element of kind of like relationship. So two of the people in the team are degree qualified. One's a construction management degree, another lady's degree is in economics, I think it is and one of the other ladies is currently studying the Chartered Institute Procurement and Supply course (Product Manager – 2016).

> We're not a very big team, there's only six of us (Purchasing Manager – 2016).

Hence, this network works towards establishing long-term partnering relationships with the supply chain, in order to enhance their processes and get the supply chain more involved in earlier stages. Indeed, having fewer but more trustworthy suppliers can help to save time and costs, as well as implement innovation and transfer it to other projects due to the continuity of the working relationship. In order to do so, the Purchasing team develops surveys to be used to screen the potential suppliers and get to know them better by visiting their factories. Once they find the right choices, they are asked to agree on and sign the supply chain agreement in order to become the main (Category A) supplier or manufacturer of a particular material, or component.

> We try to get our supply chain more and more involved in what we class as pre-construction. This is the point at which we are trying to win the project so this is design, estimating and very much adopting an approach of the companies that support us to win work are the companies that we will use to deliver the work (Product Manager – 2016).

Another important aspect of this network's responsibilities lies in training the mandated suppliers and providing learning opportunities. For example, they may supervise that questionnaires are created and submitted to the supply chain (e.g. regarding BIM). They

also manage hot-desking (e.g. they organise periods of time in which a person from the supplier firm can directly work and interact with other people within TCC) and organise workshops and events in order to enhance communication between TCC and the supply chain (e.g. “Better door” workshop, sub-regional supply chain conferences). They are also directly responsible to meet quarterly with some spokespersons of the supplier company in order to monitor whether the agreement is working in the right way for both parties, and discuss about any issues they may have, innovation, pricing, etc.

> You’re working closer together because ultimately we wouldn’t work, our supply chain wouldn’t work, etc. I think we’re in a period of change at the moment across both the housing business and the construction business in the way we are trying to work and engage with our supply chain, trying to make them feel part of our business. Simple things like some of the offices are operating like a top desk where you invite somebody in to come and work for a day in our office. They start to meet more people whereas traditionally subcontractors estimate and mainly talk to one of their estimators. But you’re trying to expose them to more people so they actually feel part of our business and share our values and culture (Product Manager – 2016).

> In supply chain conferences every year where they get a chance to go and give an award ceremony and then they get to also come and meet lots of internal people and meet each other as well and the manufacturers are there and the subcontractors are there (Purchasing Manager – 2016).

Therefore, the Purchasing actor-network aims to construct John’s strategy of reducing the number of suppliers, select the best suppliers, building stronger connections, and implement supply chain agreements which expect the use of standard components and process, BIM, and promotion of innovation. The actor-network is therefore directly connected to the CIS actor-network where it is black boxed in the decision-making process of choosing the right partners to work with and negotiate with since they are actively involved in the selection phase of the suppliers (e.g. through surveys, questionnaires, and site visits), thus in the pre-interessement phase (see Chapter 5). Hence, it is an important actor-network because it is essential for establishing the first contacts with the mandated

suppliers and involves them in long-term relationships and training opportunities. Analysing this actor-network and its relations with the others allows to respond to some of the sub-research questions: “what is the role of innovative technologies (e.g. BIM) and practices (e.g. supply chain agreements, workshops, meetings) in shaping collaboration between the firm and suppliers? Do they assume different characteristics in different contexts?”, and also “how is collaboration implemented in different contexts?”.

6.2.2 Standard House Type (SHT) project network

This actor-network is part of a “collaborative exercise” to design standardised residential houses using different types of building (timber frame, light steel frame, traditional bricks) in BIM. SHT can also be defined as an actor-network since both human (e.g. Project manager, architects, sub-contractors) and non-human actors (e.g. BIM, other software, architectural models) are present and their interactions contribute to shape collaboration. This actor-network aims to construct the object of developing standardised residential buildings by implementing BIM, as it showed a great success in the school projects. Hence, they were used as a trial for a limited selection of standardised houses. The actor-network is part of John’s strategy of extending the use of BIM and developing standardised products (houses), and it is directly linked to the supply chain agreements’ objectives. It is therefore also connected with the Purchasing team actor-network too.

> We’ve got that agreement where we’re giving them work and they’re working closely with us and they’re giving us good rates and as part of that agreement, they’re going into the BIM world in Revit with us. So this exercise is a spin off from the intentions we’ve written into that agreement (SHT Project Manager – 2016).

It involves various employees within TCC, sub-contractors, and architects. Hence, the CIS actor-network is black boxed in the SHT actor-network. The main leader of the SHT actor-network is the Project Manager who aims to schedule regular meetings and workshops with all the other actors and to follow a strict program of design, pricing, and then product launch of standardised houses. The other participants have to follow this planned program which aims to get regular enhancements in terms of detail using the software BIM and, in particular, Revit, Buzzsaw, BIM 360. The sub-contractors for timber frame, steel frame, and

roofing have to develop the models according to their level of expertise, and, as they are learning how to use BIM, collaborate with the architects to translate their models (made with different CAD software) into Revit.

> (…) we're still finding is the consultants are all over Revit and are very easy to use it. The subcontractors are still struggling. The learning experience we've had on this job is to drag GSFC and TFC's along with us because they're not quite there in Revit which is what we're talking about, different file formats and compatibility and naming conventions. What we've done here is a snapshot of where the construction industry is at the moment. Consultants will happily design in Revit but then when you get onto site and you employ subcontractors, all they want is paper copies and they'll build to that. So it's trying to get those subcontractors to use the Revit model and take it through the construction process. (…) When you come to housing and we're trying to do a house, trying to get subcontractors BIM compatible is very difficult and that's going to be a journey that we'll struggle along with for the next three or four years. We find bar these two guys, GSFC and TFC's, there not many of our subcontractors that can work in Revit (Project Manager – 2016).

The network of actors met in person about every two or three weeks, but their interactions extended outside the actual meeting. For example, the suppliers and the architects were regularly speaking via emails, phone calls, or Skype videos. Moreover, the software Buzzsaw and BIM 360 allowed to create an online platform in which the actors could share notes and notifications regarding the models, or any other issue. Hence, the actor-network had open boundaries in which the collaboration and strategizing among actors was translated outside the actual meeting with the Project Manager.

> In BIM you also have got the online collaboration which is Buzzsaw as we sit at the moment, it now might be BIM 360 but it is an online portal where all that information gets uploaded, reviewed, uploaded, reviewed till it's right and shared (Project Manager – 2016).

Therefore, collaboration in this type of network occurs in different ways: meeting in person or interacting remotely. However, both of these two ways of collaboration are employed through the implementation of technology. This new format of partnering and strategizing represents an innovation within the firm and its supply chain. Indeed, as the interactions that aimed to make strategic and immediate decisions can happen during meetings, and directly with BIM (e.g. through the use of comments and notifications which are responsively sent to all the participants of the project), technology has also role in influencing the way in which the actors communicate and collaborate. Nonetheless, the actor-network, as it was observed, was not as strong as it should have been, because there was a lack of clear communication between the actors who had to rely on BIM and the online platform to going on with the models and the level of details in order to stay on the Project manager's schedule. As I discussed in Chapter 5 (sub-section 5.2.2), this led to issues in the moment of the clash detection exercise which revealed previous problems of collaboration.

Moreover, this actor-network can be considered fluid because its boundaries are not fixed, but it is influenced by the other actor-networks. In fact, it is influenced by John's strategy as it represents the strategic guide into the development of standardised houses and BIM, and it is influenced by the Purchasing team actor-network which selected the mandated suppliers who are working on the SHT project. The SHT actor-network also implements collaboration differently according to the way in which BIM is used. For example, collaboration and communication is enhanced when they occur remotely through the software (even though it has been argued how it did not work at first with the clash detection exercise), whereas meetings in person seemed to be weaker in terms of active collaboration since the activity schedule strictly followed the project manager's programme. This means that the actors were collaborating and implementing BIM by following the lead of the project manager, and CIS was constrained by this schedule.

6.2.3 SP actor-network

The SP actor-network is also part of John's strategy of implementing BIM and standardise products, in this case schools. The object of this actor-network is to develop standardised school projects through the implementation of BIM, and the early involvement of a fewer number of mandated suppliers. Just like the SHT actor-network, it involves human and non-

human (e.g. BIM, architectural models) actors whose relationships influence CIS. We can also find the CIS actor-network black boxed in the SP actor-network, just like the previous actor-network. The projects in SP saw the introduction of BIM and standardised processes before the residential and private business of TCC. Indeed, the successful implementation of these schools has led to the decision by John to spread BIM and standardisation with the active involvement of a small and trusted number of mandated suppliers to the other firm's businesses.

> (…) our plan is to cover as many standard areas of components as we can do (National Product Director – 2017).

Hence, as with the SHT actor-network, the CIS actor-network is *punctualised* (Callon & Latour 1981) in the SP actor-network. The implementation of BIM, a fewer number of mandated suppliers, and collaborative strategizing among actors in an innovative context become black boxed into the SP actor-network. It is a consolidated actor-network since the same sub-contractors and mandated suppliers have been collaborating for a longer period of time with TCC and various school developments have already been developed. This actor-network has been (limited) observed during design review meetings involving many actors, such as: design managers, product manager, BIM director, architects, estimators, and other actors from the sub-contractors involved in the projects. It has been highlighted during interviews how design meetings involving 3D modelling, such as through BIM, can positively impact actors' discussion and decision-making. Indeed, the model can be analysed more clearly in all its parts.

> It does make design team meetings a lot simpler when you can sit and look at an issue and look at it in 3D. Everybody kind of gets it straight away. Most people you work with, they don't have any issues with two dimensional drawings, but you might need to look at a series of two dimensional drawings to see what the issue is. If you can model it and section it and rotate round it all on one model on the screen, it's so much better (SP Product Manager – 2016).

Therefore, BIM can be considered an efficient "set of technologies for generating, managing and sharing consistent building information among various AEC actors" (Papadonikolaki et al. 2016, p. 477). In particular, BIM has provided benefits within design management by contributing to more fluent and detailed visualisation (Azhar 2011; Elmualim & Gilder 2014). Even though the Product Manager has highlighted how collaborative 3D BIM is useful for design meetings in terms of design modelling and information management, it may not be very useful in design terms beyond those meetings. In TCC, although the implementation of technology to enhance efficiency is expanding towards the construction site, such as through the use of particular software by the site manager (e.g. *Fieldwork Supply Chain Usage* as discussed in one of the supply chain conference), two dimensional models are still widely used on site and are relevant for the end users, as innovative models are still not widely understood (innovation is slowly being accepted and implemented). Therefore, collaboration through BIM occurs in these design actor-networks but it is not fully implemented on site yet.

Hence, *objects* such as BIM, architectural models, and other documents used for collaborative strategizing, but also *places* such as different kind of meetings, or workshops can influence how the actors within SHT and SP interact, and strategizing is shaped. Within these actor-networks different associations of human and non-human actors can lead to different enactments of collaboration. Multiple actors are present, and collaboration is implemented differently: disparate technologies are used, and interactions are influenced by them and the surrounding environment. As Law and Singleton (2014) discussed about the foot-and-mouth disease, collaboration is "*different thing in different practices*" because it is performed differently in different settings, hence it is a *multiple reality*. Hence, the analysis of these actor-networks allows to understand all the facets of CIS by focusing on the actors, in order to answer the research questions.

Collaboration is thus enacted differently by the actors in each network, but it is also a different thing in each setting where perspectives on collaboration and the use of collaborative technologies, such as BIM, differ. However, these different practices are not detached from each other, but rather they create a *combined reality* because the actors are all working towards the same shared strategy (CIS). Collaboration should not be understood separately in single actor-networks, but rather it should be understood in its associations and as part of the bigger CIS actor-network.

Callon's (1986) model is in this sense challenged, since it does not consider the concepts of multiplicity and fluidity of actor-networks and objects. Indeed, the interessement devices discussed by Callon do not present fluid boundaries and do not change shape. Moreover, Callon considers just one reality created by the actor-network, whereas here I explored the actor-networks of punctualised actors, which create multiple realities, and in which collaboration is enacted somewhat differently in different contexts. Finally, Callon provides a top-down model where interests and identities are imposed, and power is constituted relationally in a flat ontology. My analysis suggests that these interests and identities are not imposed but are filtered through the actor-network builder as discussed in Chapter 5 in the pre-interessement phase. Moreover, the relationships between actors and objects are inter-connected and enact different collaborations in multiple actor-networks. Hence, CIS, which is the key object of the actor-network, is sustained by all these connections among actors.

6.3 The role of objects and technology in multiple realities

Multiple actor-networks and their relation towards the CIS actor-network were discussed, in order to understand the connection between the actors, and how CIS was enacted differently within them. However, as one of the research sub-question aims to answer[6], objects and technology in these actor-networks can also play an important role in shaping CIS as they are enacted differently and become different things for the actors using them. Collaboration between the firm and its supply chain takes place in different organisational settings according to the type of meeting and objectives. Within these organisational settings, various objects and technology (e.g. documents, models, software, PowerPoint presentations) are used. Hence, reality is shaped by different tools in a diversity of practices.

The type of activity implemented enacts different objects, leading to multiple realities (Mol 1999; Mol 2002). For example, this means that collaboration is enacted differently in different places in which the objectives of the meeting are different, and the objects used have a different influence on the actors' interactions. Objects and technology can thus have a role in affecting collaboration and strategizing in different contexts. In

[6] What is the role of innovative technologies (e.g. BIM) and practices (e.g. supply chain agreements, workshops, meetings) in shaping collaboration between the firm and suppliers? Do they assume different characteristics in different contexts?

classical ANT terms, objects are defined as "an effect of stable arrays or networks of relations" (Law 2002, p. 91), and are defined by Latour (1990) as *immutable mobiles*. On the other hand, here I discuss objects which have fluid boundaries, hence do not have a fixed structure; rather, they change shape and work in different ways, (cf. Law (2002); Laet and Mol study (2000)).

6.3.1 The role of BIM in different contexts

The main "object" implemented in this study is CIS, but BIM also represent an important object in CIS. BIM includes technical software, regulations and execution plans, and lived practices and processes. A first important feature of BIM is that it is recognised as a collaborative tool which increases and improves communication and information sharing among actors.

> BIM provides huge benefits that enable all teams to work better throughout the construction process to achieve the high-quality finish we expect. Being a recognised provider of BIM Level 2 means we are also well positioned to meet the Government mandate for BIM use on public funded projects (Head of BIM – from TCC website).

> We know that the customer only wants this house type so we know the house type is this material and we can just manufacture it straight away, improves our processes (Business Development Manager from roofing supplier – 2016).

In the supply chain conferences, or during strategic workshop, BIM is used as a strategic tool to enhance the involvement of the supply chain and push forward the firm's innovative strategy of standardisation and time and cost efficiency improvement. Therefore, BIM means "different things in different practices" (Law & Singleton 2014, p. 384) and multiple realities are created. However, BIM goes beyond this concept. As it will be discussed in section 6.4, BIM is enacted differently and thus it is different things in different contexts, like the bush pump in de Laet and Mol's study (2000), where the pump is a water-producing device, but also a sanitation device.

Although there are a lot of benefits which are recognised by the firm and the supply chain, this study has showed how following too much this collaborative tool and pushing for

communication mainly through the software (e.g. design notifications and notes, online portal such as through Buzzsaw, or BIM 360 Glue for clash detection) led to unexpected results when the different models had to be unified in Revit: the measures did not align.

> Technology-wise, we're using Buzzsaw, brilliant system. The issue we've got with that is people uploading the correct information at the right times, notification of that information once it's been uploaded and then just referencing of it all. If it's not done correctly and right, it becomes a nightmare for everybody. Provided it's done correctly, all the information's there and available so I think it's a really good system if done right (Business Development Manager from roofing supplier – 2016).

Hence, collaboration through BIM can assume different characteristics in different contexts. In the design meetings, such as those for the SHT and SP, it is used as collaborative software which comprises of the standardisation of components, 3D visualisation of models, and information sharing, such as in the following citations from SHT ethnography.

> If I touch a door, it's actually telling you it's a door and all the properties are there as well. When I mark it up on the right hand, that door is marked up on those other 16 drawings automatically. That's actually pretty cool.

> (…) you can notify item number 74, send it to the person responsible for that drawing; you send them a notification - just done clash test, your latest model, etc.

Nonetheless, during the SHT clash detection meeting, it showed how Revit did not enable a successful clash detection as the coordinates of the different architectural models were already misaligned (see Figure 5.1). It happened that the coordinates were not the same in Revit and in 360 Glue, which was used for the clash detection. One of the actors from TFC argued:

> So Revit is a fantastic authoring tool, fantastic designing tool but it's just not the beast for doing collaboration. We're doing this because it just gives more stakeholder's access to BIM that wouldn't normally have it, it is really simple. I can do it on any

platform, I can do it on android if I have got web access to a web browser, or if I have got an iPad. Plug your iPad in, here we go and if I want to work on one of the models, I quickly download them and I've got two days. As long as you're working on it, it just keeps renewing those two days and when I get back to the office, and I log back on it will sync all my comments back to the Cloud and when it comes up there it means if I'm on a plane, train or travelling or sitting on the beach in Portugal, people get those notifications through their email, click on, web browser, comes up.

Revit does enhance mobility and information sharing, but it may slow down collaboration when it has to "talk" to different software, such as Glue. For example, when the actors in SHT had to transfer the models into Glue for the clash detection, the misaligned coordinates had to be amended back in Revit and could not be done so directly on Glue.

So the only way to resolve that is for fusion to amend their Revit model? So you can't solve that in Glue? You can't just change the coordinates? – Project manager
No. Glue is not an authoring tool, so if we move it in Glue it means every time they upload their model, it will still be in the place. It will just come up with the original. So the fundamental philosophy is authoring software, get it right there first. Communicate it in here. – TFC

Therefore, design meetings for the standard house project also included the development of architectural models from different software. In this case, the models represented the way in which the sub-contractors used their expertise (e.g. using AutoCAD, or other software) for the timber frame, roofing, or steel frame models. These models, combined with Revit, influenced the collaboration between the actors as they had to make the software "talk to each other". The CAD models in 2D had to be transferred into 3D Revit, and in order to do so, it was important that the sub-contractors and the architects found a clear way to communicate important technical data to transfer from the sub-contractors' models to Revit. Hence, the actors were mainly communicating using these models and Revit.

Focusing too much on the communication through the software has proved to be a not easy method for collaboration according to the results of the clash detection exercise. The reason for this negative outcome was because there was a problem of communication,

which could have happened remotely, between the sub-contractors and the architects. Also, having a very tight schedule of meetings, in which the level of detail of BIM should have steadily increased, could have left some actors behind the pace since working with BIM represented a novel process for them. Moreover, being "imposed" a collaborative style of working, which most of the time took place remotely, could have been difficult to efficiently arrange since managing the design phase by collaborating directly with all the actors was an innovative way of working for them.

> Some contractors will always want you to go through them, they will not want you to even speak to the subcontractor at all because you're on a separate side, you don't even know their name essentially sometimes. But with TCC, they in some ways encourage you to speak to one another. (…) it's a challenge in time in the sense that you're going to these meetings, it's taking time and you're on the phone to subcontractors and that takes time. (…) But it's not always about time, it's also about the co-ordination and that's always a big thing (Architect for SHT project – 2016).

Hence, it was emphasised how CIS mainly occurred through effective communication and coordination behind the implementation of BIM, and how time (e.g. a strict schedule) also affects the outcomes of this collaboration. Apart from BIM and the other architectural software, other objects, which are used in meetings, workshops, or conferences, can influence CIS.

6.3.2 The role of Power Point and videos in different contexts

During supply chain conference and workshops, PowerPoint presentation and videos have been widely used to represent the firm's strategies and vision, main accomplishments, projects, and technological development. Moreover, showing pictures and videos, highlighting slogans and successful projects in front of a supply chain audience works as a way to enhance communication, build trust, and therefore collaboration between the firm and the mandated suppliers. In this way, PowerPoint presentations, videos and pictures become powerful tools of communication. By talking and interviewing the suppliers, they seem to recognise the importance of these events and motivational speaks as a way to feel more involved, building trust with the contractor, and developing collaboration.

> I enjoy this type of event, because it makes me feel part of the team. (…) no other firms gather all manufactures together. There has been a change in the last years in the way firm build relationship with the supply chain, and this can particularly be seen from TCC (Installer for school projects – 2017).

Hence, for the supply chain, Power Point presentations and videos represent objects for increased emotional involvement in the projects they are working in, and in the relationship with TCC. For TCC they become objects to communicate its strategy to the suppliers.

PowerPoint presentations have also been used to start a BIM learning process, which is divided into three main modules, within the firm and to the supply chain. The Head of BIM was responsible for this process and the PowerPoint was used to give a general overview of the software in the first module of the training ("Bronze training").

> I've designed a bronze, silver and gold training. A *bronze* is pretty much getting rolled out to everybody, so it'll be a three-hour course, really boring, death by Powerpoint. What we're doing is the fundamentals. So why the government chose to change and why they want to do it and why they're pushing it ad why it's important to them. Why it's important to us as an industry that we need to change. So it's about making people realise exactly what it is, but it's not a bit of 3D. (…) But it is a process that's there, it's designed to save money throughout that process and it's designed to really give the money saving to a client once you've finished your project, because that's when the real money gets saved and it's starting to plant seeds. So the *silver* training is more about the actual process that's set out by the government in the past document. It's about the workflow, it's about the documents that we use, why we use them, how they're different to the existing documents. It's slightly more technical so really we're only looking at maybe an estimator or a QS and the design manager to do that because they'll the ones that will effectively be taking on the role of a BIM manager between them. Then the *gold* training is actually application training, so I've sat down with a registered training company and plan a day's training based on the two free downloadable viewers that they've got (Head of BIM – 2016).

The Head of BIM also highlights how it was important to keep the PowerPoint presentations as visual as possible, by using quick slides and a lot of pictures in order to make the message passing more quickly to the recipients:

> For the bronze because it's about 80 Powerpoint slides with a few presentations in there, but some of them are literally 10 seconds, five seconds. One of them is just like a pile of money. So why are we doing it? Bang. (…) it's more as Powerpoint should be, it's more visual, there's not a lot of text on it (Head of BIM – 2016).

In this case the PowerPoint presentations assumed a different connotation compared to the supply chain events. For the suppliers, it became a learning tool to understand BIM, whereas for TCC it represented a strategy for training its own employees and the supply chain. Hence, these two examples showed how PowerPoint presentations and videos can assume different shapes and thus influencing the way in which actors define these objects. Each of these practices creates their own material reality where CIS is enacted differently, and PowerPoint and videos influence the way in which CIS occur.

For example, looking at PowerPoint as object for emotional involvement, it means that CIS is enhanced because of the greater engagement of the suppliers in meetings, or other events. In the case where PowerPoint worked as a learning tool to understand BIM for the suppliers, then it influenced the way in which suppliers, for example, approached the design meetings, as they were following TCC's leading to implement BIM. For TCC, PowerPoint as strategy for training meant that the purpose was to having suppliers and internal employees trained to implement the software in short and long-term in order to respond to the government's regulations.

6.3.3 The role of documents in different contexts

Other objects include documents such as the BIM execution plan and BIM requirements to be followed by the project participants. Each mandated supplier is given a document of BIM deliverables which are required for them to achieve. These documents represent the basis of the BIM process and must be carefully understood by the actors. In particular, the suppliers were asked, such as in the supply chain conferences, and workshops, to know these documents in detail.

> (…) the key document is the BIM execution plan. That's what we're trying to get to the end point of with these bits of forms because that captures everything and that tells every BIM design and what we have got to work through in the team. (…) Because all we need from you at the end of the day is the drawings and information have been produced and the correct naming for it (Head of BIM during meeting – 2016).

Moreover, BIM competency questionnaires also play an important role to understand the level of knowledge and expertise of BIM of the suppliers in order to continue or start a long-term partnership. However, it is made in a proactive way, encouraging the learning process of BIM:

> I think it's not a case of you're not on a BIM journey so therefore we won't work with you. If it's someone we've had a long-term relationship with, it's a case of on your BIM journey, how do we get you on our journey with us because we want to help you so we can carry on using you. And if they turn around and blatantly no, we're not prepared to even look at it, then that's probably where it all goes wrong. But it's not a case of you're in or you're out (Product Manager – 2016).

In this case, for the suppliers, BIM competency questionnaires became an object for self-evaluation in terms of BIM expertise and an opportunity to learn more about its implementation, whereas it worked as a pre-requisite for TCC in order to understand the level of knowledge of BIM of the suppliers and thus to tailor the best training and support for them and to respond to the firm's needs.

Finally, other objects regulate the relationship between the firm and the supply chain at the beginning of the long-term partnership agreement. In fact, the Purchasing team is greatly involved in the selection of the right suppliers by implementing exercises, such as pre-qualification questionnaires (PQQ) about the level of quality, innovation, and other important characteristics which should be included, and pricing exercises. This much regulated way of selecting the right mandated suppliers has proven to be successful in order to reduce the number of suppliers to collaborate with and to find the firms which share the same values and goals as TCC.

> So in terms of when we've got to a partnered supply that we'll use on every scheme, the exercise generally starts with a PQQ of some description. (…) So it's a big exercise and what you might do is send out 150/200 question PQQ to 80 companies because I've then got to review all that information when it comes back. So we picked out the high level things that were really important to us, like the PEFCs, ISOs and things that we felt were really important to the business, did a short PQQ and managed to whittle it down to 25 from these first 15 questions. Once we'd done that, we then sent a full PQQ with all of the questions and a pricing exercise out to all the companies. We then score the companies on their PQQ answers, applying weightings to certain things that we feel are important to the business and again the pricing exercise, we do a comparison to give out a score. It's generally weighted 50:50, 50% on the PQQ, 50% on price because equally they're as important to us.

In this other case, the PQQ and pricing exercise also create multiple realities. In fact, they represent an opportunity for collaboration and to improve innovation in the long-term for the suppliers. For TCC they are a requirement for the selection of the best suppliers to partner with, and, as discussed in Chapter 5, they represent the filters through which the identities and interests of the suppliers are selected to become part of the actor-network. Hence, all these objects have an active role in influencing the way in which the relationship between the firm and the suppliers is structured and how CIS is shaped in certain environments, as they create multiple realities. In particular, these employed objects are not simply "things" but are "ways of doing with things" and to conceptualize artefacts whose purpose depends on the context (Jarzabkowski 2005; Jarzabkowski et al. 2013, p. 7). These *epistemic objects* which shape social relations are not innately strategic artefacts, but they play an important role within the strategy context in which they are implemented. Hence, their properties are acquired according to the setting and thereby they shape a particular activity (Gherardi 2010).

Finally, the organisational setting itself, such as meetings and workshops, may also influence how collaboration and strategizing are implemented. The classical organization-studies literature has discussed meetings as tools for accomplishing specific tasks, such as

decisions (see Simon 1997). However, recent studies have argued that meetings have a more effective role by drawing attention to their role of "routinized social practices that serve to stabilize the wider social system of which they are part" (Peck et al. 2004, p. 3). Hence, meetings have an organisational purpose and involve discussion from different actors who may feel freer to challenge the established structures and routines. In this setting the discussion can benefit from the momentum, and the interaction among participants may lead to unexpected activities and decisions (Jarzabkowski & Seidl 2008). Moreover, the type of context may vary depending whether it is a formal strategic meeting, a design meeting, a workshop, or a conference. Based on the environment in which actors are surrounded, the way in which they interact does change and the different objects used can shape it too.

Therefore, both objects and places can influence how actors collaborate and strategize. The way in which they create multiple networks and lead to different outcomes in terms of actors' strategizing challenges Callon's (1986) model, which has a more fixed structure, and does not consider multiplicity. This section also answers my sub-research question about the role of objects in shaping collaboration and strategizing[7]. They way in which they are differently enacted, and their changing shapes results into multiple realities in which CIS is influenced by them. The following section analyses BIM as a *fluid technology* (de Laet & Mol 2000) which changes shapes and characteristics according to where it is and who implements it.

6.4 BIM as a fluid technology

The reason to examine more deeply the role of BIM, and in particular its fluidity, is to better understand the implications for CIS since BIM represented the main innovation to be observed in this study, and still reflects on the sub-research question (see footnote 5). BIM manifests in multiple ways and it changes characteristics and purpose according to who uses it and where it is implemented. As Mol and Law (1994; 2004) argued, anaemia and hypoglycaemia are both characterised by "*fixity*" and "*fluidity*" because they are manifested in multiple ways. As they are enacted differently by different practices, the process is

[7] What is the role of innovative technologies (e.g. BIM) and practices (e.g. supply chain agreements, workshops, meetings) in shaping collaboration between the firm and suppliers? Do they assume different characteristics in different contexts?

characterised by many associations and networks, even though anaemia and hypoglycaemia maintain their integrity. De Laet and Mol (2000) discuss in particular about *fluid technology* by arguing about the diversity of manifestation of the water pump, thus becoming a *mutable mobile* changing its physical shapes over time. The pump does not have a fixed structure and it is characterised by the general fluidity of the relations making up the pump itself (Law & Singleton 2005).

Throughout this analysis it has been argued how BIM can be understood as the enactment of different objects in different set of relations and context of practices, as it will be explained in the following sub-sections. Moreover, BIM can be considered a *mutable mobile* since it is characterised by a set of relations that gradually change and adapt (Law & Singleton 2005; Mol 2002), allowing it to travel to new settings. In particular, it has been highlighted how BIM cannot be intended only as design software, but it is a lot more.

> In the housing industry you find subcontractors are the ones that do the design. So it might be that they're doing sketches on plans and that's the design sort of thing, they're not actually doing a complete design process. But if you vet that in the first instance and say what are your capabilities? What software do you use? Do you use any or do you sub it out and you check with the people that they sub it out to, you're actually getting a good picture of where your supply chain is and what the capabilities are, which doesn't happen at the moment and that's another element to BIM. So when people say BIM and they think it's just a 3D clash detection tool, it's a whole lot more because you're almost instilling quality throughout the project which will then help you deliver a better project (Head of BIM – 2016).

In this interview the Head of BIM highlights how BIM leads to a wide range of quality changes within a project. From increasing the efficiency of building processes in terms of time schedule for workers, but also for the customers as they are promised an exact date for the finished product, to enhancing collaboration and integration among the project's participants; from reducing time and product waste, to reducing the cost of the components and the final products thanks to standardisation and previous agreements with the supply chain. Moreover, some companies within the supply chain can find benefit in learning and implementing BIM as a way to differentiate from other competitors in the market. Hence,

BIM changes and adapt its characteristics according to relations and practices, therefore playing a central role in influencing actors' CIS.

The following paragraphs focus on BIM as assuming different connotations that are: a collaborative object, a learning object, an innovative object, and an object for power. The reason to divide its analysis into these different connotations lies in the fact of BIM being a fluid technology, thus changing shapes, and becoming different objects with different outcomes for CIS.

6.4.1 BIM as a collaborative object

In the design meetings, such as the SHT project and the SP project, it would be easy to assume that BIM was mainly used for the design of the new residential houses, or schools; hence in particular Revit was central in this process to develop the architectural models in 3D. However, by observing these meetings, it was possible to determine how BIM assumed different connotations and meanings. First of all, it can be defined as a *collaborative object.* Regarding its design features, BIM influences the way in which actors interact during meetings or workshops as it provides a different way to look at the model.

> It does make design team meetings a lot simpler when you can sit and look at an issue and look at it in 3D (…) If you can model it and section it and rotate round it all on one model on the screen, it's so much better (SP Product Manager – 2016).

Moreover, it also influences communication and collaboration due to its intrinsic software features since the actors are expected to share a lot of information remotely, such as through Buzzsaw, or BIM 360 Glue.

> In BIM you also have got the online collaboration which is Buzzsaw as we sit at the moment, it now might be BIM 360 but it is an online portal where all that information gets uploaded, reviewed, uploaded, reviewed till it's right and shared (SHT Project Manager – 2016).

Therefore, BIM has influenced communication as a lot of interaction between TCC and the supply chain happens through the software itself. TCC has particularly emphasised, for

example during conferences and workshops, that what is needed from suppliers is delivering information through BIM to comply with standards. This means that suppliers have to send BIM components to TCC design team, and these components have to be efficient for the end users. The detail is also very important and needs to be suitable for the designers to be used, but also suitable for all the other contractors involved with TCC's projects.

BIM can also be defined as a collaborative object because it changed the way in which the contractor company collaborates with the supply chain, particularly regarding how they build relationships and long-term partnerships.

> I suppose it's affected us to the extent that we're more aware of the people that we're partnering with, forming agreements with, where are they on the BIM journey. Obviously if they've no plans to go down that route, they're probably not the company for us going forward so from a procurement role, we are assessing our supply chain on where they are with BIM (Purchasing Manager – 2016).

Hence, collaborative BIM has shown to enhance the relationship between TCC and the mandated suppliers, and to influence the communication between those actors in different contexts. As a result, CIS is partially shaped according to how BIM is differently enacted.

6.4.2 BIM as a learning object

BIM can also be defined as a *learning object*, particularly for the sub-contractors who were starting to implement it with TCC, but also internally for TCC itself.

> It's changed the way that we do things. We're finding that it's probably going to be a faster way of drawing things from our point of view, putting them through BIM (…) it has been a learning curve. We see it as a very good learning curve for us with very positive outcomes (Sales Director TFC - 2016).

> It's all about investment in education. You've got to invest in the software and you've got to educate your staff. The smaller contractors haven't got the will nor the finance

> to do that, whereas TFC's and GSFC (…) they're probably one of our biggest subcontractors we use (SHT Project Manager – 2016).

Hence, during this learning process of BIM, which involves both the contractor firm and the supply chain, TCC has assumed the leading role in spreading the implementation of BIM internally and within the mandated suppliers (e.g. through training session led by the Head of BIM, and BIM questionnaires to the suppliers). Since many sub-contractors were using different software (e.g. AutoCAD) for their projects, the firm (or external consultants) helped them translating from their previous software to BIM. It resulted in a real challenge for some sub-contractors and for TCC as well:

> In our industry, we kind of work backwards where we have some design software that designs the finished product so it can go through the machinery in the factory. But that product isn't necessarily able to talk to BIM so we've had to get over that. We're there now but that's been a real task and that is a huge problem within our industry but (…) we've been able to do it, convert files from AutoCAD to BIM (…) Revit and AutoCAD don't really talk to each other so that's been a big problem for us. We've found a way to get them to talk to each other (Sales Director TFC – 2016).

> When you come to housing and we're trying to do a house, trying to get subcontractors BIM compatible is very difficult and that's going to be a journey that we'll struggle along with for the next three or four years (…) Our subcontractors are not BIM experts so that's been challenging trying to make sure they're using the right bit of kit, they've employed the right expertise, they're doing it the right way, they're using Buzzsaw in the right way, they're naming it in the right way, putting the right amount of detail in that we want and spelling all that out (SHT Project Manager – 2016).

The importance of conducting this learning experience was emphasised during supply chain conferences and workshops. For example, one of the workshop, which I attended, and which involved mandated manufacturers and installers of doors who were construction partners of TCC for the schools' developments, had a session in which one of the manufacturers gave a brief presentation about their personal experience of investing into

BIM. Some years before they got interested in BIM, they tried to understand its value, cost, benefit, such as that digitalization was good for manufacturing, so they tried to understand what customers want. Therefore, they decided to invest in BIM with the help of external consultants. During meetings with them, they had to completely re-draw all their CAD drawings. This also represented an excellent opportunity for them to rationalise and consolidate their range of designs. In about six months, they were able to develop standard ranges for each of their sector. Eventually, they advised to the audience (the other suppliers present in the room) that it is better to "keep it simple". Hence, shared experiences among suppliers allow to enhance even more the learning process and perceive BIM as an advantageous opportunity for learning and to foster their capabilities. This early involvement of the supply chain, firstly in the learning process of BIM, then in the design meetings, fosters suppliers' interests and thus CIS.

6.4.3 BIM as an innovative object

This other enactment of BIM as an innovative object aims to focus on BIM as an innovative software and practice to be implemented both within TCC and the mandated suppliers as a new way of working collaboratively. Indeed, BIM has been implemented by the firm and by its suppliers and sub-contractors as part of an innovative strategy of working throughout the building process to foster collaboration with suppliers, engaging with suppliers in the earlier stages of projects, and reduce time and costs. Moreover, the use of BIM in residential housing has not been very common in the industry:

> It's quite good to see that TCC are pushing it because it is coming but just slowly in the residential sector, especially on the small houses because people can't see the benefits of them on a two-bed house. They can see the benefit on a flat, a block of flats but we're not quite there of people seeing benefits on house types (SHT Architect – 2016).

It has been highlighted how introducing BIM in the residential housing sector to offer standard houses represented an innovation in an industry which is quite slow on taking on innovation and change. However, the implementation of BIM on the standardisation of schools resulted in even more innovative projects. BIM has pushed towards the

standardisation of components and branding of schools which are sold into the market within a specific time period, respecting agreed costs, and with a strong marketing strategy.

> (…) SHT as we've said have been around for ages. Standard school types, they have existed in the past but perhaps not to the extent that they do now (Purchasing Manager – 2016).

Therefore, the innovation of BIM within the construction industry is not just the software itself, since it has been used for quite a long time, even though not so extensively, but it is the change that it brings within the organisation. It can be argued that it has multiple boundaries which define a set of configurations enacting a different BIM, just like the bush pump which is "framed in a range of different ways" (de Laet & Mol 2000, p. 237). BIM is about enhancing processes, collaboration among actors, reducing waste, improving certainty of delivery, increasing off-site construction, etc. For the firms this means starting with a huge initial investment in money and time to train employees, but with a strategic vision of obtaining long-term benefits. TCC has been an initiator of this innovation and has led this change towards all the firms which they collaborate with, such as the supply chain.

> Innovation doesn't necessarily mean drilling your price down. Certain instances, it was a case of offering them enhancements which may cost more money but it may prove that the job is quicker to build on site by doing it that way. So consequently the main contractor would save on so many weeks prelims (Sales Director from timber frame supplier – 2016).

From the interviews with the suppliers, it has been transparent the way in which they feel about TCC in terms of their innovation strategy. The supplier seemed to deeply understand the reasons behind TCC's choices of investing in innovation and in their project collaborators. This strong strategy and vision can actually improve the relationship with the supply chain concerning trust and shared strategy.

> (*Talking about TCC*) they are not just to make money, they are a business that wishes to make changes. They want to set themselves apart. They want to leave a legacy, they

> want to make a difference, leave something behind, not just make money (National Account Manager from suspended ceiling and acoustic solution supplier – 2017).

> It's different in the sense that all the subcontractors are involved and there's a real push from TCC to do it, which is good because it is moving towards BIM and especially in our sector, there's a lot of clients that are still quite hesitant about it (SHT Architect – 2016).

Hence, as BIM represents a collaborative and learning object for suppliers, it is also an innovative way of interacting with the contractor because the software pushes towards open discussion among the actors, just like it happened during the design meetings gathering all participants around a table. Indeed, BIM is perceived by the suppliers as the right innovative path towards greater collaboration and empowerment to effectively participate in the contractor's strategy and design, to increase market competitiveness, to improve design skills, etc. On the other side, TCC leads this innovative process of implementing BIM as part of its main collaborative innovation strategy. For them, BIM and the supply chain agreements represent the objects through which attracting the interests of the suppliers. Hence, responding to my research question[8], I can argue that BIM, as an innovative object, can lead to enhanced CIS, and also get the suppliers more involved and empowered.

6.4.4 BIM as an object of power and control

Lastly, BIM can be identified as an *object of power and control* because it affects the way actors collaborate, and it is also perceived differently according to the contractor, or the suppliers. The term "control" might seem the opposite of collaboration, however the reason to adopt this term is that the implementation of BIM resulted from TCC's strategy and it was part of the supply chain agreement. The contractor has the control of BIM to be extended to all its suppliers and sub-contractors according to the collaborative innovation strategy. Therefore, the BIM software was proposed by the firm to the suppliers as part of the supply chain agreements which they have to sign on. This means that they have to commit to learn how to use the software, as it can be seen from the supply chain agreement:

[8] Does the early engagement of supply chains around innovative technologies and practices foster effective suppliers' collaboration and empowerment with the firm's strategizing?

> Take part and engage in the Company's BIM training programme when requested (…) commitment to utilise BIM and support the Company and their partners achieve their strategic objectives in relation to BIM (…) Identify a person responsible for Building Information Modelling (from the Supply Chain Agreement).

Hence, this software can be considered a mean of power and control in the hands of the firm. In other words, it enables the meaning of collaboration to be controlled by the firm. As it was previously discussed, during the design meetings the actors were making technical decisions by following the software's guideline. The CIS was not therefore completely in the hands of the actors, but it was guided and "controlled" by Revit, Buzzsaw, and BIM 360 Glue for the clash detection exercise. Here again the term "control" appears to refer to the way in which the software influenced CIS and communication among the actors. Hence, even though the firm had the main control of the implementation of BIM, it was the software, for example through Revit and Glue, that led strategizing. If most of the work done remotely is also considered, then it can be argued that collaboration face-to-face could have been just minimal. As the John, the Product Director explains:

> (…) you can't work in real time, especially in BIM, so you still, even though you have got the benefits of digital platform, you still end up working traditionally. So you'll have a meeting ,you go through everything and you work out what you need to do and then everyone has to go off and do it and until ...you come back and you review what you have done.

On the one hand, BIM has pushed towards a more collaborative and innovative way of working and involving all the actors in the early phases of the design stage. On the other hand, even though the actors felt like they were actually collaborating more, since they were interacting during the majority of the time, collaboration remotely did affect interactions and problem-solving. In fact, the collaborative and innovative way of working using BIM showed its limitations among a group of actors who were new to the software. Moreover, even though the meetings were based on active collaboration among participants, TCC still had the main guidance of the meeting and made the last decisions. For

example, this was in the hand of the SHT Project Manager. Hence, even though collaboration can lead to flatten hierarchies, the authority and power to make the final decision is still in the hands of TCC. The supply chain is still empowered and can participate in the collaborative process, but under TCC's guidance and mandate.

6.4.5 Discussion about BIM as a fluid technology and implications

It is thus necessary to summarise the reasons to consider BIM a fluid technology, and how it influences CIS, in order to answer the research questions about the role of technology in shaping CIS in specific settings. It has been observed how creating a trustworthy environment, regular support, and communication between the contractor and the mandated suppliers positively impacted the willingness of the supply chain to actively collaborate and engage in TCC's collaborative innovation strategizing. During meetings and workshops communication between the contractor and the suppliers was pivotal and therefore the suppliers had major opportunities to express their thoughts, issues, and share their expertise.

In particular, BIM played a significant role in shaping CIS by establishing the basis for continuous collaboration, shared information, and 3D modelling. Being a *fluid technology*, BIM has moved boundaries and thus it is not fixed from one site to another, as de Laet and Mol (2000) discuss about the Zimbabwe bush pump. Hence, it can be argued that BIM acts like an actor within the actor-network under study. Moreover, being BIM collaborative working software, it entails that BIM works only with the actors of the network, as the "pump is nothing without the community that it serves (de Laet & Mol 2000, p. 234-235). Hence, how does BIM change shapes and can be considered a *mutable mobile*[9]? It can be seen from this analysis that BIM changes characteristics, and the effects on CIS are also variable, just like the capacity of the bush pump to produce clean water changes because the definition of clean water changes according to the context (Law & Singleton 2005; de Laet & Mol 2000). BIM assumes different connotations by representing different objects, such as a collaboration object, learning object, innovation, and an object of power and

[9] Definition of a mutable mobile: "an object or a class of objects may be understood as a set of relations that gradually shifts and adapts itself rather than one that holds itself rigid" (Law & Singleton 2005, p. 339).

control. This means that it is not a fixed object throughout the organisations, and it is different in different practices.

For example, during the SHT and SP design meeting, BIM represented all four connotations: it worked as a collaborative object by making the actors communicate through itself, and at the same time it represented a learning object for the suppliers who were in the process of learning how to work collaboratively and with 3D designs. Moreover, it was an innovation within the network since most of the actors did not have previous experience of designing with BIM, and, above all, with working collaboratively with the architects and the other suppliers. This led to power dynamics arising from the implementation of the software: it was observed how the software had major power in influencing the way in which the actors communicated and strategized since all the models and communication was passing through the software itself in which the models had to reach regularly a higher level of detail. Also, the actors relied on BIM 360 Glue for clash detection which revealed their errors.

During the other events observed, such as relationship meetings, workshops, and conferences, BIM was the main point of discussion regarding the strategy that both TCC and the supply chain had undertaken. Hence, BIM represented an innovation object which has fostered the standardisation of residential projects and schools, the integration of the supply chain at an earlier stage of the projects, and the suppliers' empowerment during strategizing activities. Hence, BIM has fluid and multiple boundaries just like the water pump (de Laet & Mol 2000). Indeed, BIM entails enhancing processes and innovation, collaboration among actors, reducing waste, improving certainty of delivery, and increasing off-site construction.

As discussed in the previous sub-section, the way in which BIM is, for example, a collaborative object differs according to TCC's perspective, or the suppliers' perspective. This is what makes it fluid. For instance, TCC regards BIM as a collaborative object because it is part of its strategy of enhancing an innovative way of working with and involving the supply chain in order to build a long-term relationship. The suppliers define BIM as collaborative since they are actively engaged in meetings which are designed to be characterised by open communication with all the project's participants. It can also be stated that BIM itself imposes a collaborative way of working since a lot of the communication happens remotely through the software.

BIM is then defined as a learning object by TCC because it represents the process through which get to know in very detail the expertise of their supply chain. However, it represents a learning process for TCC as well inside its organisation. The suppliers consider BIM as a learning object which can be read as a way to gain capabilities and competitive advantage in the market. Moreover, it represents also a training opportunity through the guide of TCC and external consultants in order to improve the partnership with the contractor and work for future projects. At the same time, BIM is also an innovative object for TCC since it is leading towards standardised processes and products, off-site construction, and efficiency. It is an innovation inside the firm too, since it has started to be implemented in the last couple of years. The suppliers are mostly new to BIM and are willing to introduce it to their companies thanks to TCC's partnership.

Finally, BIM can also be considered an object of power and control. According to ANT, power is relational, thus actors do not possess power, but the processes of translation, such as enrolment, produce certain relations which can constitute power, in terms of actors wielding influence and establishing associations, or relations of power (Michael 2017). In this study, it has been discussed that TCC has the hierarchical authority to lead the implementation of BIM throughout its organisation and the supply chain in order to respond to the Government's new regulations and to gain competitive advantage. On the other hand, BIM also works for the suppliers as a source of empowerment which allow them to learn and being actively involved in collaborative meetings. Nonetheless, the software itself has some limitations on the way in which communication takes place (e.g. need to work remotely, communicate through notifications, etc.).

6.4.6 Relations of power and supply chain empowerment

This section aims to elaborate the concepts of power and empowerment which result from the analysis of this chapter. The reason to do so is to respond to the sub-research questions that are: how is collaboration implemented in different contexts? What are the power dynamics arising from different organisational settings (e.g. meetings, workshops)? There are multiple ways in which the suppliers are empowered as a result of this partnership. Firstly, the suppliers are empowered through the process of knowledge sharing of training events organised directly by the firm, because in those contexts they can express their opinions, and ask for support to the contractor as part of their agreement. Secondly, they

are empowered because they are involved in the decision-making process during collaborative meetings since they have the technical knowledge to develop technical models (e.g. timber frame, steel frame, etc.).

Thirdly, they are empowered through loyalty and trust which are part of the supply chain agreement and have been particularly emphasised by TCC during the supply chain conference. Indeed, the contractor highlighted the fact that it is first important to know the internal customers (all the employees as part of the business) before the external customers. It is therefore a message towards the suppliers to motivate and engage them within the business. Lastly, suppliers have the direct control of the component's instalment: they deal in person with the installers and provide control reports to the firm regarding the way that the components were built.

Therefore, the firm shows willingness to empower suppliers and engage them in the business, even though the contractor is the main actor who responds directly to the client's requirements and it needs to manage a lot of actors throughout the projects. Hence, power is distributed between the contractor and the suppliers, and it is relational according to ANT. Since the firm under study is a contractor, the client's power is very high in making decisions within the firm (e.g. deciding on innovation). Therefore, the contractor is not completely free to decide on every innovation strategy as the innovation is mainly driven by the client. Nonetheless, John's strategy aims to control the design process as much as possible in order to develop standardised products (e.g. schools and residential buildings) through a strong focus on marketing and branding. This represents a way to exercise more power over the clients and the other competitors in the market. For this reason, the relations of power in this case are subverted between the contractor and the client, just like it happens between the contractor and the supply chain.

Hence, how does the contractor exercise power? The contractor exercises power in different ways. First of all, the contractor shows power over the implementation of John's strategy of CIS and BIM to be extended to the whole organisation and the supply chain. For example, it controls the schedule of the quarterly relationship meetings and annual review meetings with its suppliers, as part of the signed supply chain agreement. Moreover, it supervises the collaborative process among the project's participants by leading the schedule of the meetings and making the last decision. So, even though the meetings were

in a collaborative style, the firm still had the main guidance of the meeting and made the last decisions.

It has been observed how there is ambivalence towards control: although the supply chain is interested in the empowerment given by the agreements and the collaborative environment, under certain conditions, suppliers may desire control from the contractor. This was observed, during the workshop involving the firm and the suppliers within the supply chain conference. The workshop aimed to give suppliers a space for discussing some topics (about technical software, supply chain, people, and product), providing feedback to the firm, and raising any concern regarding the cited topics. The workshop therefore provided a proactive and collaborative way for discussing some major issues that suppliers were having with the firm, for example, with communication, performance, point of contacts between them. In this context, it is very important for the firm to receive the feedback from its suppliers in order to understand what needs to be changed, solved, and decide the need for more training. However, suppliers also raised the need to receive more feedback from the firm. TCC responded by scheduling quarterly relationship meetings and regular contact with the suppliers (e.g. by phone or emails). This example illustrates the relational sources of power which come from both actors.

In this context, collaboration can be understood as being in a state of tension between the actors' interests. Drawing on Hardy et al.'s study (2005), this state of tension associated with collective identity of the actors is produced through two styles of conversations: *cooperative talk* and *assertive talk*. Cooperative talks emphasise actors' similarities, and shared interests, and are characterised by shared power to make decisions. Assertive talks lead to effective collaboration by assuring that the actors' organisational interests are represented in practice through collaboration. The actors' roles are thus legitimated in the process of collaboration. The settings of the workshops and meetings discussed above reflect this situation, in which, on one side the actors interact by sharing goals and strategies, on the other side they interact by emphasising their interests which play an important role to reach collaborative effectiveness and innovation.

6.5 Conclusion

This chapter has focused and elaborated on the limitations of Callon's (1986) model in order to answer some of the research questions[10], and the main research question[11]. The main themes which have emerged across the chapter belong to post-ANT literature: multiplicity and fluidity. The discussion about the existence of multiple actor-networks and their interconnectedness, along with the role of objects to create multiple realities, has emphasised the limitations of Callon's model. In particular, different objects, such as BIM, PowerPoint presentations, and documents have been argued to possess fluid boundaries which imply they become different things in different practices. For example, PowerPoint presentations was both an object for enhancing communication and strategic vision between the contractor and the supply chain (e.g. during supply chain conferences, and workshops), and an object of learning of BIM (e.g. to be used by the actors involved in design meetings).

The concept of *fluid technology* has also challenged Callon's model. In particular, BIM has been argued to be a *fluid technology* because it enacts different relations in different practices, and it can be considered a *mutable mobile* characterised by relations which gradually change and adapt in different contexts. As it has been argued, BIM can be different objects, such as: a collaborative object, a learning object, an innovative object, and a power and control object. All these connotations influence CIS in different ways. In conclusion, the aim of this chapter has been to discuss how different actor-networks construct different objects which influence the way CIS is enacted, thus creating multiple realities. Moreover, some of the objects used within these actor-networks can be considered fluid as they are enacted in various ways and assume different connotations in specific contexts. All these elements do influence the way in which TCC and the suppliers collaboratively strategize around innovation, and affect the power dynamics of their relationship.

[10] What is the role of innovative technologies (e.g. BIM) and practices (e.g. supply chain agreements, workshops, meetings) in shaping collaboration between the firm and suppliers? Do they assume different characteristics in different contexts? How is collaboration implemented in different contexts? What are the power dynamics arising from different organisational settings (e.g. meetings, workshops)?

[11] Does the early engagement of supply chains around innovative technologies and practices foster effective suppliers' collaboration and empowerment with the firm's strategizing?

Chapter 7

Theoretical reflection and conclusion

7.1 Introduction to the chapter

The aim of this chapter is to present a reflection on the theoretical approach which has been used in my thesis in order to provide a thread of discussion including the results from the previous two chapters. Thus, it will highlight the contribution of this theoretical framework to previous studies, the challenges that I encountered by applying it, and it will also give some best-practice and guidelines about the combination of SaP and ANT. Furthermore, the chapter will discuss my contribution to future research of collaboration and supply chain management by focusing on the meaning of CIS which arises from the analysis. This discussion will also argue about the role of power in strategizing activities, as it is a concept which has been highlighted in the analysis. The way in which power emerges from one actor to another can in fact influence how strategizing is implemented in specific situations. In order to do so, a critical discussion with previous studies of power will also be included. Indeed, as the previous two chapters have mainly focused on ANT, this last chapter will aim to clarify the role of SaP, and its link with ANT as part of my theoretical approach, in order to answer the research question[12]. Finally, the impact of this research on practitioners and some limitations and suggestions for future studies will be highlighted.

7.2 Contribution of the theoretical approach

This piece of research has analysed and discussed collaboration between a construction contractor and its supply chain with a particular theoretical lens: a SaP-informed ANT study. It could appear to the reader that an ANT approach has been clearly implemented throughout the study, such as in Chapter 5 and 6, whereas the contribution of SaP within the research is more hidden. This research has used SaP as a more general perspective on this research study, while ANT is more applied on the data analysis. Indeed, the theoretical framework is a combination of the two theories and the role of SaP is mainly centred on

[12] Does the early engagement of supply chains around innovative technologies and practices foster effective suppliers' collaboration and empowerment with the firm's strategizing?

collaborative strategizing of the actors as it unfolds in everyday practices and from the bottom-up, such as by observing meetings and workshops through the combination of ethnography. According to SaP, much attention has been put on the role of the actors as the main generators of strategies (*praxis*): the analysis and discussion is indeed focused on the role of actors, both human (the actors in TCC and the actors of the supply chain) and non-human (BIM, and other objects), in implementing collaboration and innovation. Considering both humans and non-humans as actors involved in strategizing and collaboration is integral to the mobilisation of ANT within SaP, it can be seen that the two theories are interrelating to each other, as it will be discussed more deeply in the next section.

7.2.1 How SaP guided my analysis and combined with ANT

The SaP framework has been used throughout the analysis to refer to different connotations' elements of the organisation. For example, the role of space, along with the other objects, has been highlighted in influencing the way in which actors interacted and collaborated. Indeed, the importance of space has been emphasised by the SaP literature in discussions that the analysis of individual strategic activities should always be contextualised in the surrounding environment (Tidström & Rajala 2016; Vaara & Whittington 2012; Whittington 2006). This study's settings, such as meetings, workshops, and conferences, represent *strategic episodes*[13] in which their observation and analysis helped to understand the real day-today challenges of interaction between different actors in a pluralistic context. Relationship dynamics may appear different in these settings than they are depicted by the firm's managers.

Hence, the reason to adopt a SaP perspective to analyse those episodes lies in the fact that, being a practice-based approach, it emphasises the daily routines within a project and gives importance to the strategy discourse as a way of creating knowledge such that power relations and communication can be analysed by looking at language and activities, as I did during the targeted ethnographies in the SHT project, or workshops. These micro-practices may represent the response of actors to an innovation, the actors' capability of managing this innovation, and may characterise collaborative activities towards strategizing

[13] The concept has been explained in section 3.2.4

(Leghissa et al. 2016). All these spaces of strategizing are linked together with the connected networks of actors, namely the CIS actor-network discussed in Chapter 5.

The choice of developing case study research is also appropriate when the context assumes this importance towards the phenomenon under study, particularly when the subjects are business relationships and networks (Tidström & Rajala 2016; Halinen & Törnroos 2005). In fact, it represents the most common research approach within SaP (Jarzabkowski & Spee 2009). Moreover, focusing on a single case study research through targeted ethnographies increases even more the possibilities to be present when the action occurs, hence where collaboration strategizing is happening and the actors are using innovation (e.g. BIM), or are working throughout an innovative process (e.g. collaborative design meetings). Being an external observer may also represent an opportunity to interpret actors' praxis, such as collaborative activities and interactions, in a different and novel way compared to the actors directly involved (Leghissa et al. 2016). Indeed, the observation notes which have been taken during targeted ethnographies did highlight interesting insights, such as the clash detection exercise during SHT, or the discussion between the contractor and the mandated suppliers. This also allows to develop a broader discussion about the way in which innovation is implemented and managed by the actors and how their behaviour and decisions may shape strategy. This way to conduct research emphasises a flat approach to the analysis of data.

As it has been argued in Chapter 3, my theoretical approach works with flat ontology from ANT and it is thus focused on the actors and what they do together in different contexts (Seidl & Whittington 2014). This flatter ontology distances itself from the main SaP literature which reflects taller ontologies, such as the Foucauldian perspective, narratology, the Bourdieusian perspective and Giddensian perspective. This thesis draws on Latour's (2005) consideration of a flat landscapes and connections, especially to understand how certain networks and strategizing endure, and become more powerful, or 'contextual', among actors. Latour (2005) argues ANT suggests that the macro is equal to the micro: macro is no longer a wider context in which the micro is enclosed, but it is added to it and it is connected to many other contexts. Hence, he puts importance on connections which create a flat scenario, and shape structures. Following these connections allows to understand how actor are formed through network building in a flat scenario through chains of associations between humans and non-humans (Latour 1991).

Hence, SaP particularly focuses on the role of actors as *actants* shaping strategy, whereas ANT mainly focuses on their *relationships* which can change according to the context and thus influence the actors' strategizing. Moreover, ANT particularly puts equal importance on the non-human actors which played a pivotal role in this study (e.g. BIM, and other software, supply chain agreements, etc.), and pluralistic contexts, such as different organisational settings involving several actors and firms (many roles within the contractor firm, architects, sub-contractors and supplier firms). Hence, this theoretical framework has proved to be the best choice to be applied to targeted ethnographies in which a lot of observation of actors' interactions was involved, and to analyse diffuse power which characterises pluralistic contexts. This helped to answer the research questions by analysing CIS among actors, and their power dynamics.

7.2.2 Contribution of SaP and ANT theoretical approach to previous studies

How did the adoption of combined SaP and ANT contribute to the literature? First of all, there are not many previous studies drawing on SaP in the construction sector, whereas there are more drawing on ANT within the construction sector. The former mainly focus on different levels' strategizing in organisations, and the exercise of managerial power and discourse. Hence, most studies position their theoretical lens in the taller ontologies (see Seidl & Whittington 2014), by exploring the interplay of power, discourses, and macro structures or systems (e.g. cultures, economies, technological regimes). Some studies focus on the role of middle managers as strategic practitioners, and the "meso" level of an organisation (e.g. Koch et al. 2015; Sage et al. 2012).

Other authors draw on Foucauldian perspectives by focusing on the role of power and senior management producing ambiguity and contradictions within an organisation (e.g. McCabe 2009), others on how subjectivity of actors is influenced by top-down discourses and practices (e.g. Laine & Vaara 2007). My contribution using SaP to these previous studies lies in the fact of focusing on a contractor and its suppliers working towards the same strategy in specific organisational settings where CIS takes place. The ethnographic approach also contributes to a novel understanding of how this strategizing activity unfolds in everyday practices.

On the other hand, ANT studies in construction mainly focused on the implementation of innovation (e.g. Harty 2008), networks, the adoption and

implementation of technologies such as BIM (e.g. Linderoth 2010), and the role of non-human in construction projects (Sage et al. 2010; Sage et al. 2011). In particular, Linderoth's (2010) discussion about the cooperative role of BIM during the enrolment of the actors within the network, and its influence towards redefining the relationships of actors can be closely related to this study. Indeed, BIM in Linderoth's paper worked as an *obligatory passage point*, just like it happened in the analysis of my data. Specifically, BIM worked as an obligatory passage point for the suppliers in order for them to be enrolled in the CIS actor-network to gain competitive advantage and establish their partnership.

BIM also leads to increased transparency and collaboration among the actors. During the design meetings it was indeed observed how BIM worked as a collaborative software since most of communication and CIS occurred through the software itself and it was accessible to all the actors of the project (e.g. through information sharing, notifications). However, the collaboration process throughout the months of scheduled meetings (SHT) was just apparent and not as effective, since the actors found issues in communicating through the software since it was an innovative way of working for the suppliers, and time was scheduled very tight. My ANT perspective informs previous studies, and, specifically, Linderoth's (2010), by providing an analysis of how not only BIM, but also other objects shape CIS in multiple actor-networks.

The combination of strategizing and ANT is a rare empirical application in the SaP literature, and it is a novel approach in construction studies. Denis et al. (2007) discussed about five papers in which this theoretical combination and pluralistic contexts were present, and in which strategizing according to ANT can be understood through the process of translation. One paper by Knights et al. (1993) focused on the development of *strategic convergence*: it focused on the creation of a new kind of organisational-knowledge work from inter-organisational relationships in the financial sector. The authors draw on Callon's (1986) model of translation and applied Callon's (1991) analysis of communication through intermediaries. For their study, this meant that knowledge work was "a form of intermediary that is put into circulation with other forms of intermediaries" (Knights et al. 1993, p. 981), such as electronic hardware and software, and money. They also draw on Foucault's analysis of power and knowledge relations and institutional theory to consider the wider structure of inequality. Although my study draws on Callon's (1986) model of

translation too, it takes a different perspective when analysing the building of the actor-network, as it focuses on an ethnographic research of CIS of actors in specific contexts.

Another paper which has been highlighted by Denis et al. (2007), focuses on *strategic conflict*: it concerns a knowledge-based artefact (budgeting system within the University) which was mobilised by proponents and opponents to redefine strategy through a Foucauldian perspective (Ezzamel 1994). Another paper focuses on competing networks around a strategic issue (plans for river navigation) and the role of a document to adhere durable networks (Parker & Wragg 1999). The authors also highlight Hensman's (2001) study which focuses on *strategic inertia* in a pluralistic context: a group of actors at the intermediate level within the bank industry have successfully become an obligatory passage point to develop customer strategies, even though their strategy remained ambiguous, making impossible to lead to significant strategic change. Finally, the author themselves (Denis et al. 2007) developed a study around *strategic instability* concerning hospital mergers in which networks converge towards a strategic orientation, but are not able to reach a stable agreement and separate in favour of new networks and other strategic orientations.

As a conclusion from the brief examinations of these papers, they argue that it is possible to foster an understanding of strategizing by adopting an ANT approach, particularly in pluralistic contexts, in which power is diffuse and multiple objects are shifting. In my combination of SaP and ANT as my theoretical framework, I also consider the fact that power is diffuse and relational, as well as objects are multiple and are changing shapes and lead to different outcomes in terms of CIS. In particular, the construction industry may represent a suitable context to explore these themes since it is characterised by pluralistic settings, in which many organisations are present in a single project, and multiple objects are implemented (e.g. software, architectural models, documents). Moreover, the shift of construction firms towards more innovative processes and the integration of the supply chains represent an even more interesting setting in which analysing collaboration where power dynamics and technology shape the actors' strategizing. Using this background through the SaP and ANT framework allowed to answer the main research question later in this chapter, but first it is important to more carefully discuss collaboration and innovation, since they represent the main themes in this thesis, and the implications for power, and how they are related to these theories.

7.3 Discussion about collaboration and innovation resulting from analysis

As it was discussed in the literature review, collaboration, which can be fostered by the implementation of BIM, implies cooperation among organisations, and includes open communication, shared risks and rewards, and trust. This leads to the creation of shared knowledge and innovation which are the basis to reach collaborative advantage, such as process efficiency, flexibility, business synergy, quality, and innovation (a more detailed definition can be found in 2.3.1 of literature review). In particular, collaboration with the supply chain can facilitate innovation because suppliers may transfer their R&D, competences, and ideas for improved products and processes (Soosay et al. 2008). Indeed, across my empirical analysis, it has been highlighted how the establishment of collaborative working practices between the contractor and the suppliers, emphasised the importance of innovating, which was part of the requirements of supply chain agreements, and enabled the implementation of innovative technology and practices (e.g. BIM and collaborative meetings). My theoretical lens and my methodology allowed the analysis of this collaborative innovation by focusing on its application in everyday practices, such as in a specific period of time during different organisational settings, and on the actors (human and non-human) as the main *actants* of strategizing. Hence, strategy is modelled in these settings, and involves collaboration and innovation.

In this research, collaboration and innovation are strictly linked: collaboration activities with the supply chain are already an innovation for the actors, such as the collaborative design meetings through BIM and the online platform, and other collaborative workshops. Moreover, it is expected by John's strategy that enhanced collaboration with the mandated suppliers can lead to innovative ideas as result from suppliers' expertise, but at the same time innovation is required from them as part of the supply chain agreements. For example, mandated suppliers have to prove to the contractor that they keep on innovating their materials, production processes, and products.

Therefore, innovation is both an outcome of collaboration, and it also constitutes collaboration. It can also be argued that collaboration is an outcome of innovation, and it constitutes innovation. In fact, a strategy for innovation implies increased collaboration among actors and other organisations, and at the same time collaboration creates

innovation (e.g. gathering different actors with different expertise develops a context for novel ideas and solutions). Figure 7.1 illustrates this relationship between collaboration and innovation. Hence, this argument strengthens the research question, as the early engagement of the supply chain means more time is spent towards researching and implementing innovative practices and thus collaboration.

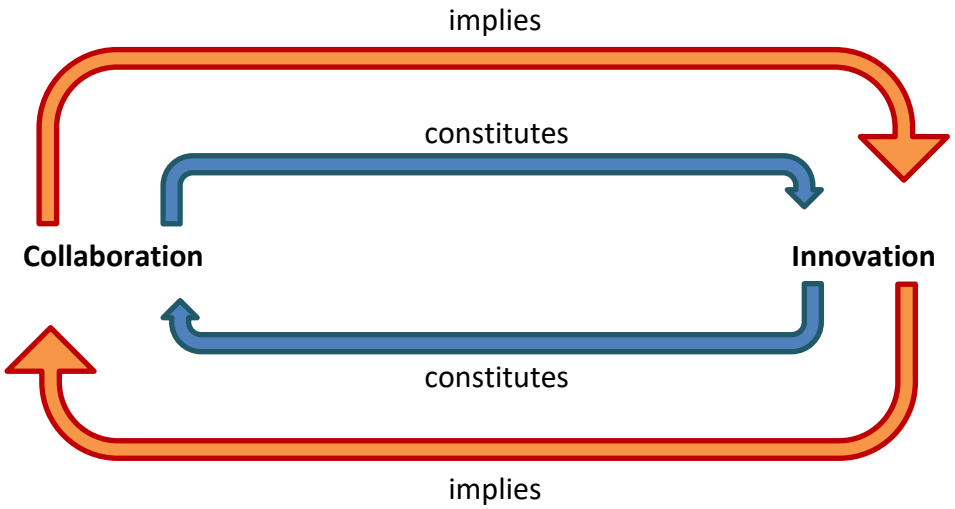

Figure 7.1 Collaboration constitutes innovation and it is an outcome of innovation, and vice versa.

As part of the collaboration strategy, the integration of supply chains becomes pivotal in creating long-term trustworthy relationships between the construction firm and its supply chain. In particular, as Papadonikolaki and Wamelink (2017) discuss, SCM and IT implementation, such as BIM, can actually facilitate supply chain integration. In my research study, the implementation of BIM on the one hand started from the "outside", that is from the client's requirements, such as in the school projects. On the other hand, its implementation in the residential and private sector of TCC was decided "inside" the organisation following the positive outcomes of the procurement projects and in order to build competitive advantage by offering standardised houses as products. Hence, in the residential housing project, the contractor has decided on the adoption of BIM throughout the design process and getting the early involvement of the supply chain. The contractor thus influenced their partners' adoption and investment of BIM (it can be seen during the interessement and enrolment moments in chapter 5), such as in "Case A" of Papadonikolaki and Wamelink's study.

It has been discussed in the literature review how trust plays a fundamental role in integrating the supply chain and allowing cooperation and collaboration. Under an ANT lens, Akrich et al. (2002) discuss how trust is directly linked to innovation, because trust defines the relations with others, and in particular what spokespersons become legitimate to negotiate the innovation process. It was indeed discussed how negotiations from the enrolment phase of Callon's (1986) model of translation (Chapter 5) continued throughout the working relationship between TCC and the supply chain and are important to assess the level of interest of actors and to keep them inside the actor-network. Trust played an important role too, as the supply chain agreements were signed once a certain level of trust was reached for both parties (e.g. this was achieved, for example, by working with the same supplier, or with TCC, in previous projects). Moreover, trust also acted as a way to strengthen the relations among the actor-networks, and a pre-requisite to sustain an effective CIS among the actors and towards the spokespersons.

Within the construction and supply chain literature, trust is catalyst to collaborative innovation, even though it is still not very widespread among construction managers because of the difficulty in understanding the process of trust building, because of misaligned incentives, diffused power negotiations, and the tendency to act opportunistically. Some authors (Fawcett et al. 2012) discuss two risk and benefits scenarios. The first one illustrates that greater relationship-commitment capabilities reduce risk and the ability of the partners to more rapidly respond to unexpected events. The other scenario illustrates that firms fostering their trust capability and thus resource sharing may be riskier, but at the same may lead to successful innovation and competitive advantage. However, choosing the right partners, such as suppliers, is really important and therefore a rigorous selection phase and then trust-building mechanism should be undertaken. For example, the "pre-interessement" phase which I added to Callon's (1986) model of translation represents the filter needed to select the right suppliers who are considered trustworthy in the long-term to implement CIS.

The authors (Fawcett et al. 2012) also argue that the most successful alliances arise from pilot projects which can protect from avoidable risks. Indeed, in this study it can be deducted that the "exercise project", that is a pilot project, of SHT has been done to reduce the potential risks and provide a collaborative environment in which involving mandated sub-contractors and architects to collaborate through BIM. This setting has actually

facilitated trust building both among them, and with TCC. The fact of it being an exercise and not having the work finished on time as previously scheduled, because of the difficulties managing information properly with BIM, made it possible to adjust from the mistakes made, and try to improve collaboration.

To sum up, my theoretical approach of SaP and ANT finds rare empirical application in SaP literature, and, in particular, in construction studies. This theoretical approach with an ethnographic study allows to analyse how CIS occurs in everyday practices where humans and non-humans interact. In these pluralistic contexts power is diffuse and relational, and multiple objects change shapes thus influencing differently CIS. An ANT approach has been highlighted in literature (see Denis et al. 2007) as the most appropriate theoretical lens to analyse these contexts. In these settings trust also plays a crucial role as an element to construct innovation through strengthened relations among the actor-networks. From my data analysis I also identify how innovation is both an outcome of collaboration, and it also constitutes collaboration, and vice versa (see Figure 7.1). Hence, this argument answers the research question by suggesting how the early engagement of the supply chain means more time is spent towards researching and implementing innovative practices and thus collaboration. Power dynamics also influence the relations among the actors, and thus impact CIS.

7.3.1 Linking power to SaP and ANT and previous studies of power

One of the sub-research questions that I set out to investigate was "what are the power dynamics arising from different organisational settings (e.g. meetings, workshops)?" It has been discussed, in the previous chapter (see 6.4.4 and 6.4.6), how power can influence the relationship between the actors, such as the level of trust, and collaboration in general. According to SaP, power is considered hierarchical, reflecting a tall ontology (see Seidl and Whittington 2014), and a possession of some actors (e.g. top managers, or middle managers). Power is also seen as a fundamental component of strategic processes inside an organisation and it is mainly discursive (Maitlis & Lawrence 2003). Indeed, discourses can have power over individuals, who can interpret them for their own purposes, linking power to subjectivity. Indeed, strategic discourses are not always aimed at gaining control, but can also create resistance (Laine & Vaara 2007).

On the other hand, ANT scholars generally do not assume that power can be possessed, but rather they argue about *relations of power*, which are part of the process of translation, and refer to how associations are formed. Hence, ANT scholars argue about the processes of translation (e.g. interessement, enrolment, etc.) which produces relations that can be considered relations of power since they are "hierarchical" but can be subverted at any time. The definition of power by ANT draws on Foucault (e.g. 1986), for whom power does not constrain actors subject to it, but instead it "makes" them individuals having particular interests and capacities (Michael 2017).

Looking back at my analysis, during the enrolment phase of the building of the actor-network, it was possible to observe power dynamics between the contractor and the mandated suppliers. As the suppliers took advantage of the learning opportunities, the special contractual relations with TCC, and long-term working partnerships thanks to the supply chain agreements, they also actively engaged and relied on TCC to take decisions and express their interests. Indeed, it has been discussed how training events, workshops, and meetings have become a platform in which both the suppliers and the contractor can interact about particular issues and support each other, and also as places of negotiations. The partnership which they built aims in fact to be mutually advantageous.

In this context, it is possible to notice how the contractor performs a "hierarchical" power relation to the suppliers: it exercise power over the implementation of John's strategy of implementing BIM and CIS with the supply chain, it leads the projects, and it controls the schedule of the quarterly relationship and annual review meetings with the suppliers. However, this power happens to be subverted by the supply chain in different ways (see 6.4.6), through which they become empowered. They are empowered through the process of knowledge sharing of training events organised by TCC; then they are empowered because they can share their expertise in collaborative meetings (e.g. SHT, SP); finally, they are empowered through loyalty and trust which TCC puts on them for the long-term partnership.

Considering the supply chain and collaboration literature, *power asymmetries* and *power-dependency* have been discussed and are often part of the collaboration happening among real organisations. As it has been argued in the literature review, these asymmetries can lead to scenarios in which one actor is more powerful than the other who may thus feel more vulnerable. Power-dependency can be considered both as power imbalance (or

asymmetric interdependence), and joint interdependence (or symmetric interdependence). In particular, *joint dependence* relationships, which are based on a sense of common purpose for the contractor (buyer) and the supply chain, mean that they rely on one another in the relationship, and are positively linked to SCM practices. Hence, joint dependence encourages long-term relationships, trust, and stability (Hoejmose et al. 2013). This symmetric interdependence can be observed in this study during the specified organisational settings, where power is constantly fluctuating between the contractor and the supply chain in order to express their interests. In this situation, an effective collaboration is reached when the actors both share the same strategies, and when they want their interests to be heard and implemented (Hardy et al. 2005). This happened in this study after the moment of interessement and pre-interessement, where the interests and identities of the suppliers are identified and then filtered by John, and after the negotiations characterising the moment of enrolment.

Objects within an organisation can also shape power among actors, such as when they are boundary objects, or are multiple and fluid. Sage et al. (2010) discussed how a single object, the "Project File", worked as a boundary object which mediated knowledge among the actor networks and also gave power to practitioners, hence shaping power within the organisation. This File, which consists of cardboard file dividers structuring the organisation's knowledge around a project, can be compared to BIM in this research since they both are not static objects, but rather they are flexible and modelled by the actors who use them. The File addresses different interpretations by the actors and helps the practitioners in managing knowledge and integrating different communities of practice. In this research, it has been argued how BIM does not only gather knowledge to be shared among the different actor-networks, such as project's information, architectural models, regulations, actors' comments, etc., but it also represents a *fluid technology* within the CIS actor-network. This means that BIM becomes mutable and changes shapes and relations around itself, resulting in different outcomes of CIS and power dynamics.

7.3.2 BIM shaping collaborative innovation strategizing

Concerning the distribution of power through technology, such as BIM, it is has been discussed by Dainty et al. (2017) how the mandated implementation of BIM within the construction sector can lead to power asymmetries between large and small businesses. In

fact, BIM can privilege larger organisations because they can more easily participate in public projects, and have the motivational, skills, usage, and digital access to ICT technology. In this context, SMEs can be left behind regarding the adoption of BIM because of the difficulties in possessing these elements. Hence, SMEs cannot profit from the benefits of BIM if they are not supported by the government or by partnerships with larger firms. In this study, it is clear the impacting role of the contractor TCC in establishing long-term strategic agreements with the suppliers (who have been scrupulously selected by surveys, questionnaires, and site visits) to initially help them in the learning process of designing with BIM as part of their shared strategy and goals. Moreover, being part of a long-term relationship with an innovative large contractor, and being involved in innovative projects also including BIM, help these supplier firms to gain competitive advantage and new skills, share resources, having access to technology, and also being more motivated for the fact of participating in a stimulating environment.

It has been discussed across the analysis chapters how BIM can influence CIS, particularly for its characteristics of being a *fluid technology* (see section 6.4). This means that BIM cannot be considered only as design software, but it is a lot more. It has been argued how BIM can be an object of collaboration, shaping the way in which actors interact, for example, during design meetings and workshops. In fact, the software influenced communication and collaboration, which mostly occurred remotely, and the relationship between TCC and the supply chain through greater communication and involvement of the suppliers. BIM can also be a learning object, since it has been recently included in the contractor's firm and widespread to the supply chain, thus being also an innovation within these organisations. In this sense, BIM itself is not just an innovative technology, but it leads to innovation in many different ways, such as through increased predictability of time and costs for project deliveries, reduced waste, enhanced and earlier involvement of the supply chain, changed design planning, different way to design the architectural models, increased of off-site construction, and standardisation of components and products.

Hence, BIM influences innovative collaboration and the strategizing of the human actors who are using it directly, and indirectly. It mainly leads to positive outcomes (as described above), but also to ambiguity, such as during the collaborative exercise of SHT. In this particular case, collaboration did not occur as it was supposed to, but presented various issues in terms of communication and outcomes in the clash detection. The difficulty that

the actors encountered was that the way in which most communication happened remotely and through the software represented an innovation for the actors who were new to BIM. Hence, even though they were enthusiastic of the idea of having collaborative meetings, and more easily sharing information through the software, in this case innovation did not imply effective collaboration strategizing. As the exercise continued and the actors insisted on understanding the software, they finally embraced the innovation and launch the standardised house types in BIM. Hence, too tight time schedules did not facilitate CIS, whereas more time and more learning of BIM led to the expected outcomes of the exercise.

The focus on BIM in this research has been particularly important to investigate how a technological innovation has been implemented inside a construction firm, firstly through public projects, then also in private projects, becoming one of the main elements of the firm's strategy for standardisation, collaboration and innovation. TCC, through John's strategy, chose to invest on BIM and changed its practices and supply chain relationships to implement it across its businesses. This process is pretty recent for the contractor, who is still in the early stages of signing the supply chain agreements and moving the standardisation and CIS strategy in the residential business as well. Hence, this study has looked at the early process of implementation of BIM in residential houses (this is the reason why SHT was an exercise), and even though the results are promising by looking at the school projects where BIM was included in projects beforehand (e.g. they have already developed a large range of standardised schools), the housing sector still needs time to develop the final house types on a larger scale, producing a stable collaborative environment during design meetings, and getting the supply chain to deeply know BIM.

Hence, it has been discussed how BIM shapes CIS and it is enacted differently, and assumes different connotations in different contexts, as my sub-research question[14] asks. My contribution to the literature on BIM addresses the need for further research on BIM and its impact on collaboration with a particular focus on the individuals involved and the different organisational settings in which BIM is encountered, developed and implemented. This contrasts with previous BIM studies which have mainly focused on structural and process aspects that enable BIM-driven collaboration within an organisation (Poirier et al.

[14] What is the role of innovative technologies (e.g. BIM) and practices (e.g. supply chain agreements, workshops, meetings) in shaping collaboration between the firm and suppliers? Do they assume different characteristics in different contexts?

2017). This research has applied a SaP and ANT, and an ethnographic approach to follow how this non-human actor influenced CIS among human actors. Particularly, its fluidity and its implementation in multiple realities showed how a single object can lead to many different outcomes in terms of collaboration strategizing, and power dynamics when BIM represents an innovation. As the implementation of BIM requires enhanced collaboration among the actors, the early engagement of the supply chain in this study was a response to this, and John's main strategy of increased collaboration. Hence, the early involvement of the supply chain around BIM eventually led to increased collaboration and empowerment of suppliers, even though some issues and ambiguity (as discussed above) occurred along the way.

7.4 Contributions

Hence, what is it possible to learn about the SaP and ANT theoretical approach to study collaborative strategizing and innovation in construction? As it was discussed, there are not many previous studies of SaP in construction, since strategy management literature has mainly focused on the macro-level of the organisation, whereas some other studies of SaP in construction focused on discourse analysis, subjectivity, activity-based view, etc. (e.g. McCabe 2009 Laine & Vaara 2007; Johnson et al. 2003). This research considers the supply chain's integration and responds to the gaps in literature to widen the strategizing network under analysis by considering external actors (e.g. suppliers, sub-contractors, consultants, etc.) as direct participants in strategizing and innovation.

The decision to combine these two theoretical lenses, in particular SaP as a general theoretical framework, and ANT as a more applied lens in the analysis, allowed to focus on the role of actors during strategizing activities happening in specific organisational settings (*praxis*). According to ANT, actors included both human and non-human relations of actor-networks through the process of translation. Hence, a great emphasis was put both on the contractor and its supply chain in collaborating and managing innovation, and on objects, such as BIM, which possessed the characteristics of being both multiple and fluid, thus changing shapes and influencing the actors' activities. The combination of SaP with ANT allowed a clearer theoretical analysis on the data, since ANT can also be considered as a methodology. Therefore, the first contribution is the focus on strategic episodes, in which

collaboration and strategizing is analysed through an ethnographic approach which made even clearer how strategy and innovation actually happens in everyday practices. This means being able to stay closer to the actors of the study and understand more deeply how non-human actors can influence collaboration and strategizing by directly observing how they work and interact.

Furthermore, both SaP and ANT emphasise pluralistic contexts, as places in which different actors can strategize and build relationships. In this study, pluralistic contexts have been central in the analysis because the organisational settings, such as meetings, workshops and other events did involve a wide range of organisations and non-human actors. These settings, which are part of actor-networks, are characterised by heterogeneity of identities and interests, and social relations. Hence, in pluralistic contexts it has been discussed how CIS occurs among multiple actors, and it is influenced by non-humans as they are differently enacted, but also assume different connotations in different contexts. It has also been argued how these objects can influence power dynamics among actors and how this power fluctuates between TCC and the supply chain. In the construction industry many organisations work on a single project, thus many interests are present, power is diffuse, and many objects are mobilised. In particular, my theoretical approach of SaP and ANT is rather suitable to analyse these contexts, giving insights on how inter-firm collaboration occur, as it is assuming more and more importance in the construction industry.

Another contribution, which is linked to Callon's (1986) model, refers to the analysis of how the actor-network has been built by John (see chapter 5). This discussion has helped to have a clearer vision of all the interests at stake, and how John has been able to focus these interests into the network, in order to enrol the suppliers. My analysis added a phase of "pre-interessement", in which John and the purchasing team used questionnaires, surveys, and site visits to detect the right supplier firms to engage with, thus trying to converge and guide shared interests into the actor-network. Therefore, the actors are not being enrolled in a top-down and impositional way that Callon (1986) discusses. My findings indicate a greater degree of negotiation and equity between actors. Moreover, my contribution to classic ANT ideas is that it is possible to talk about a "symbolic enrolment" in which actors are given a space to voice their interests and identities (e.g. during workshops, and relationship meetings).

Concerning my contribution to studies of collaborative innovation and supply chain, this theoretical approach, together with an ethnographic method of analysis, allowed for an explanation of collaboration happening in organisational settings involving different actors, therefore providing a bottom-up perspective of how CIS is shaped, and how relationships among the actors are constructed within the actor-networks. Hence, collaboration and the implementation of innovation can be understood from a point of view which has not been widely analysed in the construction industry, by taking into consideration everyday practices and strategizing as it occurs in specific contexts. Moreover, collaboration implies and constitutes innovation, and vice versa (see Figure 7.1), and their mutual implementation generates strategizing. It has been discussed how this relationship finds its application in my data, even though some ambiguity has been highlighted, for example, during the SHT clash detection exercise, as innovation (the implementation of BIM as means of communication and information sharing) did not imply effective collaboration, and thus CIS was hindered.

7.5 Answering the research questions

Before answering the main research question, this section will answer the sub-research questions and eventually the main one. The reason to do so is to facilitate the reader with the results of my data in a more logic way, as it was organised throughout my thesis. The first two sub-research questions that I highlighted in Chapter 3 are: what is the firm's strategy to engage with the supply chain? How are actor-networks built? Chapter 5 discussed this question by providing an analysis of how John's actor-network was built in order to implement the main TCC's strategy of CIS involving the supply chain. This main strategy aimed to actively engage the mandated suppliers (those selected firms which signed a supply chain agreement with TCC) in the earlier phases of a project, starting from the design process using BIM. The implementation of this software was an innovation both within TCC, and within the suppliers.

Callon's (1986) model of translation was used to analyse how the actor-network was built, and some considerations resulting from my data were discussed. These included the fact that in the problematization phase, the actors' interests and identities were not hypothesised as top-down imposed process, as in Callon's (1986), but were filtered by John through surveys, questionnaires, and site visits in a "pre-interessement" phase. Moreover,

training opportunities and workshops for the suppliers work as symmetrically reflexive interessement devices through which suppliers can share their interests and thoughts on specific subjects. Hence, actors are enrolled through more negotiations and enhanced equity. In Chapter 6 it was also discussed how the other actor-networks (the CEO and organisational board actor-network, the Purchasing team actor-network, the SHT and SP actor-network) were connected to and part of John's, and how they constructed different objects, thus multiple realities.

The following two sub-research questions, which I mainly focused on in Chapter 6, are: what is the role of innovative technologies (e.g. BIM) and practices (e.g. supply chain agreements, workshops, meetings) in shaping collaboration between the firm and suppliers? Do they assume different characteristics in different contexts? These questions aim to highlight how objects, such as BIM, but also Power Point and documents played a role in influencing CIS in specific contexts. In particular, it was argued how these objects are enacted differently in these contexts, and how they also change shape. The ways in which they change contribute to the creation of multiple realities where CIS is also enacted differently. For example, it was argued how PowerPoint presentations was both an object for enhancing communication and strategic vision between the contractor and the supply chain (e.g. during supply chain conferences, and workshops), and an object of learning BIM (e.g. to be used by the actors involved in design meetings).

Furthermore, it was emphasised how BIM could be considered a fluid technology. In fact, I discussed how it is different objects: a collaborative object, a learning object, an innovative object, and an object for power and control. For example, the way in which BIM is a collaborative object differs according to TCC's perspective, or the suppliers' perspective, and this is the reason why it is fluid. For instance, TCC regards BIM as a collaborative object because it is part of its strategy of enhancing an innovative way of working with and involving the supply chain in order to build a long-term relationship. The suppliers define BIM as collaborative since they are actively engaged in meetings which are designed to be characterised by open communication with all the project's participants.

The following sub-research questions are: how is collaboration implemented in different contexts? What are the power dynamics arising from different organisational settings (e.g. meetings, workshops)? These answers have been discussed throughout my analysis and discussion chapters since both the construction of the actor-network, and the

implementation of fluid objects in multiple realities influenced the way in which collaboration was implemented, and the power dynamics among the actors. In particular, it was discussed how the suppliers were empowered through training opportunities, their early involvement in the design phase of the projects, and through loyalty and trust established by the supply chain agreements. I argued how power is distributed between TCC and the mandated suppliers, and therefore is relational.

After a summary of the sub-research questions and how they have been addressed throughout the thesis, it is time to answer the main research question. This is: "does the early engagement of supply chains around innovative technologies and practices foster effective suppliers' collaboration and empowerment with the firm's innovation strategizing?". The short answer is yes, even though there are still some issues in the relationships between the actors and the "non-human", that is, technology. The analysis of data and its discussion depict a case study in which John's strategy is actually leading towards enhanced forms of collaboration with the supply chain which is reflected by their integration through supply chain agreements, early involvement in projects, collaborative meetings and workshops, and enhanced communication.

The suppliers' interviews have shown their enthusiasm and optimistic point of views towards TCC and their partnership, particularly regarding the way in which the contractor is able to establish close and trustworthy relationships with them, to conduct joint problem-solving, to foster their empowerment during meetings and workshops, to help them in adopting and managing technological innovations, such as BIM, and also invest in innovative products and materials (as required by the supply chain agreement). The supply chain agreements are also objects of empowerment for the supply chain since they establish long-term relationships with the contractor, and foster continuous working collaboration through multiple projects. Moreover, the mandated suppliers are involved from the early stages of the projects and their expertise and active collaboration is required all throughout the design meetings and workshops, even though TCC still retains the main control over the procedure. As previously discussed, there is a fluctuation of power between the actors who express both shared and different interests (see Hardy et al. 2005). This fluctuation is actually leading to increased collaboration.

Although many positive outcomes can be identified from this partnership, the implementation of BIM is at its early phases and it still needs time to develop properly to

include all the mandated suppliers. In fact, learning and training activities are still a big part of the firm's strategy both internally, and within the supply chain. As it was discussed in Chapter 5 and 6, communication through the software did not work very well at the beginning of the SHT project. As Whyte and Hartmann (2017) argue, digital building information is transformative and even unpredictable, because the interactions among the actors are changed, thus also the actors' roles and responsibilities. Moreover, the flexibility of the object (the software in this case), and the different interests of the actors while using it can lead to different outcomes: the technology can impact differently on the context where it is used, but also it can be affected by the context and the actors (e.g. Schweber and Harty 2010). Indeed, it has been discussed how BIM can influence CIS, and also how, for example, the suppliers can use BIM as an object of empowerment since learning how to use it helps them to gain competitive advantage and innovate inside their organisations. The implementation of BIM can therefore challenge the fragmentation of the industry's practices, by enhancing collaboration and innovation.

7.6 Impact on practitioners

Once the research question is answered, it is also important to highlight how I decided to focus on this particular question. I realised how the involvement of the supply chain was becoming a central part of TCC's strategy, in order to enhance collaboration and innovation. Hence, I wanted to understand whether their engagement in specific projects which involved innovation (e.g. through BIM and a collaborative way of working), actually led to enhanced CIS, as it was relevant for the practitioners. This thesis has highlighted how a construction firm can enhance innovation through collaboration with an integrated selection of suppliers. The thesis also explores how BIM can be implemented inside the organisation and through the supply chain in order to foster collaboration and supply chain involvement, as well as improvements in terms of delivery time, costs, waste, predictability, profit, and thus also customers' and clients' satisfaction. It has been emphasised how investing in BIM and supply chain development can be hard both for the contractor, and, in particular, for the suppliers. However, the study has highlighted how mutual trust, shared goals and resources, and shared learning experiences can facilitate the process of relationship building and collaboration through mutual support.

Concerning BIM and collaboration, the study has emphasised how BIM can be a support for CIS by involving multiple actors and organisations in design meetings, thus pushing towards a collaborative way of working through the software. Although this strategy is leading to positive outcomes in terms of increased suppliers' involvement and interest, easier access to information, and enhanced design details as part of the innovation process, the study also showed how it is not easy to establish this new process, particularly when the suppliers are not completely familiarised with BIM and its features. One of the reasons was the early stages of the sub-contractors' knowledge of BIM and its requirements. Another reason was the way in which the "exercise project" was structured: physical meetings every 2-3 weeks were mainly used to discuss what level of BIM detail was reached, and to look at each sub-contractors' models, whereas the main collaboration and interactions among the architects and the sub-contractors was happening remotely. Due to the difficulties in make the actors "talk" through BIM, right after investing in the software, a long and careful process of learning of BIM should be considered, in order to make the actors prepared for completely benefit from BIM. This investment should come both from the firm itself, and from Government's policies.

Moreover, the study has highlighted how and why involving the supply chain in formal events, such as workshops and supply chain conferences, benefited the relationships between the suppliers and TCC. Indeed, through interviews and informal talks with the suppliers, it has been widely discussed how these events are positively welcomed by the suppliers who highlighted how they can feel part of the same organisation, can get to know the contractor's employees better, therefore developing mutual trust and share opinions. Hence, in order to build strong and long-term relationship with the supply chain, it is important that practitioners decrease the number of supplier firms they work with, and also select them through a careful process of examination in the pre-enrolment phase (e.g. as in the pre-interessement phase that I discussed in Chapter 5). This could be done by assessing the suppliers' level and interest for innovation, the type of materials used, their main values and strategy goals, and everything that the construction firm might consider important in the new partnership.

It is clear from my analysis and discussion that John's strategy is leading towards more efficient and innovative processes (e.g. predictability of delivery in terms of time and cost, off-site construction, innovative materials), and the example of the school projects

shows how the implementation of BIM, long-term relationships and collaboration with mandated suppliers, and standardisation of design is beneficial in terms of profits. Although implementing BIM and find the right mandated suppliers is expensive in terms of costs and time, it has proved to be the right path to follow in the medium- and long-term in order to more quickly respond to the market's requirements, such as the need for more houses in a short period of time, and to continue innovating in an industry in which innovations are very hard to be applied.

Finally, the chosen case study represented a strong example of an innovative British construction contractor whose strategy was to implement BIM and engage more with the supply chain within a collaborative and innovative context. This study helped to better understand how CIS is enacted and influenced by the actors' interactions through specific objects and in different settings. In particular, it was discussed how these objects (e.g. BIM, supply chain agreements, workshops) can actually enhance collaboration and push towards innovative practices. Concerning BIM, the possibility of observing its implementation in practice (e.g. during design meetings) led to insights into how it shaped collaboration communication among the actors, and how the actors interacted with the innovation. Moreover, the active involvement of the supply chain within the projects under study made it possible to speak with them and observe their behaviour, and this contributed to an analysis of supply chain management from the perspective of both parties.

Hence, this study shows how partnering in the long-term with a fewer number of suppliers can lead to enhanced collaboration and increased innovation for both parties, as long as the relationship with the supply chain is nourished with regular meetings, trainings, and strategizing events. I discussed how power in these contexts fluctuates between the contractor firm and the suppliers, thus representing opportunities for the supplier to be empowered.

7.7 Limitations of this research

One of the limitations of this study is methodological. The research used targeted ethnographies, which are participant observations for short period of time (from 2 hours to half-day). This means that the research does not apply a classic ethnographic approach in terms of a long period of study of an organisation, as in that case the data collection would

have required being present on the field for longer, and continuously. The short ethnographies which I conducted were justified as the thesis focused on observing specific meetings or workshops whose duration was limited in time. Hence, the strategizing was occurring within a time frame of a strategic episode. Moreover, being able to video and audio recording these events allowed me to continue the analysis in a second time, and whenever I needed. Nonetheless, the case study could have benefited from longer periods of ethnography, through which the researcher could have been present inside the organisation for several months (e.g. having a proper desk in the firm's office to observe, take notes, and talk to employees). Furthermore, this option could have facilitated contact with the firm's employees, and the invitation to further meetings, and events which could have been useful for the research. Indeed, I often found it difficult during my data collection to keep continuous contact with some people within the firm, meaning that I sometimes missed some meetings. The reason why this longer type of ethnography did not happen was that it would have been logistically difficult.

Another limitation, which is quite close to the previous two, is the difficulty of accessing all the actors involved in the projects under scrutiny. Indeed, some supplier organisations are not considered in the data collection, or I had only one point of contact with them. Again, this is due to the fact of not being present inside the organisation continuously, and for the difficulty in talking to all the actors who were present during formal meetings, or workshops, or conferences. A further point of view from the suppliers could have informed my data concerning their opinions and experiences. Furthermore, a limitation is the fact that I was collecting confidential data both from the contractor, and the supplier firms. Hence, I was not allowed to be present on field, or record some data, which could have provided me with more insights into the relationship between TCC and the suppliers. In general, the construction firm signed a confidentiality agreement with the University, so that I was able to do most of this anyway, but some meetings (e.g. relationship meetings face-to-face with some suppliers) were not recorded, or I was not able to be present during some other events for confidentiality reasons.

Moreover, the project focuses only on one case study involving a single construction firm and its supply chain, through a qualitative and inductive analysis of empirics. This means that the results obtained cannot be generalised to other firms, but only depict a specific situation of a single organisation collaborating with its supply chain. Hence, the

results obtained concerning collaborative innovation strategizing, and BIM can only illustrate an untypical scenario in the context of construction design and innovation; however, they may still inform other practitioners and academics. Indeed, as it was discussed, this case study involved an innovative construction firm which invested a lot in BIM and standardisation of building practices and products, as well as the integration of the supply chain. Their experience can be considered informative in terms of the implementation of BIM and the integration and development of the supply chain, which are still quite limited in the construction industry, but more and more required by government's regulations. Nonetheless, a comparative study with another contractor, British, or even international, could have deepened the analysis by providing different ways to engage with the supply chain (e.g. different types of events, trainings), and different kind of projects.

A further limitation involves the theoretical approach and the subject of study. The study has applied a combination of SaP, used as a general framework for strategizing, and ANT, used more as an applied method to analyse data. The decision to focus on a flat ontology and focusing only on the connections of actor-networks between the contractor and some of its supply chain has limited the spectrum of analysis of the organisation. Although the research question was intentionally focused on the supply chain and the collaboration between those two actors, the analysis of the actor-networks could have been extended to include also clients, or other organisations involved in the projects. In this way, innovation diffusion could have been further analysed and this could have provided other consequences in terms of CIS and power dynamics.

7.8 Suggestions for future studies

Future studies may be developed starting from my study's limitations. For example, a future study, based on a long ethnography, may analyse how CIS and power dynamics occur and are transformed during a longer period of time. In such ethnography, the researcher may be inside the organisation, and thus get into contact with more organisations and follow more projects. CIS and power dynamics could also be compared as they are happening in different projects, and how they might differ compared to the objects which are implemented, and the actors involved.

Another study might want to take into account the suppliers' points of view, instead of following the contractor's as in this research. A study developed around the suppliers' point of view may offer a different type of analysis to understand how the adoption of BIM, and the establishment of long-time partnership and CIS with a contractor change their organisation's practices. In the longer term, it could also be interesting to assess how much this type of partnership would influence the adoption of innovation and its diffusion in the suppliers' firms.

Finally, a comparative study involving two or even more construction firms and their supply chain could inform practitioners and academia on the way in which CIS is enacted. Different firms may have different ways to implement and establish relationships with the supply chain. For example, if the firms are from different countries, the study might also explore how the government regulations differ in terms of the implementation of innovation and supply chain development in construction.

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