

# **Developing a theoretical framework of traceability for sustainability in the construction sector**

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## **Abstract**

With the rise of globalisation, supply chains have become longer and more fragmented, so nowadays products have long, complex journeys before they reach end consumers. As a result, customers have little awareness of where their products come from, and in what conditions they have been produced or distributed. Defined as the ability to follow the information related to a product, traceability is a key component for verifying and ensuring claims associated with production and transformation of the product as it moves along supply chain.

Traceability can be applied to a range of types of information. In the context of sustainability, through verifying sustainability claims associated with products and their supply chains, traceability can influence customer choice and play an important role in providing an incentive for sustainable production and ethical business behaviour.

The concept of traceability has been investigated in a few specific sectors (such as food, fashion, forestry), but studies have focused mainly on safety and quality within supply chains, rather than sustainability. In addition, academic scholars have tended to concentrate on the practical (operational) aspects of traceability, hence a conceptual understanding of the term is still lacking. The absence of a common theoretical framework for traceability means there is a lack of engagement in the concept, and consequently, no incentive for companies to engage with traceability programmes. Furthermore, the concept of traceability appears to be often confused with transparency and supply chain mapping, and this in turn leads to a limited understanding of the term, and its scope and application.

The construction industry plays an important role in sustainable development through contributing to the economy by generating jobs, yet it also consumes significant amounts of raw materials and energy, which can result in significant environmental impact. Despite such scale and importance, material traceability is still at an emerging stage in the construction sector, which is arguably a missed opportunity. As such, this paper is part of an ongoing PhD study in which the construction industry is being considered as a novel application context for the concept of traceability.

There is a generic need for a theoretical framework to better understand traceability, specifically for sustainability, and with respect of the ultimate aim to relate this theory to the construction industry. Hence, this paper will offer conceptual insights on traceability as a construct, through a comprehensive review of academic and standards-related literature. In doing so, the study defines the main concepts related to traceability, but importantly it does this under the umbrella of sustainability (ethics, social responsibility, transparency and responsible sourcing) and explains the relationships between them. By analysing traceability in both academic literature and standards/legal requirements and across multiple sectors, this paper aims to present a robust, yet pragmatic interpretation of traceability that can be related to the needs of the construction industry. That said, the theoretical grounding of the study means that the paper should have broader application value to other sectors and contexts.

Key words: traceability, construction sector, sustainability, transparency.

## Introduction

The topic of sustainability has extended its scope from focusing on individual companies in the past to considering the entire network of supply chains at present (Germani et al., 2015). Increased outsourcing practices that make use of developing countries and low-cost markets have resulted in growing concerns about social and environmental impacts of production and consumption (Andersen and Skjoett-Larsen, 2009), (Christopher et al., 2011). Many customers are willing to pay a premium for the products with a demonstrated commitment to sustainability (The Nielsen Company, 2015). In this light, traceability (which is the ability to follow information related to a product through its supply chain), becomes increasingly important for verifying sustainability claims associated with a product as it moves along supply chain (UN Global Compact & BSR, 2014).

The topic of traceability has been widely investigated in particular sectors (such as food, fashion, pharmaceuticals and forestry), mainly from the perspective of quality and safety, rather than sustainability. Despite the significant role of the construction industry in sustainable development (through contributing to the economy, generating jobs, extensive consumption of raw materials resulting in large carbon footprint and energy use) (Khatib, 2009), traceability issues are still at emerging stage in the sector. Hence, this paper aims to explore the topic of traceability for sustainability for the construction sector, and identify the components of a theoretical framework, which is identified as currently lacking in the literature.

The first section of the paper focuses on traceability in its broad sense - under the agenda of sustainability. The following section attempts to understand the conceptual meaning of the traceability through a comprehensive review of academic and standards-related literature. The next section investigates the topic of traceability specifically to the construction industry. This is followed by a synthesis and some conclusions and indication for further work.

## Traceability under the agenda of sustainability

There are several perspectives on the concept of traceability. The majority of academic papers stress the importance of traceability for quality and safety purposes (Dabbene et al., 2014), (Germani et al., 2015). Traceability facilitates recalls in the case of quality and safety failures (Golan et al., 2004), (Aung and Chang, 2014) and minimises scandals that are dangerous for a company's reputation (Germani et al., 2015). Traceability is also believed to improve supply chains by allowing choosing better suppliers and minimising risks (Karlsen et al., 2013) and enhancing trust in supply relationships (Sarpong, 2014). All these purposes are arguable within the scope of sustainable development, which is defined as development which *"...meets the needs of current*

*generations without compromising the ability of future generation to meet their own needs” (WCED, 1987, p.16).*

To date, only a few studies have addressed traceability issues under the umbrella of sustainability (Germani et al., 2015), (Mol & Oosterveer, 2015). Therefore, this section investigates the concept of traceability as an important element of sustainable development. To do so, we offer a model of related concepts (as shown in Figure 1), each of which is discussed in turn. Essentially, Figure 1 shows the major concepts related to traceability, which are arranged in terms of causal relationships and breadth/focus of the various concepts.

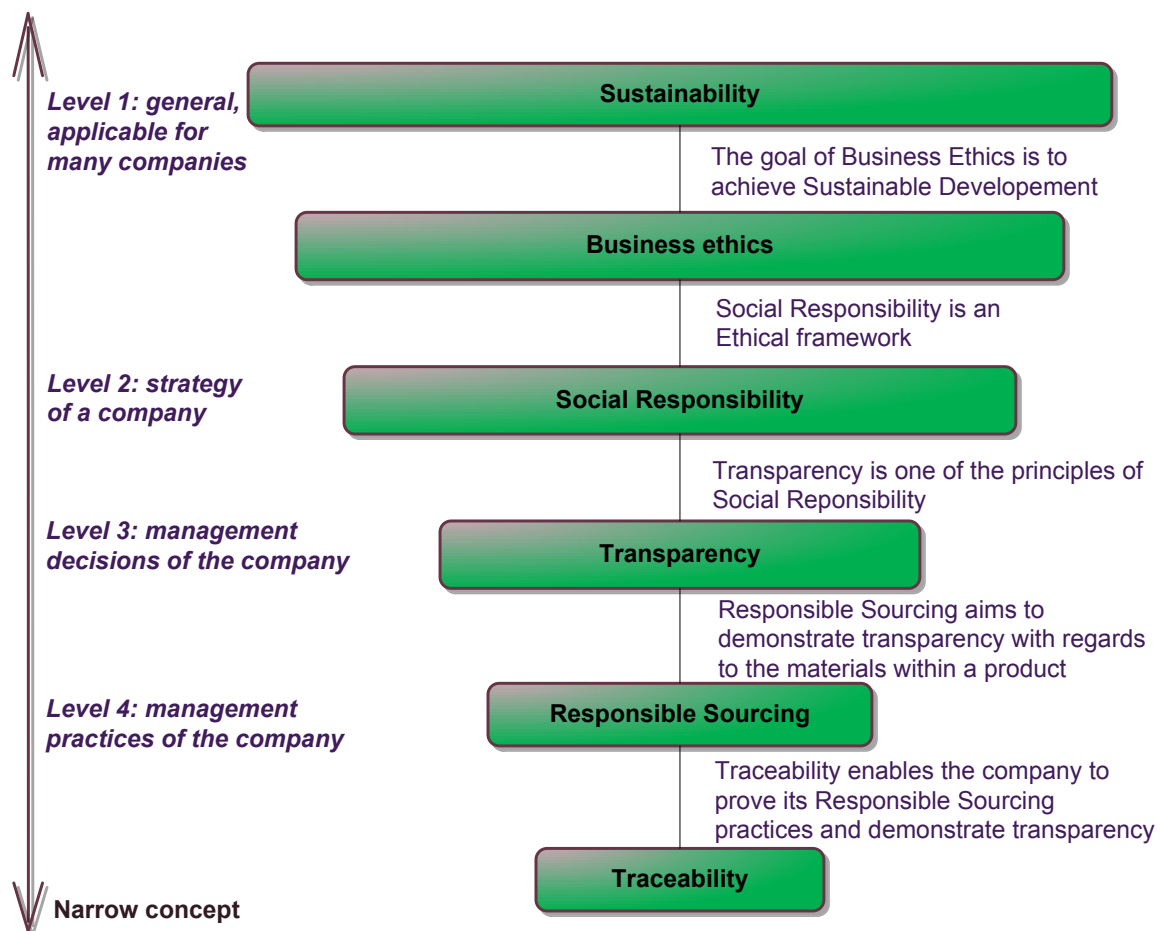


Figure 1 Diagram of the concepts related to traceability

### ***Sustainability and business ethics***

The concepts of sustainability and business ethics are presented at the first level. Sustainable development embraces environmental, social and economical aspects, and is an ultimate goal of all the concepts presented in Figure 1, including business ethics. Businesses are locomotives for economic development but also they have a potential, if they are ethically driven, to provide major contributions to society (through generating

jobs, fair wages, etc.) and environment benefit (by minimising its negative impacts on the planet) (Crane and Matten, 2007). The basic principles of business ethics are grounded in moral norms and moral evaluations that should be universally applicable (Joyner and Payne, 2002), and so remain the same across different industries, businesses and regions. Therefore, sustainability and business ethics occupy the first general level in the diagram, and are considered as being applicable for many companies.

### *Social responsibility*

Next down the categorisation is social responsibility, which implies an organisation being responsible for the economic, social and ecological consequences of their activities and decisions (Dubbink et al., 2008). Social responsibility is represented as a strategy of a company. These strategies should be tailored to individual businesses (Van Marrewijk, 2003), depending on a number of factors, such as the sector, size of the company, social and environmental impacts of company's activities, etc. Indeed, companies in the construction sector tend to report on health and safety, energy and resources, carbon emissions, supply chain and communities (Brown et al., 2009) whereas the food industry might prioritise safety and quality issues (Beulens et al., 2005), (Regattieri et al., 2007). Accordingly, the concept of social responsibility relates most closely with the level of individual organisations in Figure 1.

### *Transparency*

Transparency, responsible sourcing and traceability comprise the third level, which can be described in terms of “management decisions/practices” of the organisation. Transparency, in the context of sustainable development, can be defined as the extent to which information related to organisation's decisions and activities that affect society, the economy and the environment is disclosed and communicated to the stakeholders (Hofstede, 2003). Transparency is an essential condition for improving social responsibility (Dubbink et al., 2008), (British Standards Institution, 2010). It helps to raise awareness of stakeholders on the activities and decisions of organisations, thereby encouraging organisations to behave responsibly (Dubbink et al., 2008), (Doorey, 2011).

Implementing transparency typically involves a strategic choice by a company (Hofstede, 2003) – this may ultimately depend upon the financial costs associated with the implementing transparency, market conditions and disclosure strategies of competitors (Chen and Slotnick, 2015). However, under some circumstances businesses might be forced to be transparent. For example, The Modern Slavery Act, introduced in the UK in 2015, requires large companies to demonstrate activities undertaken to

ensure there is no modern slavery in their own business and their supply chains, which might encourage companies to investigate their supply chains more thoroughly (Parliament, 2015). Hence, legislation can force a company to become more transparent, but the literature suggests that transparency is more typically within the 'normal' managerial decision-making practices in a company.

Businesses may be highly dependent on purchasing and outsourcing activities, which means that organisations are encouraged to reveal information not only about their internal affairs, but also their suppliers' sustainable practices. Thus, the notion of transparency extends from being an internal concern of an organisation to include external relationships within its supply chains (Egels-Zanden et al., 2015), (Mol, 2015), and this gives rise to the concept of supply chain transparency. Companies tend to disclose and communicate the following supply chain information: suppliers' names and locations, sustainability conditions associated with the product (Egels-Zanden et al., 2015), (Marshall et al., 2015), purchasing practices (Egels-Zanden et al., 2015) and material provenance (Marshall et al., 2015). Provenance refers to the source of origin, often from a geographical perspective. In this context, material provenance is very close to the concept of responsible sourcing, which is described next.

### *Responsible sourcing*

Responsible sourcing (which is often termed ethical sourcing) is presented at the next level in the diagram. Organisations typically demonstrate responsible sourcing through their procurement strategies (including purchasing decisions and practices) addressing a range of environmental, economic and social considerations (Glass, 2012). Hence, the purpose of responsible sourcing is to demonstrate supply chain transparency in terms of constituent materials of a product (Glass, 2011), (Upstill-Goddard et al., 2015), (Guo et al., 2015). The term responsible sourcing is commonly used in the construction industry, as discussed later.

### *Traceability*

Finally, the concept of traceability is presented in Figure 1 as the narrowest of the concepts shown. Traceability is a key component for verifying and ensuring claims associated with production and transformation of the product as it moves along supply chain (UN Global Compact & BSR, 2014). The concept of traceability is closely linked to transparency and responsible sourcing, because in order to disclose information related to suppliers, this information must be traced. Traceability is the ability to follow information related to a product through its supply chain (see next section). Therefore, traceability is an essential condition for supply chain transparency (Sarpong, 2014). On the other hand, transparency is important to enable traceability. Thus, when tracing a

product, a company needs to connect with its suppliers and obtain information about the product; it means suppliers need to be transparent when revealing information to the company (Skilton and Robinson, 2009). It is clear that traceability and supply chain transparency are involved in sharing and communicating of the same information. This implies that traceability information might involve: suppliers' names and locations, sustainability conditions associated with the product, purchasing practices and material provenance.

Regarding the link between traceability and responsible sourcing, traceability serves as means through which responsible sourcing within an organisation's supply chain is demonstrated and ensured. Hence, traceability enables companies to account for their environmentally and socially responsible practices, as associated with products and supply chains. In this way, traceability can influence customer choice and play an important role in providing an incentive for sustainable production and ethical business behaviour. Presenting traceability in this manner indicates how it fits within a categorisation of related concepts, and provides an initial sense of the business context for the idea of tracing product information. The next section presents a more detailed account of current understanding of traceability.

## Understanding the concept of traceability

This section aims to unpick the conceptual meaning of traceability through a rigorous review of definitions provided in both standards/legislation and academic literature.

### *Traceability in standards, legal acts and reports*

An initial literature review revealed that the majority of academic papers referred to standards and legislation when defining traceability. Therefore, it is important to review how traceability issues are addressed in standards, legislation and global organisation' reports as both material and integral to the subject matter.

The word traceability is a derivative of two words "ability" and "trace", so the majority of definitions use these to designate the term. Trace refers to following downstream flow to identify the origin of products, while track means following upstream supply chain to identify the point of localisation of products (Dabbene et al., 2014). Other key verbs frequently used to describe traceability include "track", "follow", and "identify".

The most widely cited definitions of traceability are given by the International Organization for Standardization (ISO) in a number of specific standards. Table 1 shows how interpretations of traceability by ISO have developed over time to the current definition.

Source	Verb phrase	Traceability information	Object (Trace what?)	Scope (Trace where?)	Method (Trace how?)
ISO 8402:1994 Quality management and quality assurance. Vocabulary	Trace	History, application or location	Entity (activity or process, product, organisation, system person, or any combination thereof.)	-	By means of recorded identification
ISO 9000:2000 and ISO 9000:2008 Quality management systems - Fundamentals and vocabulary	Trace	History, application or location	That which is under consideration	-	-
ISO 9000:2015 Quality management systems - Requirements	Trace	History, application or location	Object (material, non-material or imagined)	-	-

**Table 1 Definitions of traceability in ISO standards**

According to ISO 8402:1994, traceability refers to the “*ability to trace history, application or location of an entity by means of recorded identification*”. By entity the standard implies an activity or process; product; organisation, system or person; or any combination of them. Distinctly from later versions, ISO 8402:1994 outlines that traceability should be implemented by means of “*recorded identification*”.

Following versions of Quality Management standards (ISO 9000:2000 and ISO 9000:2008) describe the object of traceability with the vogue “*that which is under consideration*”. Finally, the recent ISO 9000:2015 standard defines traceability as the “*ability to trace the history, application or location of an object*”, that can be material (for example, an engine, a sheet of paper, a diamond), non-material (for example, conversion ratio, a project plan) or imagined (for example, the future state of the organization). In other words, definitions of traceability have evolved from tracing an “*entity*” to material, non-material or imagined “*objects*”.

Notably, ISO Quality Management standards do not specify whether traceability should be implemented throughout an object’s stages of production, processing and distribution, or only in specified ones.

Table 2 depicts how other global organisations perceive traceability.



Source	Verb phrase	Traceability information	Object (Trace what?)	Scope (Trace where?)	Purpose (For what?)
<b>GS1 Global Traceability Standard (2012)</b>	Track forward  Trace backward	The movement  The history, application or location	Of that which is under consideration	Through specified stage(s) of the extended supply chain	-
<b>United Nations Global Compact and BSR (2014) Guide to Traceability</b>	Identify and trace	The history, distribution, location and application	Products, parts and materials	-	To ensure the reliability of sustainability claims, in the areas of human rights, labour (including health and safety), the environment and anti-corruption

**Table 2 Definitions of traceability given by global organisations**

GS1 is a global non-profit organisation for the design and implementation of electronic commerce tools, such as global location numbers, GS1 corporate prefixes, global trade identification numbers and barcodes (Charlebois et al., 2014), and developed a Global Traceability Standard, which focuses on safety, quality, and risk management objectives. Importantly, it recognises traceability as an integral part of the business process, which is not separate from logistical processes and/or product safety and quality programmes (GS1, 2012). The standard allows implementing traceability through specified stages of the extended supply chain rather than through entire supply chain. In contrast to GS1, the United Nations Global Compact (UN Global Compact) and BSR focus on sustainability aspects *“to ensure the reliability of sustainability claims, in the areas of human rights, labour (including health and safety), the environment and anti-corruption”* (UN Global Compact & BSR, 2014, p.6). They are global non-profit organisations; their guide analyses existing schemes across multiple sectors.

It is noteworthy that traceability requirements have been established in the food sector. In the European Union traceability for all food and feed products is enforced by legislation. Many other countries, such as Norway, Finland, Switzerland, Canada, Japan, Australia, New Zealand and Brazil have implemented traceability programmes for specific types of food, including animal products and rice (in the case of Japan). Regulation 178/2002 of European Union suggests a “one step back” – “one step forward” approach, according to which all food sector operators shall outline from whom and to whom their products has been supplied (European Commission, 2002), (Charlebois et al., 2014).

However, there are discrepancies in terms of the scope of traceability requirements in food sector. According to EU Regulation 178/2002 beef should be traced “from farm to fork”, i.e. throughout its entire lifecycle, whereas livestock traceability within Australia and Japan covers animals from birth to slaughter, but no further. These differences are reflected in the academic literature: some expect traceability to be implemented across all stages of a product’s life cycle, yet others use traceability in specified stages.

In terms of the construction industry, to date traceability has only been defined in the BRE’s framework standard on responsible sourcing BES 6001 (as shown in Table 4). Early versions of the standard (BES 6001 issue 1 and 2) provide definitions of traceability that are almost identical to the EU Regulation 178/2002 for General principles and requirements of food law. Quite reasonably, traceability has been redefined from “*food, feed, food-producing animal or substance*” to refer to the “*constituent material*”. Yet neither this definition suggests what information should be traced. The latest version of BES 6001 (2014) provides guidance on how traceability should be implemented to comply with the standard, rather than defining the term itself.

Given this shortcoming, potential traceability issues for the construction sector in greater detail in a later section of the paper, but there follows a specific section which analyses the extant academic literature on traceability, such that it can be understood as a concept.

Source	Verb phrase	Traceability information	Object (Trace what?)	Scope (Trace where?)	Method (Trace how?)
<b>BES 6001: ISSUE 1.0 and 2.0 Framework Standard for the Responsible Sourcing of Construction Products (2009)</b>	Trace and follow	-	Constituent material intended to be, or expected to be incorporated into a construction product	Through all stages of production, processing and distribution	-
<b>BES 6001: ISSUE 3.0 Framework Standard for Responsible Sourcing (2014)</b>	-	-	-	-	Link (through documentation) one production stage with another

**Table 3 Definitions of traceability in the construction sector**

## *The concept of traceability in academic literature*

Very few academic studies offer an underpinning, conceptual meaning of traceability, and the majority of these relate to the food sector, namely (Moe, 1998), (Olsen & Borit, 2013), (Karlsen et al., 2013), (Bosona and Gebresenbet, 2013), (Aung & Chang, 2014), (Ringsberg, 2014). Indeed, these studies tend to interpret traceability differently, and it is challenging to find consensus. For instance, Olsen and Borit (2013, p.148), through a systematic review of definitions, concluded that traceability is: *“The ability to access any or all information relating to that which is under consideration...”*. However, the verb *“access”* could cause confusion with the term supply chain transparency. Indeed, many researchers associate accessibility of information related to product with transparency (Hofstede, 2006), (Michener and Bersch, 2013). Therefore, defining traceability simply as the ability to *“access”* information might be confusing.

Bosona and Gebresenbet (2013, p.35) define traceability as *“part of logistics management that capture, store, and transmit adequate information”* about a product. This is in line with the GS1 Traceability standard that describes traceability as a part of a business process and not one which is separate from logistical processes (GS1, 2012). More precisely, according to Moe (1998) and Karlsen et al. (2013), traceability is based on the principle of unique identification. This corresponds with the definition of traceability by ISO 8402:1994 (p.31), which emphasises that traceability should be implemented by *“the means of recorded identification”*. The GS1 Global Traceability standard also distinguishes the idea of unique identification and recording as one of the principles of traceability, together with: information exchange among supply chain partners and *“linking inputs through changes or processing to outputs, be that the same traceable item or a new traceable item”* (GS1, 2012, p.37).

Academic literature (similarly to standards, legislation and global reports) also suffers from inconsistencies in defining the scope of traceability Schwagele (2005), Van Rijswijk et al., (2008), Skilton and Robinson (2009), Olsen and Borit (2013), Bosona and Gebresenbet (2013) argue that traceability should be implemented through all stages of supply chain. In contrast, Tamayo, et al. (2009) specify the distribution chain., and Moe (1998) allows traceability through all and specified stages of supply chain.

Having reviewed interpretations of traceability, it is clear that it is associated with ability to trace (or track, or follow) information related to a product (object, entity, service, project) through recorded identification. This information can depict a history, application and location of a product (note definitions in ISO standards), but in the context of sustainability it may also include data on sustainable practices associated with the product's supply chain (such as suppliers' names/locations, sustainability issues associated with the product, purchasing practices and material provenance, etc.).

## Traceability in the construction supply chain

This section aims to examine the role of traceability for the construction sector, through the lens of sustainability issues. It also provides a brief overview on how traceability is currently being addressed in the construction sector.

### *The role of the construction sector in sustainable development*

The construction sector comprises a wide range of activities from mining, quarrying and forestry to the construction of buildings and infrastructure, and the manufacture and supply of products (Designing Buildings Wiki, 2016). It plays an important role in sustainable development through contributing to the economy, generating jobs, but also through extensive consumption of raw materials resulting in large carbon footprint and energy use (Khatib, 2009). The construction industry accounts for almost 7% of total GDP and 10% of total employment in the UK (BIS, 2013).

Construction activities certainly have a major impact on the environment. The UK construction industry consumes over 90% of non-energy minerals extracted in the UK, and is responsible for almost half of the total carbon emissions, while manufacturing and transportation of construction materials, and construction processes alone account for around 10% of the total carbon dioxide emissions (Constructing Excellence, 2008). The UK government has committed to cut greenhouse gas emissions from built environment by 80% by 2050 compared to 1990 levels (HM Government, 2013).

In terms of social issues, the construction sector is vulnerable to human rights abuses, such as bonded labour, delayed wages, inappropriate working conditions and other forms of modern slavery. To combat this, the UK government introduced the Modern Slavery Act in 2015, which obliges large companies, including those in the construction sector, to demonstrate that they are working to eradicate modern slavery within their supply chains in the country and overseas.

### *The role of traceability for sustainability within the construction supply chain*

Construction supply chains are highly fragmented; involving many parties with different purposes and relying heavily on subcontracting. In a typical £10 million construction project the main contractor may have over 40 sub-contractors and suppliers (EC Harris, 2013). Figure 2 shows a simplified structure of construction supply chain, as an illustration of the complexity involved in discussing traceability within this industry.

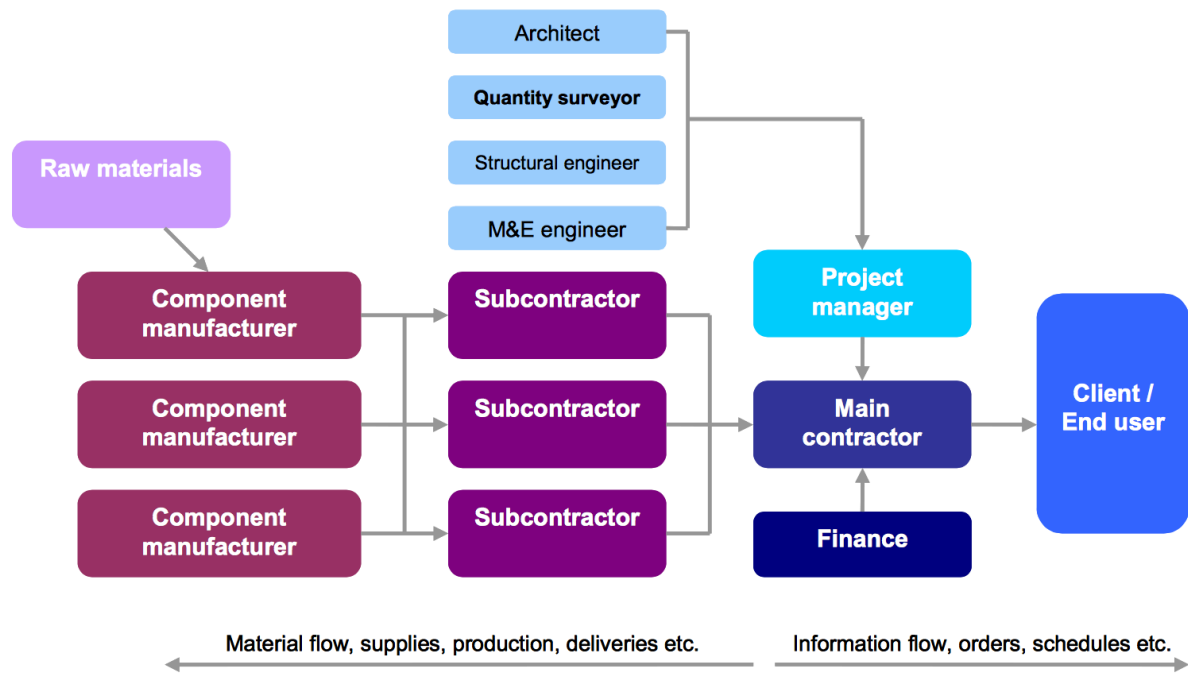


Figure 2 Typical construction supply chain (Source: BIS, 2013)

All the supply chain parties are involved in complex, sometimes adversarial, relationships, where each could attempt to derive maximum benefit at least cost though transferring risks and responsibilities down to the next level of the supply chain (Cox and Townsend, 1998), (Pryke, 2009). In addition, the procurement strategies used by the construction industry have been criticised for their inefficiency. Thus, the tendering process, widely used in the construction sector, implies selecting suppliers who offer the least expensive bid. This results in low quality of work and use of cheaper construction materials (Pryke, 2009), which exposes the risk of human rights violations at the work site and choosing not ethically sourced materials, etc. As a result, the construction industry has a poor public image (Cox and Townsend, 1998), (Wilkinson, 2014).

Regarding responsible sourcing of construction materials, almost all construction materials in the UK are extracted locally, within the country (BIS, 2013). However, the sector is not completely invulnerable to modern globalisation trends associated with sourcing from developing countries where production and labour is cheap (as, for instance, textile, electronics and many other sectors). A survey of construction supply chain, conducted in 2013 (EC Harris, 2013), showed that UK construction companies tend to prioritise cost factors when selection materials/products. Hence, there is a risk of materials penetration from low cost international markets (EC Harris, 2013), which might lead to non-ethical sourcing practices. This is illustrated in recent years by the large increase in imports of reinforcing steel from China which was cheaper than UK produced rebar, but queries were raised about quality and production control (BBC, 2016).

On the other hand, the construction supply chain is characterised by high customer influence (Vrijhoef and Koskela, 2000), (Behera et al, 2015) and project uniqueness. In contrast to many other industries (for example, manufacturing and automobile sectors) where production size is based on market forecasts, so end clients are not known before manufacturing, each project in the construction sector is tailored to its customer's requirements. The end customers (including Government, which is a large client of the construction) thus have an important role in transforming the construction supply chain (HM Government, 2013).

Increasing public interest in environmental and ethical issues and government's strategies towards sustainable development are important drivers for the potential adoption of traceability in respect of construction materials for buildings and infrastructure. In the context of sustainability, traceability is highly worthwhile for verifying sustainable practises along construction supply chains, such as ethical sourcing of materials, environmental impact of production and distribution of construction materials, modern slavery, health and safety conditions of employees, etc. Hence, traceability of sustainability claims along supply chains has great potential to improve the reputation of construction companies and improve data exchange.

### *Configuring traceability in the context of construction*

Yet in contrast to other sectors, such as food industry, fashion, forestry and pharmaceuticals, traceability issues are still at an emerging stage in the construction sector. At present, there is minimal academic literature on traceability with just a few studies noting traceability in relation to responsible sourcing of construction materials (Glass, 2011), (Livesey and Hughes, 2013), (Upstill-Goddard et al., 2015).

As discussed earlier, traceability requirements in the sector appear to be addressed exclusively in the standard BES 6001 (BRE Global Ltd, 2014) on responsible sourcing of materials (mainly construction materials but also others), developed by Building Research Establishment (BRE) in the UK. Traceability of materials at each stage of the supply chain from its source is a compulsory requirement for certification against the standard. Accordingly, the organisation responsible for constituent materials at each stage of the supply chain must be certified against ISO 9001 Quality Management standards or demonstrate equivalent documented evidence of traceability. A minimum of 60% of the mass and volume of input materials must be traceable to suppliers responsible for extraction of raw materials; recovery of recycled materials; production of by-products or processing of commodity traded chemicals (see Figure 3 for details).

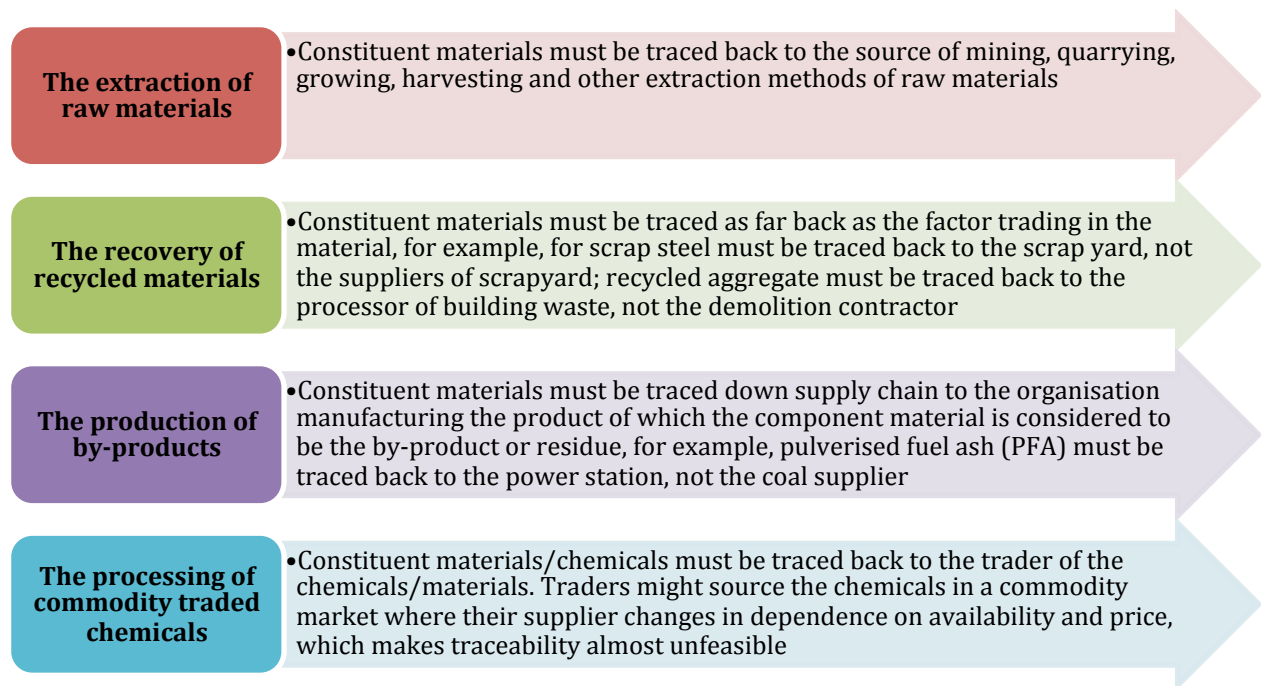


Figure 3 Types of source of constituent materials (BRE Global, 2014a)

If constituent materials are sourced from a supplier based outside the EU/OECD, the organisation seeking BES 6001 certification must perform a risk assessment for 98% of constituent materials by mass and volume. Also the organisation must demonstrate monitoring of suppliers' compliance with the ILO Declaration on Fundamental Principles and Rights at Work (through, for example, membership of the Ethical Trade Initiative; membership of the United Nations Global Compact; certification to the Social Accountability International SA8000 standard) (BRE Global Ltd, 2014).

However, the standard does not provide suggestions on how to actually implement traceability programmes, which is a major shortcoming, but it should be recognised that guidelines also do not exist in other sectors either (Karlsen et al., 2013). In addition, the lack of academic literature on traceability within construction supply chain might lead to a poor understanding of the concept of traceability and hence it would not be reasonable to expect the industry to engage with the idea to any meaningful degree.

Given this situation, it can be argued that there is a strong need for a clear theoretical framework for traceability in the context of sustainability that can be applied to the construction sector. A better understanding of the notion of traceability, as well as a clear breakdown of what it means to operationalise and implement traceability within a construction project supply chain could be beneficial to information sharing when it comes to sustainability issues, which are significant and 'shared' across various parties. Subsequent stages of this research will examine the different types of information that might be the subject of a traceability programme in construction, and also examine the drivers and barriers to implementation, but the scope of this paper is to focus on theoretical underpinnings.



This paper documents research, which is in progress, but it is still feasible to being to outline some of the major features of a framework. It should:

- Clarify the conceptual meaning of traceability. It is important to have a common understanding what constitutes traceability. The definition of traceability should be applicable for many contexts (purposes and sectors) in which the term is used.
- Specify which key variables influence the concept of traceability and outline the relationships between them. This can help to shape the scope of traceability and avoid confusing of the concept.
- Define the main concepts and theories related to traceability. This can help in understanding of traceability in its broad sense.

## Conclusions and further research

This research is focused on the concept of traceability from the perspective of sustainable development, within the construction industry. For that, the main concepts related to traceability under the umbrella of sustainability (ethics, social responsibility, transparency and responsible sourcing) have been outlined, and the relationships among them are explained. To understand the conceptual meaning of traceability, the paper reviewed how traceability issues are addressed both in academic literature and standards/legal requirements. There is an agreement in literature that traceability involves following (or tracing, tracking, etc.) information related to a product (object, service, project, entity) through means of recorded identification. In the context of sustainability, such information includes data on sustainable practices associated with the product's supply chain (for example, as suppliers' names and locations, sustainability conditions associated with the product, purchasing practices and material provenance). However, interpretations of traceability differ in terms of whether to implement traceability across all stages of supply chain or specified ones. This indicates a poor understanding of traceability requirements and its scope, and so, there is a need to develop a theoretical framework of traceability specifically for sustainability in any case, but we argue that this is particularly pertinent to the construction industry.

Despite the significant role of the construction industry in sustainable development, traceability issues are still at an emerging stage in the sector, as such there is a minimal academic literature on traceability. The standard on Responsible Sourcing BES 6001 is the only source that addresses traceability requirements in the construction sector and even this does not specify what a traceability programme should entail. Hence, this paper outlines the need for further investigations on traceability for sustainability from the perspective of the construction sector as a means to potentially improve the management of sustainability in supply chains.



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