BLOCKCHAIN FOR CHANGE

An exploratory research on the potential of blockchain technology to create more sustainable global value chains

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Date of submission: August 14th 2018

Preface

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Acknowledgements

This Master thesis marks the end of my years as a student and the finish of the master program Global Business and Sustainability at the Rotterdam School of Management, Erasmus University of Rotterdam. It has been an intense last couple of months full of hard work, nevertheless, with tremendous and valuable learning experiences. I would like to take this opportunity to express my gratitude to some people without whom the completion of my master thesis would not have been possible.

First, I would like to thank my coach Prof. dr. Rob van Tulder, for guiding me throughout this process. His extensive knowledge offered me valuable insights and our discussions challenged me to further explore the topic from a broader perspective. I would also like to thank my co-reader Dr. Frank Wijen, for his valuable input and for helping me narrow down my research topic when needed. The constructive feedback received from both coaches have been profoundly helpful to me.

Furthermore, my appreciation goes out to all interviewees, for devoting their time and sharing their knowledge, experiences, thoughts and ideas on this topic. Likewise, Timo, thank you very much for your time and effort, and for proof-reading.

In addition, my gratitude goes out to my family and friends. First, my brother, who encouraged me to step out of my comfort zone by exploring this topic, which has been challenging but very interesting and educational at the same time. My mother and sister, for their unconditional support and encouragement, when I needed it most. And last, but certainly not least, my friends and fellow GBS students, for their endless motivational words, support and the necessary distractions.

Rachel van der Pol

Rotterdam, August 2018

Executive summary

The contemporary era of globalisation has stimulated the growth of international trade, creating complex and dispersed global value chains. Despite the various benefits that have arisen from these developments, several complex societal issues have emerged, as these opportunities are rather unequally distributed amongst stakeholders in value chains. This created a societal 'trust gap', whereby the governance of global value chains has come under dispute. Nevertheless, this emerging void creates new space and herewith opportunities to tackle societal problems in innovative ways. In response, numerous sustainability standards and certifications have emerged as control mechanism to provide solutions to the unsustainable global value chain practices. Yet, challenges with this conventional approach remain and previous research has recognised the limitations of this approach. In addition, the potential of inventive technologies enhancing sustainable development is widely acknowledged. Consequently, practitioners are considering the novel blockchain technology as an innovative approach to create more sustainable value chains. Though, previous studies identified that technical solutions to wicked societal problems could lead to even bigger problems and new challenges. Thus far, scientific research into the potential of blockchain in relation to conventional sustainability standards to create sustainable value chains is still incredibly limited.

This research, therefore, explores the claimed potential of blockchain technology as a technical solution to address the wicked sustainability problems in the global value chains. In addition to research on existing literature, a qualitative, exploratory research design is applied, to explore and generate in-depth and rich information, for which a Delphi study is used. The sample is selected through purposive sampling, which assures to provide a wide range of information based on varying experiences and perspectives from experts on the research question. In order to create a complete picture of this subject, the study critically assesses the possibilities and limitations of both conventional sustainability standards and blockchain technology encountered among various global value chains, which are identified in the research.

The research findings signify that blockchain can be applied in every value chain where there is any flow of commodity or transaction between actors to establish mutual trust. It can digitise the value chain, nevertheless, it is not a solution in itself and should rather be seen as a complementary technological innovation to the conventional sustainability standard approach. Various attributes of the technology contain possibilities and hold potential to bring benefits to the value chains to promote sustainable development. Though the chance for progress that was indicated, only applies to parts of this wicked problem and does not adequately captures the interrelated problems. Moreover, it can create transparency, yet this does not necessarily lead to more sustainable value chain practices. Finally, the benefits and success of blockchain primarily depend on the condition that all actors are involved and participate in the network. Though this condition brings several challenges and limitations, as for example, all stakeholders must be willing to share data and create transparency. Further, the findings tended to indicate several contextual variety challenges, depending on the type of value chain one is operating in.

Overall, this study is a further step in understanding the potential of a technological innovation to address sustainability issues and enhance sustainable development, which future research can build on.

***Keywords**: Sustainability, Global Value Chains, Blockchain Technology, Sustainability Standards and Certifications, Wicked Problems*

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1 Introduction

“Our global economy is in crisis. The exponential exhaustion of natural resources, changing climate, declining productivity, rising unemployment and growing economic inequality between the rich and the poor forces us to rethink our economic models” – Rifkin, 2016

These words of Rifkin (2016) sum up a few of the enormous challenges that our business and society are currently facing. The contemporary era of globalisation and internationalisation has stimulated the growth of economic trade, which largely takes place on an international scale. Consequently, production and consumption processes are no longer taking place within one country, creating widespread global value chains with multiple actors involved. Despite the various benefits that have arisen from the growth of international trade, several complex issues have also emerged from these global developments. The trend of outsourcing has created dispersed and decentralised production and distribution processes, which caused a loss of control over the entire value chain for the focal companies (Vurro, Russo & Perrini, 2009). Herewith, a growing distrust in these companies is triggered by exposed corporate misconduct, unfair practices and unethical behaviour (Jenkins, 2003; Vurro et al., 2014). Globalisation has come with a ‘dark side’, as its benefits and opportunities are rather unequally distributed amongst the value chain (Kaplinsky, 2000). In response to fill the institutional void that resulted from the globalisation of value chains, numerous sustainability standards have emerged to fill this void and address the unsustainable global value chain practices (Muradian & Pelupessy, 2005). By initiating various sustainability standards and certification programs, such as Fairtrade, collaborative initiatives have attempted to limit irresponsible business behaviour and to encourage the business environment to establish more responsible and sustainable global value chains (Manning, Boons, Von Hagen & Reinecke, 2012; Prakash & Potoski, 2006).

Despite these efforts, questions and concerns are rising regarding the relevance and effectiveness of currently established standards and certifications for fair and sustainable global production and consumption practices, after nearly two decades of implementation and research (Bush, Oosterveer, Bailey & Mol, 2015). The demand of society towards more sustainable business practices and processes is embodied in Sustainable Development Goal 12: Responsible Consumption and Production. SDG 12 is one of the 17 Sustainable Development Goals, which is a universal framework that was introduced by the United Nations in 2015, to address the global economic, social and environmental challenges our planet is currently facing. SDG 12 and its targets are found at the core of the global economy, as it combines the economic elements of production and consumption, the social aspects driven by and derived from production and consumption processes and the environmental effects from the entire product lifecycle (Akenji & Bengtsson, 2014; Bereuther & Stappmanns, 2017). Accordingly, Waddock (2012) states that the unsustainability of the current world system can be conceived as a truly wicked problem, and coping with this requires wicked good solutions. While the world is facing many challenges, at the same time technology advances and new forms of collaboration and organisation allow for new approaches to societal challenges. Hence, Van Tulder (2018) argues that where societal boundaries shift, fade or completely dissolve, ambiguity and uncertainty thrive. Moreover, the emerging voids can create new space and thus opportunities to tackle societal problems in innovative ways. On the contrary, it can also generate new complex challenges and problems (Van Tulder, 2018).

The potential of technology contributing to positive, societal change on an international level has been extensively discussed. Blockchain technology is a novel technology that has received a lot of attention lately, mainly in the financial industry due to the emergence of digital cryptocurrencies and the hype around Bitcoin. It is not Bitcoin itself, but the underlying blockchain technology, of which practitioners claim that it could fundamentally change the way interaction and global trade are currently organised and create a new foundation for present economic and social systems (Brakeville & Perepa, 2016; Swan, 2015). Blockchain technology is as a new type of database structure, that runs decentralised and records value transactions across an immutable, peer-to-peer network. Furthermore, the technology creates a shared database that relies on the verification of transactions by all actors involved in the network. These features of blockchain technology are contemplated to enhance trust, transparency and integrity among the various actors involved in transactions. Consequently, practitioners are considering blockchain technology as an innovative approach to address the sustainability problems in the global value chains. Nevertheless, not everyone is convinced that technological innovations, such as blockchain technology, are suitable approaches to address wicked societal problems. Technical solutions for complex or wicked problems could lead to even bigger problems or unforeseen consequences (Head & Alford, 2015; Rittel & Webber, 1973). Furthermore, Vasishth (2013) argues that technology can be 'an obstacle in the path to a sustainable future', while at the same time 'holds strong potential to show us the way forward'.

Triggered by the pressure on sustainable practices, and the revealed sustainability problems in supply chains, interest in the field of sustainable supply chain management has risen (Seuring & Muller, 2008). Previous academic research has indicated that conventional sustainability standards are reducing the chance of unsustainable business practices (Giovannuci & Ponte, 2005) and improving the coordination of global production and distribution system (Nadvi & Wältring, 2002). Moreover, academic literature recognises the importance of effective use and implementation of new technologies to enable more efficient and responsible production practices and to achieve the Sustainable Development Goals (UN ECOSOC, 2017; UNEP, 2015). Although the importance of innovative technologies in the creation of sustainable value chains is acknowledged, current research into the role of blockchain in sustainability is still incredibly limited. Earlier research in this field focused on blockchain and its energy consumption (Vranken, 2017), solely focussed on bitcoin and sustainability (Giungato et al, 2017) or concentrated on blockchain as a social contract for sustainability (Faber & Hadders, 2016). Nevertheless, the potential of blockchain in relation to conventional sustainability standards is an undiscovered field of research. Moreover, as previous research identified that technical solutions for wicked problems could lead to bigger problems and new challenges, the claimed potential of blockchain has not been studied yet from this perspective, (Head & Alford, 2015; United Nations, 2016). This research intends to address this identified research gap and further explore this fairly novel field of research.

1.1 Research objective and research questions

This research, therefore, seeks to explore the claimed potential of blockchain technology as an approach to address the wicked sustainability problems in the global value chains. To achieve this objective, the current problems of the global value chains are first identified. Based on this foundation, the research critically assesses the possibilities and limitations of conventional sustainability standards and examines blockchain technology and its potential to address the occurring sustainability problems in global value chains. In order to create a complete picture of this subject, the study explores these aspects among various global value chains, which are identified in the research.

The central research question therefore is:

Under what conditions is blockchain a better control mechanism to establish sustainable global value chains compared to the conventional sustainability standards?

In order to answer this main research question, the following sub research questions were defined:

1. *How are the global value chains currently organised?*
2. *What are the control possibilities and limitations of conventional certified sustainability standards to establish sustainable global value chains?*
3. *What are the control possibilities and limitations of blockchain technology to establish sustainable global value chains?*

1.2 Relevance of the research

This study seeks to explore the potential of a new, rapidly developing technology of which it is claimed to be able to address various key sustainability problems within the global value chains. Blockchain technology and its implementation to value chains is a fairly novel topic in academic literature, with little established scientific research. This thesis, therefore, conducts further research into the topic of technological solutions to wicked societal problems to contribute to existing scientific knowledge. Further, as this study aims to explore the possibilities of creating more sustainable value chains through the application of blockchain technology within different value chains, it also contains managerial relevance for both practitioners in the field of sustainability and blockchain technology. Overall, the research is a further step in understanding the potential of a technological innovation to address sustainability issues and enhance sustainable development, which future research can build on.

1.3 Structure of the research

In this introductory chapter, the subject of the research is introduced. Moreover, it states the research objective, the research questions and discusses the relevance of this research. The literature review in the following chapter provides theoretical background and establishes the context around the topic. At the end of Chapter 2, the insights that are derived from the literature review are formulated in a conceptual model. The methodology of this research is discussed in Chapter 3, which encompasses the research design, data collection and analysis methods. Chapter 4 presents the empirical findings of this research. Subsequently, in Chapter 5 an answer to the research question is formulated, the limitations of the research are discussed and recommendations for future research are provided. Furthermore, at the end of the report, the reference list and the appendices can be found.

2 Literature Review

2.1 (Un)sustainable global value chains

2.1.1 The emergence of global value chains

We are living in a world with dynamic and changing conditions that is more interconnected than ever before (UNDP, 2018). The current era of globalisation has led to the blurring of boundaries and a more closely connected and integrated society. This has stimulated a growth of economic trade, which largely takes place on a global scale. Innovative information and communication technologies, together with the low-costs of shipping, have stimulated companies to outsource their production processes (Kim & Davis, 2016). As a result, the processes of production and consumption are no longer taking place within the boundaries of one country, but are often globally spread (Bush et al., 2015; Seuring & Müller, 2008). In many industries, this created disaggregated global value chains which replaced the vertical integrated companies of the 20th century (Kim & Davis, 2016). Global value chains or global supply chains are often referred to as global production networks, as this terminology emphasises the complexity of the trading activities in commodity chains (Levy, 2008). Global production networks consist of complex horizontal, diagonal and vertical linkages that create a multidimensional and multiple layered structure (Henderson, Dicken, Hess, Coe & Yeung, 2002). These complex, transboundary value chains comprise multiple stakeholders around the globe (Vurro et al., 2009). Stakeholders mainly include raw material suppliers, distributors, manufacturers, retailers, and end consumers (Francisco & Swanson, 2018). The numerous involved actors in a chain all add market value to the product at different stages along the process (Manning et al., 2012). Sequentially, globalisation and the internationalisation of production stimulated that global value chains grew more dispersed and decentralized, with multiple actors involved in the production and movement of goods (Levy, 2008; Gereffi, 1994).

Hence, these global value networks require a high degree of coordination and demand for effective management, which is referred to as supply chain management (Levy, 2008). According to Handfield & Nichols (1999) supply chains include all activities related to the flow and transformation of products from the stage of raw materials through to the end user, as well as the related information flows. Subsequently, supply chain management entails the integration of these activities through improved supply chain relations to establish competitive advantage (Handfield & Nichols, 1999). Moreover, the organisation and allocation of all these activities, including financial, material and human resources along the value chain, is explained by Gereffi (1994) through the concept of value chain governance. Value chain governance refers to the power relations in a value chain, which can be explained as the governing entities that have the capability to set or enforce parameters under which other actors in the chain must operate. The chain actors that possess the position to determine parameters are able to control and coordinate the other parts of the value chain (Von Geibler, 2013). These parameters define the production process in its broadest sense, including what is to be produced, how and when it is produced and how much, at what price (Humphrey & Schmitz, 2001; Taylor, 2005). The companies that control and govern the supply chain are also referred to as focal companies (Seuring & Müller, 2008). Globalisation stimulated the expansion of focal companies, often through the acquisitions of companies' suppliers and distribution channels (Kim & Davis, 2016). Subsequently, those companies brought the control over their entire value chain within the organisational boundaries, establishing a strong value chain governance. It can be concluded that governance in value chains is related to the exercise of control and power along the chain. Additionally, by understanding the governance of a chain, one can better understand the distribution of value along the chain, as those governing entities have the ability to define the parameters (Humphrey & Schmitz, 2001).

2.1.2 Global value chains and sustainability challenges

2.1.2.1 Unequal value distribution

The last decade, the governance of global value chains has come under dispute. Globalisation stimulated an international growth of trade, and with that, it created opportunities for a significant growth of income, a better availability and quality of products, and an increased product differentiation for many (Kaplinsky, 2000). Despite these benefits, it has been widely discussed that globalisation also comes with a 'dark side', as these benefits and opportunities are rather unequally distributed (ibid.). Due to the increased global economy, companies felt pressured to search for ways to increase efficiency and reduce production costs, to avoid loss of competitiveness (Levy, 2008). To reduce costs, companies started to outsource their low-skill manufacturing activities to low-income countries (Boström et al., 2015). Trade export is considered as a vital source of income for developing countries, however, the growth of income in developing countries has lagged on the growth of global income (UNCTAD, 2002). It is concluded that developing countries only account for a very low proportion of the total income generated through exports in our global economy (Giovannucci & Ponte, 2005). Moreover, Kaplinsky (2000, p. 117) draws attention to the fact that "there has been an increasing tendency towards growing unequalisation within and between countries and a stubborn incidence in the absolute levels of poverty, not just in poor countries". Even though production largely takes place in the base of the value chain, a significant proportion of economic returns flow to the developed countries (Neilson & Pritchard, 2011). Levy (2008) argues that corporate interests are in conflict with those of society as a whole, as reducing wages is not a way of 'creating value'. Porter (1985) initially developed the concept of the value chain, which links all the 'value adding' economic activities and actors of a production process. Various intermediaries in the production process, including buyers, exporters, and credit providers account for a large part of the value in the value chain. Yet, it is discussed that the largest amount of 'added value' is realised in the major Western consumer markets, which transfers the wealth from workers to shareholders, leading to prosperity for developing countries (Levy, 2008). Talbot (2004, p. 163) defined that the distribution of value along the chain is a function of "struggles over the structure of the commodity chain and the politics of its governance". In addition, Boström et al. (2015) state that equal power distribution amongst actors in the chain is essential to create a more responsible and sustainable governance of value chains.

2.1.2.2 Transparency and trust issues

The emergence of global value chains also raised concerns about the social and environmental circumstances in which products and services are being produced (Seidman, 2007). The trend of outsourcing and subcontracting caused a loss of control over the stages of the production and distribution processes for the focal companies (Vurro et al., 2009). With that, a growing distrust in these companies is caused by exposed corporate misconduct, unfair practices and unethical behaviour (Jenkins, 2003; Vurro, Russo & Costanzo, 2014). It is argued that the interests of corporations have been in contrast to those of society, which has increased the demand for corporate responsibility, transparency and traceability in global supply chains (Perez-Aleman & Sandilands, 2008). Globalisation has stimulated new views on the responsibilities of companies. As a result, it is demanded of governing companies involved in globalised supply chains, to accept responsibility for the social and environmental issues along their entire value chain (Boström et al., 2015). The pressure for sustainable value chains is not only coming from NGOs or international institutions, but also society and its consumers are demanding more sustainable goods and services and responsible and transparent supply chain practices (Bereuther & Stappmanss, 2017; Francisco & Swanson, 2018). For example, consumers want assurance that their clothes are produced without child labour practices or they want to be certain that their jewellery is authentic and mined and produced in a sustainable manner. These concerns mainly occur when supply chains are complex, multi-tiered and globally spread (Francisco & Swanson, 2018). Therefore, focal companies in the global value chains are more and more confronted with requirements for sustainable production and consumption and are held responsible for the sustainability performance of their suppliers (Boström et al., 2015). To act upon these responsibilities, companies need insight into the sustainability performance of their supply chains. This requires transparency which, in a supply chain context, is identified as information available to actors involved in a supply network (Francisco & Swanson, 2018). Transparency requires information on what is happening in the value chain and concerns detailed information on the flows of value in the chain to origins (Pagell & Wu, 2009). Additionally, this demands traceability, which is necessary to track and trace the origin of raw materials and provide context to a final product. In this way, traceability helps to identify and assign responsibilities on where improvements can be made (Pagell & Wu, 2009). A strong link between transparency and social responsibility can be identified here, as both transparency and traceability help to ensure that the entire value chain and its related processes are organised in a responsible and sustainable manner (ibid.).

2.1.3 Sustainability in global value chains

Triggered by the recent environmental and social problems revealed in supply chains and the pressure on sustainable practices, interest in the field of sustainable supply chain management has risen (Seuring & Müller, 2008). Sustainable supply chain management is defined as the management of material, information and capital flow, as well as collaboration between companies in the value chain while integrating objectives from all three dimensions of sustainable development: economic, environmental and social objectives (ibid.). This approach is connected to the Triple Bottom Line concept of Elkington (1999), which explains this as a focus that is beyond the traditional measures of profit and the economic value a company adds, but also includes the environmental and social value that is added or destroyed by the business (Elkington, 2004). Thus, it includes the promotion of social equity and environmental sustainability in global production and trade processes, next to achieving economic prosperity (Manning et al., 2012). In sustainable value chains, all actors must meet the environmental and social criteria, while simultaneously competitive advantage and economic objectives are achieved (Seuring & Müller, 2008). By ensuring that suppliers incorporate sustainable innovations into activities and processes, supply chain managers can establish sustainable value chains (Mahler, 2007).

Companies are increasingly facing pressure to address social activities related to their international operations (Levy, 2008). By expressing criticism, activist exerting an intense pressure on these companies, forcing them to change their unsustainable behaviour to avoid boycotts (Zadek, 2004). A complete transparent value chain could guarantee a responsible production process, which also demonstrates the long-term well-being and social equity of every actor in the value chain (Pagell & Wu, 2009). This includes not only environmental aspects but also human rights, labour conditions (including health and safety) and anti-corruption, amongst others. Finally, Giovannucci & Ponte (2005) argue that transparency depends on the balance of power between companies and social organisations and their increasing willingness to cooperate.

2.1.4 Societal interrelatedness of the sustainability issues

As previously discussed, companies are faced with an increasing pressure to take responsibility for addressing the sustainability issues in their global value chains (Levy, 2008). Nevertheless, it is argued that the growing global economy and its related production and consumption patterns pose specific challenges for sustainability management (Von Geibler, 2013). As these global production systems are complex and widespread, single value chain actors cannot effectively manage those sustainability issues on their own (ibid.). Whereas companies have not entirely taken up the responsibility to address these issues, it is discussed that governmental regulation on environmental and social conditions of globalised productions is falling behind (Raynolds, Murray & Heller, 2007). Correspondingly, Bush et al. (2015, p. 8) claim that "state authorities have proved to be increasingly unable to regulate and govern the sustainability of globalised production and consumption".

In response, this lack of regulation has led to a variety of emerging initiatives consisting of NGOs, industry associations, civil society groups and public-private partnerships (Bush et al., 2015; Raynold et al., 2007). This resulted in a pro-active development of numerous self-regulatory standards on sustainability (Manning et al., 2012). These standards are thus created by established non-state governance collaborations through co-defining and reaching agreements on standards and certificates that actors in the value chain must live up to, in order to establish sustainable product and production processes (Bush et al., 2015; Manning et al., 2012; Wijen & Ansari, 2007). This resulted in an establishment of new governance structures, including codes of conduct, standards, certification schemes, processes and auditing (Boström et al., 2015; Levy & Kaplan, 2008). All these approaches demand companies to demonstrate greater responsibility and transparency and are targeted at limiting and shaping the behaviour of the focal companies in the value chain (Kolk & Van Tulder, 2005). Section 2.2 of the literature review further elaborates on these sustainability initiatives as an approach to establish sustainable value chains.

Yet, from this it can be concluded that these value chain issues are interrelated and materialize at the interface between public and private interests, making it a 'wicked problem' (Van Asperen & Van Tulder, 2016). Head & Alford (2015) defined that wicked problems are mostly associated with multiple stakeholders, institutional complexity and scientific uncertainty. Consequently, wicked problems are not objectively given, as they involve multiple perspectives of various stakeholders with different interests (Head & Alford, 2015). Therefore, each stakeholder probably has a different view on both the best outcome and the best solution to the problem (Van Bueren, Klijn & Koppenjan, 2003).

Van Asperen & Van Tulder (2016) describe that the wickedness of a problem can be assessed on the societal origins of the problem. Figure 1 reflects the societal triangulation analysis. This analysis includes the three key societal stakeholders; state, market and civil society and whether they have and take responsibility for addressing the problem. Moreover, it is argued that mostly in the case of economic growth issues, collective action beyond individual responsibilities is needed to implement a minimum level of social, economic and ecological regulation. However, not all actors feel responsible, resulting in a risk that involved parties refuse to address the issue (Van Asperen & Van Tulder, 2016). Van Tulder (2018) describes that the societal centre of the triangle demonstrates the common pool problems which are also referred to as the 'institutional void'. This void is linked to significant 'trust gaps', which reflects the lack of 'societal checks and balances' that are induced to share power and are deemed necessary to create a healthy ecosystem. Moreover, it is argued that the institutional void can only be addressed by the collaborative action of each of the societal sectors (ibid.)

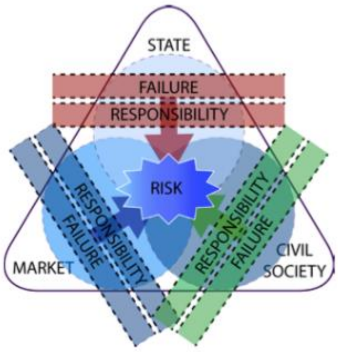

Figure 1 Societal triangulation (Retrieved from: Van Asperen & Van Tulder, 2016)

2.1.5 SDG 12: the ambition for sustainable global value chains

As earlier stated, the complex global value chain issues cannot be addressed effectively by a single actor (Von Geibler, 2013). Moreover, it is argued that government regulations have been lacking, and so far companies have been failing in addressing all the issues simultaneously. Furthermore, society is demanding more responsible and sustainable products and services (Bereuther & Stappmanss, 2017). Thereafter, they have demonstrated responsibility through conflicts, such as boycotts and name-and-shame campaigns, but also through the earlier discussed development of standards and regulations (Camilleri, 2017). Yet despite these efforts, the problems still exist. The need for more sustainable business practices and processes is embodied in Sustainable Development Goal 12: Responsible Consumption and Production. SDG 12 is one of the 17 Sustainable Development Goals, a universal framework that defines the world's aspirations for 2030. The SDGs were introduced by the United Nations in 2012 and can be considered as the world's strategy to address the global economic, social and environmental challenges our planet is currently facing. SDG 12 and its targets combine the economic elements of production and consumption, the social aspects driven by and derived from production and consumption processes and the environmental effects from the entire product lifecycle (Akenji & Bengtsson, 2014). Since consumption and production are at the core of the global economy, the accomplishment of SDG 12 will support the achievements of other SDGs on for example food, water and energy, and will create synergies (UN Chronicle, 2015). The United Nations Development Programme (2018) defined that achieving Goal 12 requires a better understanding of the impact of goods and services, which can be considered as a twofold case. A change in consumer behaviour and lifestyles within our society, as well as a transformation in current business practices is required, to reduce our ecological footprint (UN Global Compact & WBCSD, 2015). The latter implies increasing efficiency and productivity throughout the supply chain and lifecycle of products and therefore acknowledges the importance of the private sector in participating to successfully achieve these goals (Bereuther & Stappmanns, 2017). According to the UNDP (2018), a crucial first step to improve the environmental and social impact of the system is by identifying 'hot spots' within the global value chain, where interventions have the greatest effect. As Bocken et al. (2014, p. 42) state: "with prospects of a rising global population, accelerating global development and associated increasing resource use and environmental impacts, it seems increasingly apparent that business as usual is not an option for a sustainable future". SDG 12 reveals that this ambition is both in the interest of business and society, therefore there is a responsibility for all actors to act upon this goal (UN Chronicle, 2015; Van Asperen & Van Tulder, 2016).

2.1.6 In summary

The era of globalisation and internationalisation has triggered the rise of complex and dispersed international global value chains, around which production and world trade are increasingly structured. Along these decentralised value chains, numerous actors are involved in the process of adding market value to the product. Besides the various economic advantages emanating from the growth of international trade, these developments have also resulted in complex sustainability issues and challenges, especially concerning the transparency of practices of focal companies and the distribution of value of this economic growth amongst all actors in the value chain. The need for more responsible and sustainable production processes has been formulated in UN's Sustainable Development Goal 12, which requires collective action to fill this void and address this wicked problem. The following section elaborates on the emergence of sustainability standards and certifications as an approach to address the global value chain issues and fill the void to stimulate responsible and sustainable global value chains.

2.2 Conventional sustainability standards and certification to establish sustainable global value chains

2.2.1 The emergence of sustainability standards and certifications

Various private actors, such as corporations and civil society organisations, but also multi-stakeholder initiatives, have emerged to provide solutions to the unsustainable global value chain practices, through initiating global sustainability standards and certification schemes (Manning et al., 2012; Prakash & Potoski, 2006). Most sustainability standards commenced out of social movements and are mainly established without the direct involvement of (inter)governmental organisations and thus can be considered as examples of private global governance (Von Geibler, 2013) or non-state market-driven governance (Cashore, Auld, Bernstein & McDermott, 2007). These global voluntary sustainability standards attempt to fill the institutional void that has resulted from lacking state regulations to the globalisation of value chains (Montiel, Christmann, Zink, 2016; Raynolds et al., 2007). By establishing and enforcing global standards, these actors try to equate the global playing field for companies from all countries (ibid.). Several standards provide third-party certifications that partaking stakeholders in value chains must adhere to, in order to assure sustainable production (Manning et al., 2012). Nadvi & Wältring (2002, p. 6) define standards as "agreed criteria by which a product or a service's performance, its technical characteristics, and/or the process, and conditions, under which it has been produced or delivered, can be assessed". Standards can take many shapes and include international standards which apply to product specifications, sector-specific standards and labels, as well as company specific codes of conducts (Nadvi, 2008). Further, they aim to influence business practices on a wide range of problems, covering social, environmental, ethical, quality and safety issues in production and consumption processes. In addition, certification is defined as a procedure by which a third party guarantees in writing that a product, process or service meets certain specified standards, on the basis of audits and assessments carried out according to the agreed procedures (Bass, Thornber, Markopoulos, Roberts & Grieg-Gan, 2001).

2.2.2 The possibilities of sustainability standards and certifications

Sustainability standards and certification initiatives are considered as promising market-based instruments, targeted at addressing sustainability problems related to economic, globalisation processes (Taylor, 2005). The following section outlines the benefits and possibilities of this approach.

2.2.2.1 A new collaborative form of governance

Addressing these complex and diverse issues that occur along the value chains is not a task that can be done by a singular party in the chain. Therefore, most of these private governed sustainability initiatives are typically collaborating with stakeholders on a global level. It is discussed that standards and certifications are an interesting form of governance because they operate at the boundary between globalisation processes, which are focused on market interest and localisation commitments, which prioritize people and development (Bass et al., 2001). This form of governance lies at the root of many of the biggest economic, environmental, social and political challenges of the moment, which involve finding the right compromises for sustainable development (ibid.). In addition, 'they reflect new forms of global and regional governance that can both support and challenge the regulatory domains of nation-states' (Nadvi, 2008). The engagement of different actors increases their market power and can stimulate implementation of these standards to influence production conditions (Cashore et al., 2007; Von Geibler, 2013). To illustrate, examples of wide-known standards are found in fair trade, sustainable forest management and responsible soy and palm production (Von Geibler, 2013). Thus, standards stimulate new or improved forms of collaboration among actors in a specific sector or country (Jaffee, 2003). Moreover, standards and certification schemes facilitate knowledge and resource sharing, which delivers benefits to participating actors (Charlemagne et al., 2015).

2.2.2.2 Increasing consumer trust

In response to the growing demand for information about production conditions by consumers in developing countries, codes of conducts and certification and labelling schemes have emerged in a wide variety of global economic sectors (Muradian & Pelupessy, 2005). These standards, certifications and labels are tools for companies to transmit information to consumers on the compliance of criteria that are set for the process of sourcing to production (Nadvi, 2008; Muradian & Pelupessy, 2005). It enables companies to communicate information about themselves or their products to potential end-consumers in a reliable manner (Christmann & Taylor, 2001). Moreover, these initiatives enable participating companies and suppliers to demonstrate their skills and production standards, which increases consumer confidence (Muradian & Pelupessy, 2005). Therefore, it is seen as a useful tool that helps companies' further establish trust with their consumers (Charlemagne et al., 2015).

2.2.2.3 Improving the position of smallholders

It is argued that sustainability standards are especially important for the farmers and companies in developing countries, as it determines the conditions for participating in global value chains (Giovannucci & Ponte, 2005). Hence, Potts et al. (2014) discuss that sustainability standards strengthen the possibilities for stakeholder participation in decision making throughout the value chain. Therefore, sustainability standards can alter the weak position of smallholders in the chain and provide a more just form of governance, by involving them in the standard-setting process (Muradian & Pelupessy, 2005). In addition, it is stated that the influence of stakeholders on the development of various certification schemes, both direct and indirect, is increasing (Charlemagne et al., 2015). Henson & Reardons (2005) note that while public and private were initially introduced to ensure minimum requirements for international trade, private and voluntary sustainability standards have become more important to improve the competitiveness of smallholders in international value chains. Moreover, it is discussed that standards are an essential tool for reducing poverty for smallholders in developing countries (Ruben & Zuniga, 2011). Daviron & Ponte (2005) argue that if a price premium is paid, these standards can benefit the producers by improving the distribution of added value in the value chain. Research indicates that participation in standard certification schemes tends to benefit producers in terms of their socioeconomic situation and income (Brandi, 2016).

2.2.2.4 Stimulating competitiveness for sustainable development

Standards and certification can serve as a strategic business tool, as it provides suppliers with the opportunity to improve their product and process (Jaffee, 2003). Meeting a certain standard or achieving compliance can be an important way for suppliers to add value and to differentiate themselves from the competition (Nadvi & Wältring, 2002). Consequently, this stimulates international competitiveness and creates competitive new niche markets (ibid.). These initiatives, therefore, promote a market shift towards more sustainable production processes.

2.2.2.5 Improving coordination of value chains

Moreover, instead of assessing a final product, many standards mainly try to assess the entire value chain, including all interconnected processes of production, processing and trade (Giovannucci & Ponte, 2005). Nadvi & Wältring, (2002) state that standards improve business to business links by improving the coordination of global production and distribution systems. Therefore, these initiatives provide a set of commonly understood norms, which is considered as an important factor in improving trade relations. Subsequently, they can enhance market efficiency in the increasingly interconnected global economy (Nadvi & Wältring, 2002). Further, the strict checks and balances of standards and certifications are reducing the chance of unsustainable business practices (Giovannucci & Ponte, 2005).

2.2.3 Limitations of sustainability standards and certifications

Despite the progress that has been made with the rise of sustainability standards and certifications and its potential, there are also several limitations and drawbacks to this approach that have withheld the establishment of entirely sustainable global value chains. The following section discusses each identified limitation.

2.2.3.1 Lacking involvement of all actors

The first limitation of sustainability standards relates to the fact that standards and guidelines often evolve without the active involvement of all actors (Giovannucci & Ponte, 2005). Primarily, the developed country actors are the ones that set the standards, instead of the developing country producers, who are supposed to benefit most from setting these standards. Further, there may exist contradictory perceptions of certain norms and values, for example, whether child labour should be allowed in global value chains. These opposing ideas can create conflicts about what standards should guide export-oriented production in developing countries (Neilson & Pritchard, 2010). Additionally, the credibility of these initiatives is questioned, when not all stakeholders are involved in the development process (Giovannucci & Ponte, 2005). It is discussed that the impact of sustainability standards is likely to remain limited when only developed country actors determine what is included in the standards (ibid.). Moreover, transparency is lacking when only particular actors decide how information will be measured and monitored (Boström et al., 2015; Nadvi, 2008). Despite the benefits that it may hold for producers, it does not change the power relations in the value chain when producers are not involved in key decision-making processes (Giovannucci & Ponte, 2005). Lund-Thomsen & Lindgreen (2014) define that a wide range of actors is required to effectively manage the value chain.

2.2.3.2 Effectiveness and relevance

Despite the efforts to create more sustainable value chains through current established standards and certifications, these initiatives are struggling with demonstrating their value and relevance (Von Geibler, 2013). The effectiveness of these initiatives is questioned, due to a lack of information about the effects and consequences of the certification process (Bush et al., 2015; Van Oorschot et al., 2014). Concerns are rising, as it is not clear whether the direct benefits, particularly price premiums, reach the bottom of the value chain (Giovannucci & Ponte, 2005). It has been argued that benefits can be lost along the value chain, due to the fact that the distribution of these benefits is not consistently and accurately documented (Giovannucci & Ponte, 2005). Furthermore, it is discussed that many standards enlarge the total income value of the supply chain by asking for a price premium, which does not correct the current power asymmetries and market distortions (Muradian & Pelupessy, 2005). Moreover, social auditing schemes have reported limited improvements in workers' conditions (Lund-Thomsen & Lindgreen, 2014). Additionally, there is inadequate evidence that factories are systematically expelled in case of non-compliance, nor is there proof that they are rewarded when displaying high levels of compliance (Ruwanpura & Wrigley, 2011).

2.2.3.3 Legitimacy challenges

Additionally, standards and certification initiatives are facing challenges related to achieving legitimacy (Von Geibler, 2013). O'Rourke (2003) expressed concerns about whether publicised third-party audits are entirely to be trusted to generate reliable evidence about work conditions in production factories. Moreover, it is discussed that these auditing practices have prompted some local suppliers to participate in auditing fraud (Lund-Thomsen & Lindgreen, 2014). To illustrate these fraudulent practices, Harney (2008) explains that in these cases workers were trained to provide 'correct' answers during audits and that tailored computer programs were used to forge worker records. These illegitimate activities create an appearance that certain suppliers are complying with the set standards. Every time these corporate misconducts are exposed, it results in credibility threats on the buyer's side (Giovannucci & Ponte, 2005). Furthermore, the intrinsic motivation of focal companies to meet sustainability standards and obtain certification has been questioned. It is contended that compliance is often superficial and regularly initiated to improve the image of the company (Boiral & Gendron, 2011; Raynolds, 2009). This is also supported by Giovannucci & Ponte (2005), who claim that the message regarding the actual impact of standards is unclear, making standards and certification an instrument to build customer relations and stimulate purchases. When codes and standards are implemented rather to reduce risk, improve a corporate image or to establish new market opportunities, they are merely adopted as strategic instruments, which is also considered to be a form of 'greenwashing' (Kolk & Van Tulder, 2005).

2.2.3.4 Implementation challenges for focal companies

Moreover, the complexity of value chains is considered as a limitation to implementing sustainability standards (Kim & Davis, 2016). The dispersed nature of value chain networks makes it difficult to outline the entire journey from sourcing to end product and to identify all involved actors along the chain (ibid.). Barbosa-Povoa et al. (2017) argue that due to the complexity of supply chains, companies need tools and involvement from the strategic to the operational levels to establish sustainable value chains. This can create barriers for implementing standards and certifications, as suppliers and factories in the past have refused to cooperate or to provide information and have resisted assessing performance (Faisal, 2010). Although researchers agree that due to sustainability standards and certifications conditions among first-tier suppliers are improving, difficulties still exist in identifying fourth or fifth-party suppliers (Kim & Davis, 2016). This is making communication and collaboration, which are both required for implementation, even more complicated (Börjeson, Gilek & Karlsson, 2015). Additionally, the complexity of value chains often creates a trade-off between quantity and quality of standards implementation, where decisions have to be made between numbers of participating parties and the quality of implementation procedures and compliance (Utting, 2014). This is also substantiated by Muradian & Pelupessy (2005) who discussed the large gap between potential and actual certified sales. Thereby they elaborate on Fair Trade coffee, who has been unable to certify the total production of all registered organisations, as the total certified sales only accounted for 13.6% of the total production of registered producers.

2.2.3.5 Implementation challenges for suppliers

Additionally, there are certain challenges for adopting sustainable standards from the producers' perspective. The producers are confronted by a range of different product and process standards that they must meet. This heightened the competitive challenges they face and brings them in a disadvantaged position (Nadvi, 2008). First of all, they often lack required knowledge of sustainable production, which complicates their transition to comply with standards and certification (Bacon, 2005; Van Oorschot et al., 2014). Moreover, the implementation of certification and fulfilling the different requirements may involve substantial costs and can sometimes be a long process (Giovannucci & Ponte, 2005; Raynolds et al., 2007; Van Oorschot et al., 2014). These cost implications can especially create barriers for smaller suppliers, as they usually have limited access to both financial means and profitable, sustainable production methods (Utting, 2014; Van Oorschot et al., 2014). Another disadvantage discussed in the literature is that the implementation of sustainability standards and certifications can induce a lock-in effect for suppliers (Ewerhart & Schmitz, 1997; McCluskey, 2000). This lock-in effect can be explained as a situation in which a company, supplier or farmer, loses flexibility, innovation and diversification, due to the specific investments made in a certain label, standard or certification (Van Lakerveld & Van Tulder, 2016). Despite the benefits of obtaining a certification, it can create the risk of becoming too locked-in, being 'stuck' to one particular standard or label. This causes a level of dependency for the supplier on the sustainability initiative party, which can be an issue as standards do not adjust to changes in consumer preference (McCluskey, 2000). Moreover, the uncertainties of competing standards are an issue for actors in developing countries, because these often lack access to information on current and future standards and the resources to achieve certifications to multiple standards (Montiel et al., 2016). Besides, it is argued that obtaining a standard does not stimulate producers or suppliers to achieve quality improvements above the requirements and therefore discourages further innovation, which may result in a reduction in the degree of 'drivenness' in value chains (McCluskey, 2000; Ponte & Gibbon, 2005).

2.2.3.6 Monitoring and control challenges

Monitoring compliance is required to guarantee that sustainability standards and procedures are met along the value chain. Ensuring compliance is necessary to accomplish legitimacy and credibility, which in turn, establishes trust (OECD, WTO & World Bank Group, 2014). Yet, as Boström et al. (2015) indicate, formulating sustainability guidelines and principles is one thing, but ensuring compliance is another thing. The complexity of value chain networks is limiting a companies' ability to effectively monitor and control processes (Francisco & Swanson, 2018; Kim & Davis, 2016). Further, it is argued that sustainability initiatives often possess limited verification systems to monitor compliance and that both these systems and the related inspection processes considerably vary between the different certifiers (Giovannucci & Ponte, 2005). Moreover, a lack of systematic assessment and accurate documentation are considered as key limitations of sustainability standards (Giovannucci & Ponte, 2005; Utting, 2014). In general, audits are conducted on a regular basis, although this quickly becomes more difficult as the number of certified producers increases. Besides, it is argued that the re-viewing of certified producers is not always performed regularly (Giovannucci & Ponte, 2005). Another aspect related to the monitoring challenges arising from sustainability initiatives is that they are mostly carried out by commercial auditing organisations. It has been discussed whether these auditing institutions can generate truly credible, independent evidence (Boiral & Gendron, 2011; O'Rourke 2003). These concerns have arisen due to the fact that these auditors are often hired and paid by the organisations they have to audit (Bazerman, Morgan & Loewenstein, 1997). This means that the continuation of the auditing business often depends on maintaining good relationships with their clients (Lund-Thomsen & Lindgreen, 2014). To solve some of these third-party concerns, Auret & Barrientos (2004) discussed participatory social auditing, which aims to transform standard-setting and auditing in the global value chains. This approach requires auditors to be able to communicate in the native language of the workers and to be knowledgeable of the local context. In this way, auditors could go beyond the quick tick the box approach or fly in-fly out visits, which rarely reveal the fundamental violations (Lund-Thomsen & Lindgreen, 2014). These monitoring and controlling challenges are closely related to the previously discussed legitimacy and effectiveness challenges of the initiated sustainability standards and certifications. Van Oorschot et al. (2014) argue that paying more attention to assessing, controlling, and documenting, will contribute to demonstrating the added value of making supply chains more sustainable by means of voluntary certifications. Moreover, these efforts will form a base for determining improvement targets (Van Oorschot et al., 2014).

2.2.3.7 Multiplicity of initiatives

Over the past twenty years, an increasing number of sustainability standards have been developed in every sector to promote different methods and standards (Barbosa Povoa et al., 2017; Manning et al., 2012). Despite their good efforts, it is found that both consumers and producers have difficulties making a distinction between the many different certification labels and systems (Van Oorschot et al., 2014). The multiplicity of sustainability standards created the difficult task for companies to identify the best practices to use (Barbosa-Povoa et al., 2017). Moreover, the compliance requirements and assessment methods lack transparency, which makes it even more difficult for companies to understand what is needed (International Trade Centre & European University Institute, 2016). All standards differ in certain aspects, such as level of stringency, the rate of adoption and targeted user (Manning et al., 2012). Montiel et al (2016) discuss that rather than filling the institutional voids, the multiplicity of initiatives creates extra non-tariff barriers for developing countries stakeholders. According to Sustainability Map (2018), there are at the time of writing, 241 different standards, codes of conduct and audit protocols, all addressing certain sustainability hotspots in global supply chains. The continuous development of sustainability standards, their ambiguity and competition also result in a lack of consolidation into one single solution (Reinecke, Manning & Von Hagen, 2012).

2.2.4 In summary

In the course of time, a wide variety of standards and certifications have emerged, all serving as checks and balance mechanism to fill the institutional void, which has arisen from the globalisation of value chains. By addressing social and environmental issues in the complex global production and trade chains, these standards and certifications have been playing a valuable role in increasing consumer trust and improving the position of smallholders in the chain. Yet, challenges remain and several concerns and limitations of this approach to create sustainable value chains, in general, have been identified and discussed. It is still being debated whether this approach and these tools are sufficient to establish responsible production and consumption processes. Additionally, the potential of technology contributing to positive, societal change is being widely discussed. The following section elaborates on one of these rising technologies and its potential and limitations to address the sustainability issues of the global value chains.

2.3 Blockchain technology to establish sustainable global value chains

The potential of technology contributing to positive, societal change on an international level has gained more attention lately. It is argued that the effective use and implementation of new technologies can help to achieve the Sustainable Development Goals (UN ECOSOC, 2017). The UNEP (2015) stated that technology is one of the two mediating factors in consumption and productions systems. Rising innovations and technologies can enable more efficient and responsible production practices and systems and stimulate sustainable development. Nonetheless, not everyone is optimistic that technological innovations are the solution to address societal problems. Technical solutions for complex or wicked problems could lead to even bigger problems or have unforeseen consequences (Head & Alford, 2015; Rittel & Webber, 1973). Others describe that, even though technological innovations can address various challenges within economic, social or political fields, these developments are also accompanied with considerable uncertainty and risks (Ramalingam, Hernandez, Martin & Faith, 2016). The various eras of technology evolution have disrupted many ways of interaction and reduced costs related to searching, collaborating and exchanging information (Mougayar, 2016). Technological innovations have resulted in the creation of online platform places to facilitate human economic activity (TED, 2016). Currently, society is facing a novel technology that is claimed to redefine the way interaction and trade are organised. Practitioners assert that this technology can create a new foundation for our economic and social systems (Swan, 2015). The following chapter comprehensively explains this technological paradigm, the potential benefits of this technology and its limitations to establish sustainable global value chains.

2.3.1 Blockchain technology

In essence, blockchain technology is a new type of database structure that can change the way we exchange value. It is as a decentralised, shared infrastructure and should be considered as another layer on top of the Internet (Mougayar, 2016). The blockchain is a public ledger that can be used for registering, confirming and transferring all types of assets and contracts in a public or private network. Swan (2015) explains that a system like blockchain is not only to be used for transactions including any currency, financial contract or soft or hard assets. It should be seen as a giant interactive spreadsheet, a registration and inventory system to record, track, monitor and transact all assets (Swan, 2015). This database runs decentralised and records all transactions across a peer-to-peer network. Every transaction that is entered into the database will be permanently recorded; it cannot be erased or changed later, it can only be sequentially updated. The transactions are secured through cryptography. The system locks the transaction history in blocks of data, all cryptographically linked together and secured. This creates an immutable chain of transactions, the start of a so-called blockchain. New transactions that are added to the chain must be approved by all participants in the network. This results in a peer-to-peer, shared infrastructure in which trusted, mediating third parties that usually facilitate those transactions, are omitted. The platform offers all participants the ability to verify the authenticity of every block in the chain, which enhances trust, transparency and integrity among the various participants. This technology enables "trusted transactions directly between two or more parties, authenticated by mass collaboration and powered by collective self-interest, rather than by large corporations motivated by profit" (Tapscott & Tapscott, 2017). Mougayar (2016) concludes that blockchain can be explained from the following three perspectives; technically, it is considered as a back-end database that maintains a distributed ledger, openly. From a business perspective, the blockchain can be seen as an online peer-to-peer exchange network suitable for any type of transactions that entails value, without the involvement of intermediating third parties. From a legal point of view, this technology facilitates transaction validation and replaces entities that were previously trusted to do this (Mougayar, 2016). To be able to explore how this technology can affect current markets, it first has to be understood how this technology functions.

2.3.2 How the technology works

Warburg (TED, 2016) makes the comparison between blockchain and Wikipedia, to explain how blockchain technology works. Like Wikipedia, blockchain applications need the Internet to function. Both are considered as a peer or social production, a database produced by individuals where one can find information but also can add information in records. Wikipedia is an open platform that is used to store information and images, blockchain is an open infrastructure that stores many kinds of assets.

Instead of being the Internet of information, it can be seen as the Internet of value. Similarly, on both databases information is continuously being reviewed and updated by the participants and changes can be tracked over time. Though, with Wikipedia, it is very hard to fully validate all content. Furthermore, when users access the Wikipedia page, they will see an updated version of the 'master copy' and control of the database remains with Wikipedia administrators. This is the most important aspect in which blockchain technology differs from an open database, such as Wikipedia. Since this database is decentralised, every participant must approve the new transaction, which is done by each participant or so-called 'node' mathematically verifying the record. The transaction information is collected in 'blocks', which are added chronologically on the computers of all participants, each record being updated separately (Holotiuk, Pisani & Moormann, 2017). In this way, trust is assured through the network, instead of having a central third party involved to guarantee accuracy and trust.

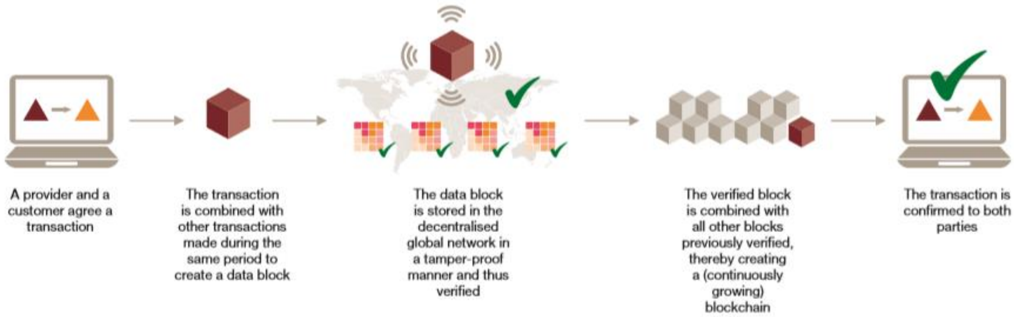

Figure 2 The blockchain process. (Retrieved from: Hasse et al., 2016)

Blockchain technology is considered as a meta-technology, as it consists of several technologies itself and it challenges other existing technologies (Mougayar, 2016). It is seen as a combination of the following three major technologies: private key cryptography, a distributed network with a shared ledger and an incentive to facilitate network transactions, record-keeping and security (Bauerle, 2017). Mougayar (2016) describes the technology in a similar way, by considering blockchain as a combination of cryptography science, peer to peer networks and game theory, which is visualised in Figure 3.

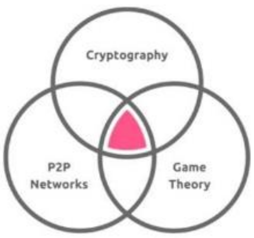

Figure 3 Blockchain as a combination of three technologies (Retrieved from: Mougayar, 2016)

1. *Cryptography science*

Cryptography science is a fairly technical story, though to create basic understanding this research will explain the three basic concepts on which it is based: keys, hashing and digital signatures. All three concepts serve the purpose of safeguarding the network through creating a secure digital identity (Mougayar, 2016; Bauerle, 2017). Within the network, there are existing two type of cryptographic keys: public and private ones. Mougayar (2016) compares the use of those keys with a persons' home address. A person can make one's home address public, though this does not give others information on what that house looks like. To figure that out, a private key is needed, which is only in possession of the owner. In addition, no one can claim that address, as it is already claimed by the owner (Mougayar, 2016). Every participant in the blockchain network has a private key, which consists of a unique 30-plus-character alphanumeric address. Participants can decide to stay anonymous or prove their identity by sending their public key to others. Transactions that have happened over a certain time period are verified using algorithms and then combined and stored into blocks of data (Swan, 2015). Subsequently, the algorithm ascribes a unique hash to every block; a digital fingerprint that consists out of a series of numbers and letters. Due to hashing, the necessity to actually see the content to reconfirm it is eliminated since the hash represents the exact content of the original file (Swan, 2015). This hash function facilitates the process of verifying that a certain piece of information is not modified or changed (Hasse et al., 2016). The hash adds a timestamp to the blockchain transaction, which is proof of the existence of that digital asset, at that moment (Swan, 2015).

2. *Game Theory*

The idea of game theory is the second concept that is integrated into the blockchain technology. Before every transaction is combined in blocks and linked to preceding blocks of data, transactions first need to be verified. The continuous process of verifying, clearing and storing all blocks with transactions is called 'mining'. After a transaction is started, it is sent to the miners, which is a network of computers that are running on mathematical calculations. These miners are responsible for checking the correctness of those transactions and ensuring that valid transactions are put together into a new block. This is done through computers, thus machines, which search for the specific hash that corresponds to the content of the block (Hasse et al., 2016). Miners are competing to solve this difficult mathematical problem to receive an incentive that is given for facilitating these network transactions. They are rewarded for their performance, which depends on the computing power that is contributed (Hasse et al., 2016). Whenever a block is validated and consensus is reached, the block is distributed through the network and recorded on the global ledger. Ultimately, miners who solve the mathematical problem most quickly are rewarded with tokens, for example, bitcoins (Hasse et al., 2016). Additionally, the combination of cryptography with a decentralised consensus, or control model involving a network of miners ensures that stored blocks containing data cannot be deleted or altered (Iansiti & Lakhani, 2017). It would require a change in hash functions of all subsequent blocks, due to the interconnected combinations of hashes (Hasse et al., 2016). Rewriting the transaction history would be detected by the miners in the network, who will reject this and thus prevent the block from being altered on the chain (Tapscott & Tapscott, 2016).

3. Peer to peer networks

Finally, the innovative computer engineering feature build with this technology is that it is a distributed network with a shared ledger is, creating a shared public, peer to peer network without relying on a central database (Iansiti & Lakhani, 2017; Hasse et al., 2016). Each blockchain is distributed among each node, which are computers connected to the network and runned by volunteers over the world, which is visualised in Figure 4. As a result, all data is locally stored, meaning there is no central database that could be hacked. In addition, there is no single institution or intermediary party in charge for keeping records or auditing transactions. Consequently, the blockchain database is open to the public, everyone can access it at any time since it resides on the network (Tapscott & Tapscott, 2016). According to Swan (2015), allows a distributed network for 'the disintermediation and decentralisation of all transactions of any type between all parties worldwide'. Furthermore, this innovative distributed network can serve towards the current emerging paradigm connected world of computing (Swan, 2015). With this, it is claimed that blockchain technology enables a shared, trustworthy infrastructure that cooperating and competing actors can use as a shared database (United Nations Foundation, 2018). Therefore, blockchain can be viewed as a new network approach, creating a decentralised transaction network, instead of just a technological paradigm.

Figure 4 Central database vs. decentralized shared ledger (Retrieved from: Bauerle, 2017)

These three key aspects combined create the technology of blockchain; "the database that is shared by all network nodes, secured through cryptography, continuously updated by miners, monitored by everyone and owned and controlled by no one" (Swan, 2015, p. 1). Figure 6

2.3.3 Different blockchain structures

The term blockchain is widely known as one technology, however, a distinction between different structures can be made, based on the extent to which they guarantee anonymity and are openly accessible. Thus, it determines who gets to control and participate in the process of validating transactions (Mougayar, 2016). Further, each construct serves a different purpose. The variations can be classified in three different structures, which include public, private and hybrid or consortium blockchains (Pilkington, 2016; Seppälä, 2016). All constructs can be seen as different types of collaborative platforms, which can offer many possibilities for a new kind of organisation and society (Tapscott & Tapscott, 2017).

Public blockchains are completely open platforms, accessible to every Internet user and are therefore often called to as permissionless blockchains. This type is considered to be a fully decentralised network and the participation of individuals is encouraged through an incentivising mechanism. The benefits of this construct arise when more people collaborate in the network. Nevertheless, the accessible character of a public blockchain also has a few limitations. To maintain the widespread network, a large amount of computational power is required. Additionally, every node in the network is solving the complex, resource-intensive cryptographic problems that consume a lot of energy. Further, the open network enables participant with insight in every transaction, which implies little privacy regarding the details of a transaction (Jayachandran, 2017).

1. *Private blockchains* are designed in a way that one or more nodes hold the administration rights of this permissioned network and control the participant authorisation (Pilkington, 2016). Restrictions are placed on who is allowed to participate in this network, as one must receive an invitation to join and participate in this private blockchain (Jayachandran, 2017).
2. *Private blockchains* have the advantage that transactions are only shared with permitted, trusted participants that are using the network. This increases confidentiality and privacy in, for example, business transactions. However, this construct does not offer anonymity to participants that validate transactions. Furthermore, a private blockchain lacks transparency for parties that are not allowed to participate.

3. *Hybrid blockchains* or consortium blockchains are a third type that consists of a mix between both the public and private concepts (Pilkington, 2016). This construct represents a partially decentralised platform, in which a certain number of participants collaborate and together maintain the power to verify transactions and to decide who obtains access.

These different structures allow companies to collaborate in new ways by sharing an immutable, transparent database. Herewith, new business models and opportunities are currently emerging due to the increased ease of establishing trusted partnerships (Seppälä, 2016). Further, the collaborative nature of the technology requires large alliances for collaboration, which can create decentralised transaction networks for organisations. Therefore, blockchain should not be seen as a technology alone, but as a technology that can establish new forms of organisations and networks.

2.3.4 The possibilities of blockchain technology

It is argued that the blockchain technology will challenge traditional business models and with that, can change the way all our economic, social, political and scientific activities and contracts are organized (Brakeville & Perepa, 2016; Mougayar, 2016). It is discussed that it can offer some solutions to the dilemma of privacy and security regarding transactions, identity and balancing data (Mougayar, 2016). In particular, the unique construction of the technology can offer several benefits related to the value chain operations and organisational issues.

2.3.4.1 Transparency

Transparency and active openness about relevant information to employees, customers, shareholders and other stakeholders are central in earning their trust (Tapscott & Tapscott, 2017). Additionally, it has been found that a lack of financial and commercial transparency can negatively affect business relations and result in commerce delays (Niranjanamurty, Nithya & Jagannatha, 2018). Supporters of this technology claim that blockchain increases transparency in transactions. When a transaction is validated and recorded on the blockchain, it is distributed among the network. This growing list of records results in an immutable chain of transactions, which is accessible and viewable for the public. Every participant can see the transactions history that reveals all details about every transaction. Further, all transactions are signed with a private key, which belongs to only one person. Therefore, transactions can be directly linked to the person who made the transaction (Seppälä, 2016). This technology provides all parties with increased insight and visibility regarding the entire transaction process which increases overall transparency. From a business perspective, increased transparency in the value chain can be beneficial to improve and optimise the flow of goods (Kehoe, O'Connell, Andrzejewski, Ginder & Dalal, 2017).

2.3.4.2 Traceability

Linked to transparency, is the traceability of value exchanges. Traceability is considered fundamental in supply chain management and has gained a lot of attention lately as the sustainability of supply chains is being discussed (Bateman, 2015; International Trade Centre and European University Institute, 2016). Traceability entails the ability to verify the history and location of a good or transaction through recorded identification. For an organisation, it can be valuable to track and trace their value chain to obtain detailed information about the entire process. This information can be used to manage and improve efficiency, safety, security and performance of supply chain processes (Bateman, 2015). Improved traceability within a value chain can help companies and organisations to address problems more easily and to ensure compliance on standards and regulations. Blockchain creates a growing, chronological chain of transactions that is claimed to be secure, irreversible, time-stamped and completely verifiable. Since the blockchain is a shared, public register, it can enable participants to track and trace the entire transaction trail from its origin. In this way, the system reduces the time and money spent on an auditing company to trace a certain supply chain (Tapscott & Tapscott, 2017). Further, the detailed information provided with blockchain can be a great advantage to ensure the authenticity of the assets (Niranjanamurthy et al., 2018).

2.3.4.3 Security

Confidence in supply chain security is essential to maintain a smooth flow of products and services in global value chains (Lee & Whang, 2005). Nevertheless, both public and private sector concerns regarding security in global supply chains have increased in the 21st century, due to various factors. First, the increased global economy both generates and depends on the free flow of information, people and goods. Second, businesses have become more dependent on efficient supply. And third, a rise in threats of terrorist attacks created a need for enhanced supply chain security (Closs & McGarrell, 2004). Proponents of blockchain technology argue that it will improve transaction security. Every transaction on the blockchain is recorded and verified through cryptography. Thereafter, the authenticity of the 'block' is guaranteed by the ascribed hash that consists of a public and private key. Through cryptography, the technology establishes a secure platform (Tapscott & Tapscott, 2017). The cryptographic codes and the peer controls in the network prevent transactions from malicious practices and risks, such as hacking and fraud. Further, because the transaction data is stored encrypted and decentralised, it is argued that data cannot be tampered with, which increases the security of the chain (Hasse et al., 2016). Though, section 2.3.5.1 outlines a possible challenge to this. Moreover, due to the decentralised nature of the database, the network is not relying on a single, centralised server (Niranjanamurthy et al., 2018). This distributed structure makes it extremely difficult for hackers to corrupt, because the data is shared and continuously verified by a network of trusted computers (Atzori, 2015). The blockchain system is therefore resilient to single points of failure; even when one participant is hacked or fails, the network remains intact (Mougayar, 2016).

2.3.4.4 Privacy

The privacy of individuals in online networks is an issue that has received a lot of attention lately. The rise of the Internet has strengthened the position of third parties, as they help us to create an online identity and establish trust in online transactions and interactions by providing an online platform. Though, these third parties have come under increasing scrutiny as they often collect personal data for commercial gains. The recent Facebook scandal is an example of where personal privacy became at dispute, as personal data was leaked and misused (Cadwalladr & Graham-Harrison, 2018). It is envisioned that blockchain technology could address this issue, as it enables users to have full control over their identity (Mougayar, 2016). The system has no identity requirements, meaning that it does not enforce users to provide their personal details to download and use the network (Tapscott & Tapscott, 2017). In addition, personal details are not stored in a central database and are therefore not controlled by a third party. As previously explained, blockchain guarantees the identity of an individual by using cryptography to verify user identity. Each user of the network possesses a public and a private key which display a persons' identity on the network. The protocol of the blockchain provides users with choosing the level of privacy they are comfortable with in every transaction. Participants are provided with control over their own level of privacy, as they can choose to remain anonymous or to proof their identity by releasing their public key to others (Mougayar, 2016). This can help to address the privacy issues related to online interaction and better protect a persons' identity as it enables user anonymity by choice and thus increases identity ownership (Tapscott & Tapscott, 2017).

2.3.4.5 Autonomy

As earlier discussed, intermediating third parties function within the current economic model to establish trust between transactions. This current structure is defined as the traditional transaction model. Blockchain technology operates with a peer-to-peer network, which can potentially disrupt the current transaction models, as Figure 5 shows. This entails that transactions instantly occur between individuals, organisations and machines, without having an intermediary involved (Swan, 2015). De Filippi (2017, p. 2) explains that "blockchain technology is ultimately a means for individuals to coordinate common activities, to interact directly with one another, and to govern themselves in a more secure and decentralized manner". This indicates that blockchain facilitates transactions and interactions amongst users on a large-scale global scale without delays (Swan, 2015; Iansiti & Lakhani, 2017). This allows transactions to be made without banks but also contracts to be signed without the involvement of lawyers. Thus, this peer-to-peer transaction network implies a shift towards an entirely different, decentralised value exchange structure. Decentralisation can prevent market abuse by monopolies (Dütsch & Steinecke, 2017). Further, it provides users with autonomy in transactions, which strengthen the market position of individual consumers and producers and implies a shift in governance (Dütsch & Steinecke, 2017).

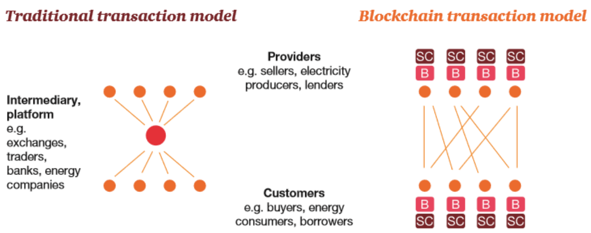

Figure 5 How blockchain can change the current transaction model (Retrieved from: Hasse et al., 2016)

2.3.4.6 Process efficiency

Following the previously discussed characteristic of autonomy, it is stated that with eliminating the intermediating third party, transactions on the blockchain are directly done between two parties. Furthermore, as the technology has the ability to manage smart contracts and transactions automatically, processes can be streamlined (Niranjanamurthy et al., 2018). Thereafter, it is argued with blockchain, transactions take place faster and time from the transactions will be removed, which will positively influence the efficiency of processes (Iansiti & Lakhani, 2017). Additionally, due to the transparency and traceability features of the blockchain, businesses obtain detailed information about the value chain process, which can be used to manage and improve the efficiency of processes (Bateman, 2015). Further, it is discussed that digital technologies stimulate interconnectedness, creating economies that are closely linked to one another (Waddock, 2012).

2.3.4.7 Trust

Trust is required in order to facilitate value exchange and is considered as an essential condition of the digital economy (Neu, 1991; Tapscott & Tapscott, 2017). Many activities and technologies have been applied to improve the trust aspect in supply chains, though trust issues still occur (Chen et al., 2017). According to Chen et al. (2017) is the lack of trust in networks and value chains caused by the following three aspects: the self-interest of participants along the chain, information asymmetry in the process, and cost and limitations of inspections. It is discussed that blockchain can be considered as a promising technology to address these issues and therefore it is claimed that it can enable trust (Chen et al., 2017; Niranjanamurthy et al., 2018).

The formerly discussed benefits of this technology are all adding up to the establishment of trust in transactions. First of all, as previously explained, the technology claims to facilitate transparency and traceability of transactions. By revealing detailed information on every step in a transaction process, it reduces the problem of visibility and information asymmetry in value chains, thus providing more trust in the process (Chen et al., 2017). Secondly, the security provided through the cryptographic technology ensures that transactions cannot be tampered with. Malicious or unreliable transactions will be identified through the network (Atzori, 2015). This reduces the risk of fraudulent activities of participants who act according to self-interest and can thus generate trust. Similarly, privacy risks related to data collection by third parties is claimed to be reduced through the level of anonymity that blockchain provides. Moreover, as previously explained this technology provides autonomy towards its participants by establishing a peer to peer network. Consequently, it affects trust as it removes reliance on a central, third-party and makes participants rely on a network of trusted computers that ensure its security (Atzori, 2015; Niranjanamurthy et al., 2018). Antonopoulos (2014, para. 1) defines this as a “shift from trusting people to trusting math”.

2.3.5 The limitations of blockchain technology

Contrary to the listed potential benefits of this technology, every novel technology comes with its drawbacks and challenges (Tapscott & Tapscott, 2017). Many sceptics are questioning the promises of this technology. Moreover, it is discussed whether blockchain technology is a solution looking for a problem. This section neglects the complex technical aspects of this technology, but primarily focusses on the challenges and limitations that can be identified when blockchain is considered as a network technology.

2.3.5.1 Transparency, privacy and security concerns

In addition to the benefits arising from increased transparency and traceability, it also raises concerns regarding the promotion of transparency in transactions. All participating actors will have to share their data, which will reveal details about every transaction in the value chain. This entails that anyone can trace the path of the transaction, including specifics regarding the origin and the value. Mougayar (2016) argues that transparency will expose business ethics and therefore, adoption of this system is likely to be resisted, as it could make businesses vulnerable. Additionally, on the blockchain, all data is publicly shared amongst participants, which raises questions about confidentiality. This level of openness and transparency may not coincide with the contemporary privacy and confidentiality demands. Further, the cryptographic technology of blockchain establishes digital identities, which enables user anonymity in transactions (Mougayar, 2016). This anonymous nature of the system provides participants with the opportunity to create a pseudo-anonymous identity. All transactions are publicly visible and traceable, but information on the transactions is not linked to real-world identities (Pilkington, 2015). Consequently, the network is therefore considered to be used for money laundering activities by criminals (Tapscott & Tapscott, 2017). This has been a limitation for policymakers and governmental institutes to adopt this system (Mougayar, 2016). On the same note, the encrypted and decentralised network features claim a tamper-proof database. Nevertheless, Niranjanamurthy et al. (2018) argue that cybersecurity issues still have to be addressed before the public will entrust their personal data to this network technology. Moreover, although extremely difficult, if 51% of the miners, thus the controlling majority of the computing power on the network, decides to prevent other miners from completing blocks and disrupt the process of registering new blocks, they could also rewrite the transaction history (Floyd, 2018). This is referred to as a 51% attack on the blockchain (ibid.). Moreover, as blockchain transactions are increasing, data becomes bigger, which results in scalability problems (Lin & Liao, 2017). This problem is explained as the blockchain scalability trilemma, in which tensions between scalability, security and decentralisation of the technology result in trade-offs that have to be made between those three properties.

2.3.5.2 Regulatory challenges

With blockchain technology, the role of trusted third parties is eliminated, which creates a decentralised and distributed network. Consequently, it creates a shift of power towards the public. This raises questions on who is accountable for this network technology and how it should be managed (Sangokoya & Ajoku, 2018). A blockchain ecosystem is a universally wide data-sharing network, therefore a certain type of governance might be needed to set standards, adopt policies and develop knowledge to build this global infrastructure (Mougayar, 2016; Tapscott & Tapscott, 2016). The development of this technology is currently still in an early developing phase, therefore a regulatory framework with standards and processes is not yet established. It is argued that a multi-stakeholder approach is required to initiate effective regulation and governance on how these networks shape society (Tapscott & Tapscott, 2016; Sangokoya & Ajoku, 2018). It is also debated whether stronger regulations could prevent this technology from being used for illegal purposes. Moreover, as long as it is not clarified who manages this network, confusion and uncertainty will remain for everyone involved (Mougayar, 2016).

2.3.5.3 Adoption challenges

According to Pilkington (2015), trust remains the fundamental blockchain question. For society to rely on a network of computers that are running on mathematical calculations, rather than relying on a known, trusted third institutions, can result in a behavioural challenge (Mougayar, 2016). Trust has to be placed in the network, which changes the nature of trust. Adoption by society, therefore, comes with uncertainty and fear. Additionally, the advantages that are promised with blockchain largely depend upon enough parties adopting this technology and participating in the network. This phenomenon is referred to as the network effect, whereby the value to the users of a product or services increases when more people use the product or service (Osterwalder & Pigneur, 2010). The implementation of a telephone network illustrates this concept. In the early days, when almost no one possessed or had access to a phone, the service was not as useful. Though the more people started to possess a phone, the more valuable this communication service became to the users. This resulted in more people that wanted to own a phone and also wanted to connect. The same applies to the adoption of social networks like Facebook or Airbnb. The more people subscribe to these online networking platforms, the greater the value towards all participants, as each individual then can interact with more people. Consequently, all stakeholders of a value chain need to be aligned and involved, resulting in a substantial challenge to ensure universal adoption of this ecosystem (Mougayar, 2016). The unlikelihood of sufficient adoption is discussed to be one of the key limitations that determine the success of blockchain (Bloomberg, 2017).

2.3.5.4 Uncertainty

As mentioned earlier, blockchain technology and the way it will further develop is accompanied with a lot of uncertainty. It is argued that technological progress has been a solution to many problems, though it has always created new challenges at the same time (United Nations, 2016). Socio-economic development is inextricably linked to technological innovation, as technology, society, economy and the environment co-evolve (ibid.). Therefore, technology change can be a source of conflict as well, and its uncertainty can lead to even bigger problems or unforeseen consequences (Head & Alford, 2015; United Nations, 2016). Moreover, it should be noted that technological change itself is often not neutral, hence there is a risk that benefits are disproportionally distributed. This could exacerbate inequalities, as technologies invented or adapted in developing countries are likely to be more suitable for use in other developing countries (Sustainable Development Knowledge Platform, 2016; United Nations, 2016). One of these consequences relates to the fact that all technologies consume resources, which might increase unsustainably (Sustainable Development Knowledge Platform, 2016). The large energy consumption of the technology is one of the main concerns that have arisen with the development of this large, connected online network. The process of miners solving mathematical cryptographic problems to store the blocks on the network, demands a substantial amount of computer power, thus consumes a lot of electricity (Tapscott & Tapscott, 2017). The energy issue is of blockchain is twofold; next to the energy that is used to run the computers, energy is needed to cool down these computers and data centres and prevent them from crashing (ibid.). Improvements on the consensus model have been made to reduce the electricity consumption, which is mainly a concern for Bitcoins' blockchain network. Though, the uncertainty of consequences is an important barrier for the further development of this technology.

2.3.6 In summary

Blockchain is a rising digital information technology that creates a shared database system, in which value exchange can be registered and controlled. Compared to other database technologies, this technology maintains a decentralised governance structure that can dismiss the role of intermediating third parties in transactions. Thence, it is argued that blockchain can disrupt the traditional business models and change the way interactions and transactions currently take place. The unique construction of the technology is discussed to offer various benefits related to the organisation and operations of value chains, including greater transparency and traceability in the chain and autonomy for all stakeholders, among others. Supporters of this technology argue that all these elements will lead to more trust in transactions and society, as these elements prevent the tampering data. Though, it is argued that every technology comes with drawbacks. Limitations regarding transparency, privacy and security have been discussed. Moreover, the novelty of the technology creates regulatory challenges, next to uncertainty and adoption challenges.

2.4 Summary literature study

Summary Literature study			
Global Value Chain Problems	**Sustainability standards**	**Blockchain Technology**	
	Limitations	**Possibilities**	**Limitations**
Value chain complexity / Multi-stakeholder involvement / Loss of control over process *Kim & Davis, 2016; Von Geibler, 2013; Vurro et al., 2009* **Lack of governmental regulation** *Raynolds et al., 2007; Bush et al., 2015* **Governance / power position of focal companies** *Böstrom et al., 2015, Talbot, 2004, Humphrey & Schmitz, 2001* **Demand for responsible practices** *Boström et al., 2014; Bereuther & Stappmanss, 2017; Francisco & Swanson, 2018; Seuring & Müller, 2008; Levy, 2008*	**Who governs the standard / involvement of actors** *Giovannucci & Ponte, 2005; Nadvi, 2008; Neilson & Pritchard, 2010; Lund-Thomsen & Lindgreen, 2013; Böstrom et al., 2014* **Effectiveness, demonstrating value, impact of standards, relevance** *Ruwanpura & Wrigley, 2011; Lund-Thomsen & Lindgreen, 2013; Van Oorschot et al., 2014; Robbins et al., 2000; Giovannucci & Ponte, 2005; Bush et al., 2015; Von Geibler, 2013; Muradian & Pelupessy, 2005* **Legitimacy challenges, fraud, credibility accountability, greenwashing** *Bush et al., 2015; O'Rourke, 2003; Giovannucci & Ponte, 2005; Ponte, 2004; Lund-Thomsen & Lindgreen, 2013; Harney, 2008; Von Geibler, 2013; Raynolds, 2009; Boiral & Gendron, 2010* **Implementation: (focal company perspective) complex value chains, quantity vs quality**	**Autonomy, empowered users** *De Filippi, 2017; Swan, 2015; PwC, 2017; Iansiti & Lakhani, 2017; Dutsch & Steinecke, 2017* **Collaboration and communication, Streamlining internal documents, ecosystem simplification, process efficiency and productivity, Reduce paperwork** *Casey & Wong, 2017; Niranjanamurthy et al., 2018* **Public transparency traceability & Auditability, trust** *Tapscott & Tapscott, 2017; Niranjanamurthy et al., 2018; Seppala, 2016; Chen et al., 2017;*	**Governance question, Legal regulatory and compliance** *Sangokaya & Ajoku, 2018; Mougayar, 2016; Tapscott & Tapscott, 2017; Iansiti & Lakhani, 2017;* **Transparency, privacy and security issues: confidentiality and illegal practices** *Tapscott & Tapscott, 2017; Mougayar, 2016; Pilkington, 2015; Niranjamurthy et al., 2018; Lin & Liao, 2017* **Under developed infrastructure: (Technical challenges) Trilemma: scalability, security and decentralization** *(Lin & Liao, 2017, Mougayar, 2016, Niranjanamurthy et al., 2018)* **Adoption challenges, Complexity, behavioural challenge, Trusting a network Accessibility, Uncertainty**

Unequal value distribution *Levy, 2008; Giovannucci & Ponte, 2005; Kaplinsky, 2000; Neilson & Pritchard, 2011; Talbot, 2004* **Demand for transparency / traceability/ trust** *Perez, 2008; Francisco & Swanson, 2018; Pagell & Wu, 2009; Kim & Davis, 2016; Giovannucci & Ponte, 2005, Vurro et al., 2014*	*Kim & Davies, 2016; Barbosa-Povoa et al., 2018; Muradian & Pelupessy, 2005; Faisal, 2010; Utting, 2014* **Effective and secure monitoring and evaluation, who monitors standards** *Boström, 2014; Kim & Davies, 2016; Giovannucci & Ponte, 2005; Nadvi, 2008; Lund-Thomsen & Lindgreen, 2013; O'Rourke 2003; Utting, 2014; Boiral & Gendron, 2010* **Wide-variety of standards / Ambiguity and competition prevents consolidation** *Barbosa-Povoa et al., 2018; Manning et al., 2011 Reinecke et al., 2010; Van Oorschot et al., 2014* **Implementation (supplier perspective) Lack of resources producer: costs/ limited access to financial means / lack of knowledge** *Bacon, 2005 uit Manning et al., 2011; Raynolds et al., 2007; Van Oorschot et al., 2014* **Uncertain conditions:** **Lock-in effect / demand lags behind** *Van Lakerveld & Van Tulder, 2016; Brockhaus, 2013; Van Oorschot et al., 2014;* **Reduction in drivenness producers** *Ponte & Gibbon, 2005*	**Security through cryptography, immutability and decentralization, reduce or eliminate fraud in supply chain** *Tapscott & Tapscott, 2017; PwC, 2016; Niranjanamurthy et al., 2018, Atzori, 2015; Mougayar, 2016* **Privacy through cryptography and anonymity** *Mougayar, 2016; Tapscott & Tapscott, 2017;* **Lower transaction costs, reduce operational costs** *Mougayar, 2016; Niranjanamurthy et al., 2018, Tapscott & Tapscott, 2017*	*Pilkington, 2015; Mougayar, 2016; Osterwalder & Pigneur, 2010; Bloomberg, 2017; Morabito, 2017; Saqaf & Seidler, 2017* **Risk of (human) error** *O'Sheilds, 2017; Bauerle, 2017* **Unsustainable, large energy consumption** *(Morabito, 2017; Jayachandran, 2017; Tapscott & Tapscott, 2017; Niranjanamurthy et al., 2018)* **Costs, high investments for implementation** *Mougayar, 2016; Niranjanamurthy et al., 2018*

2.5 Conceptual Model

A conceptual model was developed in order to structure and visualise the analysis that is made in this thesis. The conceptual model displayed in Figure 6 is derived from the key literature aspects in this area of research and demonstrates how the previously outlined literature topics are linked.

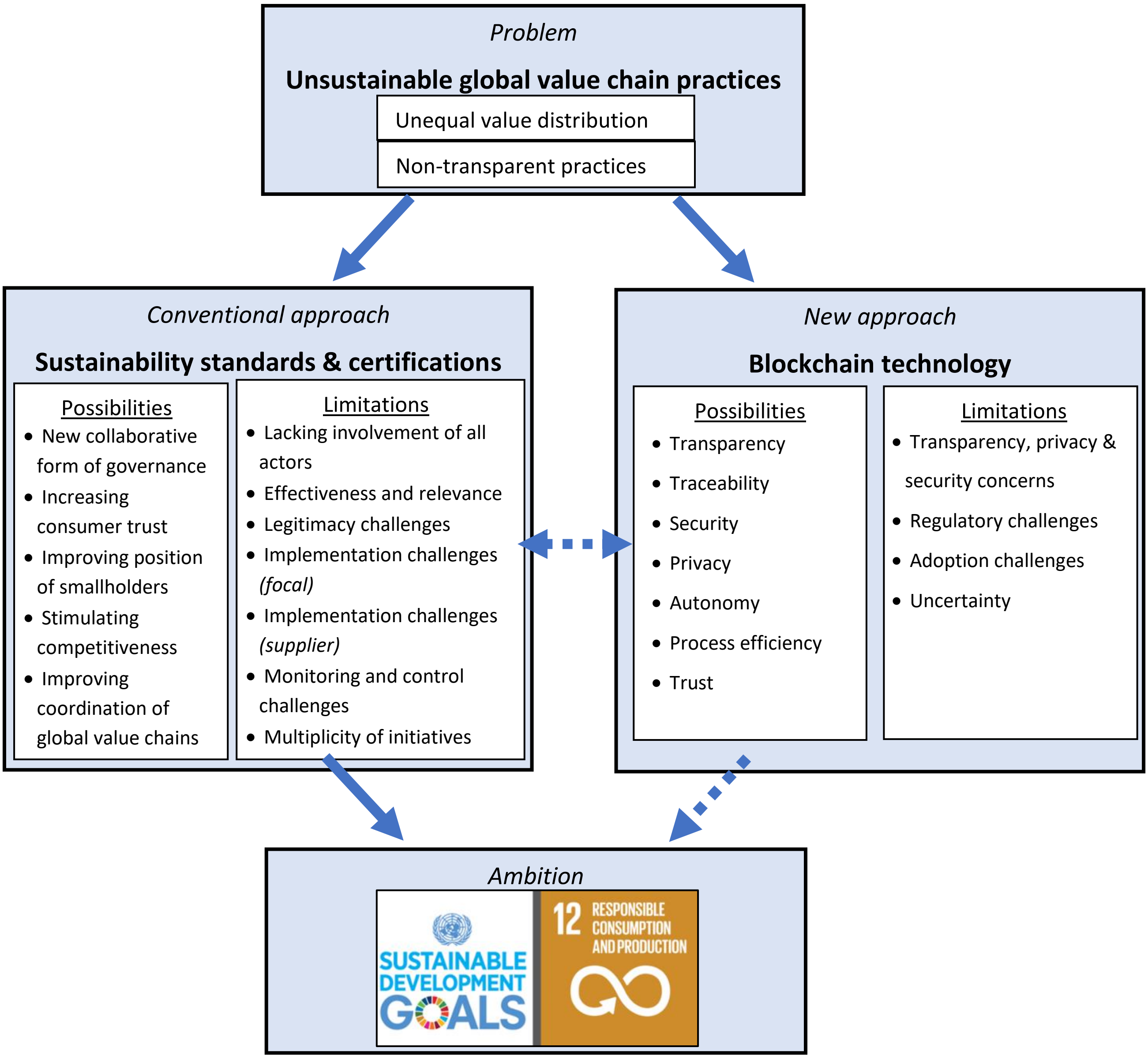

Figure 6 Conceptual model

The model visualises the relevance of the research, the problem of unsustainable global value chains. Moreover, as identified in the literature, this problem consists of two key issues: the unequal value distribution and the non-transparent practices within the value chains. Further, it illustrates that two approaches also referred to as control mechanism, have emerged to address these global value chain problems and fill the institutional void.

First, it outlines the current, conventional approach of sustainability standards and certifications. The model classifies both the identified possibilities and limitations of this approach. Moreover, the arrow towards the Sustainable Development Goal indicates that the literature has recognised the impact of this approach on the ambition to create more sustainable value chains. On the other side, the model displays blockchain technology as a new approach emerging to address the problem of the unsustainable value chain practices. The model also delineates both the main possibilities and the limitations that are contented to come along with this approach. On the basis of the literature, the conceptual model identified the research gap that is indicated by the dashed line. This research addresses this gap and intends to explore this area of contention by researching the question: *Under what conditions is blockchain a better control mechanism to establish sustainable global value chains compared to the conventional sustainability standards?* The variables that are assumed to determine whether the new approach is a better control mechanism, compared to the conventional approach, are outlined as possibilities and limitations within both approaches.

3 Research methodology

3.1 Research design

The conceptual framework in Chapter 2 provided various areas of contention. Therefore, this research seeks to explore the claimed potential of blockchain technology as an approach to address the wicked problems in the global value chains. Blockchain technology and its possibility in value chains is a fairly novel field of research that has not been researched extensively and sufficiently before. Reflecting on the objective of this research this research aims to further explore, enlarge and clarify the understanding of this phenomenon and its related concepts (Saunders, 2011). Due to the exploratory nature of the study, a qualitative research design is deemed most suitable, because it allows for gathering, in-depth and rich expert information on the research question. In addition, Shields (2007) argues that a qualitative research approach does not attempt to eliminate what cannot be eliminated, and does not try to simplify what cannot be simplified. Moreover, Yin (2015) defines that qualitative research takes into account real-world contextual situations and challenges. Both are valuable aspects to this research, as it focusses on approaching wicked societal problems that concern real-world challenges and often cannot be simplified. Thereafter, a qualitative, exploratory research approach provides a holistic understanding of the topic. Moreover, an abductive approach is applied as the objective of this study seeks to choose the best possible explanation from the information that is known. Abductive reasoning is a logical approach, as this research' objective is an attempt to attain an idea on this phenomenon and to discover new things, instead of immediately achieve understanding and explanation (Dubois & Gadde, 2002; Peirce, 1960).

3.2 Data collection methods

The emphasis of this research is on exploring and collecting multiple perspectives from experts, for which a Delphi study is used. This is defined as an "iterative process used to collect and distil the judgements of experts using a series of data collection and analysis techniques interspersed with controlled feedback" (Skulmoski et al., 2007, p. 2). This technique is deemed valuable when there is incomplete knowledge about a certain problem or phenomenon, and when the aim is to improve understanding of problems, opportunities, or solutions. It is a widely used technique, which aims to achieve consensus of opinion on specific real-world issues (Hsu & Sandford, 2007). Moreover, this systematic and interactive method is used to delineate pros and cons, explore different options and to structure models (Linstone & Turoff, 2002). The aim of this study is to create a better understanding of the possibilities and limitations of the two different approaches to establish sustainable value chains, sustainability standards and blockchain technology respectively. When using a qualitative approach, the Delphi method can be used to gather rich contextual data to make sense of a phenomenon (Creswell, 1998) and to gain a holistic understanding of the subject (Mason, 1996).

The Delphi method usually consists of a multiple-round study but allows for flexibility and thus the number of rounds can be modified to suit the research question and the circumstances (Skulmoski et al., 2007). The method relies on the input of a panel of industry experts, which can provide useful information in order to reach informed consensus on a complex issue (Skulmoski et al., 2007). Leonard-Barton (1998) defined that industry experts should be used when the technology maturity is unknown, as they have specialised and excellent knowledge about a particular industry. This is exactly in line with the topic of the research, as it concerns two different areas of expertise, of which one is a relatively novel technology. However, the Delphi method also has several drawbacks and has therefore been subject to criticism. One limitation of this method is that it is considered a fairly time-consuming process that requires commitment of participants, creating a risk of participant drop-outs (Landeta, 2006). Another discussed drawback of the Delphi method is that the results are entirely based upon opinions, whereby the quality of these results completely depend on the input of the subjects (Yousuf, 2007). Though, as this research is exploratory, the input, perspectives and standpoints of subjects are very much valued.

In order to fit in the timeframe of a master thesis, a single round Delphi is applied in the form of a semi-structured interview. The interview guideline is formulated based upon the results of the literature study and includes both subjects and fields of expertise (sustainability standards and/or blockchain technology). By choosing for a semi-structured interview, it provided the researcher with some flexibility to adapt the interview to the different backgrounds of the subjects and to explore certain responses more in detail. The interview protocol including the semi-structured interview guide can be found in Appendix I. This method can provide reliable, detailed qualitative data, though the process of collecting and analysing data can be fairly time-consuming (Saunders, 2011).

3.3 Context & subject selection

The data collection process started by selecting an appropriate group of experts. Choosing suitable subjects is a critical component and can be considered as the most important step in the entire process because it is directly linked to the quality of the results (Judd, 1972). The opinions and knowledge generated from the chosen subjects serve as a base for the output of the Delphi study. Based on the multidisciplinary focus of the study (sustainability standards and blockchain technology), it is most appropriate to have experts from both fields. Moreover, the research aimed to include experts belonging to different value chains to create a holistic understanding of the topic. Despite the fact that choosing appropriate subjects is a critical component, there are no set standards regarding the selection of Delphi participants defined in the literature (Hsu & Sandford, 2007). Oh (1974) argues that the selection of appropriate subjects is generally based on the judgement and discretion of the principal researchers. Hence, Adler & Ziglio (1996) discuss that individuals are deemed eligible to participate in a Delphi study if they meet the following requirements; their background and experience align with the researched issue making them able to make meaningful contributions: all participating subjects have experience with or knowledge on either sustainability standards or blockchain technology. Besides that, subjects should be willing and able to participate, they must have sufficient time to participate. By accepting the invitation to be interviewed for this research and their elaborate, open answers during the interview, the respondents showed they were able and willing to participate in the research. Finally, effective communication skills were deemed necessary to obtain rich data for the research (Adler & Ziglio, 1996).

Context selection

Prior to selection the subjects, more desk research was performed to establish a context selection. This context selection contains the selected global value chains and the identified related sustainability and blockchain initiatives, as visualised in Table 1.

Global Value Chains	Key Value Chain Specific Problems	Sustainability Standards and Certifications	Blockchain Initiatives
Clothing & Apparel	Transparency: child labour, unequal value distribution counterfeiting (authenticity)	*Fair Wear Foundation, *Fair Labour Association, *Better Cotton Initiative	*Provenance, *Waltonchain, *Vechain
Seafood / fishing (Aquaculture)	Traceability: Quality and safety, unsustainable production practices (illegal and unregulated fishing), mislabelling	*Marine Stewardship Council certification *Aquaculture Stewardship Council certification (by WNF & IDH)	* Hyperledger Sawtooth (Intel) * WWF with ConsenSys (tuna tracking) * Viant /Ethereum (tuna tracking) * Provenance
Minerals : Jewellery, Automotive & Electronics (3TGs including gold, Diamonds)	Traceability: Authenticity, Unsustainable Sourcing, Labour issues, Conflict minerals	* Kimberley Process Certification Scheme *Responsible Jewellery Council certification (RJC) *Diamond Development Initiative International *Fair mined certification	*Everledger (Diamond supply chain) *iPoint (minerals) *Fairphone
Agriculture (Coffee, Cocoa, Tea, Sugarcane, coconut)	Transparency: Unequal value distribution (unfair wages), Labour issues, Food quality issues,	*Fairtrade (by FLO), *UTZ Certified *Rainforest Alliance Certified (by SAN)	*Moyee Coffee (coffee), *Right Origins (cocoa), *Fairfood (e.g. vanilla, coconut, sugarcane) *Tea project of Unilever & Provenance in Malawi
Forestry	Unsustainable sourcing, Environmental concerns,	*Forest Stewardship Council *Programme for Endorsement of Forest Certification (PEFC) *Sustainability Forestry Initiative	*Potential has been discussed*
Palm oil	Transparency & Traceability: Unsustainable sourcing & production (deforestation, degradation ecosystem and biodiversity), child labour, human rights abuses	Certified Sustainable Palm Oil (CSPO) by Roundtable of Sustainable Palm Oil (RSPO)	*Potential has been discussed*
Travel and tourism industry	Intermediate fees, corruption in taxation Inclusive / fair taxation Ecotourism investment due to corrupt regimes	*Global Sustainable Tourism Council Standard (GSTC) *Sustainable Tourism Stewardship Council (STSC)	*Windingtree (collaboration of airlines and hotels including Lufthansa, Swiss Airlines & CitizenM) *Slock.it (blockchain alternative to Airbnb) *PwC- techxcies initiative for Sustainable Tourism Sri Lanka

Table 1 Context selection: Overview section global value chains and related sustainability and blockchain initiatives

To create a complete understanding of the topic and to be able to answer the research question, the study focussed on several global value chains in diverse industries. The study examined the challenges that sustainability standard and certifications are facing in addressing issues in the global value chains for clothing & apparel, seafood, agriculture, forestry, palm oil, minerals and travel & tourism. This collection of sectors reflects the various sustainability challenges encountered in the different global value chains, including both environmental and social challenges. In addition, this division comprises every sector according to the three-sector theory. The primary sector involves the extraction of raw materials from the earth, which includes the mining, agriculture, forestry, fishing and palm oil sector. The research primarily focussed on these sectors, as these industries are the starting point for nearly all production. Thereafter, these sectors exert direct pressure on biodiversity and are largely responsible for shaping the world's current and future biodiversity (Kok et al., 2014). The secondary sector is concerned with producing finished goods and includes the clothing and apparel sector. This sector is selected as it is considered to be the most global industry, next to the fact that it is one of the largest and oldest export value chains in the world (Gereffi & Frederick, 2010). Finally, the travel and tourism industry belongs to the tertiary sector, as this is seen as the service sector. Further, for every chosen value chain the largest two to three conventional sustainability initiatives were identified. Moreover, further desk research led to the identification of various blockchain initiatives per sector, which can be found in Table 1.

Based on the context selection, the subjects for the research were deliberately selected (Polkinghorne, 2005), using both the network of the researcher and the supervisor. Furthermore, subjects were selected and approached via their e-mail addresses or their LinkedIn profiles found online. Additionally, the snowball sampling technique was applied to gather other subjects through the network of those that had already accepted the invitation. The selection of subjects was based on their field of expertise, ensuring that for every sector or value chain and related sustainability standard that was identified in Table 1, someone was selected to provide relevant experience and data for this research. Due to limited time and availability, 11 subjects were interviewed as outlined in Appendix II.

The sample provides a mixed representation of different stakeholders involved in at least one field of expertise (sustainability standards or blockchain technology) and having knowledge and experience on at least one of the identified sectors or value chains; therefore enhances the quality of data.

3.4 Data analysis methods

To capture the interview data effectively, the interviews were recorded with an audio-recorder, after consent was given by the subjects to record the interview. When conducting interviews, the subjects' concerns about privacy and confidentiality are to be respected. Therefore, it is important to obtain the participants' informed consent (Kvale, 2007). Prior to the interview, the subjects were briefly informed about all purposes and intents of the research and were asked for permission to record the interview. By having the interview recorded, this ensured that the researcher could focus on the interview content and examine any verbal cues (Jamshed, 2014). Further, the interviews were transcribed as soon as possible after the interview, which is considered to be significantly more reliable than handwritten notes during the interview. All text served as qualitative data, which was analysed by means of coding to find recurring themes and relationships (Gibbs, 2007). Coding is defined as the process of organising and sorting data, which allows for summarising and interpreting the gathered data (Campbell et al., 2013). In this research, hybrid coding or 'thematic analysis' was most suiting the abductive orientation of this thesis, as it combines elements of inductive and deductive coding (Fereday & Muir-Cochrane, 2006). An initial coding scheme was based upon the conceptual model that consists of the findings from the previously conducted literature study and desk research. Following the advice of Miles & Huberman (1994), the initial set of codes remained open to redefine or remove codes that do not fit the empirical data. Regarding the abductive nature of the research and particularly in the absence of sufficiently established theory, this coding strategy seemed appropriate as it was not possible to identify all relevant codes a priori. Coding was done by utilising ATLAS.ti software, which made it possible to combine the qualitative data of all interviews and link them to the set coding categories. This allowed for in-depth data analysis. Moreover, the transcribed interviews were read thoroughly, and opinions and perspectives were gathered systematically. (Appendices including example of transcript, coding and code groups can be viewed upon request).

3.5 Validity & Reliability

Particularly in qualitative research, evaluating on the credibility and reliability of the research is important, since it is criticised that the subjectivity of the researcher can easily influence data interpretations (Brink, 1993). Thence, validity and reliability measures should be reflected upon, to establish and ensure a trustworthy research, which accurately reflects and represents the broader context (Yin, 2015).

Validity measures of the research can be subdivided into two categories: internal and external validity. Internal validity refers to the degree to which a methodological approach accurately measures what it intended to measure (Saunders et al., 2009). Whereas external validity refers to the extent to which the results of a study can be generalised to all relevant contexts, and thus if the sample accurately represents the population (ibid.). Yin (2003) stated that internal validity is not considered an issue in exploratory research, as this type of research does not deal with establishing causal relationships.

The external validity of the research can be affected by several flaws in the sample. In this research, instead of using random sampling, the sample was deliberately selected through purposive sampling, which, in general, does not yield a high generalisability (Yin, 2016). Nonetheless, subjects were selected according to their field of expertise. Moreover, it was ensured that the sample represented sustainability experts from different value chains, to create an accurate and holistic view of the topic. Additionally, various experts that were interviewed were working for organisations abroad, and as such data can be generalised beyond the Netherlands.

Reliability in research refers to the degree to which data collection techniques yield consistent findings (Saunders et al., 2009). To ensure reliability, consistent data gathering and processing procedures were applied. Prior to the process of data collection, an interview guide was created that was utilised during the interviews, which included pre-defined questions and procedures (Appendix I). Further, interviews were recorded and forthwith transcribed. Additionally, an initial coding scheme was established based upon the literature review, which creates more transparency in how sense was made from the data (Saunders et al., 2009).

4 Empirical findings

The following chapter presents the findings of this research. It describes the challenges that conventional sustainability standards, in general, are encountering. Each challenge will be immediately followed by the findings on whether blockchain technology provides a solution to this particular challenge. Consequential, it discusses the expressed challenges blockchain technology does not address and potential problems it creates to create sustainable value chains, including context-specific challenges.

4.1 Challenges of conventional standards and certifications and blockchains' possibilities to address these challenges

First of all, throughout the interviews, it became clear that there are indeed various challenges that have to be overcome by conventional sustainability standards and certifications to establish truly sustainable value chains. Interviewee VIII (2018) states: *I would actually say a lot of them are not addressing the problems and that none of us are advanced enough to actually really truly address the problems when you look at where it should be.* Thereafter, it must be stated that nearly all interviewees did not regard the two approaches that were discussed, conventional sustainability standards and certifications and blockchain technology, as mutually exclusive, but rather as complementary (Interviewee I, 2018; Interviewee III, 2018; Interviewee VI, 2018; Interviewee VII, 2018; Interviewee VIII, 2018; Interviewee IX, 2018; Interviewee X, 2018). From a conventional standards perspective, there is argued that *blockchain is a technology that standards and certifications may potentially use to improve what we already do* (Interviewee VII, 2018). Similarly, blockchain practitioners expressed that conventional standards should consider this new infrastructure as an opportunity to build a new foundation for their business to establish new ways to cooperate, exchange information, record transactions and access data (Interviewee III, 2018). Thus, a large majority of the interviewed experts agreed upon the vision that these two approaches should merge (Interviewee I, 2018; Interviewee III, 2018; Interviewee IX, 2018).

The following section outlines each conventional standard challenge and directly provides an answer on whether blockchain is a solution to that particular problem.

4.1.1 Legitimacy challenges addressed by blockchains' transparency attribute

Although sustainability standards and certifications are currently seen as the best approach to establish sustainable value chains, all sustainability practitioners confirmed that they are dealing with difficult legitimacy challenges, due to a lack of transparency. Accordingly, it is argued this conventional standards problem can be addressed by the transparency attribute of the blockchain.

Blockchain practitioners claimed that multiplicity of standards and certifications of the conventional approach creates a difficulty in understanding for consumers and undermines their legitimacy (Interviewee I, 2018; Interviewee II, 2018; Interviewee IV, 2018). A large majority of the sustainability practitioners confirmed that their organisations are dealing with legitimacy challenges, due to a lack of transparency for consumers. Interviewee VII (2018) elaborated on this problem with the explanation that conventional standards and certifications are dealing with an issue of different labels on products. A lack of scientific control behind those labels has damaged the reputation of all standards and labels, which consequently has reduced consumer trust. Though, Interviewee VII (2018) provided a divergent response and argued that this is mostly a problem in value chains where there is not one key global player in the field of sustainability initiatives, which is for example not applicable to the seafood value chain. Nevertheless, sustainability practitioners agreed upon the fact that there is a strong market demand for more transparency to have a better understanding of standards and certifications (Interviewee X, 2018). As a result, sustainability initiatives are all searching for ways to create more transparency to be able to proof their legitimacy and improve their image to establish more consumer trust. The majority of these practitioners indicated that the solution to the transparency problem is currently sought in technology (Interviewee VII, 2018; Interviewee VIII, 2018; Interviewee X, 2018).

The trait of transparency of blockchain is argued to overcome this particular issue by all blockchain practitioners. First, it allows end-consumers to verify and check sustainability certificates (Interviewee III, 2018). Moreover, it creates the possibility to share information in real-time, instead of representing a snapshot of the situation (Interviewee IV, 2018). Thus, blockchains' transparency attribute would enable standard and certifying institutions to prove their sustainability claims towards consumers (Interviewee II, 2018). In addition, half of the blockchain practitioners envisioned that the transparency of blockchain will push other businesses to act more sustainably (Interviewee I, 2018; Interviewee II, 2018). It is argued that when various companies create more transparency for their consumers, it will also make consumers more critical. Consequently, it is imagined that it can stimulate a positive change, as other businesses will have to follow this trend of creating transparency for customers (Interviewee I, 2018).

4.1.2 **Monitoring and control challenges**

Many of the blockchain practitioners claimed that with the conventional approach, corruption and fraudulent activities are still found amongst various value chains (Interviewee I, 2018; Interviewee III, 2018; Interviewee IV, 2018). Although argued that it does not occur often, this problem was confirmed by a large majority of conventional sustainability practitioners (Interviewee VII, 2018; Interviewee VIII, 2018; Interviewee X, 2018). Thereafter, this was found to be a two-fold problem associated with the way in which value chains are currently being monitored and controlled by conventional standards and certification bodies.

4.1.2.1 Data monitoring issues addressed by blockchains' security attribute

More than half of the conventional standard practitioners expressed that they are facing data monitoring issues, largely due to their paper-based systems. Subsequently, all blockchain practitioners reasoned that this particular problem of the conventional approach will be solved by blockchains' attribute of security.

Various blockchain practitioners implied that the way information regarding standards and certificates is being stored and accessed is a limitation of the current approach of sustainability initiatives (Interviewee I, 2018; Interviewee III, 2018; Interviewee XI, 2018). A large majority of the interviewed conventional standard and certifying bodies confirmed that their data storage is manually organised at the moment, which poses a serious challenge to identify data corruption along the value chain. To illustrate, within the sustainable forestry standard chain they are *[…] trying to identify what we can do within the amount of data that we have available, though a lot of it is unfortunately very manual, which makes things very complicated (Interviewee VIII, 2018).* Similarly, within the sustainable seafood standard chain, paper-based systems are also indicated as being a true challenge for tackling fraudulent activities (Interviewee VII, 2018). Most of the sustainability practitioners agreed that despite the developments in technology, data poverty is still an unsolved issue, as *there is so much we don't know, and so much data we don't have yet (Interviewee VII, 2018).* Moreover, it is expressed that within these conventional standard organisations, they are trying to overcome this problem by striving to become 100 per cent digital (Interviewee VII, 2018; Interviewee VIII, 2018).

All blockchain practitioners explained that blockchains' feature of security can address this particular problem of data fraud. Blockchain will create an immutable chain of digital data (Interviewee III, 2018), that is accessible to the public and thus would reveal whether data has been changed (Interviewee IV, 2018). This is therefore argued to solve the problem of fraud in the paper-based data systems of the conventional approach. It is explained that blockchain essentially, *[…] provides this additional layer of security that, once the information is collected it hasn't been altered (Interviewee XI, 2018).*

4.1.2.2 Data control issues addressed by blockchains' autonomy attribute

Almost all sustainability practitioners indicated to deal with data control issues, for which it is argued by blockchain practitioners that these challenges can be addressed by the autonomy feature of the blockchain.

A large part of sustainability experts of conventional standards expressed that their organisations are struggling to cope with fraudulent activities in value chains, due to manner data is currently controlled. Although it is argued that the current verification and inspection processes executed by auditing bodies on a regular basis are seen as the best control tool at the moment (Interviewee VIII, 2018), it is expressed by the sustainability practitioners that their weakness revolves around the fact that everyone is relying on this third-party verification (Interviewee VIII, 2018; Interviewee X, 2018). This issue is clarified by Interviewee VIII (2018) who explained that within high-risk supply chains, it could happen that someone cheats the auditor by making them believe that the process or situation is better than it actually is.

Likewise, all blockchain practitioners contended this dependency on a third-party as a limitation of the conventional approach. Thence, this was given as a strong argument to implement blockchain technology (Interviewee I, 2018) since the autonomy of the blockchain network empowers all stakeholders in a network and enables cross-checking (Interview III, 2018). Consequently, the autonomy element of blockchain provides self-governance and thus will offer every stakeholder in the network with more control on the data (Interviewee IX, 2018). Furthermore, practitioners in both fields of expertise envisioned that implementing blockchain in value chains might induce a change in the role of a third party verification (Interviewee VIII, 2018; Interviewee X, 2018; Interviewee XI, 2018). Section 4.2.2 elaborates further on this aspect.

4.1.3 **Effectiveness and implementation challenges**

Throughout various interviews, it became clear that representatives of standard and certifying bodies feel that their impact with the conventional approach is helpful but still too limited. The effectiveness challenges of these sustainability initiatives partly relates to the limitations in providing a full value chain overview of the conventional approach.

4.1.3.1 Full value chain overview addressed by blockchains' traceability attribute

Providing a full value chain overview through including the entire value chain in auditing processes is indicated by a large majority of sustainability practitioners as a limitation to the effectiveness of conventional standards. Although the traceability attribute of blockchain could provide full value chain overview, this will only occur on the condition that every stakeholder partakes.

From the interviews it became apparent that several blockchain practitioners claimed that one of the biggest limitations of the conventional approach is that traceability systems do not provide full value chain overview, as they mainly start at a larger farmer level and do not include all smallholders (Interviewee VI, 2018; Interviewee III, 2018). In line with these assertions, the majority of interviewed sustainability practitioners stated that the limited effectiveness of the conventional standard approach is indeed related to the fact that the entire value chain is currently not included in many auditing processes (Interviewee II, 2018; Interviewee X, 2018; Interviewee VIII, 2018). Additionally, this problem is illustrated by Interviewee VIII (2018) who explained that many of the conventional standards *[…] never look in between companies, so what happened as the product moves from A to B.* Thus, it appeared that the links between companies and suppliers are often not to be taken into consideration. Subsequently, Interviewee VIII (2018) pointed out that it is difficult for the conventional standards to have this complete overview of the supply chain to identify problem areas, as long as systems are not digitalised. Moreover, Interviewee X (2018) indicated it to be a challenge of the conventional approach to include all smallholders that participate in the value chain, to link all steps of the process together.

Interviewee IX (2018) argued that blockchain could address this problem and create a full supply chain overview, due to the traceability feature of the technology. Yet, blockchain practitioners explained that for a system like blockchain to be effective, *every actor has to be involved in the supply chain data (Interviewee VI, 2018)*. Thus, if blockchain would be successfully implemented, all stakeholders from the entire supply chain will be involved, which will lead to full supply chain traceability. Nevertheless, including every stakeholder and ensuring full supply chain adoption remains also a condition when applying blockchain to the value chain. Thus, the challenges of traceability and full supply chain overview will only be addressed and guaranteed by blockchain, on the condition that every stakeholder in the chain is participating and entering correct information (Interviewee IV, 2018).

4.1.4 In summary

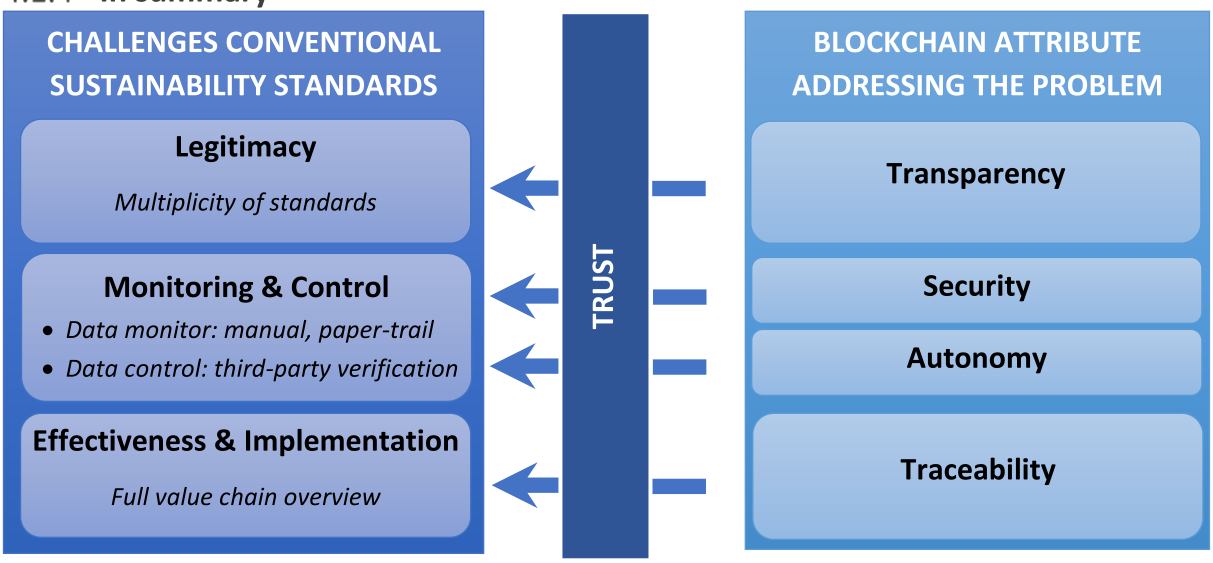

Figure 7 In summary: Challenges conventional standards addressed by blockchain attributes

In sum, Figure 7 displays the previously discussed challenges of conventional sustainability standards and the attributes of blockchain that can address that particular problem. The findings indicated that the blockchain is a technological solution, for which it is argued it holds the possibility to address conventional legitimacy challenges that have emerged due to the multiplicity of sustainability standards and certifications, by providing transparency towards the public. The transparency of blockchain enables end-users to verify and check the sustainability claims, which will establish more consumer trust. Second, blockchain can address the fraudulent activities that exist due to the conventional approach to monitoring and control of data. By providing a digital, immutable data system blockchain creates a secure system in which corruption can be more easily identified, compared to the current paper-trail system. Moreover, instead of having one third party in charge of controlling the data, blockchain provides all stakeholders with the opportunity and the responsibility to cross-check data entries. Thus, the element of autonomy can solve the limitation of the conventional approach which requires everyone to rely on and trust one central party. Both, the autonomy and security that blockchain provides towards stakeholders, enhance trust in the process. Finally, the effectiveness of the conventional approach is indicated to be limited due to a lacking of a full value chain overview. Blockchains' attribute of traceability could address this issue, though this depends on the involvement of all stakeholders along the chain.

4.2 Challenges, conditions and limitations of blockchain to establish sustainable value chains

Blockchain technology contains several features that can positively address the discussed value chain issues that are still occurring with the conventional approach of sustainability standards and certifications. Nevertheless, there are various challenges and conditions for addressing these issues with blockchain as well. Moreover, this technology can also cause new problems to exist. The following section outlines the conditions that are attached to the blockchain, which can result in limitations. Moreover, it outlines several challenges to this approach.

4.2.1 Involvement and participation of all actors

First of all, the involvement and commitment of the entire value chain is a condition that needs to be met in order to guarantee the effectiveness and success of a blockchain network (Interviewee V, 2018). This can become a strong limitation of the blockchain system, as it cannot be guaranteed yet that everyone is willing or can be convinced to adopt this new technology. Interviewee XI (2018) explains that this is a true challenge, as […] *we can make it a requirement for people that sell stuff into our supply chains, but we might not always be that 51 percent that can actually switch or turn them around and make them do it (Interviewee XI, 2018).* Moreover, it is argued that there has to be a clear reason and understanding for everyone to participate, which is something that is currently lacking in society due to the complexity of the system. Further, it is found from the first-movers and the developed use-cases that there should be an incentive for all stakeholders along the supply chain to adapt to this technology, since everyone has their own systems in place (Interviewee IV, 2018). Further, from both perspective of expertise, there is discussed that, similarly to the conventional sustainability initiatives, implementation of a system like blockchain requires multidisciplinary teams, including people from the industry, government and researchers (Interviewee I, 2018).

4.2.1.1 Data transparency: willingness to share

The blockchain is working on the condition that there is a willingness to share data and to be transparent towards others, though it clearly expressed throughout the interviews with practitioners that this is a challenge which the technology does not address in itself. Subsequently, having incentives or establishing strong change management processes are indicated as potential solutions to this problem.

Conventional standard representatives discussed that transparency is not always desired from a business perspective, as it can make companies quite vulnerable (Interviewee II, 2018). In addition, it is argued there is a resistance to become fully transparent, as companies and industries fear to lose their competitive advantage as soon as sensitive information regarding a companies' production location and their suppliers will be revealed. Willingness to be transparent is argued to be both an obstacle in the apparel sector as well as in the forestry value chain (Interviewee V, 2018; Interviewee VIII, 2018). Similarly, from other digital database solutions that have been created by the conventional standard and certification bodies, it appeared that stakeholders' willingness to share data was the biggest challenge (Interviewee X, 2018). Interviewee XI (2018) elaborated: *No one wants to share the data as long as you don't make it mandatory. Well, good luck.*

Correspondingly, the majority of blockchain practitioners indicated that a certain level of transparency can create some obstacles. Therefore, it is argued that it should be wisely considered what information will be shared with the network, since it is openly accessible (Interviewee III, 2018). To overcome this practical implementation problem, from both perspectives it was indicated that participants should see the added value of the system or that there must be an incentive for them to participate (Interviewee III, 2018; Interviewee XI, 2018). *Unless we do a very very big and comprehensive change management process, where we lead them to the change of moving into such a system (Interviewee VIII, 2018)*, conventional sustainability initiatives stated they do not see this technology to be successfully implemented and establish more sustainable value chains. This change management process should create understanding in why data is collected, what for, and what will be done with the collected data (Interviewee XI, 2018).

4.2.1.2 Data reliability: human error

One of the challenges expressed throughout the majority of the interviews, is that the blockchain works on the condition that actors have good intentions and truthfully enter data. This is both a challenge and a limitation of using blockchain within, or over conventional sustainability standards, since this means that with this approach, data is not entirely reliable after all, as the technological solution does not entirely remove the risk of data error. Essentially, it is indicated that blockchain remains a database system that is still relying on people entering data, similarly to the conventional approach of sustainability standards. One of the blockchain practitioners explained that […] *because of the immutability of blockchain, a lot of people assume that means that it produces good data. They'll think well it is in blockchain, therefore it must be true. Forgetting that it's massively garbage in garbage out. It's not this wonderful database of pure, truthful data. It's still completely susceptible to human beings error and fraud. So yeah, a lot of the benefits that people give blockchain and think blockchain have, they forget that they are easily whipped out if there's human error or fraud there (Interviewee IV, 2018).* All sources indicated that data entry mistakes made by humans will therefore not be removed when blockchain would be implemented in a value chain. Thence, Interviewee XII (2018) stated that blockchain is just a technology and that it is all about what data, and the quality of data that goes into the system. Additionally, Interviewee IV (2018) discussed that fraudulent, purposeful errors also can still occur. This is substantiated by an example given by a blockchain practitioner, who explained […] *If I have a biological coconut, I put it on the blockchain, I give it a barcode with a sticker. At one point there is a trader that says I have another coconut here but I actually want that biological coconut for myself. I just put the sticker on the other coconut that maybe I used pesticides on, and I keep the biological one. So in that case, it's very easy for a human to fraud the system. This is still a problem, blockchain doesn't change that (Interviewee I, 2018).* Despite this, Interviewee I (2018) added to this explanation that a tremendous benefit of the system is that human errors and fraudulent activities are more exposed and can be tracked more easily. Interviewee VI (2018) agreed to this and elaborated that blockchain ensures that, whenever an error occurred and it was corrected later, this becomes visible. Thus, a large majority of the blockchain practitioners acknowledged that blockchain technology does not hold the possibility to completely ban fraud or errors, nevertheless, it will reduce these unsustainable practices to a large extent since the risk of getting caught of fraud becomes higher as more people are involved (Interviewee I, 2018; Interviewee VI, 2018; Interviewee VII, 2018).

4.2.1.3 Implementation challenges smallholders

The lack of resources of smallholders in the value chain is pointed out by a large majority as a cause that withheld further implementation of the conventional approach. This also remains a challenge with blockchain technology and it can create a limitation to achieve involvement of all actors as it can form an extra barrier, which can cause new problems to exist.

Currently, many sustainability initiatives indicated that they do not have full supply chain coverage and not all stakeholders of the chain are involved. The majority of interviewees found this issue to be partially explained by the lack of resources of the smallholders or suppliers in the value chain (Interviewee VII, 2018; Interviewee VIII, 2018; Interviewee X, 2018). Interviewee X (2018) illustrated *[…] there are challenges that relate to smaller players, in terms of resources they maybe be limited, and also in terms of capacity they are limited, as well as in understanding*. Next to that, the administrative burden for companies that come with being certified, especially for the smaller stakeholders, is currently identified as a challenge of the conventional standard approach (Interviewee VIII, 2018). Interestingly, Interviewee VIII (2018) denoted that complex technological systems, like blockchain, can create a barrier for people getting certified or maintaining their certification. This was therefore identified as an unintended consequence of this technological solution to this complex problem.

Similarly, most blockchain practitioners did not see blockchain technology as a solution to this particular problem. Interviewee IV (2018) wondered why stakeholders would want to be involved in a complex system like blockchain, as it is not removing the administrative burden, but only creating extra work for them by being a node. Furthermore, it is argued that a great advantage of the conventional sustainability standard approach is that it does not demand much change within a companies' administration, whereas with new digital solutions, like blockchain, this creates another obstacle (Interviewee VIII, 2018). Nevertheless, a small number of blockchain practitioners claimed this will not be an issue. To illustrate, Interviewee VI (2018) expressed to be confident that even though the smallholders in the chain do not have the capacity to lock the data, features on phones could be created to solve this problem.

4.2.2 **Role of sustainability standard organisations**

Interviewee X (2018) explained that there are two streams of argumentation, one in which blockchain will make certification obsolete, in the other it creates a more efficient way for those organisations to transport data. Throughout all interviews, strong arguments are given for the reasoning that blockchain will not hold the potential to make standards and certification organisation obsolete, as the evaluation system defined and provided by those organisation is still necessary to evaluate which practices are sustainable and which are not (Interviewee I, 2018). Moreover, it is envisioned that blockchain can induce a shift in the role of certifying organisations.

4.2.2.1 Determining the data

First, it is expressed that sustainability standard and certification bodies are still deemed necessary when blockchain would be implemented, to determine the required level of sustainable practices.

Interviewee VIII (2018) explained […] *I don't see blockchain as a contradiction to the sustainability model of standards. Blockchain essentially only lets you move things from A to B, but the actual change within any sustainable system is the sourcing of the resources. So you will always need sustainability standards to begin with, to actually certify and alter the way raw materials are being produced and the way people in that production are being treated. Blockchain won't solve that for you.* Interviewee VII (2018) added to this, that blockchain can make huge amounts of information available to the consumer, but that does not change the fact that it is difficult for consumers to know when something is actually sustainably sourced or farmed. Further, Interviewee VII (2018) argued that implementing other technologies, such as the Internet of Things and Radio Frequency Identifiers, also require some standards and certification, to measure the correct things to provide information about sustainability. Thereafter, it is discussed that sustainability standards and certifying organisations will always remain important, as experts are required to analyse and determine whether practices are sustainable and what are the limits (Interviewee VI, 2018; Interviewee VII, 2018). Finally, it is argued that the key value of sustainability standards and certifiers is that they make data comprehensive to the customer by summarising the data into a label on the product that tells you whether you should buy a product or not (Interviewee VII, 2018). Though, it is discussed that a label is not necessarily needed anymore when everything is digitalised (Interviewee I, 2018; Interviewee III, 2018). It is explained that whenever a consumer scans a QR code or an electronic tag and sees the related information behind the product, it should be the information related to the standard or certificate. By providing digital evidence, consumers are able to check and verify themselves whether the product complies with the certain requirements and passed the certification. Interviewee II (2018) explained that *[...] this will entail that sustainability initiatives enter a new phase, where they move from 'trust me I'm doing good', they actually have to prove it by being very open and transparent.* It will make their impact stronger (Interviewee VI, 2018) and it will increase the confidence and trust of consumers in these initiatives (Interviewee III, 2018). Thus, blockchain is not considered to be revolutionary content-wise, but revolutionary in the way it provides information (Interviewee VII, 2018). Consequently, *this is expected to have an effect on the role of the certification bodies, not necessarily their existence,* argued Interviewee XI (2018). It is envisioned that the role of certification bodies will turn more into a data brokers, who deploy the technology and gather and analyse data, in order to provide partaking stakeholders with data analytics and advice (Interviewee XI, 2018). After all, the standard and certification bodies are still considered necessary to establish market understanding on the perception of sustainability and to develop the data determinants for this technology.

4.2.2.2 Process improvement

Further, many of the interviewees of conventional standard organisations expressed to maintain a compliance approach, for which it was argued that it does not directly improve value chain conditions and processes. Blockchain practitioners indicated that blockchain is not addressing this particular problem, though maybe when the role of sustainability practitioners might change.

Especially when conventional sustainability initiatives provide certification to a stakeholder in the value chain, it is explained that they are struggling with the fact that a certification creates the assumption that at a given point, for example a clothing factory, is seen as fully fair and sustainable (Interviewee V, 2018). This would imply for a stakeholder that sustainability is reached at that certain point. Interviewee VIII (2018) elaborated that *[…] the problem is that all of our different certification systems are always built around compliance so we set standards and then you verify whether or not people live up to that standard. But you never look above and beyond, you never look outside the very specific scope of that one standard*. Additionally, this is referred to as remediation problems (Interviewee V, 2018). The effectiveness of certifying bodies is argued to be limited because assessing non-compliance is only one aspect, but actually improving labour conditions remains a challenge according to the majority of interviewees (Interviewee V, 2018; Interviewee VII, 2018; Interviewee VIII, 2018). Moreover, it was indicated that a few of the conventional standards would like to move from compliance-based to a risk-based framework, where problems can be more easily identified (Interviewee VIII, 2018). All blockchain practitioners agreed upon the fact that blockchain could make the impact of conventional standards bigger by improving their traceability systems, yet few of the interviewees realised this is only the first step in the process. Interviewee VI (2018) declared that blockchain can only make data visible but *we do need standard and certifying organisations to manage this* (Interviewee VI, 2018). Thus, blockchain is not the solution to the problem of remediation and stimulating direct change in the value chain. Though, as it was argued that blockchain might induce a shift in the role of the auditing party, this might address the problem and improve processes.

4.2.3 **Uncertainty and development**

Blockchain is still found to be in a developing phase, which entails that the technology comes with a lot of uncertainty. The risks and unknown consequences of this technology are expressed to create hesitance for further development.

Blockchain technology is still extremely novel, thence, all use-cases that have been developed and were discussed, are still in an evolving phase. Consequently, the majority of blockchain practitioners acknowledged that the possibilities, limitations and effects cannot be outlined with certainty yet. Interviewee XI (2018) explained *[…] we are often still arguing or talking in a vacuum.* It is pointed out that, as the technology is so new, there have not been many evaluation studies on blockchain conducted to truly know what its positive and negative impact is (Interviewee II, 2018). Subsequently, several blockchain practitioners discussed that negative effects might always be a risk when implementing a new technology, as it is known that every technology can have negative consequences. This is illustrated by an example given in one of the interviews; *[…] looking at the nuclear technology for example, what was ironically once meant to solve all energy problems in the world. And later of course with different types of inventions, it was miss-used and created bombs (Interviewee I, 2018).* This is agreed upon by various practitioners, who recognised that the concerns coming along with the development of blockchain are legit, as it can have effects and potential dangers that are not foreseen yet (Interviewee XII, 2018). Yet, another perspective on this is expressed by Interviewee I (2018), who states that unforeseen consequences can never be ruled out completely.

One example of the uncertainty about the negative consequences of using this technology, is the implications regarding the energy consumption. Though, this was only expressed by sustainability practitioners as a concern to adopt this technology, as they are striving to not create other sustainability issues (Interviewee X, 2018). In addition, blockchain practitioners admitted that they are working in a very unstable industry with uncertainty about regulations (Interviewee IX, 2018). Due to these uncertain and unstable conditions, most conventional standard organisations are a bit hesitant to explore and invest in this technology. Interviewee VII (2018) elucidated: *We can't say whether the future is in blockchain or something else. So we are not putting our money on it just yet*. The fact that there are more digital database solutions developing is also by others given as an uncertainty of blockchains' potential (Interviewee VIII, 2018). In addition, it is argued that there are lots of risks and costs involved with the development of this technology. Further, a blockchain system can be designed in a way that it provides both privacy and transparency, depending on the design choice (Interviewee I, 2018). Though the key question remains who should take the lead and the responsibility in further developing and implementing this technology. From a conventional approach perspective it is stated that when they initiate complex IT systems, it becomes too expensive for smallholders in the value chain to participate, as this is currently already a challenge (Interviewee VIII, 2018). Though, when the blockchain will be developed by a single organisation, *[…] you basically dictate how one should run their business from an IT perspective* (Interviewee VIII, 2018). Thereafter, collaboration is required to truly alter power positions. Similarly, the blockchain experts were realistic about this and admitted that *[…] technology is never a solution to something, it is always how people between themselves create new solutions and accept them. That's far more than technology* (Interviewee I, 2018). Interviewee IV (2018) takes this even further and stated that although blockchain has potential, if humans are not collaborating, putting a complex technology on top of it will only make things worse. Further, as the technology needs to be iterated and developed, this will take time (Interviewee IV, 2018).

4.2.4 **Contextual variety**

Finally, the research findings tended to indicated that there are specific challenges that the conventional sustainability initiatives are facing, depending on the value chain in which they are operating. All blockchain practitioners stated that blockchain can be applied in every value chain, where there is any flow of commodity or transaction from one person to another (Interviewee I, 2018; Interviewee III, 2018; Interviewee VI, 2018; Interviewee IX, 2018). Though it is acknowledged by one of the blockchain experts that [..] *we cannot say that applying blockchain in one sector is more difficult than in another one, but every sector has its own challenges* (Interviewee VI, 2018). Further, it is discussed that one should evaluate per business case whether blockchain would be relevant, for example, it was agreed that blockchain is not an efficient database for internal use (Interviewee I, 2018; Interviewee III, 2018). The following section outlines the indicated contextual variety and includes the different conventional challenges and blockchains' possibilities and limitations along various contexts.

4.2.4.1 Change of commodity in the chain

Standard and certification processes are found to be more challenging in value chains where a commodity or products change shape, or when the volume that is passed on in the chain is altered throughout the process (Interviewee VII, 2018; Interviewee VIII, 2018). Within these chains, it is claimed that with the conventional approach, reliable tracking and tracing of the actual product is extremely difficult. A majority of interviewees indicated that this challenge will not be different when blockchain would be applied within these value chains. Further, the agricultural sector is found to be the most convenient sector to implement blockchain, as basic food items are often the same product from the start (Interviewee IV, 2018; Interviewee VII, 2018; Interviewee VIII, 2018). Multiple interviewees provided examples of agricultural value chains, where blockchain use-cases have been tested or applied, such as the cocoa, coffee beans and coconut value chains (Interviewee I, 2018; Interviewee IV, 2018). In contrast to this, Interviewee VIII (2018) explained that implementing blockchain will likely be more difficult in the forestry value chain, where a certain amount of wood eventually is turned into paper. Also, the mineral sector is argued to be fairly difficult. An example of a blockchain initiative is given, where there was aimed to track minerals from sourcing to end product. Here, challenges occurred as soon as the weight of minerals changed, when it was melted into another product (Interviewee IV, 2018). Similarly, the fishery value chain is envisioned to face implementation challenges as it is seen as a complex commodity chain (Interviewee VII, 2018). This is illustrated by an explanation of the process of tuna fish, in which *the tuna goes to a manufacturer where parts of the fish are put into cans of tuna* (Interviewee IV, 2018). Thereafter, the shape and the weight of the product change throughout the process, making tracking more difficult. Opposed to this, one blockchain expert explained that different supply chains have common problems and argued that they can all be solved (Interviewee IX, 2018). Others appeared to be more sceptical and argued that, at this point in time, technology is not there yet to address these issues (Interviewee III, 2018).

4.2.4.2 Complexity of the value chain

Second, the level of complexity of value chains appeared to vary considerably and is identified as one of the key contextual challenges in conventional standards and certification process. It was argued that the conventional standards often not take the entire value chain into account and thus the traceability element of blockchain would address this issue. Nevertheless, it is recognised by all blockchain practitioners that the complexity of a value chain also remains a challenge in whether implementing blockchain would help in making the value chain more sustainable. One of the blockchain experts explained *[…] when the number of actors in the supply chain is very low, the complexity of implementation is not that high (Interviewee III, 2018).* Moreover, establishing a blockchain tend to become more complicated when different countries are involved in shipping and when different forms of transportation are used (Interviewee IV, 2018). It is explained that it will be more difficult to implement blockchain then because the technology needs to be provided to all actors and stakeholders and their acceptance must be received. Nevertheless, blockchain practitioners have considered this issue and stated that workshops should be created and given to ensure that the blockchain applications are used in an effective way (Interviewee IX, 2018). Thence, it is found that most use-cases that are currently established are working with really short supply chains, which involve only a small number of stakeholders. Whereas most international supply chains actually include many stakeholders, this is considered as a challenge for wide-spread adoption and implementation (Interviewee III, 2018).

4.2.4.3 Level of development of the value chain

Moreover, it was agreed upon by the majority of interviewees that the level of development of the value chain in which they operate is posing a specific contextual challenge to the conventional sustainability initiatives. For example, one sustainability practitioner explained about the forestry value chain *[…] we are working with so many different scales. We are working with companies that have half of their employees on computers from 1999, and we are working with companies that only use faxes and checks and don't trust IT systems. And we are working with the best and first moving companies on a global scale. We need to develop IT solutions that are applicable for all these different companies (Interviewee VIII, 2018).* Further, an example is given on the apparel supply chains, where many different stakeholders are participating in the chain and most of them are argued to be very low tech. Interestingly, only few blockchain practitioners recognised this is as a challenge, though pointed out that access to the Internet is indeed required to be able to communicate and participate in the blockchain (Interviewee I, 2018). Nevertheless, it is envisioned that in twenty to forty years' time, technology and the Internet will no longer be a barrier for any stakeholder (Interviewee I, 2018).

4.2.4.4 Social sustainability focus

Another aspect in which the various conventional standard approaches turned out to differ, is whether there is a focus on social or environmental issues along the chain. Interviewee V (2018) explained that one of the problems with social standards compared to environmental standards is that social standards cannot be measured in the final product. Whereas with environmental standards, it can be measured more easily whether a product contains chemicals, for example. This is in contrast to social standards, where it cannot be measured in the end product whether it has been made under unsustainable conditions, thus if there has been child labour or workers worked overtime in order to make the product (Interviewee V, 2018). Thus, the 'human approach' is tended to be required, especially to verify social conditions, according to the conventional standards with a primary focus on social conditions (Interviewee V, 2018). This is agreed upon by Interviewee II (2018) who argues that *[…] with blockchain the qualitative part of auditing would be eliminated. When doing audits, there is a person who does your audit and not only quantifies data, but there is a more personal side of things, that is not possible when you only use blockchain.* Accordingly, it is argued that these type of requirements will be very difficult to include in any technological system without having a third party controlling and verifying (Interviewee V, 2018).

4.2.4.5 Accessibility of the value chain

Further, a large majority of sustainability practitioners debated that conventional standard and certification processes are more difficult in value chains that are not easily accessible. This makes processes more difficult to track and identify issues. Interviewee VII (2018) elaborated on this and argued that every value chain has issues and challenges, but in some sectors, those might be easier to identify. A comparison between an agricultural value chain and the seafood value chain is made and it is explained that *[…] an agricultural field, where crops are growing, it is easier to get there it's easier to see what people are walking on the land. You can take a sample and see what pesticides are used on the soil. Fish is way more complicated and I think it's often the most complex commodity because you know fish is not static, it moves around and people go out on boats sometimes for weeks or months, where there's no one to really watch what they're doing (Interviewee VII, 2018)*. Corresponding, both fields of expertise discussed that this problem might be overcome by further developments in technology, such as satellites, Internet of Things, RFID and smart tags (Interviewee III, 2018; Interviewee VIII, 2018).

4.2.5 In summary

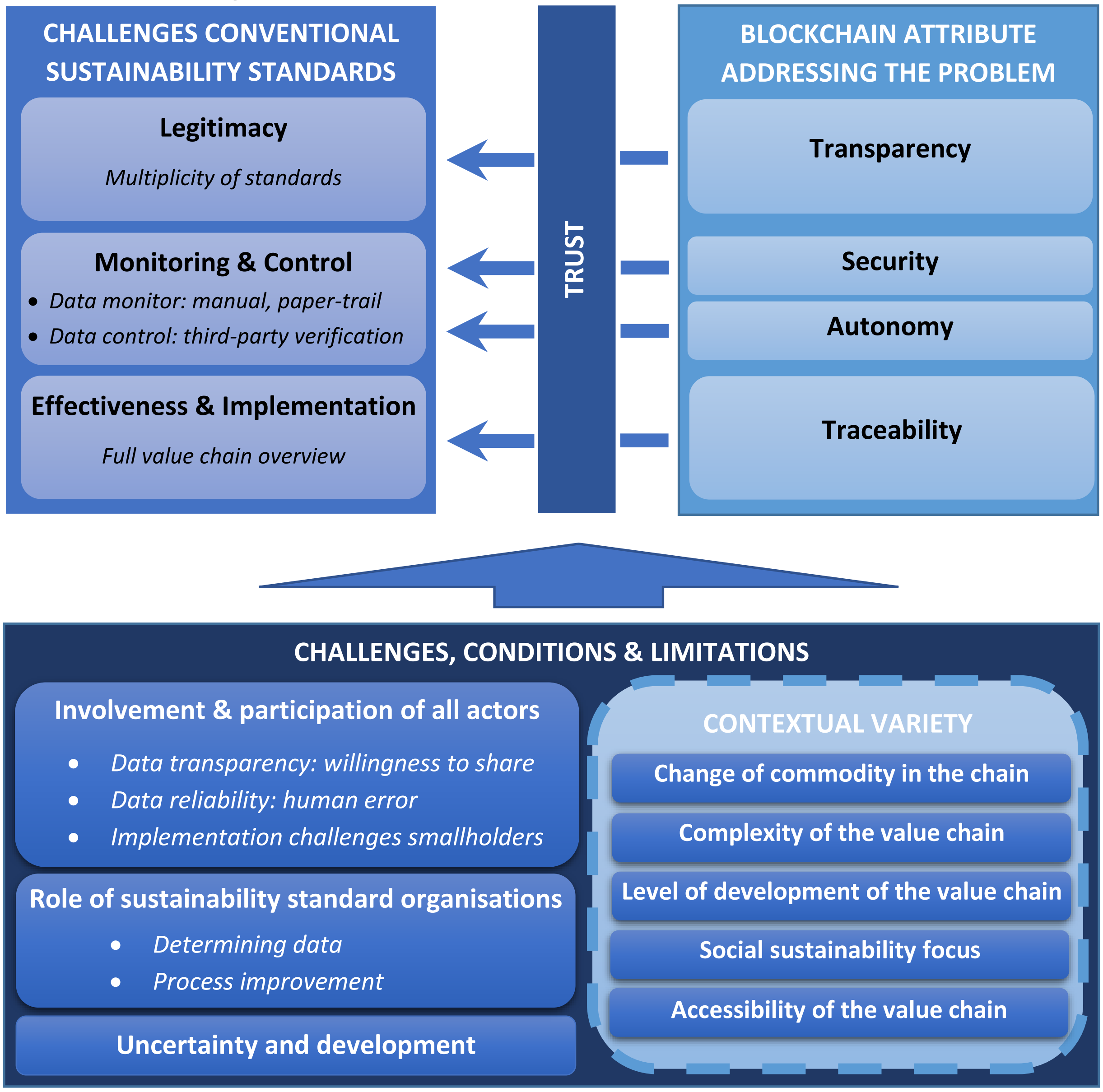

Figure 8 Findings in summary: Challenges, conditions and limitations of blockchain

This section outlined the conditions that are attached to the blockchain, which can result in limitations. Moreover, it described several challenges to this approach, which are all summarised and visualised in Figure 8. First of all, it is expressed that the benefits and success of blockchain primarily depend on the condition that all actors are involved and participate in the network. Though, this condition creates several challenges, as stakeholders must be willing to share data to create data transparency. This is more likely to be achieved when the adding value of the system is clear and understood, which requires a strong change management process. Further, data monitoring and control are found more secure by having a digital shared database system. Yet, blockchain does not contain the possibility to completely eliminate fraud or errors. It is thus indicated that the system still functions on the condition that actors have good intentions and truthfully enter data. Nevertheless, it does reduce this risk to a large extent, because of the transparency and involvement of other stakeholders in the network. Finally, the lack of resources from suppliers is found to be a challenge within the conventional approach, which also remains a challenge when blockchain would be applied. It can even create an extra barrier for smallholders to adopt more sustainable practices.

Further, findings indicate that the role of the sustainability standard and certifying bodies will not be eliminated as it is expressed that blockchain will make data transparent, but it does not directly define when something could be considered sustainable farmed or produced which still requires experts in the field. In addition, blockchain will help to identify hot spots in the value chain where process improvements can be made, yet it does not create a direct improvement in case of non-compliance. Moreover, the role of standards and certifying organisations is envisioned to change more into data brokers, when blockchain would be implemented throughout the value chain.

Currently, the uncertainty about the evolvement of this technology and the consequences cannot be outlined entirely yet, which creates hesitance. However, the technology in itself is not found to be a solution, especially as blockchain requires the collaboration of all actors. A successful implementation is based on the condition that all stakeholders are involved, which raises questions on who is responsible for taking the first step in further development of this technology in a collaborative manner.

Finally, although it is argued that blockchain is applicable in every value chain, the findings tended to indicate several contextual variety challenges, depending on the type of value chain one is operating in. Challenges with blockchain remain in value chains where commodities change shape throughout the process, in value chains that are not easily accessible and where the focus lies on social conditions, as these aspects cannot be measured in an end product. Additionally, as the technology is still not fully mature, its implementation is not yet established in highly complex value chains.

5 Discussion & Conclusion

The main objective of this research was to explore the claimed potential of blockchain technology as an approach to address the wicked problem of creating sustainable global value chains. In the results section the challenges which blockchain does and does not address have been indicated, and the conditions and potential problems it can create, are outlined. To get a deeper understanding of the results, this discussion tries to find the reasoning behind the outcome of the results. Expectations, causes and consequences are identified by analysing and interpreting the results, in order to draw valuable conclusions. Additionally, the limitations of the research and directions for further research are identified.

5.1 Discussion

First of all, the findings in this study confirm what the literature already described, for wicked problems there are only solution-oriented approaches with unknown outcomes (Van Tulder, 2018). A large majority of the practitioners expressed that as blockchain technology is still in an evolving phase and limited use-cases are developed, this is truly posing a challenge to understand what the positive and negative impact of this technology is, or eventually will be. As Vasishth (2013, para. 10) stated, "The problem with technology is that it is both panacea and problem simultaneously". Likewise, the findings clearly indicate that implementing a new technology always comes with the risk that it can have negative or unintended consequences. Therefore, in line with the literature, blockchain technology certainly holds the possibility to create more sustainable value chains, nevertheless, it also creates new challenges at the same time. Furthermore, it should be noted that the framework established from the data delineate a simplification of reality. The findings indicated that blockchain contains possibilities and holds potential to bring various benefits to the value chains and promote sustainable development. Though the chance for progress that was indicated, only applies to parts of this wicked problem and does not adequately captures the interrelated problems. Although the findings summarised in Figure 8 help to create an overview of the challenges and whether it was identified to be addressed by various blockchain attributes, the overview links the various challenges and attributes separately, though the reality is that every challenge and possibility is interconnected, which requires a more holistic approach.

5.1.1 Stimulating inclusiveness?

The nature of wicked problems is such that with every solution that is implemented, new challenges arise and become more pronounced (Head & Alford, 2015). This also appeared to be the case when utilising blockchain to address the global value chain problems. First and foremost, the literature identified that the unequal value distribution is a key issue in the current global value chains (Kaplinsky, 2000; Levy, 2008). Partly for that reason, control mechanism were found to emerge to address this issue, among other things. Interestingly, only little was expressed in the interviews about blockchain and the economic implications for smallholders in the value chain. In addition, various previous studies indicated that stimulating economic growth is not sufficient to reduce poverty and unequal distribution of income, if developments are not inclusive (Van Tulder, 2018). Here, questions arise on the feasibility of implementation and adoption of this technology on a large scale at the moment, and whether it actually stimulates sustainable development. In accordance with the literature, the unlikelihood of sufficient adoption is considered as a key limitation that determines the success of blockchain (Bloomberg, 2017). Practitioners realise that the full network possibilities and benefits of blockchain will not be achieved without widespread adoption by the industry and all stakeholders involved, which was referred to in the literature as the network effect (Osterwalder & Pigneur, 2010). Moreover, the literature illustrated this with the adoption of a telephone network, where in the beginning no one possessed a phone, the service was not as valuable. Though, contrary to this insufficient network adoption problem in the literature, the findings indicate that there might even be negative effects to blockchain, when not everyone participates or is able to participate. Whereas Waddock (2012) argues that digital technologies stimulate interconnectedness, creating economies that are closely linked to one another, the findings tend to refute this, as it is pointed out that internet access is required to be able to connect and participate in the blockchain. Yet, at the moment still 1+ billion people do not have access to reliable phone service (UN, 2015; Van Tulder, 2018). Thereafter, the findings express that involvement of the entire value chain, including the smallest actors, the farmers in the rural areas is a condition that needs to be met in order to guarantee the success of a blockchain network. Hence, it is disputed if implementing blockchain technology will truly add to sustainable development and create a healthy ecosystem, or if opportunities arise only for the ones in a privileged position to reap the fruits of this development (Van Tulder, 2018). One of those risks of addressing a wicked problem with technology that thus appeared from the findings, which the literature also describes, is that technologies invented or adapted in developing countries are likely to be more suitable to be used in developed countries, which could exacerbate inequalities (United Nations, 2016). In addition to the literature, the interviewees express that the speed of expansion of Internet and technology in developing countries will therefore play an important role in determining the effectiveness and success of blockchain, which is a matter of time, for which the majority of blockchain practitioners seems to hold a positive perspective on. An aspect that is not covered in the literature, is that findings indicate that, in the meantime, blockchain can create an extra barrier and scare away smallholders in the value chain, which can negatively impact inclusiveness. Further, it could be argued that, similar to the conventional approach, blockchain can create new legitimacy problems, as the idea of collaborative advantage would be threatened when not all stakeholders are involved (Huxham & Vangen, 2004).

5.1.2 Altering governance and power relations?

Moreover, the literature defined that sustainability standards are embodied a promising new form of governance, as they operate at the boundary between globalisation processes and localisation commitments (Bass et al., 2001). The research findings indicate that blockchain could take this to the next level by establishing a decentralised governance structure which would empower all actors in the chain as it enables cross-checking. As found in previous research by Boström et al. (2015), equal power distribution amongst actors in the chain is essential to create a more responsible and sustainable governance of value chains. The literature indicated that conventional sustainability standard and certifications alter the weak position of smallholders in the chain, by involving them in the standard-setting process, which provides for a more just form of governance (Muradian & Pelupessy, 2005). Moreover, the literature also described that blockchain truly achieves this by providing stakeholders with autonomy in the chain (Dütsch & Steinecke, 2017). The findings indicated that, if properly implemented, blockchain can indeed create a shared network in which all actors are equally responsible for entering and validating data. Along with the literature that expands on the evolvement of different structures, blockchain practitioners explain that a blockchain system can be designed according to the design choice, which determines the level of privacy and transparency. Nevertheless, a critical note could be made here as different structures of blockchain and different use-cases are evolving. From the findings it is not yet clear if all different structures will deliver the promises of blockchain to everyone. Thereafter, it can be disputed if certain applications of blockchain technology will truly alter the power positions in the chain and provide change to the entire process, or whether blockchain will be merely used as a 'marketing' effort that can boost a companies' brand image, as it is still a hype at the moment.

Additionally, the blockchain literature emphasises that with a blockchain network, transactions take place without the involvement of intermediating third parties (Mougayar, 2016). This shared, peer-to-peer database is therefore claimed to be disruptive, as it is omitting the role of mediating third parties (Tapscott & Tapscott, 2017). Further, the literature defined that with blockchain trust is assured through the network, instead of having a central third party involved to guarantee accuracy and trust (Atzori, 2015; Swan, 2017). Nevertheless, the findings tend to show a contradictory perspective to this. Practitioners expressed that sustainability standard and certifying organisations will always remain important, as these experts are deemed necessary to determine and analyse practices and to provide guidelines and information to business and society on what is perceived as sustainable. Interestingly though, various practitioners express that the role of sustainability standard and certification parties might change more towards data-brokers or consultants in sustainability, that steer the improvement process.

5.1.3 Truly increasing trust?

Further, literature indicated that conventional sustainability standards enable companies to communicate information about themselves or their products to potential end-consumers in a reliable manner, which was found to increase consumer confidence and trust (Muradian & Pelupessy, 2005). Though, as the trust gap is growing, the literature identified that the approach of blockchain enhances trust through addressing the problem of visibility and information asymmetry in value chains, by revealing detailed information on every step in a transaction process (Chen et al., 2017). The interviewees agreed upon this and elaborated that blockchain is taking a further step in strengthening the position of the consumers by providing proof of the sustainability claims. Interestingly, what the literature does not describe, but what appears from the findings, is that the majority of blockchain practitioners presume that blockchain contains the possibility to push other companies to act more sustainable, by creating greater transparency for consumers. Here, blockchain technology is considered from an optimistic stance and expressed as a force for positive change, which can stimulate the sustainability transition in the value chains. Remarkably, Hasse et al. (2016) describe that the security of blockchain is assured, due to the fact that data is stored encrypted and decentralised. Subsequently, the literature outlined that data cannot be tampered with, and the system is extremely difficult to corrupt (Atzori, 2015; Hasse et al, 2016). Contradictory with what was expected, is that findings illustrate that corruption is not entirely eliminated with blockchain. Although conventional standard and certifying data monitoring and control issues can be addressed to a large extent, the majority of experts indicate that the system is still susceptible to human-beings errors and fraud.

5.1.4 Collaboration is key

Conventional sustainability standards and certifications were found to take a collaborative approach to the existing problems in the global value chains. Nevertheless, Kim & Davis (2016) pointed out that the complexity of value chain networks creates a limitation for implementing standards, as it makes it difficult to outline the entire journey from sourcing to end product and to identify all involved actors along the chain. Additionally, Schneider at al. (2017) discuss that with wicked opportunity comes collaborative complexity. This is exactly what also describes blockchain technology, and both the possibilities and the challenges of blockchain in global value chains. The system is designed to establish equal collaboration in the chain, yet findings reveal that ensuring involvement of all actors remains the essential first step to achieve this. From the findings it can thus be argued that blockchain, to address the global value chain problems, is less a technical challenge, but rather a societal challenge. To deliver its thorough sustainable value to the chain and fill the institutional void, collaboration of each of the societal sectors remains a key condition. Thus, even if all privacy, technical and implementation challenges are faced and the technology is further developed, it all depends on the interaction and engagement of all stakeholders.

As identified in the literature, transparency depends on the balance of power between companies and social organisations, and their willingness to collaborate (Giovannucci & Ponte, 2005). Similarly, the research findings indicate that a key limitation to the implementation of blockchain technology is that there must be a willingness of all stakeholders to create transparency and share data with all actors involved. Subsequently, Head & Alford (2015) argued that the issue of a wicked problem is that there is no definitive statement of the 'problem' and there are multiple perspectives on the problem. Each actor that has a stake in the problem, holds a different perspective on what the best outcome and best solution should be (Head & Alford, 2015; Van Bueren, Klijn & Koppejan, 2003). The findings appear to be aligned with previous research on 'solutions' for wicked problems. Practitioners expressed that stakeholders might hold different perspectives on the level of transparency that is desired. Consumers want to see and know where the product comes from and what the farmer earned, while focal companies do not want to disclose their production places to avoid a loss of competitive advantage. This can create tensions that can prevent full market adoption, if not closely communicated and agreed upon the level of transparency when designing a blockchain, which requires strong collaboration.

In a perfect world, this entails a move from the current integrative partnerships of sustainability certification programs, towards so-called transformational partnerships. As Austin & Seitanidi (2012) and Van Tulder (2018) describe, this would imply a change in focus of balancing the interests of organisations involved, into partnerships that create interaction with all relevant societal stakeholders, to respond in an equal manner to the needs and resources of all stakeholders. This is heralded as a 'level 4' intervention in the societal triangulation, which demands collective action and open and inclusive innovation, together with consumers and stakeholders, to address the wicked societal problem, fill the trust gap and achieve the envisioned systemic change in the chains.

Thereafter, it could be argued that it takes brave and forward-looking parties that see this as a wicked opportunity, who have to take the lead and responsibility in further developing and implementing this technology, since these companies have the means and knowledge to stimulate this change. This would require companies to overcome the tipping point and move from a narrowly perspective of shareholder value creation to a broadly defined orientation of stakeholder value creations (Van Tulder, 2018). Though, as it was expressed, there are lots of risks and costs involved in the development and implementation of blockchain technology. Thus, for companies to engage in transformational partnerships evolving around blockchain, it is the (joint) responsibility of all actors to take their stake in sharing the risks. Thereafter, this reveals the importance of SDG 17, partnerships for the goals, as the facilitator to create more sustainable value chains and achieve the Sustainable Development Goals.

To conclude, as Head & Alford (2015) defined, wicked problems are mostly associated with multiple stakeholders, institutional complexity and scientific uncertainty. Blockchain technology as an approach to establish more sustainable global value chains is found to relate to all three aspects, making it at this moment in time, a solution-oriented approach with unknown outcomes (Van Tulder, 2018).

5.2 Research limitations

Although this research delivers valuable insights, there are also several limitations that need to be addressed. One of the key limitations of this research is that the phenomenon blockchain is a significant new technology that is still immature and in its early developing stage. The first implication to this is that academic literature on the subject is in its infancy, thus a coherent and consistent body of theory is lacking at this point in time. This is reflected in the literature review, in which the available scientific knowledge on the topic is supplemented with information from other sources, such as blog articles and white papers, as accurately as possible. Second, the novelty of the topic leads to the fact that there are little-recognised experts and few completely developed and established use-cases. Thereafter, the research results are accompanied with a lot of uncertainty and speculations and thus it may be argued that no clear and definitive statements are, nor could be, given at this time of research. As the research is of exploratory nature, it is not going into the greatest depth and generalisation of the results per value chain was not possible.

Additionally, the research design poses several limitations to the research. It can be pointed out that the number of conducted interviews (11) is a limitation to the research. A few challenges that emerged during the research process were both the overall lack of expertise available in the specific field of sustainability standards and blockchain technology, and the dependency on these experts. Unfortunately, due to time restrictions, the limited number of experts in the field and their unavailability, it was not possible to conduct more interviews in the given time frame. Further, not all targeted experts of the selected value chains were possible to reach. As a consequence, the sample did not truly reflect both perspectives in every value chain, which would have been the ideal situation, to compare both as well as possible. Also, the fact that per value chain only one or two interviewees reflected that specific value chain, poses a serious limitation to the research. Hence, the small sample captures the views from both perspectives and consists of an equal amount of blockchain and sustainability standard experts. This aligns with the explorative nature of the research and the subjective stance towards the topic.

Further, it should be noted that when collecting qualitative data through interviews, results are entirely based on subjective opinions and dependent on the experts' knowledge. This kind of research is always subject to biases. A side note on the reliability of the obtained data should be made here as well, as most of the blockchain practitioners were considered to be supporters of this technology. Despite this, it was found that most of them maintained a critical eye on the topic. Further, as blockchain technology is still in a developing stage technology, the knowledge of the experts can be incomplete. Additionally, it was difficult to interview the right people regarding the information I wanted to gather as not all of the interviewees were knowledgeable about both approaches, which would have been the idealistic situation.

Moreover, limitations to the reliability of data collection and analysis exist, since data was gathered and analysed solely by one researcher. In addition, the interviews were mostly not conducted face to face, which would have helped to establish common ground and create mutual trust. Though, this was not feasible, because the interviews were conducted with experts located in different countries, ranging from the UK to Malaysia. Moreover, the research design is composed of only one method and thus lacks triangulation to validate the data.

5.3 Implications for practitioners

The results of this study have led to several implications for practitioners. As this research explored the possibilities of creating more sustainable value chains through the application of blockchain technology, the findings can be insightful for practitioners in the field of blockchain and sustainability. The research may help to create a better understanding of the possibilities and limitations of a technological innovation to address sustainability issues and the conditions that are required for successful implementation. Moreover, it is advised to be not too optimistic about this technology as an approach to the problems, but to remain critical and maintain a holistic approach. Eventually, blockchain can connect the entire value chain and can establish trust amongst stakeholders, though it argued to be a highly complex shared database system, with quite some limitations at this time. Therefore, it should be deliberately questioned whether the complexity of blockchain is really necessary and providing the solution to the problem, or whether for example, another database technology will address the matter. It is advised to consider per case whether implementation of blockchain technology is beneficial, as the research identified various value chain specific challenges that are not per se addressed by this new technology thus far. Finally, the implications of blockchain technology in global value chains are dependent on the actual implementations and development of this technology.

5.4 Conclusion

This research was conducted to explore the claimed potential of blockchain technology and to identify whether or not this technology would be a suitable approach to address the wicked global value chain problems, in comparison to the conventional sustainability standards and certification approach. Blockchain technology and its implementation to value chains is a fairly new field of research, which explains the exploratory nature of this study. The research examined the following main research question:

Under what conditions is blockchain a better control mechanism to establish sustainable global value chains, compared to the conventional sustainability standards?

The contemporary era of globalisation and internationalisation has stimulated the development of complex and dispersed global value chains, from which various benefits have arisen. Despite this, several complex issues have emerged from the way the current global value chains are managed and controlled. These key issues include unfair and untransparent business practices and unequal distribution of value and power along the value chains, which created a significant ‘trust gap’. This ‘trust gap’, also referred to as institutional void, reflects the lack of ‘societal checks and balances’ and thus explains the necessity of having control mechanism to address the unsustainable global value chain practices and fill this institutional void. This is considered a ‘wicked problem’ as it involves multiple stakeholders, is associated with institutional complexity and comes with scientific uncertainty (Head & Alford, 2015). These global value chains represent an opportunity to foster economic, social and environmental sustainability, and this ambition has been formulated in Sustainable Development Goal 12: responsible consumption and production patterns. SDG 12 reveals that this ambition is both in the interest of business and society, therefore there is a joint responsibility for all actors to act upon this goal (UN Chronicle, 2015; Van Asperen & Van Tulder, 2016).

From an academic perspective, this research contributes to the existing theory in several ways. As previously stated, business and society are in search for solutions to address the complex sustainability challenges and to enhance sustainable development. While the UN stresses the importance of innovative technologies for sustainable development (UN ECOSOC, 2017; UNEP, 2015), the understanding of blockchains' potential for sustainability is far from established. As the literature seemed to show a gap in the possibilities and limitations of blockchain technology in creating more sustainable global value chains, this research explored the relationship between a new technology and whether this would be a suitable approach to address a wicked societal problem. Subsequently, the research identified two different control mechanism, conventional sustainability standards and blockchain technology, and compared these approaches to address the unsustainable global value chains problem and fill this institutional void. As blockchain technology and value chains lie at the interface of innovation, economy and society, advancing understanding on this topic aids in the dispersion of innovations that create sustainable value on all three dimensions of sustainability.

The research findings signify that blockchain should rather be seen as a complementary technological innovation to the conventional sustainability standards and certifications approach, instead of considering these two approaches as mutually exclusive solutions for the complex global value chain problems. First of all, blockchain will not eliminate the role of sustainability standard and certifying bodies. The findings indicate that blockchain is not a solution in itself, it will only help to digitise global value chain and create transparency. Though, it does not define when something could be considered sustainable farmed or produced, which still requires experts in the field to determine the required level of producing sustainably. Moreover, blockchain does not address the conventional standard problem of remediation, which refers to the necessary process improvements in case of non-compliance. It can create transparency, but this does not necessarily lead to more sustainable value chain practices. Hence, it is envisioned that blockchain might induce a shift in the role of standard and certifying organisations, more towards consultants or data brokers, who can stimulate implementation and adoption amongst stakeholders.

Nevertheless, the research findings demonstrate that blockchain has the possibility to be a better control mechanism to global value chains, as this innovative digital information system addresses several challenges of the conventional sustainability standards. First of all, blockchain can overcome the current legitimacy problems of conventional standards, due to the multiplicity of standards and labels that have emerged. Blockchains' element of transparency enables standards and certifying organisations to prove their sustainability claims towards consumers, which allows them to verify, track and trace these claims. Moreover, conventional standards are facing fraudulent activities related to the current organisations of monitoring and control of data. Blockchain creates a more secure, digital data storage system, in which all stakeholders of a value chain are empowered to share the responsibility on data control. This can address the fraudulent issues that occur due to the paper-based systems and the dependency on third-party verification. Moreover, blockchains' traceability attribute helps to identify hot spots within the value chain, where improvements need to be made to create more sustainable value chains. These attributes of blockchain all add up to the establishment of trust amongst value chain stakeholders, which serves an important role in economic exchange and cooperation and is therefore needed for society and economy to be successful (Ring, 1996; Sundaramurthy & Lewis, 2003). Thus, blockchain can be a better control mechanism in value transactions, when there is low trust between stakeholders. Though, it should be stated that blockchain does not eliminate trust, it shifts societal trust more towards technology.

Blockchain can be a solution to a few of the identified challenges of the conventional sustainability standards, hence it is expressed that it is certainly not a magical solution to all value chain problems. Several conditions were identified that will determine the success of blockchain. First, the effectiveness of blockchain is still depending on the involvement, participation and input of all actors along the value chain. This entails not only their willingness to create transparency and accurately share data, but also their capability to participate. The former condition remains a wicked problem, as the various actors in a chain likely hold different perspectives on what level of transparency would be desired. Moreover, as the findings indicated, fraudulent activities can still occur, as blockchain remains a database system that is relying on the correct and truthful input of people. Though, it will reduce fraudulent activities to a large extent, due to the transparency and involvement of all stakeholders. The unlikelihood of sufficient adoption largely determines the functioning of a blockchain network, but it is also debated if blockchain will exacerbate inequalities. Since Internet access is defined as a requirement to participate in the blockchain and the conventional problem of lacking resources and knowledge of smallholders in the value chain is not altered. Thereafter, it can be disputed if certain applications of blockchain technology will truly alter the power positions in the chain and provide change to the entire process, or whether opportunities arise only for the ones in a privileged position.

Finally, although it is argued that blockchain can be applied in every value chain where there is any flow of commodity or transaction between actors, the findings point to that there are specific contextual variety challenges, depending on the type of value chain. One of these findings revealed that verifying social conditions in value chains remains the role of sustainability standard and certifying bodies, as these aspects cannot be measured in an end product. Additionally, as the technology is still immature, its implementation is not yet established in highly complex value chains and further contextual challenges appear in value chains where commodities change shape.

Implementing a new technology to address complex societal problems is not necessarily a wicked problem, but rather a wicked challenge or wicked opportunity that comes with collaborative complexity. Blockchain requires the involvement of many different stakeholders and it challenges contemporary power relations. It demands incremental and adaptive change and comes with substantial uncertainty and unforeseen consequences. Consequently, it is associated with high-risk investments. Therefore, filling the trust gap that has emerged with blockchain will only work on the condition that there is collective action, which demands (joint) responsibility of all stakeholders involved to share the risks. Creating these transformational partnerships is an enormous challenge in itself. The sustainable value that blockchain can deliver must first entirely be understood and outweigh its limitations and conditions, before this technology will ever be fully accepted and established within our economy and society. Further development of collaborative use-cases and change management processes have to reveal the true implications of this technology.

This research has explored the claimed potential of blockchain technology as an approach to address the wicked sustainability problems in global value chains. Moreover, it indicated to what extent this technology contains the possibility for standard and certifying bodies to address the challenges they are currently facing. Though, more time and further research will tell if the future of establishing sustainable global value chains truly lies in blockchain technology.

5.5 Directions for further research

Besides its implications, this research provides several opportunities for future research. The conducted research concerns a fairly novel topic, in a rapidly evolving field. Therefore, further analysis is highly encouraged, especially more from a technological perspective, as new use-cases are currently being explored and (technical) issues are being solved. This research did not take the tertiary, service sector into account, which would be another interesting area of research. Further, as it became apparent throughout the interviews that certifying organisations are exploring blockchains' potential, an extensive case study in one of the value chains would be interesting, when applications are entirely implemented and at the time that blockchain is expected to reach its technological maturity. Such research could also provide recommendations, on whether blockchain truly is a sustainable solution in a specific case.

Moreover, it would be interesting to conduct further research on the way partnerships with blockchain are created and how these initiatives are governed, to gain more insight in the impact on the contemporary power relations in business and society. Further, it would be interesting to conduct more research on the topic from a more specific perspective, for example from a consumer point of view, to understand the needs and demands of consumers and explore if blockchain would actually create sustainable value for this stakeholder. A comparative case study in which blockchain and it is possibilities and limitations would be compared to another novel database that creates value chain traceability and transparency would also be an interesting area of research.

Additionally, another suggestion for future research is to study blockchain technology and its possibilities and limitations for creating sustainable value chains in combination with other innovative technologies mentioned during the interviews, such as the Internet of Things, Radio Frequency Identification and QR codes. Finally, it would be very interesting to conduct a comprehensive quantitative impact study, to ascertain its true effect on the sustainability of value chains, including the environmental footprint of the technology and the impact on the value distribution along the chains.

Although this research provides valuable insights, it will take time until we can tell with certainty how this technology will evolve and what actual impact it will have on business, society, the environment and the way we control the global value chains to ensure sustainability. Meanwhile, it can be concluded that much more research is needed, on both academic and practical level.

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7 Appendices

Appendix I Interview Protocol

Semi-structured Interview Guide
Introduction
• *General introduction of the researcher* • *Explanation of research project as deemed appropriate* • *Expectations (why, context, aims, duration)* • *Ask for consent to record the interview* • *Ask for introduction:* - Role of the person in [name organisation]? - What is your connection with sustainable global value chains? - In what way do you feel that there are currently sustainability problems within the global value chains?
Approach (Control medium 1): Sustainability standards addressing Global Value Chain problems
A common known and long-established approach to address these issues are certain sustainability standards and certifications - In what way do you believe that sustainability standards are addressing the **key problems** of global value chains? *Probe the following issues:* ○ the issue of unequal value distribution in the supply chain? ○ the demand for responsible practices? (transparency, traceability, visibility) ○ the value chain complexity / multi-stakeholder involvement which withholds sustainable value chains? ○ lack of trust in companies to establish sustainable value chains? ○ lack of governmental regulation to establish sustainable value chains? - Who is governing the sustainability standards, who is setting the standards? ○ What is the role of 'lead companies' in these standards? ○ How are these standards controlled? - Are there any **general limitations/challenges** with using sustainability standards as a control medium to establish sustainable global value chains *probe the following issues:* ○ Credibility legitimacy ○ Effectiveness, demonstrating the value ○ Monitoring challenges (3rd parties) ○ Implementation challenges (complex value chains) ○ lock-in effects and other economic issues (like lacking diversification) ○ What is the potential of these standards to really become 'mainstream' (i.e. cover the whole value chain rather than being a niche strategy - Are there any sector-**specific challenges**/limitations to 'your' sustainability standards / your field of expertise? *Probe:* ○ <u>Clothing&Apparel:</u> Transparency, unequal value distribution, child labour, counterfeiting (authenticity) ○ <u>Seafood:</u> traceability, quality & safety, unsustainable/illegal production practices, mislabelling ○ <u>Minerals</u>: Traceability, unsustainable sourcing, labour issues, conflict minerals

- Agriculture: Transparency, unequal value distribution, child labour, food quality,
- Forestry: unsustainable sourcing, environmental concerns
- Palm oil: transparency & traceability, unsustainable sourcing & production, child labour, human rights abuses
- Travel industry: intermediate fees, corruption in taxation
- Other?

Approach (Control medium 2): blockchain technology addressing the Global Value Chain problems

A relatively new approach that potentially can address these issues is blockchain technology

- Do you have basic knowledge of this technology? (if not explain what it is, score if they don't know this)

Blockchain technology is blockchain technology is a new type of database structure that can change the way we exchange value. It is decentralized, and records all transactions publicly, creating a shared online network. Additionally, all transactions are linked and secured, therefore they cannot be erased or changed later.

- In what way do you believe that blockchain technology is or can address the key problems of global value chains? *Probe the following issues:*
  - the issue of unequal value distribution in the supply chain?
  - the demand for responsible practices? (transparency, traceability, visibility)
  - the value chain complexity / multi-stakeholder involvement which withholds sustainable value chains?
  - lack of trust in companies to establish sustainable value chains?
  - lack of governmental regulation to establish sustainable value chains?
- Who is governing the blockchain, who is setting the standards?
- What actors are involved?
- How is this technology controlled?
- A typical problem related to 'technological solutions' for complex societal problems is that they create all sorts of unintended (negative) effects; (1) have you thought about that, (2) what effect can you envision and (3) how can these effects be mitigated?
- Can blockchain be applied in every sector (fee. apparel, agriculture, palm-oil, travel)? Where is it applicable and when or where not? Why?
- Are there any limitations/challenges with using blockchain technology as a control medium to establish sustainable global value chains? Context-specific?
- What would be the limitations/challenges of applying or using blockchain within your field of expertise? Why?

Comparing the possibilities and limitations of both (human/technical) approach

- What are the benefits of using sustainability standards over blockchain technology to ensure sustainable value chains, if there are any?
- What are the benefits of using blockchain technology over sustainability standards to ensure sustainable value chains, if there are any?

Ask any additional or missing information
Thank for the interview and ask if it is okay to send any further questions by mail

Appendix II Overview of subjects

Interviewee	Position	Organisation	Field of expertise
Interviewee I (Netherlands)	Co-founder blockchain startup and consultant	Independent Project Design & Research	Blockchain
Interviewee II (Netherlands)	Sourcing & Development Manager	Fairtrade Original	Sustainability standards: Agriculture value chain
Interviewee III (United Kingdom)	Consultant/project manager blockchain technology for charities, NGOs and social enterprises	Delft University / Humanity X (Centre for Innovation, Leiden University)	Blockchain
Interviewee IV (Bulgaria)	CEO & Co-founder	ReCheck Blockchain start-up	Blockchain
Interviewee V (Netherlands)	International Verification Coordinator	Fair Wear Foundation	Sustainability standards: Clothing & Apparel value chain
Interviewee VI (India)	CEO blockchain start-up, expert	Rights Origin (cocoa fair chain)	Blockchain & sustainability standards (agriculture value chain)
Interviewee VII (Netherlands)	Commercial and Fisheries Manager	Marine Stewardship Council	Sustainability standards: seafood & fisheries value chain
Interviewee VIII (Denmark)	Senior Officer, Digital innovations FSC Global Development	Forest Stewardship Council	Sustainability standards: forestry value chain
Interviewee IX (Ukraine)	Project Manager & Marketing Analyst	Ambrosus, blockchain	Blockchain (specifically supply chains)
Interviewee X (Malaysia)	RSPO Special Projects Director	Round Table of Sustainable Palm Oil	Sustainability standards: Palm Oil
Interviewee XI (Sweden)	Research Assistant	Lund University	Blockchain & Sustainability standards

Further appendices available on request