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ANDREI HERASIMAU

BLOCKCHAIN TECHNOLOGY AND GOVERNANCE IN THE GLOBAL VALUE CHAIN OF THE DIAMOND INDUSTRY: A CASE STUDY

RIO DE JANEIRO

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Master's dissertation presented to the Instituto COPPEAD de Administração, Universidade Federal do Rio de Janeiro, as part of the mandatory requirements in order to obtain the degree of Master in Business Administration (M.Sc.).

Supervisor: Prof. Leonardo Marques, PhD.

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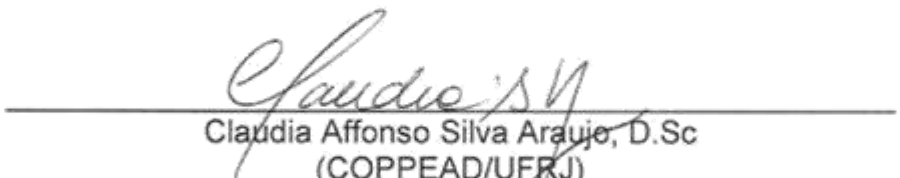

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Abstract:

The business in the 20th century has been mainly driven by trade globalization and the Internet. Global trade has led to the creation of complex supply chains in different industries all over the globe, while the Internet made it possible to effectively exchange information between the participants. The issue of governance in supply chains is of high importance and has been of great interest of many researchers and practitioners from the supply chain field. In the 21st century, blockchain technology emerges as a potential driver of the further development of businesses. Blockchain technology is considered to be a new way how companies have control over material and information flows in their supply chains. This research is carried out as a case study in the diamond industry since it is a first mover on the adoption of this technology. This study investigates the impact that blockchain initiatives can have on this industry and its supply chain. The case study shows that governance in the global diamond supply chain will highly likely move from relational to captive type, which means power shift towards the lead firm and more control exercised over the supply base. This finding points out to blockchain potential in affecting supply chains, which should be studied in other largely dispersed industries that make transparency and traceability key elements in the management of supply chains.

Key words: blockchain, global value chain, governance, supply chain, diamond industry

1 Introduction

Today we live in the globalized world and the global trade has shaped supply chains, which are characterized by high complexity and large geographical spread (JOHNSON, 2006). Complex and large supply chains need effective supply chain management to grant companies a competitive advantage over the rivals since the competition is no longer between organizations, but among supply chains (LI et al., 2006). In the competitive environment, a company's supply chain may be vulnerable and be considered its Achilles' heel (KOLLENSCHER; RONEN; COMAN, 2014). Companies need to take much care about their supply chains in order to succeed and avoid jeopardizing relationships with the clients. The infamous Sialkot industrial area in Pakistan had had an issue of child labor exploitation for decades before it attracted the NGOs and public attention in the 1990s (INTERNATIONAL LABOUR ORGANIZATION, 1997). As a result, a huge public concern in the Western developed countries led to a campaign against child labor in football-stitching industry in Sialkot (NASEEM, 2010). Another case is the horse meat scandal of 2013 in Europe that raised a huge concern about traceability in food supply chains (EFRACOM, 2013). It had very negative consequences for the UK retailers. The food products advertised as containing beef were found to contain horse meat instead. Further investigation revealed pork in beef products which also raised an issue for Muslim and Jewish communities. As a consequence, some UK retailers, like Tesco, had to recall tens of thousands of its products from the shelves. However, apart from direct financial losses the scandal led to a drop of Tesco's market value after the decline of share price (WILLIAMS, 2013). The situations above could take place because there was no traceability in supply chains of sports brand companies and retailers. These examples also show how crucial it is for companies to be able to trace their supply chains and to guarantee that the suppliers meet social and environmental standards required by consumers. Traceability turns out very important to maintain and enhance relationship with end consumers.

A growing consumer awareness of the importance of embedding sustainability within supply chains lead companies to reconsider their supply chain strategies. Companies face risks associated with sustainability and social responsibility during the process of manufacturing, packaging and transportation. This reflects the necessity of managing supply chains in a sustainable manner and points to the need for greater transparency and traceability of supply chain processes (GIANNAKIS; PAPADOPOULOS, 2016). Thus, traceability in today's

business environment plays an important role in companies' strategies, especially if their supply chains are global.

Global supply chains being dispersed in different countries and even continents are often longer and more complex than if they were local. The flow of materials from the uppermost supplier to the final consumer usually takes more time and passes through a greater number of intermediary suppliers. The longer the supply chain, the harder it is to track the material and information flow in it. To address this problem, companies can resort to information technologies that are more sophisticated now than they were at the time of the Sialkot scandal.

Traceability is often enabled by information technology (IT). IT can offer a means for competing in a globalized business environment, since it is a way to meet the global market consumers' requirements. According to Briggs (2015, p.68) *"companies today consider information technology (IT) as an effective tool to control and manage the complex supply chains as well as improving efficiency and logistic operations, while remaining responsive to changing customer demands and market situations"*. Among the latest ITs available and emerging in the business world a particular place belongs to blockchain technology.

Blockchain is a form of distributed ledger technology consisting of "blocks" of information. Each "block" contains a record of the transactions that occur within a network and it is encoded with a "hash", or arithmetically produced code which is generated from the data contained within the block (WHITE, 2017). To add a new block, or validate transactions, there should be the consensus of the majority of the participants which guarantees integrity of information about transactions. White (2017, p.440) says "*This makes it extremely difficult to falsify new or existing parts of the blockchain, since the hash of a previous block determines, in part, the hash of future blocks. In order to change one block, the entire blockchain would need to be rewritten.*" Blockchain is an IT that may cause major disruptions in the way supply chains are organized and managed and which can provide businesses with traceability and transparency they need to compete.

Today many major companies in various industries understand a disruptive character of the blockchain technology in the nearest future and the need to adapt to it in order to prevent loss of competitiveness (DELOITTE, 2017). Blockchain technology is seen by researchers as one of the promising solutions to burning issues in the area of supply chain management, like

securing assets transfer and ensuring delivery of goods and services to the recipients and customers (TILL et al., 2017; CASEY; WONG, 2017). Apart from being a disruptive technology, blockchain is also viewed as an institutional technology. Unlike a general-purpose technology, where the main effect is to provide productivity gains, institutional technologies introduce a new mode of economic coordination and governance. Blockchain is argued to drive economic evolution from the perspective of the evolution of economic institutions (DAVIDSON; DE FILIPPI; POTTS, 2018).

The purpose of this research is to understand how the blockchain technology can reshape relationships between different stakeholders and make governance shift in global supply chains. In the light of the above discussion, the following research question, and three sub-research questions were formulated:

RQ1: How can blockchain technology influence governance and power asymmetry in a global supply chain?

RQ1a: How can blockchain technology affect the complexity of transactions in a global supply chain?

RQ1b: How can blockchain technology affect the ability to codify in a global supply chain?

RQ1c: How can blockchain technology affect the capability of the supply base in a global supply chain?

This study is conducted in the diamond industry, an exemplar where risks are high and the value of transparency is promising. The diamond industry is quite mature, and its supply chain includes exploration, extraction, sorting, distribution, wholesale, polishing, jewelry and retailing. Figure 1 shows the diamond industry pipeline.

Figure 1. Diamond industry pipeline. Source: http://www.botswanadiamonds.co.uk

This industry is very attractive by the fact that there is a long process of huge value creation along its supply chain from around $13 billion in rough diamond sales to $72 billion in the world's diamond jewelry demand with a few major players controlling the rough diamond production (WORLD DIAMOND COUNCIL, 2017). The demand for rough diamonds is expected to grow 1% to 4% annually through 2030 with USA, India and China as major engines of the growth (BAIN & COMPANY, 2017).

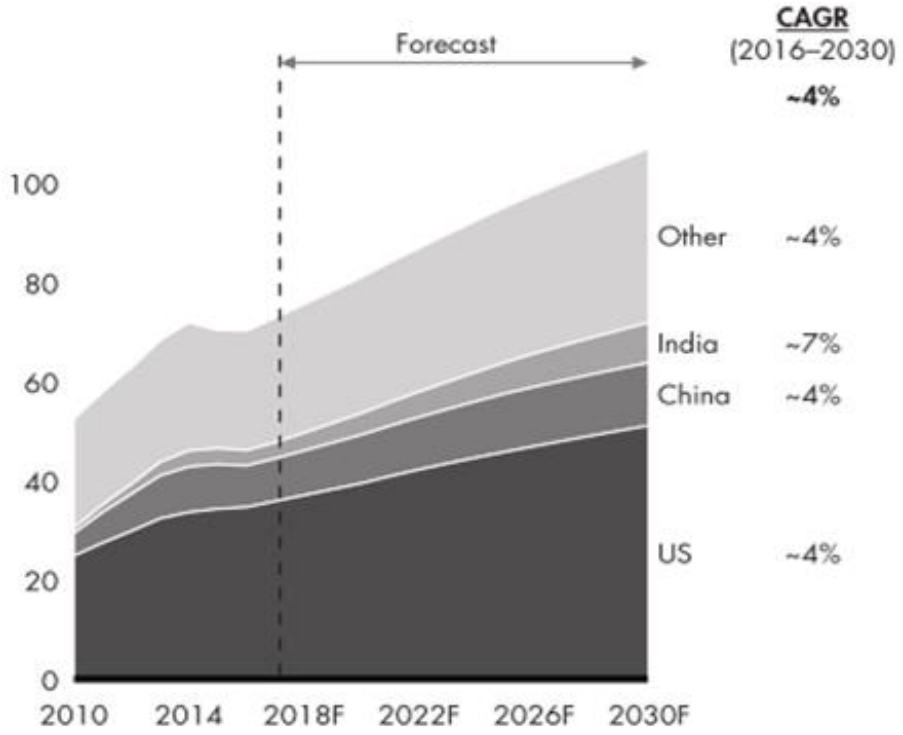

Figure 2. Diamond jewelry demand, $ billions, 2010 – 2030, optimistic scenario. Source: Bain & Company

The diamond industry similar to what it is now appeared in the end of the 19th century after the foundation of De Beers company. De Beers controlled the world diamond production through the first half of the 20th century up to 1970s when it began to face a fierce competition by national producers from Canada, Australia and U.S.S.R.

Today the rough diamonds market is highly concentrated with three major producers controlling the supply. They are ALROSA, Rio Tinto and De Beers that together hold the market share of around 70%. De Beers' rough diamond production is concentrated mainly in African countries like Botswana, Namibia and South Africa, though it also has facilities in Canada, while ALROSA operates in the Yakutia region of Russia. The supply control allows the producers to exercise high power over the cutters, polishers and wholesalers. The cutters and polishers are the ones who are struggling to reap at least some value in the whole process of value creation but with profit margins of just 5% they cannot exercise power over retailers and rough diamond producers, whose margins reach 40-60%.

The lead firm in this case study is De Beers. It was the only company from the diamond industry and one of the few companies, along with Walmart and Visa, that publicly announced in the end of 2017 about its plan to introduce blockchain into its supply chain. De Beers plays a double role in its supply chain: rough material supplier and brand retailer. Except for cutting and polishing, it is practically in each stage of the value creation process from mining to retailing. De Beers sells rough diamonds to its sightholders, or authorized buyers, and then gets back some part of cut diamonds to retail them through its two own brands: Forevermark and De Beers Jewellers. Because of the described above nature of this business, where only authorized companies can buy raw materials from a few producers, the complexity of transactions must be high. Selling rough diamonds to a certain number of buyers certain times per year through closed exclusive events makes transactions complex by definition. Other requirements like Kimberly process, a multilateral trade regime established in 2003 with the goal of preventing the flow of conflict diamonds, which is imposed on every single participant in the global diamond trade, add complexity to transactions between parties as well. It is not a free market where any buyer can find a supply at any time from a big number of suppliers, like what happens in the international commodity markets.

This research consists of five sections including this introduction. The following section presents a review of the literature covering the development of the supply chain management, the global value chain framework, traceability and provenance in them and blockchain

technology as a possible solution. In the section three the research methodology and data collection method will be presented. Further sections will cover data analysis, reflections and discussions of the results using the theoretical framework. The conclusion with theoretical and managerial implications and further research suggestions will close this research.

2 Literature review

This section covers three areas of knowledge. It starts with the background of supply chain management, then discusses the global value chain framework, and finally the blockchain technology and its potential applications in global supply chains.

2.1 Supply chain management

Supply chain management (SCM) concept was born and coined at the consulting firm Booz, Allen & Hamilton in 1982 by Keith Oliver (HECKMANN; SHORTEN; ENGEL, 2003). In the beginning, one of the first applications of SCM was to provide pragmatic and essentially modern approach to logistics. (HOULIHAN, 1983)

Many definitions have been given to SCM. Cooper et al (1997, p. 2) say that SCM appeared as a development of Logistics Management and define it as *"the integration of business processes from end user through original suppliers that provides products, services and information that add value for customers"*. Characteristics of SCM as an approach that differentiate it from other channel relationships can include inventory management, cost efficiencies, time horizon, amount of mutual information sharing and monitoring, joint planning, speed of operations, etc. (COOPER; ELLRAM, 1993). This research is based on the definition by Gibson et al. (2005, p. 22), stating that SCM "*encompasses the planning and management of all activities involved in sourcing and procurement, conversion, demand creation and fulfillment, and all Logistics Management activities. Thus, it also includes coordination and collaboration with channel partners, which can be suppliers, intermediaries, third-party service providers, and customers. In essence, Supply Chain Management integrates supply and demand management within and across companies*". SCM is a way to manage the demand and supply and meet them together. It allows to look at different factors which define supply chain structure (GIBSON; MENTZER; COOK, 2005).

The structure of supply chains depends on many components. Lambert et al. (1998) proposed three primary aspects of supply chains structure: 1) the members of the supply chain;

2) the structural dimensions of the network; 3) the types of processes and links across the supply chain. Increased competitiveness in the market of developed countries in the end of the 20th century forced many industrial manufacturers to seek cost reduction by outsourcing and offshoring a great part of its production activities to developing countries. This strategy reduced costs but increased risks in supply chains by introducing new members from developing countries, changing structural dimensions and modifying processes and links across new supply chains. The supply chains became longer and globally dispersed with new participants from developing countries in them. Large geographical spread of supply chains added complexity and challenges to manage them efficiently both from operational and strategic perspective.

Besides managing flow of goods and services downstream the supply chain, SCM also controls and monitors flow of information up and downstream the chain, as seen in Figure 3. In the early 2000s some SCM research works reflected the importance of sophisticated information technologies (IT) in order to maintain the two-way flow of information in supply chains by showing sufficient correlation between companies' IT capabilities and the overall product quality, companies' performance, and customer relationships (TAN, 2002).

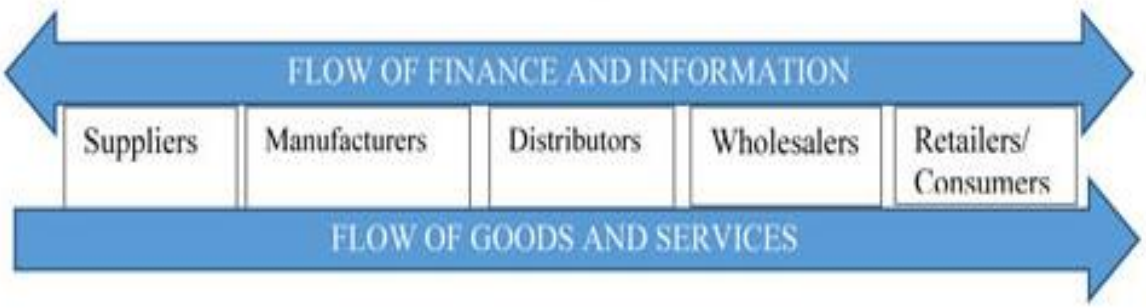

Figure 3. Flow of goods and information in the supply chain. Source: (BRIGGS, 2015)

In today's global trade relations paradigm with supply chains becoming more complex and geographically distributed, the essence of keeping them flexible makes firms constantly monitor their supply chain partners closely through information flow. This makes it more evident that without information and information technologies (IT) no supply chain can be effective and efficient (BRIGGS, 2015). However, not only operational efficiency is of great importance when structuring supply chains.

Cox (1999) argues that many supply chain researchers pay attention only to operational aspects of supply chains rather than those of strategic importance. He states that for a success

and survival of a business it has to understand how to "appropriate value". The process of value appropriation goes along with exercising power in relationships between the focal firm and its suppliers and customers. According to Cox (1999), the issue of governance in such global supply chains became critical in value appropriation. To be able to understand governance and eventually value distribution in global supply chains we need to resort to the global value chain framework.

2.2 The global value chain framework

The notion "global value chain" (GVC) appeared after some scholars (GEREFFI, 1994) studied global commodity chains and developing countries' role in them. Two distinct types of governance structures in the global commodity chains (GCCs) emerged in the past which gave names to the GCCs as "buyer-driven" and "producer-driven". In buyer-driven global commodity chains design-oriented brand companies, which usually operate in the sector of consumer goods, apparel or footwear such as Nike, Reebok, Apple, etc. control the chain, retrieve the most value and usually do not own production facilities (GEREFFI, 1994). On the contrary, producer-driven GCCs refer to those industries in which multi-national corporations (MNCs) or other large integrated industrial enterprises play the central role in controlling the production system. This is mostly a characteristic of capital- and technology intensive industries like automobiles, computers, aircraft, and electrical machinery. The geographical spread of these industries is transnational. International subcontracting of components is common, especially for the most labor-intensive production processes. What distinguishes "producer-driven" production systems is the control exercised by the administrative headquarters of MNCs (GEREFFI, 1994). The author draws parallel and sees relations between the type of a commodity chain and economic development strategy of a country, i.e. import-substituting industrialization strategy tends to exist in producer-driven global commodity chains, while export-oriented industrialization strategy is often seen as part of buyer-driven GCCs.

On the basis of GCCs the notion of GVCs emerged later. Authors like Humphrey and Schmitz (2001) introduced the idea of governance as the central to the global value chain approach. At the same time Gereffi (2001, p. 30) says that "*of particular importance in global value chains is the issue of governance, which refers to the key actors in the chains that determine the inter-firm division of labor, and shape the capacities of participants to upgrade their activities*". The term governance was used to explain that some firms in the chain set and enforce the parameters under which others in the chain operate. Basically, a chain without any

governance is just a free market with market relations. The authors also point out the leverage points for exercising policy initiatives. Because of the governance strength of lead firms, at some point or under some condition, i.e. if the government agencies require some standards compliance, they can exercise pressure on suppliers to raise environmental, ethical and labor standards.

The positive point of a highly governed structure in supply chains can be the fact that the agents external to the chain imposing some requirements do not need to require this from each and every supplier but only from the lead firm which results in improvement of layout and production flows as well as raises local workforce skills. To be sure that parameters from the buyer to the supplier in the chain meet the requirements, usually the inspection of external agents like NGOs or independent monitors is needed. (HUMPHREY; SCHMITZ, 2001). This can be seen on the example of the Sialkot scandal where Western NGOs put pressure on the lead firms. As a result, Nike had to exercise power in its supply chain and demand labor compliance from Pakistani hand-stitched balls manufactures removing those who could not meet this requirement (NASEEM, 2010). The Sialkot case shows how power asymmetry in Nike's supply chain eventually led to a positive effect on labor standards compliance.

The theory of governance in GVCs helps explain how global supply chains are organized and managed. According to the theory there are three factors which characterize the governance in global supply chains: i) complexity of transactions, ii) ability to codify transactions and iii) capability of supply base.

According to Gereffi et al. (2005, p. 85), complexity of transactions refers to "*complexity of information and knowledge transfer required to sustain a particular transaction, particularly with respect to product and process specifications*". For complex products and those which require specific standards the complexity of transaction is usually higher. With an increase of complexity of transactions, there must be more coordination by the lead firm.

Ability to codify transactions is the *"extent to which this information and knowledge can be codified and, therefore, transmitted efficiently and without transaction-specific investment between the parties to the transaction"* (GEREFFI; HUMPHREY; STURGEON, 2005, p. 85). Nadvi (2008) says that through implementation of standards the ability to codify transactions can be improved. Higher ability to codify transactions through existence of technical standards requires less coordination by lead firms which means a shift from relational

and hierarchical to modular or market-based forms of governance. However, Nadvi (2008, p. 10) also points out that codification through standards will not necessarily result in a clear move from more to less coordination by lead firm, because it will depend "*on the standard, the form of compliance monitoring and the risks for lead firms associated with compliance failure*".

Capability of supply base shows whether a supplier can meet the requirements imposed by lead firms. Gereffi et al. (2005, p. 85) define it as "*the capabilities of actual and potential suppliers in relation to the requirements of the transaction*". Companies which do not have special expertise or specific production assets or technologies cannot exercise power in their supply chains and are subject to coordination by lead firms. On the contrary, when a supplier has a technical capability to create a product required by a client and there is a small number of such firms in the market, it leads to more bargaining power for the supplier.

Having three factors and two values of high and low, theoretically 8 different types of governance can exist. However, Gereffi et al. (2005, p.86 - 87) were able to identify only five of them:

1. Markets. Market linkages do not have to be completely transitory, as is typical of spot markets; they can persist over time, with repeat transactions. The essential point is that the costs of switching to new partners are low for both parties.
2. Modular. Typically, suppliers in modular value chains make products to a customer's specifications, which may be more or less detailed. However, when providing 'turn-key services' suppliers take full responsibility for competencies surrounding process technology, use generic machinery that limits transaction-specific investments, and make capital outlays for components and materials on behalf of customers.
3. Relational. It is characterized by complex interactions between buyers and sellers, which often creates mutual dependence and high levels of asset specificity.
4. Captive. Small suppliers are transaction- ally dependent on much larger buyers. Suppliers face significant switching costs and are, therefore, "captive". Such networks are frequently characterized by a high degree of monitoring and control by lead firms.

5. Hierarchy. This governance form is characterized by vertical integration. The dominant form of governance is managerial control, flowing from managers to subordinates, or from headquarters to subsidiaries and affiliates.

Each governance type provides a different trade-off between the benefits and risks of outsourcing (GEREFFI; HUMPHREY; STURGEON, 2005).

Table 1. Key determinants of global value chain governance. Source: (GEREFFI; HUMPHREY; STURGEON, 2005)

Governance type	Complexity of transactions	Ability to codify transactions	Capabilities in the supply-base	Degree of explicit coordination and power asymmetry
Market	Low	High	High	Low
Modular	High	High	High	
Relational	High	Low	High	
Captive	High	High	Low	
Hierarchy	High	Low	Low	High

Table 1 shows that market governance type and hierarchy are two extreme cases where explicit coordination and power asymmetry exercised by lead firms goes from the lowest to the highest degree. Also, governance in supply chains is a characteristic which is not static but that can change over time. Gereffi et al. (2005) talk about these dynamics in GVC analysis. For example, moving from the market to hierarchy governance type, which are two extreme cases, leads to the complexity of transactions getting high, the ability to codify transactions getting low and a decrease in the capability in the supply base along with concentration of power and coordination in the hands of the vertically integrated firm. The opposite, i.e. shift from the hierarchy to the market, is true as well which, for instance, the bicycle industry saw in the 20th century (GEREFFI; HUMPHREY; STURGEON, 2005). Many changes in the way how companies did their businesses and reached customers happened due to an increased role of IT in the global business environment.

In the times of the early stages of development of the Internet some authors noticed that the rise of such a disruptive new technology gave potential to some companies like Oracle, Ariba, Commerce One and others to transform their traditional supply chains and become key players in the rapidly emerging B2B marketplace. The efforts of companies like Covisint,

operating in the automotive industry and providing B2B services on the Internet, led to "substantial realignments in the relative power and profitability" in future supply chains (GEREFFI, 2001).

A joint venture named Covisint began in 2000 as a form of cooperation between the largest automakers in the USA that combined the purchasing activities of General Motors, Ford, Daimler/Chrysler, Renault, Nissan and thousands of their suppliers. Initially designed to lessen procurement costs by means of online auction platform, Covisint reshaped the global car supply chain by "*loosening tight vertical structures which used to bind the majority of parts suppliers to specific manufacturers*", and strengthening large and technologically advanced global suppliers that "*became preferred partners in all the major automakers' supply chains*" (GEREFFI, 2001, p.37).

Gereffi (2001) predicted that the impact of the Internet in both B2B and B2C transactions would be captured and integrated into the business practices of the major manufacturers, retailers and marketers in diverse industries. The fact that today many producers made a complete or partial shift from "bricks to mortar" to "click to mortar" in their supply chain and mass customization approach demanded by customer leads to a suggestion that the introduction of blockchain in B2B and B2C marketplace could also realign power and profitability in global supply chains.

2.3 Blockchain technology

The way the companies and organizations do business today can be reshaped in the nearest future. After the invention of the internet and its later advent to the mass use in early 1990s the next technology which may have such a big disruptive potential in a variety of industries is blockchain (WHITE, 2017). Since blockchain first application was a cryptocurrency, in the beginning it was seen as a key disruptor across the financial services industry (SCOTT; LOONAM; KUMAR, 2017).

Considering blockchain as a disruptive technology, it can be said that some authors claim that innovation in supply chains can bring some participants above normal margins. It depends on who innovates and who controls the supply chain. Usually the value generated downstream through the supply chain is often captured by lead firms which control the whole

chain (DEDRICK; KRAEMER; LINDEN, 2010). This kind of supply chains is similar to what Gereffi (1994) calls “buyer-driven chain”.

Blockchain was pioneered by an anonymous author or group of authors named Satoshi Nakamoto whose idea behind this technology was to have an ability to not rely almost exclusively on financial institutions serving as trusted third parties to process electronic payments. The first application of blockchain was cryptocurrency named Bitcoin which served as a peer-to-peer payment system. Bitcoin allowed to make transactions which did not depend on a third trusted party and proposed a solution to the double-spending problem using peer-to-peer network (NAKAMOTO, 2008).

Blockchain has a decentralized and distributed data architecture. It is a data ledger which stores records of transactions and is not controlled by anyone (ADAMS et al., 2017). The idea behind the blockchain is to remove the need for a trusted third party in order to guarantee a transaction. To put it simply, it is a public or private ledger, or database, with just a more modern way to map out the actual transfer and ownership of assets and to keep records about it (PILKINGTON, 2016). Decisions on modification and approval inside this “cryptoweb” are based on distributed consensus on validation of transactions without participation of third parties by providing simple rule sets. This radically reduces bureaucracy and, thus, all transaction-related costs, replacing traditional intermediary top-down structured organizations with machine consensus. The rule sets of the consensus layer allow a much simpler coordination of a disparate group of people who do not know or trust each other (SHERMIN, 2017).

In the digital world big platforms like Amazon, Facebook, AirBnb, etc. act as third-party regulators and charge somehow one or all platform participants. All of them are trusted third parties who perform their governance-like functions at a certain cost borne by the participants. Blockchain is a novel solution to the age-old human problem of trust. Blockchain offers a peer-to-peer network of users whose contracts will not depend on third parties and where all the members of the network maintain a distributed, shared, trusted, public ledger of transactions which everyone can inspect, but that no single user controls (SHERMIN, 2017).

Vitalik Buterin, who is a co-founder of Ethereum, a decentralized platform built on the blockchain technology, calls blockchain ledger as a state transition function. The “state” can express possession of anything: money, property, identity, etc. He also gives an example of state in the banking system as a balance sheet. A transaction of state means to debit one

participant in favor of another (BUTERIN, 2014). Another definition of blockchain is a “magic computer”. Anyone can upload programs on it and leave the programs to self-execute, where the current and all previous states of every program are always publicly visible. As blockchain allows applications to run on it, it helps convince the users of the applications that the logic is transparent and that they are doing what was advertised. Blockchain gives a high degree of availability of data stored on it and reliability that the applications will talk to each other. Applications built on blockchain can be used to guarantee identification and reputation of individuals on the basis of historical data of transactions. This can benefit hundreds of millions of users (BUTERIN, 2015).

Another potential application of blockchain is a smart contract. The idea behind the smart contract is a protocol with user interfaces to formalize and secure relationships over computer networks. Many kinds of contractual clauses (such as collateral, bonding, delineation of property rights, etc.) can be embedded in the hardware and software we deal with (SZABO, 1997).

Wheeler (2017) analyzing Mcneil’s theory of contract states that the absence of a single point of control or authority gives each user of the blockchain a very high level of trust in the instrument itself. He uses an example of house and room rentals in sharing economy such as Airbnb as a potential application of blockchain technology in a form of a smart contract which would allow the host to opt for an insurance policy, the terms of which are locked, date-stamped and uploaded to a distributed ledger. Once on the ledger, the policy cannot be amended or duplicated and can be viewed by host, guest and underwriter (WHEELER, 2017).

However, there are concerns regarding the core of the blockchain technology – decentralization. An example of Ethereum, an open-source, public, blockchain-based distributed computing platform, shows that even the idea of total decentralization can be in a certain way a subject to modification, since Ethereum has a centralized institution in the background, the Ethereum Foundation, which can or maybe does regulate some aspects and still can be held accountable before national regulators (SHERMIN, 2017). This means that blockchain can have distributed governance which relies on a number of agents who must be trusted to ensure the operations of the network – those include the developers of the software, the miners validating the transactions and, more generally, all the active participants in the network. A perfectly trustless technology without having to trust anyone and still having the system working is nothing more than an ideal (FILIPPI, 2016).

There are also certain risks related to the very nature of blockchain. Some of them are (LI, Xiaoqi et al., 2017):

- vulnerability issue, which theoretically can occur if a single miner's hashing power accounts for more than a half of the total hashing power of the entire blockchain needed to validate transactions;
- criminal activity, since blockchain allows users to hide identity and can be used to exchange assets for illegal purposes;
- security issues caused by flaws in design which can lead to leakage of transaction private data and other attacks

2.4 Blockchain in global supply chains

Blockchain has a potential to be used as an innovative technology in global supply chains and networks by means of embedding the structure which may be used to share the vital information among the members and track and record global shipments (WHITE, 2017). Here provenance of products and traceability of transactions can play an important role for all the participants of supply chains.

A power shift and profitability realignment can be caused by a growing concern from clients and end consumers in many supply chains about the provenance of products and compliance with ethical and environmental standards in the process of manufacturing, packaging and distribution of goods and services. Gallenti et al. (2016) show this in their study on the example of consumers' concern about fair trade and provenance in the coffee supply chains.

In fact, firms build traceability systems to improve SCM, increase safety and quality control and track the provenance. They can market food with credence attributes, i.e. attributes that are difficult for consumers to detect, such as whether a food was produced through genetic engineering. The benefits associated with these objectives include lower-cost distribution systems, reduced recall expenses, and expanded sales of high-value products. In each case, the benefits of traceability translate into larger net revenues for the firm (GOLAN et al., 2004). Thus, one of the applications of blockchain can be development of traceability systems, where the data are immutable and stored unchanged since the moment of registration in the ledger.

This would allow firms to gain competitive advantage through a big differentiation over the rival companies.

As Gereffi et al. (2005) mentioned, governance in supply chains is not a constant, because it can change over time. Implementation of standards can lead to a shift in the governance mode. Especially in technical products, introduction of process standards improves the ability to codify information which can shift the governance type from relatively hierarchical forms to more modular or market-based which results in less coordination by lead firms in global supply chains (NADVI, 2008). Yet Nadvi (2008) argues that in some supply chains, like horticulture, standards codification appears to have not moved universally the governance mode towards modular or market-based. In the light of this the blockchain technology can be used as a useful tool to facilitate introduction and compliance of standards in supply chains which eventually can shift the type of governance. Thus, ability of blockchain to enhance traceability and provenance can also change the degree of explicit coordination and power asymmetry in global supply chains.

If lead companies that have the power concentrated in their hands adopt blockchain solutions from third party stakeholders or develop them themselves in-house, it can change the status quo through a downgrade in capabilities of suppliers to respond to the downstream requirements on traceability and provenance. In the same way blockchain can improve lead companies' ability to codify the product specifications through specific standards which can lead to a shift in power asymmetry and change in governance.

Additionally, an existing gap in the SCM literature was identified. It relates to potential implications of the blockchain technology on SCM from the perspective of several theories (TREIBLMAIER, 2018). This research will try to respond to Treiblmaier's "*call for action*" by studying a possible impact of blockchain in supply chains from the perspective of the GVC theory.

In order to address the sub-research questions mentioned in the introduction, this study will look for three variables – complexity of transactions, ability to codify and capability of supply base, since according to the GVC framework, the combination of these parameters defines the type of governance and indicates to what degree lead firms can enjoy power asymmetry over their suppliers. The variables can be found in Table 2. The study will try to reveal the current governance type that exists between the lead firm and polishers in the

diamond supply chain. Then a projection about a possible governance shift in case of blockchain introduction will be made.

Table 2. Sub-research questions and variables derived from the GVC governance framework

Sub-research question	***Variable***
RQ1a: How can blockchain technology affect complexity of transactions in a global supply chain?	complexity of transactions
RQ1b: How can blockchain technology affect ability to codify in a global supply chain?	ability to codify
RQ1c: How can blockchain technology affect capability of supply base in a global supply chain?	capability of supply base

The variables chosen for the study are quite common among researchers who fully or partially utilize the GVC framework by Gereffi et al. (2005) in their research. For example, Vik and Kvam (2017) use the methodology of case study and semi-structured interviews for data collection and explore such variables as "complexity of transactions", "ability to codify" and "capability of supply base" in the whey protein supply chain in order to define the governance type between protein producers and suppliers. Te Velde et al. (2006) use the same approach while analyzing entrepreneurship of non-timber forest products. However, partial applications of the governance framework also take place. De Vasconcellos et al. (2015) use "capability of supply base" in their methodological framework as the specific variable that plays a role in the GVC dynamics.

3 Methodology

In this section the research method will be chosen. According to a survey made by Deloitte (2017), blockchain technology is entering or at least on its way to penetrate and disrupt various industries and is still little understood as a phenomenon which can bring such changes like new business models and revenue streams, better security, lower cost and greater speed of transactions. Since blockchain in supply chain is a phenomenon which has been little explored and understood, Creswell (2014) recommends qualitative approach as an appropriate way to cover this research study.

3.1 Research design

In order to choose the appropriate design for this research work authors like Yin (1994) recommend to define first the type of research question. Based on this, the questions which tend to ask “how” and “why” led to case study research design. Case study design serves as an empirical inquiry to investigate a contemporary phenomenon within its real-life context. Such a research strategy allows to cover the contextual conditions which might be pertinent to the phenomenon of study (YIN, 1994).

Case studies help not only explore some phenomenon, but also find causality and explain contemporary events when the researcher does not have control over the relevant behaviors involved. In order to understand the effect of the phenomenon of blockchain on a supply chain, the case study’s strength is its ability to deal with a full variety of evidence – documents, artifacts, interviews, and observations (YIN, 1994).

According to Yin (1994) a good case study design might include five components:

1. The study’s questions
2. The study’s propositions based on theoretical framework
3. Unit of analysis
4. The logic linking the data to the propositions
5. The criteria for interpreting the findings

Yin (1994) advices using some theoretical framework or at least a sufficient blueprint to embed into the research design. He highlights that this will help come up with theoretical propositions of the study and will provide a strong guidance in determining the appropriate research design. A theoretical framework also will be useful in understanding what data to collect and which strategy to apply for analyzing the data. According to him, it will become “*the main vehicle for generalizing the results of the case study*”.

When researchers face such constraints as limited timeframe, lack of financial and human resources this normally influences the research design as well. Tellis (1997) emphasizes that, as a result, the researcher tends to select a case which would maximize what can be learned in such conditions. Case studies can be carried out with the focus on a single case or multiple cases. Single-case studies serve to explore a phenomenon in just one situation, while multiple-case study design allows to apply the same logic to various cases in order to make cross-case comparison and get a broader picture of the phenomenon. Although the evidence from doing

multiple-case study is considered by some researchers more compelling and the study overall is regarded to be more robust (YIN, 1994), however, broader does not mean deeper and more detailed. Advocates of single case studies point out that this type of research design allows the researcher to have a deeper understanding of the exploring subject (GUSTAFSSON, 2017). They state that single case studies "*allow in-depth analysis of one setting with regard to a large number of aspects, allowing a broad and detailed analysis of organisational dynamics, and the production of the rich descriptions*", while a multiple case design "*usually sacrifices detail and richness of description for the opportunity to make comparisons across several settings*" (DOOLIN, 1996, p.25). Similarly, Bennett and Elman (2006, p. 459) claim that "*a single "smoking gun" piece of evidence may strongly validate one explanation and rule out many others*", whereas numerous cases "*may fail to identify which of two incommensurable explanations is more accurate if there is no evidence on key steps in the hypothesized processes on which they differ*". Additionally, for the reason of time and resource constraints the current research was decided to be carried out as a single-case study. Such a design satisfies the requirements to answer the research question.

3.2 Unit of analysis

This case study stems from the initiative of De Beers, world rough diamond producer and diamond retailer, to introduce blockchain in its supply chain. So, as it was mentioned in the introduction section, the diamond supply chain will be a target in this research. The supply chain in this industry includes many stages of flow of materials and information. Here in the beginning it deserves mentioning that the research will not cover the supply chain for industrial diamonds. The reasons are the fact that the supply chain of industrial diamonds, which are of a much lower quality than gemstones, is shorter and that there is no such a huge process of value creation as compared to commercial diamonds.

The value creation includes exploration, extraction, sorting, cutting, polishing, wholesale, jewelry production and retailing to deliver the final product to its consumer. In such a mature industry one of the major diamond production companies De Beers has recently made initiatives to introduce blockchain technology in its supply chain. The company controls the supply of rough diamonds and is represented in almost every single stage of value creation except for the process of diamond cutting and polishing.

To study the phenomenon of blockchain the global diamond supply chain was chosen as a unit of analysis. As Yin (1994) suggests, the principal source of data will be semi-structured interviews with participants in the diamond supply chain. The secondary data included company media releases, letters and annual reports.

3.3 Data collection

Data collection was carried out by sending emails directly to companies acting in the diamond industry. Most companies came from publicly available lists of sightholders of De Beers and ALROSA. As a result, the following companies were contacted:

- 2 rough diamond producers (2 emails and 22 LinkedIn inmails sent)
- 107 polishers, cutters, wholesalers and retailers (258 emails sent). The majority was taken from De Beers publicly available sightholders list
- 3 brand retailers (5 emails sent)
- 4 blockchain solutions providers (4 emails sent)

On the whole 116 companies were contacted with 291 emails sent. As a result, 13 responses were received with the response rate of 4.43%, i.e. the number of responses received divided by the total number of emails sent, which led to 4 semi-structured interviews: three polishers and cutters and a blockchain solutions provider. The company engagement rate was as low as 3.45% which is a number of companies interviewed divided by the total number of companies contacted. Such a low response and engagement rate can be partially explained by the closed character of the industry whose participants are reluctant to share information. The interviews were conducted with executives responsible for sales, marketing and customer relationships, as seen in Table 3, because they were the ones who gave consent to the interview on behalf of their companies. This also can be explained by the closed character of the industry. Additional interviews with mid-level managers in the companies might have enriched the data, though.

Table 3. Information about interviewed companies and interviewees

Company name	***Industry role***	***Region***	***Interviewee's position***	***Relevant experience, years***	***Interview duration***	***Words transcribed (in the interview)***

Comp. A	Cutter and polisher	Middle East	Global sales manager	13	25 min	2034
Comp. B	Cutter and polisher	Europe	Commercial and marketing director	~10	55 min	6585
Comp. C	Blockchain solutions provider	North America	Global customer support director	5	24 min	3430
Comp. D	Polisher	North America	CEO	44	53 min	5934

The protocol with open-ended questions was used to conduct semi-structured interviews. The questions mainly covered relationships among participants in the diamond supply chain, existing risks and challenges, as well as use of technologies in general and blockchain in particular. The questions can be found in Table 4 and they vary depending on the company's role in the diamond supply chain.

Table 4. Protocol with open-ended questions for semi-structured interviews

Questions Section	**Polishers and cutters**	**Blockchain solution providers**
Introduction	Please, tell me about your main responsibilities and experience in the company. Describe the core business of your company.	Please, tell me about your main responsibilities and experience in the company. Describe the core business of your company.
Complexity of transactions	Tell me about the relationships with your clients. What is important for your clients? Tell me about the relationships with your suppliers. What is important for them? How do you maintain the relationships with your clients and suppliers?	Please, tell me about your relationships with the clients. Where and how do you create most value for your clients? How do you maintain these relationships?

Ability to codify	Describe the flow of materials and information from you to your clients and suppliers. Are there some standards, requirements you have to meet in your business/ industry? Who imposes them?	What do you think about the benefits that blockchain can bring? Share your vision about the industries where it can be required and applied. Share your opinion about the reasons that companies have for introduction of blockchain into their supply chain.
Capability in supply base	How easy/ difficult is it to meet the requirements of the clients and suppliers? Tell me about risks in your business. Tell me about digital technologies in your business. What can you tell me about transparency and traceability? Are they important for final consumer? Have you heard about Kimberly process? What do you think about it? What can you tell me about synthetic diamonds?	What do you think about transparency? What do you think about traceability?
Blockchain	Have you heard about blockchain? What do you think about it?	Tell me about possible impacts on the ecosystems of your clients if they apply blockchain in their supply chain. Please, share your thoughts about the impact that blockchain can have on the supply chain of the diamond industry.
De Beers' initiative	What can you say about De Beers initiative to introduce blockchain into supply chain? In your opinion what can happen after De Beers starts this project?	Have you heard about De Beers initiative about introduction of blockchain into their supply chain? What do you think about it?

Three interviews were conducted via Skype and one through face-to-face conversation at the company's site. It is interesting to notice that the face-to-face interview was longer in time, thus richer in information. It was clear that the interviewee felt free to talk and even joked when he saw the interviewer in front of him. While talking on Skype it was noticed that physical barriers between participants resulted in lack of intimacy and maybe trust. Afterwards, all the audio recordings were transcribed for later qualitative analysis. It is worth mentioning that one of the interviews originally was not in English so it had to be translated after the transcription.

In order to guarantee validity of the research, data triangulation was used. Creswell (2014) recommends triangulation strategy as a means to assess the accuracy of findings. This strategy is focused on triangulation of different sources of data by examining evidence from these sources. This strategy claims to add validity to the study (CRESWELL, 2014). Following this recommendation, some secondary sources of data were used, as seen in Table 5.

Table 5. Secondary sources of data

Source	***Document type***	***Source***	***Date***	***Words counted***
(CLEAVER, 2017)	CEO public letter	www.debeersgroup.com	04/12/2017	957
(ANGLO AMERICAN, 2018)	Media release	www.angloamerican.com	16/01/2018	341
(HEEBNER, 2018)	Media release	www.diamonds.net	15/02/2018	587
(DE BEERS, 2018b)	Media release	www.debeersgroup.com	10/05/2018	595
(DE BEERS, 2018c)	Annual report	www.debeersgroup.com	19/09/2018	17040
(DE BEERS, 2018d)	Media release	www.debeersgroup.com	24/05/2018	381

3.4 Data analysis and coding

In order to analyze the data, computer-assisted qualitative data analysis software (CAQDAS) NVIVO 12 Pro was used. There are numerous types of qualitative coding methods that can be used depending on the type of research and its aims. For example, Saldaña (2009)

describes 29 coding methods. He also states that depending on the type of research and its goals it can require sometimes its own unique approach. A mixture of two known coding methods was used: descriptive coding and hypothesis coding.

As Saldaña (2009, p. 70) states that descriptive coding "*is appropriate for virtually all qualitative studies, but particularly for beginning qualitative researchers learning how to code data, ethnographies, and studies with a wide variety of data forms"*. The basic aim of using this method is to understand the current situation in the study by answering questions like *"What is going on here?"*. Descriptive coding is just one approach to analyzing the data's basic topics to assist with answering these types of questions (SALDAÑA, 2009).

Saldaña (2009, p. 123) defines hypothesis coding as *"application of a researcher-generated, predetermined list of codes onto qualitative data specifically to assess a researcher-generated hypothesis. The codes are developed from a theory/prediction about what will be found in the data before they have been collected or analyzed".* Since presented earlier in Table 2 sub-research questions seek to understand effect of blockchain on certain variables derived from the GVC framework, hypothesis coding with pre-defined set of codes is appropriate. These codes are: complexity of transactions, ability to codify, capability of supply base.

The first cycle coding started with the descriptive method and 67 codes were retrieved through the collected data. These codes describe the current situation in the industry, the relationships between the cutters, rough diamond producers and jewelry retailers, as well as cover the aspects of competition, the future of blockchain and synthetic, or lab-grown, diamonds. The codes can be categorized in groups as follows:

- Situation in the market (competition, tendencies, etc.)
- Relationships between polishers/cutters and rough diamond producer
- Relationships between polishers/cutters and wholesalers/retailers
- Risks
- Kimberly process
- Blockchain technology
- Lab-grown diamonds
- Other

Then the data were recoded one more time and it was evident that some similar codes could be merged into one code. This gave a total of 39 codes. After applying hypothesis coding method, some codes retrieved during the first cycle coding were grouped into pre-defined codes. As a result, the analysis came up with the following:

- Complexity of transactions: 4 codes, 25 references
- Ability to codify: 3 codes, 13 references
- Capability of supply base: 5 codes, 32 references

In order to answer the research question, we have to understand first which is the current governance type in the diamond supply chain between polishers/cutters and the lead company, i.e. De Beers. This can be done by addressing the sub-research questions which seek to understand the effect of blockchain on complexity of transactions, ability to codify transactions and capability of supply base.

4 Case analysis and discussion

4.1 Current governance type

4.1.1 Complexity of transactions

After the 2nd cycle coding there are 4 codes and the analysis of the data shows that the complexity of transaction in the diamond supply chain is high.

Table 6. The codes which refer to the complexity of transactions

Code	***Quote***
Value creation	*"Also, they require that we add value in some way. That you don't resell it immediately to someone."* (Company A)
Lead firm's specific requirements	*"So, we have suppliers of rough diamonds in the market. They are De Beers and ALROSA, the two biggest suppliers in the market. But also, there are other suppliers, companies that have production. They only allow us to buy diamonds if we follow certain standards. They only allow to buy to approved buyers."* (Company A)
Requirements on ethics and sustainability	*"This is the only industry in the world that has regulated itself about its own product. It's the diamond companies… If you want to import diamonds anywhere in the world, rough diamonds, if it's not a company by the Kimberly process certificate, it can't come and*

	sell. Nobody will touch it except for a few countries that refused to sign the agreement…" (Company D)
Financial requirements	*"There is let me say a rule how you can become a client of our company. I mean in the beginning this concerns the conditions under which you buy the cut diamond. I mean if you are new, so it means 100% of prepayment..."* (Company B)

Value creation refers to prohibition for polishers and cutters to immediately resell diamonds after buying from the supplier. Also, it refers to providing retailers with solutions to meet their customers' requirements. This increases complexity of transactions.

The lead firm imposes specific requirements on polishers and cutters. First, in order to buy rough diamonds from suppliers a polisher or cutter has to be an approved buyer, or sightholder. Second, the lead firm prohibits approved buyers, i.e. polishers and cutters, to work with lab-grown diamonds. These limitations are contractual obligations between parties and thus increase complexity of transactions.

Requirements on ethics and sustainability refer to Kimberly process obligations, ethical sources of rough diamonds and sustainable practices. Kimberly process is an industry-specific international treaty which is ratified by the majority of countries which guarantees adherence to standards of diamond trade which aims to exclude blood diamonds from circulation. Also, the code refers to maintaining ethical standards in terms of work conditions at the participating companies. This increases complexity of transaction between all the participants.

Special financial requirements as prepayments and proved financial capability are also the factors that increase complexity in the diamond supply chain.

As the analysis indicates, complexity of transactions is high.

4.1.2 Ability to codify

Ability to codify means whether information and knowledge can be codified and therefore transmitted efficiently and without transaction-specific investments between the parties to the transaction (GEREFFI; HUMPHREY; STURGEON, 2005). This relates to whether standard procedures to codify specification on products transferred between the parties

exist. Three codes which refer to ability to codify transactions were found and it can be inferred that it is low.

Table 7. The codes which refer to the ability to codify transactions

Code	***Quote***
Individual approach	*"The relationship is different from client to client. The client is different… I have clients with whom I am doing business for years and clients who I can hear from today and then I won't hear for months. It depends…"* (Company D)
Product quality standards	*"Standards… when producing diamonds there are some definite standards. They differ depending on the country as well. I mean in America it is the Gemological Institute of America's standard. Thus, there are categories by quality of cut. They are "excellent", "very good", "fair good" and so on. Also, there is European Gemological Institute. They have other categories… And also the Russian cut – the groups of cut A, B, C, D. We divide it like this. It's hard to say that there is a direct correspondence, for example, that A corresponds to "excellent" by GIA. They are a little bit different [requirements] and not every gemstone we have from the A group will correspond to "excellent" [by GIA]."* (Company B)
Personal relationships	*"We meet them, we stay in close contact and we become friends with them. And it's always what you have done for them lately. We create value both for our suppliers and customers. Also, there are personal relationships."* (Company A)

Individual approach means that one client's demand can be so different from another that polishers have to approach them in a different way which implies additional transaction-related costs, thus information and knowledge cannot be transferred efficiently without transaction-specific investments between the parties. This refers to additional time and financial resources invested in individual clients. It means lack of procedures to standardize (or codify) approach.

There are product quality standards which differ from country to country, i.e. from client to client, in the diamond supply chain. This means that the process of buying and selling gets

more complicated. This means lack of transaction efficiency and need for additional transaction related investments (GEREFFI; HUMPHREY; STURGEON, 2005). The reason is a difficulty to efficiently codify of transactions.

Personal relationships is a code that means that the way the lead firm and its suppliers codify information and knowledge is not very efficient, so they have to meet/phone/mail each other frequently. In order to maintain these close relationships and eventually make transactions both parties have to make transaction-specific investments, e.g. time and money.

Thus, the data analysis shows that ability to codify is low.

4.1.3 Capability of supply base

This means capabilities of actual and potential suppliers in relation to the requirements of the transaction. Several codes were found which point out a high capability of polishers and cutters in creating a special product with particular characteristics. The cutters can meet the most sophisticated demands.

Table 8. The codes which refer to the capability of supply base

Code	***Quote***
Certification	*"We are producers, and mainly wholesalers buy from us. Then it goes… they sell as wholesalers or even as retailers. So, we don't retail rough diamonds. Only as certified cut diamonds. We have a lab in which we certify them…"* (Company B)
High qualification	*"I mean to make a high international standard gem is not a problem for us. This is just a specific set of parameters: quality of polishing and quality of cut. We have enough qualifications of workforce, quite good equipment to do all this."* (Company B)
Meeting industry-specific and ethical standards	*"As a matter of fact, most of my diamonds… I guarantee the origin of the diamonds to my clients."* (Company D)
Satisfying customers' requirements	*"It's not a commodity as I noticed earlier in the conversation. It is not a commodity. It needs to be you know a story, to have a story. The diamond has a story that it comes to tell… where it creates employments, where it creates clean water for the people, where it creates schooling, where it creates scholarships*

	for many of the children of the miners and up in universities today and study." (Company D)
Asset specificity	*"And of course, we have our own [color extraction] technology which I mentioned before which makes the diamond shine in a special way. That's a very unique and a new technology that we are very proud of."* (Company A)

Certification is a code that defines the cutters' ability to provide their clients with certificates which guarantee the highest quality. This points out high capability of suppliers of the lead firm.

High qualification refers to special cut and ability to meet the highest demand on quality of cut diamonds. Quality of gemstones is one of the main requirements, so being able to meet it means high capability of supply base.

Polishers and cutters meet industry-specific standards like the Kimberly process, which relates to conflict-free rough diamonds, and meet requirements on ethics at the production facilities, on sustainable practices, etc.

Satisfying customers' requirements means that polishers and cutters have an ability to sell a diamond with a unique story, a journey, embedded in it. The diamond is not a commodity and consumers expect to hear its unique story. This also indicates high capability of the supply base.

Asset specificity relates to specialized machine tools, processing facilities, technologies and expertise that allow the polishers and cutters to make special cuts, extract color, etc., which De Beers does not possess. This also indicates high capability of the supply base.

Thus, it can be concluded, that polishers and cutters' capability of supply base is high, since this variable is defined as "*the capabilities of actual and potential suppliers in relation to the requirements of the transaction*" (GEREFFI; HUMPHREY; STURGEON, 2005, p.85).

According to the GVC framework, we can say that high complexity of transactions, low ability to codify and high capability in supply base lead to relational type of governance, as seen in Table 9.

Table 9. The current governance type in the diamond supply chain

Complexity of transactions	High	Governance type: RELATIONAL
Ability to codify	Low	
Capability in supply base	High	

4.2 Future governance shift

4.2.1 The impact of blockchain technology

Before we move to discussions about how the current governance type can change in the future, we should pay attention to what interviewed companies think about blockchain, traceability and provenance. In fact, one of the interesting things is that the polishers and cutters (company A, B and D) know about blockchain, but have not seen so far any huge potential for an impact in their industry, which is the opposite view of the blockchain solutions provider (company C). The polishers and cutters consider their industry conservative and "old-school" which means it takes a long time before big changes in the way they do business can happen.

"Well, we are very old school type of industry. But there are some technologies which can do polishing diamonds almost by itself. Also, there are cutting machines that help cut diamonds…" (Company A)

"I will say again -- the industry is very conservative. Technologies of processing diamonds have not changed for many decades." (Company B)

While De Beers' management has the same opinion, they do believe this situation will change soon.

"The advent of blockchain technology offers the opportunity to provide assurance in a way that was not previously possible and several new initiatives aim to do exactly this, helping to meet Gen Z's desire for organisations to move from 'tell me' to 'show me'." (DE BEERS, 2018c)

The polishers, cutters and blockchain provider recognize the importance of traceability and provenance in the diamond supply chain.

"It is really important for people to have the ability to trace the diamond: where came from, what this diamond is. And this could be the part of the blockchain technology that could be implemented…" (Company A)

"I think we need to look at traceability and transparency. A lot of supply chains don't know the huge extent of what they actually own, where things are…" (Company C)

"I think it will change. I think that the public will be probably asking questions about the origin of the diamonds and I think that's a good thing. I think it's an important thing." (Company D)

De Beers points out the necessity to transform the diamond industry and bring transparency to all its participants. However, the company aims to place high importance on the issue of sensitive information treatment as well.

"Respectful of privacy: we understand the importance of privacy for anyone who participates in the blockchain, so the solution combines transparency with privacy of sensitive information." (CLEAVER, 2017)

"Tracr [solution provider] verifies the uploaded data at each key milestone of a diamond's journey – ensuring its accuracy and continuity – while enabling users to be in full control of what they share with other participants through the use of privacy controls." (DE BEERS, 2018b)

4.2.2 Complexity of transactions remains high

This stems from the very nature of the diamond business. The requirements imposed on suppliers like adherence to ethical standards at work, proven financial capability and necessity to be authorized sightholders to do business will remain. The same can be said about the Kimberly process – even transformed in something else it will remain characterizing high complexity of transactions.

"Well probably soon it will stop to be important. I mean if conflict zones from where the principal flows of diamonds in Africa used to come… let's say if they disappear, thus this Kimberly process won't make sense. But it's not only about blood diamonds supply, but also it

controls illegal flow of diamonds. I mean maybe it will be transformed into something or will remain as it is and will hold control at least over illegal supplies" (Company B)

Also, blockchain will provide provenance and transparency required by final consumers. Since Gereffi et al. (2005, p. 85) define complexity of transactions as "*complexity of information and knowledge transfer required to sustain a particular transaction",* additional information about the full track of diamonds from the mine to shop windows and characteristics of stones, such as quality, size, color and weight, passed via blockchain will increase or at least maintain high the complexity of transactions.

4.2.3 Ability to codify from low to high

The current low level of ability to codify is a result of availability of different standards and inefficient information and knowledge transfer among the participants. As a result, companies have to meet each other and maintain close personal relationships which means additional transaction-related costs to be able to pass specifications. Blockchain can solve this by giving an efficient way of passing information and knowledge that incurs less transaction-related costs, as the data below indicate.

"So, thinking about the clients of De Beers I think... I think first of all you start cutting down on costs, so they start becoming more efficient with their supply chain. I think it's only as they are connected in with the network that De Beers is using. You now have information, you can provide your customers with more information about where exactly this diamond comes from, when was mined, how was mined, who mined it, who's touched it along the way." (Company C)

"It will "reduce inefficiencies, such as having to check stones against paper invoices, and easily source primary information — cut, color, and where it was found — and secondary data like grading certificates that it accumulates along the way."" (HEEBNER, 2018)

Blockchain can provide traceability of transactions through increased ability to codify them. It can serve as a platform where different participants can exchange data and avoid misinformation. Lower transaction-related costs will be the result of increased ability to codify transactions, as Company C and secondary data indicate below.

"And you can have someone transferring products, you know products that are created in China, that have been shipped over to the EU. That stuff can change hands twenty times while it's in transit and all that stuff can put paperwork and money in all the stuff. And creating environment where all the transactions can happen in one platform really cut sum of costs and cut sum of time. You don't need some different pieces moving, you create a lot of efficiency using your network." (Company C)

"Once fully established, it is anticipated that the blockchain will operate as an open platform, on top of which a range of applications that benefit the industry can be built." (ANGLO AMERICAN, 2018)

Since ability to codify is characterized by *"extent to which information and knowledge can be codified and, therefore, transmitted efficiently and without transaction-specific investment between the parties to the transaction"* (GEREFFI; HUMPHREY; STURGEON, 2005, p. 85), increased efficiency and lower cost of exchange of information between participants on blockchain will result in a high level of ability to codify.

4.2.4 Capability in supply base from high to low

This refers to the need of meeting the provenance demands from clients. The end consumers want to be sure that the quality of the stones correspond to what it really is. A new generation of customers exhibits a strong demand for information about the authenticity and origin of the product they buy. This becomes also inevitable because of increasing presence of lab-grown diamonds in the world marketplace. It creates additional worries for final consumers because of increased risk of fraud, i.e. having synthetic diamonds instead of natural ones bought.

"I think that consumer really cares about the source of the product and he wants to know all information about it…" (Company A)

"It does take place. There was information that in small sizes, I mean stones of up to 2 mm in lots, which the Indians sell, there were around quarter and up to a third of synthetic diamonds. This is the information which many dealers who work with them confirm." (Company B)

"Blockchain is therefore a hugely valuable way to provide consumers with enhanced assurance that the diamond they are buying is natural, conflict-free and has moved through legitimate channels at every stage of its journey. The issue of responsible sourcing is particularly important for emotionally significant purchases such as diamonds…" (DE BEERS, 2018c)

Demand for traceability and provenance will require involvement of all the participants in the diamond supply chain. But only the lead firm, i.e. De Beers, will have resources to provide what end customers want by investing in blockchain and will eventually have control over the platform. The polishers and cutters will have low capability to meet fully the requirements imposed on blockchain participants. Participation in blockchain network will require polisher and cutters with profit margins of just 5% to label cut diamonds which will increase their costs.

"What can I say? Theoretically, it is possible. Theoretically… In practice, it will make significantly more expensive our product. I tell you again, our profit as a producer is hardly reaching 5% from the wholesale of cut diamonds. If you add here costs of labelling…. Yes, it's possible, but it will completely kill the diamond processing [cutting and polishing] in the world." (Company B)

The cutters and polishers don't have resources to organize an effective way of access to data regarding their product and will have to resort to the lead firm, i.e. De Beers in this case, and ask for the access and somehow share their information. This is because of low capability to provide this for their clients. De Beers will have a full access to the information from all the blockchain initiative participants and hence be able satisfy the needs of end consumers partially at the cost of the cutters and polishers.

"It is intended that a digital certificate created by Tracr for each diamond registered on the platform, storing its key attributes and transactions, will enable retailers to provide consumers with confidence that their diamond is natural, conflict-free and has been tracked across the value chain." (DE BEERS, 2018d)

"I am telling you that they will have access to the information in that blockchain. And if they don't have it right away, they will have at some point." (Company D)

As a result, increase in ability to codify and decrease in capability in supply base will lead to more power asymmetry and a shift of the governance type from relational to captive, as seen in Table 10.

Table 10. Shift from relational to captive governance type

Complexity of transactions	High → High	Governance type: RELATIONAL → CAPTIVE
Ability to codify	Low → High	
Capability in supply base	High → Low	

The results suggest that the lead firm will have information about transactions in the supply chain stored on blockchain. De Beers, a large rough diamond producer and brand retailer, having a proprietary control of the blockchain solution can provide customers with traceability and transparency by showing the path of stones literally from the mine till the shop window. Meanwhile, polishers and cutters that buy rough diamonds from De Beers, will face demand for traceability from their other clients, i.e. brand retailers, and will have to ask for access to information controlled by De Beers. Thus, information turns out a strategic asset controlled by the lead firm in the supply chain. Vik and Kvam (2017) show a similar result arguing that a lead firm can improve its power position due to control over such critical assets as information and knowledge.

A particular attention should be paid to provenance. Kimberly process as an industry-specific standard addresses the issue of conflict-free diamonds, however, ethical and sustainability issues are of concern as well. Standards guarantee adherence to ethics and sustainability (NEILSON, 2008). Ponte and Gibbon (2005) study standards as an element of GVC governance. They argue that trust between supply chain participants becomes institutionalized in standards. However, demand for sustainable practices and ethics can have their complications for small and medium-sized enterprises (SMEs) in supply chains. For example, Neilson (2008) argued that a need for sustainable practices by small-size coffee bean producers in Indonesia could result in pressure on them because of transaction costs of compliance. Consequently, this could drive profits down leading to further exclusion from global supply chains (BLAŽEK, 2016). The current case study suggests, that blockchain technology can effectively address the issue of trust in supply chains and provide provenance and traceability that are necessary for compliance with standards at low transaction costs.

Change of governance mode is quite a normal phenomenon because governance is dynamic over time (GEREFFI; HUMPHREY; STURGEON, 2005). Many researchers speak about how suppliers in developed and developing economies are involved in upgrading, i.e. capacity of SMEs to increase the value added in the supply chains they take part in, in order to participate more in value sharing. This is made through gaining expertise in the key technical areas and marketing, which turns out to be a key resource in supply chains driven by the buying firm (HUMPHREY; SCHMITZ, 2002). While cases of SMEs that gain more power by leveraging technology and acquiring skills (GIULIANI; PIETROBELLI; RABELLOTTI, 2005; ASPERS, 2010; PONTE; EWERT, 2009) are common, this research shows that the opposite can also be true. A lead firm can invest in blockchain technology and enhance its position in the supply chain by gaining more power, and thus, shifting governance mode to a mode with more power asymmetry and coordination.

Despite the fact that the mining industry is considered very conservative in terms of technological advance by the interviewed participants, De Beers is investing in blockchain technology. The strategic decision to leverage IT can be explained by an intention to regain a previous leadership position in the diamond market. De Beers exercised significant power and control in the past but lost it because of arrival of new competitors and transformation of the market structure from monopoly to oligopoly. Today, with advance in IT solutions and increasing consumers' preferences towards ethical consumption and demand for provenance, the comeback of De Beers to the leading position is very likely. At the same time, oligopolistic market structure suggests a similar strategic movement by the competitors. Indeed, the main competitor ALROSA is reported to be joining the pilot project of De Beers' blockchain initiative (DE BEERS, 2018a).

5 Conclusion

The purpose of this study was to understand how blockchain technology can change the mode of governance in global supply chains on the example of the diamond supply chain. The research has been based on the case of introduction of blockchain solutions by De Beers in its diamond supply chain. Using the GVC framework by Gereffi et al. (2005), this study has tried to understand to what changes in governance blockchain can lead and how it can influence power asymmetry and control in supply chains. Because of the character of the diamond supply chain, where the lead firm De Beers is represented at almost each stage of the value creation process, except for diamond cutting and polishing, the case study looks at the governance type

at a specific node: between the lead firm (rough diamond producer and brand retailer) and polishers/ cutters.

The results of a qualitative analysis show that blockchain technology will likely change the governance mode between the lead firm and polishers/ cutters from relational to captive. Thus, De Beers, as a lead firm, will exercise more power over polishers and cutters. The variables complexity of transactions, ability to codify and capability of supply base help identify the current governance mode between the lead firm and polishers/ cutters as relational, as well as help indicate a shift from relational towards the captive governance type. This will be possible due to information control exercised by De Beers by means of blockchain.

The key point is that end consumers demand more traceability and transparent verifiable information about the product they consume. Consumers want to be sure about the quality of the stone, its natural origin and ethical source. The quality and natural origin are of importance because of a growing concern about fraud regarding the quality of cut and presence of lab-grown diamonds in the market that are sold instead of the natural ones. The demand for ethics and sustainability is explained by already existing standards in the diamond industry, such as Kimberly process, and a trend among consumers, who are primarily from developed countries, towards ethical consumption characterized by increased attention to corporate social responsibility and sustainable practices. Interviewed polishers and cutters do indirectly confirm that this trend takes place in the diamond industry.

5.1 Theoretical implications

This research contributes to the SCM literature by filling in an existing gap regarding potential implications of the blockchain technology on SCM (TREIBLMAIER, 2018). It responds to Treiblmaier's "*call for action*" by studying the influence of blockchain on governance in supply chains from the perspective of the GVC theory. The results of this study can be useful for researchers and practitioners in such industries, as food and beverage, pharmaceuticals, fashion goods, etc. which are characterized by an increasing demand from consumers for traceability and provenance, as well as by existence of health, labor, environmental and sustainability standards.

From the theoretical perspective, this research also contributes to the GVC theory. It indicates that the GVC framework by Gereffi et al. (2005) although being a "*set of ideal-types*",

as some researchers in the field state (COE; HESS, 2007, p. 11), is extremely helpful in addressing the issue of blockchain as a new phenomenon in supply chains that affects intercompany relationships. The findings indicate that blockchain technology has a potential in affecting governance in global supply chains. The results show that introduction of blockchain can give a lead firm more power and coordination over its supply base. The main benefits provided by blockchain are provenance and traceability that are demanded by end consumers.

Also, the findings can be of interest for researchers who study IT in SCM. The study contributes to the literature about a positive impact of IT on firms' competitive advantage in supply chains. In fact, the results show how a firm can gain a leading position by investing in blockchain. A company that introduces blockchain technology in its supply chain can acquire a strategic asset through control of information and access to it to other participants. Finally, this study contributes the promotion and spread of blockchain as a new institutional technology that offers a new way of coordinating economic activity (DAVIDSON; DE FILIPPI; POTTS, 2018).

5.2 Managerial implications

This study can inspire management to invest in blockchain as a means of obtaining competitive advantage and gaining more power in their supply chain. While some researchers (GIULIANI; PIETROBELLI; RABELLOTTI, 2005; ASPERS, 2010; PONTE; EWERT, 2009) in the context of the GVC theory speak about upgrading of suppliers from developing economies through acquisition of technical expertise and marketing capabilities for moving along the value-added chain, this research concerns a particular situation where a lead firm is trying to regain power and control in its supply chain by investing in technology. By shifting power towards the lead firm, blockchain can enhance enforcement of standards compliance at a low cost and effectively drive the sustainability agenda (TOUBOULIC; CHICKSAND; WALKER, 2014). Thus, from the managerial standpoint, the results of the study can be of interest for managers of lead firms operating in industries that are characterized by consumers' demand for provenance, traceability and sustainability. Additionally, by changing the governance mode from relational, which implies mutual dependence, towards captive, which means suppliers' dependence on the lead firm, blockchain can indicate to managers the necessity to realign the supplier relationship strategy from cooperative towards competitive approach in order to guarantee further suppliers' performance (TERPEND; KRAUSE, 2015).

This case study can be useful for policy makers and NGOs. Since blockchain can serve as a tool to guarantee and trace standards compliance, policy makers and NGOs can benefit from inducing companies that operate in industries with labor, environmental, health and sustainability standards to introduce blockchain in their supply chains. Blockchain can enhance standards enforcement at a lower cost, thus reducing public expenditures on standards compliance.

5.3 Limitations

This research is carried out as a case study and counts with primary and secondary source data. The validity of data was performed by triangulation approach using transcribed interviews and secondary data from the industry. The case study design per se has some limitations. It does not allow to generalize conclusions, since it is qualitative in nature. Also, it involves subjective judgement of the researcher.

A relatively small number of interviewed companies due to the closed character of the diamond industry and limited resources available for the research does not present constraints on answering the research question. However, a greater number of interviews may have shed light on some additional patterns and intercompany relations in the global diamond supply chain. The same can be said about the positions of the interviewed executives. Additional data collected from mid-level managers might have brought some insights as well.

Another limitation is lack of interviews with other actors from the diamond supply chain. Interviews with brand retailers that have direct contact with final consumers might have enriched the data and brought insights. This also can be explained by the closed character of the diamond industry.

Additionally, it can be considered as a certain limitation the time frame of the study which looks at the blockchain introduction at a specific moment prospectively. In contrast, data collected after the actual introduction of blockchain by De Beers compared with a pre-introduction stage would possible lead to more robust conclusions. However, such a design would be more time-consuming.

5.4 Future research

In order to extend the findings of this study the author recommends to carry out further researches in other industries that have globally dispersed supply chains and that are about to adopt blockchain solutions. As mentioned above, the main candidates can be pharmaceutical industry, food and beverage industry, and fashion goods. Of a particular interest would be a case study about a non-lead firm introducing blockchain in its supply chain or a case about introduction of blockchain in a global supply chain with market or modular governance mode.

From the research design perspective, quantitative or mixed research methods could probably measure the extent of influence of blockchain on governance in global supply chains.

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