Analyzing the Impacts of Blockchain Technology for Supply Chain Management in Space Industry: A Comprehensive Explanation of Case Studies From Major Companies in Space Industry

Author: Monica Sabrina JUSUF

Supervisor: Victor DOS SANTOS PAULINO

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Abstract

The space industry is shifting to serve not only for the government but also for commercial use. This influenced by the facts of rapid development on sophisticated technologies, which rely on satellites' data. Therefore, the space industry viewed as a vital and profitable industry. Companies are competing to be competitive and responsive to market demands. Most of them strive to integrate advanced technologies into their supply chain management (SCM). SCM is in the heart of companies and essential to continue increasing its efficiency. The current trend is to integrate digital supply chain (SC) platform in the business process. It proved to smoothen the entire SC processes and perceived as an efficient solution for SCM. However, the challenge is digital transformation makes SC vulnerable to cyber attacks. Companies urged to discover answers to provide tighter security to their SC. Blockchain later introduced as a technology to answer the challenges. It has several characteristics such as distributed ledger, transparency and immutability. Those characteristics, which make blockchain become a promising solution for SC.

Keywords: Blockchain, SCM, Supply Chain, Digital SC Platform, Space Industry

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1. Introduction & Methodology

Technology development has led to many sophisticated solutions for daily life. Most of these solutions are highly dependent on satellite performance. Some samples of satellite's usage include cable and network TV, Electronic Data Capture (EDC) machine used for payment, Automatic Teller Machine (ATM), cellular network, navigation software (i.e. Google maps), weather forecast, airplanes communication with ATC, climate and environment monitoring and many more. The rapid development of new innovative technology that relies on satellite and shifting in customer demand push companies in the space industry (i.e. satellites manufacturer) to act responsively and become more competitive. Thus, companies begin to discover the crucial part where significant improvement needed. They noticed that the SC should be improved. The reason implies that SC influences the speed and productivity of the delivery process. Speed and productivity linked to costs, hence it is essential to consider in enhancing speed and productivity as well as diminishing the costs. To accomplish that objective, the company should determine efficient SCM(S. Perepa, 2014). Purposely, there are five major tasks of SCM such as planning SC to achieve strategic value, build internal collaboration process, strengthen partnership with suppliers, maintaining SC information and reducing SC costs (C.M. Meyer et al., 2019). The utilization of SCM within companies allow them to decrease operation cost, provide more reliable services, diminish inventory level, lessen cycle time, drop the number of backorders, advance customer satisfaction and bring competitive advantage (M.S. Ab Talib and A.B.A. Hamid, 2014). Thereby, companies seek for an excellent solution to improve SCM. The answer is to integrate advanced technology into the SC process.

In the space industry, order and delivery processes are highly dependent on the collaboration process. It is proven by the fact that the delivery dates and quantities not only determined by companies but also declared in a specific agreement with suppliers (SupplyOn, 2012). Thus, the integration of digital SC expected to enhance the collaboration process and implies positive influences on the entire SC. Airbus, as one of the major players in the space industry, claimed that they obtain benefits from the adoption of digital SC called AirSupply platform. The benefits such as seamless collaboration process, standardization processes, reduce cycle time and workload, paperless purchase orders and invoices as well as e-payment process. Thanks to advanced technology which made it possible to obtain efficient SCM. However, the integration of SC platform increases the dependency on digitalization. Thus, the challenge is the SC vulnerable to cyber-attacks that might obstruct its network. As precautionary, high-security protection required to assuring the network remains safe. In this sense, companies may append complementary technology to tighten the security of their digital SC. Combining blockchain into the system will overcome the challenge. Blockchain is a technology that used to record transactions and offers decentralization, transparency, security and immutability. Blockchain records transactions, but it does not mean blockchain used to replace the

database. Indeed, blockchain serves as a database. Yet, it brings much more advantages than the traditional database (M. Gupta, 2018).

Since its emergence, blockchain continues extended for several business purposes. A recent study showed that blockchain technology had used in the airport industry SC, it has positive impacts on operational efficiency (A. Di Vaio and L. Varriale, 2019). Improved in operational efficiency means an increase in customer satisfaction therefore it boosts the revenue streams. IBM and Maersk in August 2018 launched a blockchain-based solution for shipping industry called TradeLens. It applies blockchain to supports secure and efficient global trade, as well as bringing transparency in data sharing with various participants while promoting innovation (IBM, 2018). Other study conducted by Kshetri (2017) highlighted several implementations of blockchain in various industry. It showed that blockchain helps to increase transparency in the fishing industry by providing information on the number of fish caught by fishermen as well as help customer to identify the source of their foods, blockchain support e-commerce to avoid counterfeit products by improving integrity and traceability of global SCM, blockchain implies significant cost reduction and enable effective response for food retailer, blockchain governs the process of drugs delivery and assure that they meet the requirements, also blockchain ensure secure and direct payment through digital wallet,

Based on these facts, it is worth to emphasize how blockchain can be adopted in the space industry SC. This thesis starts with a theoretical background that explains why the space industry selected, the reason why focusing on SCM and highlight the benefits of blockchain in SC. Literature reviews then present brief descriptions of three main pillars which underlie the writing of this thesis and provides a comprehensive knowledge of the topic. Literature reviews build upon summarizing some academic paper related to blockchain technology, SCM and space industry. The third section is to discuss case studies of several big companies in the space industry. Case studies aim to explain how they integrate digital SC platform into their business model. The result of case studies later analyzed through within-case-analysis. Based on the explanation of within-case-analysis, the explanatory model brings insights into the adoption of blockchain technology in the space industry. The explanatory model aims to answers several research questions which cover the scopes and boundaries of the thesis:

RQ1: How blockchain transforming the space industry SC?

RQ2: To what extent blockchain could be adopted in the space industry SC?

RQ3: What are the impacts of blockchain-based SC for the space industry?

The fourth section of this thesis indicates the proposition and managerial implications. This to further propose the utilization of blockchain in the space industry SC. On the other hand, the manager implications prepared to give suggestions to managers before decide to develop the blockchain solution. Ultimately, the fifth section is the conclusion of the whole thesis. It highlights the

benefits of adopting blockchain in the space industry SC but also mentions the drawbacks of blockchain.

2. Theoretical Background & Literature Review

2.1 Theoretical Background

In this digitalization age, we might not conscious of how vital the space technologies in our life. Satellites are one of the samples that play a critical function to sustain our infrastructures and deployment of technologies. What will arise if satellites not functioning anymore? The answer is an immense breakdown of multiple aspects of our life. Disruption on the computer-based system, no more television broadcast, flight cancellation, the failure of international phone calls are samples of its impacts (R. Hollingham, 2013). Those likely occurred, as today infrastructures and sophisticated technologies become highly dependent on satellites data. Consequently, it is necessary to enhance productivity and advance the performance of the space industry, particularly the producer of satellites. To accomplish those objectives, companies should start from the critical part, which is SCM. By enhancing the efficiency of their SCM, companies produce better performance, while increasing their productivity.

Functionally, SC involves multifaceted processes as well as entails many stakeholders such as suppliers, manufacturers, customers and final customers. This means that its success determined by the collaboration process between stakeholders. However, some challenges could hinder the collaboration process like the gap in coordination, non-added value activities and asymmetry information. To overcome those challenges, a seamless solution required to smoothen the process. Along with the development of technology, it is possible to create a solution for efficient SCM. As the trend is shifting to digitalization, then integrating advanced technology will be an option. Some biggest companies in the space industry have proven to adopt digital SC into their SCM. Additionally, the usage of digital SC generates high exposure to risks. Hence, adding complementary technology to the existing digital SC facilitates to lower the probabilities of the risks. Such relevant technology is blockchain. Adopting blockchain can be appropriate for SC performance.

Most studies on blockchain have highlighted its concrete impact to SCM in terms of transparency between stakeholders, cost reduction, accountability and integrated data sets in different contexts such as manufacturing, food, agriculture and logistics transportation. In this context, blockchain technology outlined to coordinate stakeholders into a level of integration that depicts a competitive advantage for the firm (A. Di Vaio and L. Varriale, 2019). Blockchain technology empowers industries to transform their SCM, which support to boost customer satisfaction as well as maintain a healthy relationship between stakeholders. The new face of the SC holds the potential to be faster, more agile and efficient. As results, the time to market reduced, real-time information

support in decision-making, also the completion of end-to-end transparency within the whole supply chain process.

2.2 Literature review

In this section, author will briefly describe the concept of blockchain technology, supply chain management and space industry. Prominent background will be presented by summarizing current knowledge from several papers, which aim to underline and explain theoretical concepts related to problems in research.

2.2.1 Blockchain Technology

Blockchain technology firstly introduced as a technology that runs public transaction ledger of a famous cryptocurrency named Bitcoin. The purpose was to invented transparent, time-stamped, and decentralized transactions (Nakamoto, 2008). By design, blockchain is block-stored information distributed between the peer-to-peer networks to be validated and appended into a chain in the chronological order. Its technology rests on three characteristics namely decentralization, transparency, and immutability. The figure below demonstrates the various step involved in blockchain.

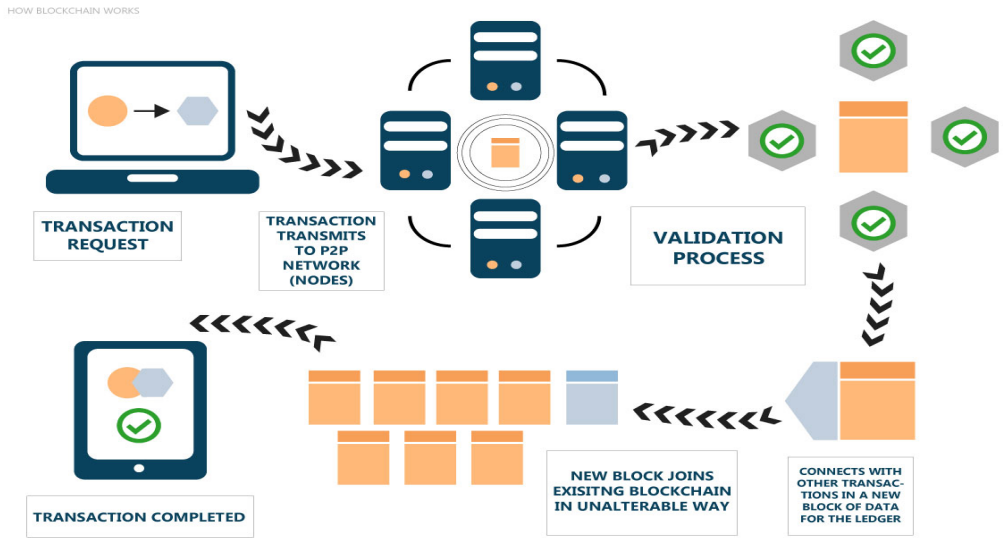

Figure-1. How blockchain works (www.agiboo.com, 2017)

Firstly, the process begins with the necessity for an exchange that later describes as a transaction request. A request then modified into a hashed transaction to guarantee integrity and authenticity before stored in a block and proceeds to the next step (Step 1). The transaction distributed into peer-to-peer network for further processing and authentication while parties should provide credential information to identify their identity (Step 2). Once the transaction authenticated by parties, blockchain run a validation process that includes

consensus mechanism to verify the transaction (Step 3). Furthermore, the verified transaction must be connected with other transaction to forms a new block of data for the digital ledger (Step 4). The new block appended to the existing blockchain and placed in chronological order (Step 5). Eventually, when the new block already chained; the transaction considered as completed. From figure-1, it shows that blockchain allows decentralization of digital ledger, which are managed and updated by participants in the network. Thus, it enables each party to perform a real-time transaction and exchange ownership of the information (V.J. Morkunas et al., 2019). Besides, from security perspective the merit of this decentralization is to eliminate the risks that might occur when data being held centrally; in case the worse thing happened, there will be no single point of failure.

Since decentralized nature inflicts to redundancy, as a consequence it influences how the information stored in the network. Parties could benefit from the spreading of information because it increases transparency and build trust. Moreover, in the blockchain-based system, all the activities recorded and could not be erased or modified. Thanks to the immutable nature of blockchain. Additionally, the consensus mechanism plays an important role to tighten security. It requires parties to prove that the work done by them and they have rights to add new transaction into the blockchain. Above all, blockchain is highly secure and reliable since each block linked to each other through a chain that contains a unique hash key, which makes the pieces of information stored in blockchain are immutable and tamper-proof (J. Pereira et al., 2019). Falsifying information in the blockchain involves extra effort for the intruders since they must generate the new hashed key for a given block and modify the consequent blocks' hashes to avoid someone discovers the break in the chain. (Böhme et al., 2015).

Blockchain has developed into one of the biggest state-of-the-art technologies with the prospect to impact various industry. Consequently, blockchain becomes the concern of academia, practitioners, and regulators to dig deeper into the impact and how it could transform the way people do business. A recent study based on economic theory discussed how blockchain technology forms innovation and competition in the digital platform. It explained that blockchain imposes impacts on the cost of verification and the cost of networking. Blockchain technology allows a reduction in the cost of verification by running the validation process, which is important to guarantee the authenticity of data stored in the blockchain as well as protect leakage to unauthorized parties. For that reason, blockchain fulfills the requirement to alter the authorized intermediaries and generate inexpensive verification. Moreover, reductions in cost of networking depend on the cost of verification. The reduction affects the ability to bootstrap and operate the market without intervention from intermediaries. This achieved because of the compounding of inexpensive verifying process and incentive mechanism that stimulates participants in digital markets to share infrastructure and digital public utilities which result in lower

networking cost as the platform operated independently (C. Catalini and J. S. Gans, 2019).

Other study explained how blockchain could impact the business model and create new value. The authors briefly described two models of blockchain: private blockchain and public blockchain. According to the value proposition, both imply different impacts on the business model. Private blockchain model brings some good point to a firm, such as reducing time and cost. Conversely, public blockchain projected to contribute to some disruptive idea for industries, for instance, the case of disintermediation in Bitcoin. At some points, those highlights of blockchain model can be references for firms to appraise what type of blockchain strategy that influences the business model and generates commercial value (V.J. Morkunas et al., 2019). A big technology company named IBM mentioned four types of blockchain network. The types are public blockchain where everyone can join and participate in the network, private blockchain where one central authorization organize the network, execute consensus mechanism and maintain the distributed ledger, permissioned blockchain where the concept exactly the same with the private one but with extra permission to access certain information, the last is consortium blockchain where multiple organization share the responsibility to maintain the network. Since blockchain offer several type of network, the private one is highly recommended for business purposes.

2.2.2 Supply Chain Management (SCM)

According to Larson and Halldorsson (2004), the definition of a supply chain (SC) is the incorporation of the whole processes from suppliers to final customers that involve the movement of original products, service, and information to provide added value for the customers and other stakeholders. Relating to that definition, supply chain management (SCM) seen as sequence decisions and actions that designed to manage the flow of goods or services from raw materials, the inventory and finished products from production to the consumption point. The principal idea is to deliver products or services at the right quality, price, quantity, time and destination. Therefore, SCM generates streamlined and cost-saving processes designed to enhance customer satisfaction (V. Anca, 2019). Concerning that, there are principal critical success factors (CSFs) for SCM such as collaborative partnership, IT integration, top management support and human resources that should be prioritized by companies (M.S. Ab Talib and A.B.A. Hamid, 2014). Collaborative partnership expected to create transparent, common and visible demand pattern distributed in an extensive range. Thereby, collaboration shall build in two directions, vertically (customers-suppliers) and horizontally (competitors). Successful collaboration generates positive impacts such as costs reduction, higher efficiency, boost revenue streams as well as enhance the flexibility. IT integration is one of the key ingredients to perform business. Nowadays, almost all businesses depend on the usage of IT devices. Taking an example from inside of the aerospace industry, most of the companies currently integrate

digital SC platform to perform responsive SC, simplify the collaboration process and to be more competitive. In this sense, IT portrays a crucial function to support the achievement of SC objectives. Top management support is vital to the internal business of companies. Supports can come in several forms like strategic decision making, resources planning, form strategic suppliers relationships, new ideas to enhance SC (i.e. integration of digital SC), psychological and behavioral support for employees. Hence, top management support help to create a more agile environment for the entire SC. While human resources play an influential role within the hiring process in the company. They are in charge of picking the competent candidates to be placed and support the SC process. In this context, the idea is to be smart in choosing people as human factor influences productivity, failure rates as well as safety. Besides, human resources also subject to enhancing employees' skill by providing appropriate training. Therefore efficient SC achieved through the participation of several competent people who place brains together to accomplish SC goals.

To gain a better understanding of how SCM implemented in a company, an example of a manufacturer within the aerospace industry demonstrated in figure-2.

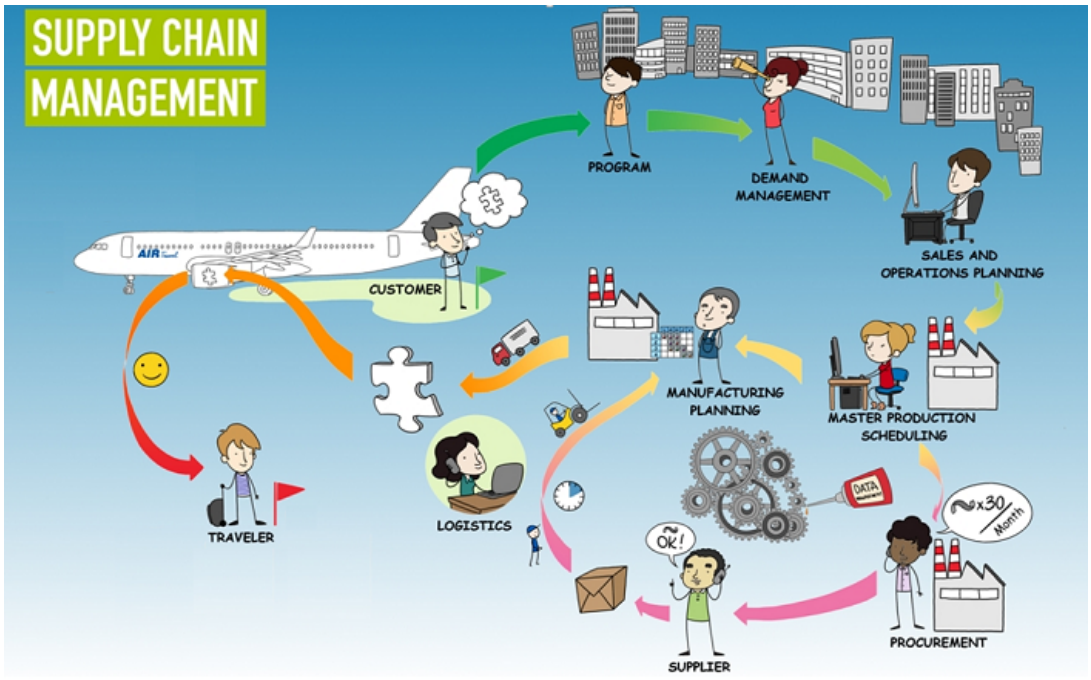

Figure-2. Safran Supply Chain Management, Source: (adopted from: www.safran-group.com)

Safran is one of the biggest manufacturers for the aerospace industry. From the figure, it showed that Safran designed its SCM to be as lean as possible. This achieved through their right strategies that result in efficient SCM. Furthermore, SCM considered as one of their success keys to perform excellence operation

and production process. The example of Safran points out that SCM placed the focus on enhancing its efficiency. Since efficient SCM perceived as a determiner for the performance of the operation and production processes. Hence, in designing SCM, managers encouraged to consider the risks and select the right strategies to achieve the highest efficiency. Sequentially, SCM should continuously improve to reach commercial goals and maintain performance.

2.2.3 Space Industry

The space industry defined as a group of firms whose main activities are manufacture components that explore earth's orbit or beyond, such as launchers, rockets, satellites, and other kinds of space hardware and service (J.L. Bromberg, 2000). Since the commencement of the space industry, both government agencies (i.e. ESA, NASA) and military organizations (i.e. Air Forces, Ministries of Defence) significantly contribute to construct and develop space technologies and space systems. According to the European Commission (2017), space industry plays a crucial role in transportation, communication, and Earth observation also security and defence. These are the reasons lie behind huge investment from the government in the development of space technology and space systems. Looking at that fact, the objective of the space industry mostly dedicated to fulfilling the needs of government and military organizations.

Nevertheless, the recent trend shows that a new era of the space industry is dawning. Space no longer becomes the concern of government and military organizations but also attracts the attention of non-government parties. Those trends projected to increase, as there is a growth in demand from commercial applications. The growth of demand closely related to the development of efficient solutions in the commercial market. For instance, the use of navigation systems such as GPS, Galileo, Glonass to support location-based service on the smartphone, current use of space data for smart transport and logistic, the use of Internet of Things (IoT) technology, communication for commercial airlines, financial forecasting, and so forth.

Furthermore, the space industry categorized as high-risk industry because the products are highly complex and don't have the fault correction mechanism once they've launched to space (L. Rapp et al., 2015). Indeed, only a few companies that has the competency in providing launchers, rockets, satellites, and other kinds of space hardware and service. Nowadays the market dominated by several big players in space sectors like Thales Alenia Space, Airbus Defence & Space, OHB SE, Boeing, Lockheed Martin and SSL. Thus, resulting in highly concentrated supply and demand while in some case could lead to the oligopoly market. Besides, the products mostly produced in a small number because it is demand-driven. The costly price and long development time also contribute to reducing the number of transactions. On top of that, the main difference that distinguishes the space industry market from other industries is the direct intervention of government. Space technologies considered as a strategic asset for national defence and security purposes (P. Barbaroux, 2016).

3. Case Study Research & Results

3.1 Case Study

By the purpose to answer the research questions, the author conducted qualitative research through several case studies. The case study used to convey empirical studies on the actual phenomena in the space industry. Case study research utilized to bring new insight into the topic. The essential backbone of this case study is that phenomena studied in their real environment and theories generated from practice (S. Tönnissen and F. Teuteberg, 2019).

To assure that the case studies are valuable, multiple companies in the space industry chosen to obtain vigorous results. The research of information related to case studies focused on several companies in the space industry that applied supply chain platform to smoothen the processes and foster robust relationships with suppliers. The results point out that some companies implemented supply chain platform within their business. The author later decides to choose three companies namely Airbus Defense and Space, Boeing and Thales Alenia Space. The selection of case studies builds on the fact that these companies are the most significant players in the marketplace of the space industry.

3.1.1 The Case of AirSupply: Airbus Defence and Space (D&S)

BoostAeroSpace SAS founded by Airbus, Dassault Aviation, Safran and Thales. It is a digital platform for collaborative and safe data exchanges inside the Supply Chain of Aerospace & Defence for European industry. In this context, BoostAeroSpace supports the development of AirSupply. In particular, AirSupply focused on fostering SCM efficiency. The concept is to strengthen the coordination between customers and suppliers through a centralized platform and to alter individual supplier portal. The platform builds upon proven business processes and allows various functions such as excellent capacity planning, responsive fine-tuning of shipment quantities and dates as well as order status tracking. Besides, the benefits for Airbus are seamless communication and standardization of process within its suppliers. Whereas, for suppliers are reducing risks of late-payment and improve their efficiency. Moreover, for both Airbus and suppliers are reducing cycle time and workload, paperless purchases orders and invoices, utilization of a single platform from ordering to the payment process.

In general, the platform supports three major processes including order, shipment and payment. Order process involves numerous actions such as coordination between customer and suppliers to review weekly forecast and daily order, suppliers create demand planning based on customer's ERP system, the customer later submits short-term requirements and place orders, suppliers will ensure their ability to meet the orders. In case of suppliers unable to complete the orders, the alternative proposal generated for the customer. Finally, if customer and suppliers reach an agreement, suppliers release commitment then the collaboration process is completed. Orders are further processed for shipment. The shipment process begins with the delivery of

despatch advice to verify that the materials correspond to the purchase order requirements while submitting materials' receipts. The status of orders is available for tracking purpose. Ultimately, the payment process entails self-billing. The self-billing help to simplify the sourcing and buying process as it automatically creates purchase orders and invoices. Borne in mind that all processes established in the platform and real-time.

Additionally, AirSupply supports Vendor Managed Inventory (VMI) where suppliers can prepare deliveries based on the stock level as well as future demands. Suppliers gain total visibility into their customer's inventory level. They can accurately meet demand while making better anticipation when variations arise in the future. Whereas, customer benefits from the declining in safety stock, lower inventory holding cost and decreasing stock shortage.

Implementation of AirSupply significantly changes Airbus' SC process. It proven to gives some relevant guide to the operational and management level in term of decision-making. Furthermore, efficient SCM is one of the essential drivers for Airbus' decision to expand its businesses. In the latest of July 2019, Airbus stated that the company created a joint venture with OneWeb called OneWeb Satellites. This joint venture aims to transform the satellites and space industry in general. OneWeb Satellites is the first plant that applied mass-production techniques for satellites production, enabling a tremendous reduction in cost and development times. It capable to produces one satellite per production shift or two per day. By delivering high qualities satellites at a lower cost and faster development time, OneWeb Satellites allows the development of Internet connectivity as well as making space technology accessible. Additionally, in term of production capacity, OneWeb will supports the rapid scaling of the OneWeb network. They start to form a constellation of 650 satellites and scaling to 1,980 satellites in delivering global connectivity. Concerning that, efficient SCM needed to succeed. In fact, as mention in Airbus' site, OneWeb Satellites' currently hired 3,000 indirect jobs through the SC. In that way, the company is certain to achieve their targets.

3.1.2 The Case of Boeing Supply Chain Platform (BSCP): Boeing

Boeing supply chain platform (BSCP) designed to provide a secure access point to suppliers who want to collaborate with Boeing. BSCP enables suppliers to obtain information associated with the global supply chain from Boeing, contracts with Boeing, as well as tools to manage order and payment process. The implementation of BSCP allows those kinds of information accessible by suppliers from all around the world. Hence, BSCP leads to supply chain globalization. Exostar, Boeing's partner for the development of the platform explains that the main features of BSCP are a single point of entry into Boeing, simplified access to complex information also links to news and events on supplier activities within Boeing.

Furthermore, from a security perspective, the platform relatively secure as its access restricted only for registered suppliers and partners. As mentioned by Exostar, BSCP also adds a 2-Factor Authentication (2FA) for secure log in to the

platform. This requirement applies to all users that log into BSCP. The 2FA pertains to access code that sent to the mobile phone or presented as a token. Access code commonly in the form of one-time password (OTP) used to login into the platform. An email sent to suppliers provides the instruction of the login process. The guidance is accessible via a link in the email. Once they click it and follow the instruction, they will receive a welcome email says the account already set up.

The decision to implement BSCP is a breakthrough for Boeing's SC process. It helps Boeing to strengthen its relationship with various suppliers through a safe platform. Besides, the platform carries transformation in term of globalization supply chain for Boeing. That means Boeing could benefit in several aspects such as expand sourcing opportunities, reaching new customer in a new market, growing the business and production, and cost-saving on spending. A global market supports diverse suppliers and materials. However, significant advantage of globalization is to enlarge options for Boeing in term of sourcing materials and transportation. Broad options mean broad chances to save on spending and boost earnings. Furthermore, globalization improves visibility to reach the new customer in the new market as it enhances the confidence of the company to serve the new customer. Indeed, extending borders also means growing businesses and corporation like in the example of Boeing and Australia Space Agency. Boeing affirmed that in April 2019, to develop Australia's domestic space industry, both have signed a Statement of Strategic Intent. The statement highlights Boeing assistance for investments in research and development (R&D), innovation, Science, Technology, Engineering and Mathematics (STEM) education also government programs aligned with the Australian Space Agency's priorities. Expanding relationship with Australian Space Agency is an important step to prove Boeing's presence globally and reaffirm the long-term relationship with Australia in space field.

3.1.3 The case of IVEN: Thales Alenia Space

In the middle of June 2019, Thales Alenia Space mentioned a solution for the sourcing and buying process in the aerospace industry called IVEN. IVEN is the first dedicated digital marketplace invented to connect aerospace and defence companies with suppliers of parts and spare parts. With a growing ecosystem for components and attendant suppliers, purchasing processes might be slower, costly, complex and sometimes inefficient. As an experienced company, Thales Alenia Space then initiates to develop IVEN to answer these challenges. IVEN designed to acts as a trusted third party that connect customers and certified suppliers via a single interface. The aims are to simplify and protect transactions as well as improvement in the customer response time.

IVEN specifically intended to become a bridge between customers and suppliers in aerospace and defence industry. The platform provides transparency and traceability within the purchasing and payment process. Thus, it contributes to exhibit the availability of materials, reducing inventory holding cost as well as lowering purchasing costs. In particular, IVEN dedicated for

professionals and specialist suppliers to meet specific purchasing, financial, logistical and operational constraints faced by firms. In the first phase, the service only serves the suppliers but currently available for both seller and customers. “Thales is already on-boarding suppliers with a goal of 100 on line by the end of 2020. Commercial access for customers will be open from beginning 2020. By the end of 2020, IVEN targets more than 100,000 references on line”(Thales, 2019).

3.2 Result

3.2.1 Within-case Analysis

By investigating the case studies, the result showed that the implementation of the SC platform brings significant consequences to the company. In particular, impacts on improvement collaboration between customer and supplier as well as the intensity of their relationships. A question then arises, why collaborative communication is necessary for the company? The answer relies upon the facts that the interaction among stakeholders in the entire process contributes to efficient SC (J. Cambra-Fierro and R. Ruiz-Benitez, 2009). Therefore, companies initiated to create an environment in which there is checking and protection process on data sharing with their suppliers while introducing a new way to manage communication. The environment commonly refers to a platform designed uniquely to assist the needs of stakeholders within SC. Such a platform builds upon proven business processes with aims for process standardization and seamless interaction.

In the case of AirSupply and BSCP, they utilize advanced technology to build the platform. Both Airbus and Boeing opted to collaborate with the expert in the digital supply chain. This option based on the reality that they want to concentrate on their core activities, but at the same time, they require to control the activities within their supply. The controlling itself is to emphasize better information flow together with smooth and instant access to obtain information. Moreover, the role of information flow is also critical to establish responsive SC. Consequently, information considered as an integral part of the SC network. Information perceived as vital elements to provide stakeholders in the SC with the ability to observe, understand, forecast, correlate and trade-off to the available information resources (H.C.W Lau and W.B. Lee, 2000).

Indeed, the adoption of digital SC platform transforms the business process, the perspective of the stakeholders, and the value delivered. The findings in the case of AirSupply show that Airbus has successfully reduced manual works, which is good to avoid human error in term of generating purchase orders. Additionally, Airbus also benefit from the standardization process as it simplifies the complex process within its SC. In reverse, for its suppliers, they become more productive and effective in term of demand fulfillment. That achieve through the VMI feature supported by the platform. Moreover, suppliers also benefit from late payments reduction. Since late payments disrupt materials' flow. Besides, if the suppliers have difficulties with the cash flow, it will be the main reason that affects their performance. In such a case, they are likely not

performing well. On top of that, the improvement on the SCM allows Airbus to expands their business as seen in the OneWeb Satellites. Airbus succeeded in inventing a new way of satellite's production.

Farther, BSCP brings new outlook for Boeing's SCM. They decided to cooperate with Exostar to provide comprehensive protection to the platform. Boeing wants to assure that only verified suppliers that connected to the platform. That intended to regard the platform as a medium to build efficient supply chains and support the development of global supply chain management. Affirming a concept-driven strategy to become globally-oriented enable Boeing to possess a good position in the marketplace. That strategical decision gives the strength to sustain their presence as one of the giants in the space industry. The agreement between Boeing and Australia Space Agency is one of the conclusive evidence of how much they want to prove their experiences and encourage the expansion of Australia's domestic Space Industry. Therefore, Global SCM gives added value to Boeing and causes the company to remain competitive in the market.

Ultimately, IVEN the digital marketplace invented by Thales Alenia Space more focusing on increasing the visibility to SC. IVEN designed for buyer and seller of parts and spare parts of Aerospace & Defence industry. IVEN targeted for the sellers (i.e. suppliers) and buyers (i.e. manufacturer in aerospace and defence industry) where the platform perceived to help them do the transactions through online platform. This completely changes the way of sourcing and buying within the industry. Commonly, to purchase materials, there are complicated and time-consuming processes required. The main reason is that the space industry is highly complex and involves high-quality supplies for the production process (P. Barbaroux, 2016). The idea to gather verified suppliers in such environment will generate some benefits for the manufacturer such as simplify communication with suppliers, quick access to purchase the materials, get the right price, also advancing the production process. Above all, IVEN is a breakthrough in the SC of the space industry. It will be an innovative trend, while the implementation will impact the growth of the space industry. Since IVEN is relatively new, not so much information found.

In sum, it is appropriate to emphasize the real changes in communication and information flow within the whole SC process. Since the trend is shifting rapidly into digital channels and force the companies in the space industry to remodeling their SCM. As a result, processes and services added to substitute activities in traditional SC. Furthermore, these changes generate synergy among stakeholders, thereby obtaining responsive SCM and transparency in information flow.

3.2.2 Explanatory Model

Explanatory model dedicated to answering the research questions. In this section, a further explanation will be described. Conceptually, NASA defines space industry SC as a group of companies and suppliers that produce space-related items and distribute them to customers. Activities within the SC include

transforming process of raw materials such as hardware and materials, components and parts, assemblies and subsystems into final products like a satellite or launch vehicle. In 2017, NASA conducted a study focused on the upstream process of space industry SC. It noted that, there are five tiers involved. Tier relates to a group of companies that produces particular goods. Although in specific cases, it is usual for a company to operate in multiple tiers. That is feasible because of vertical integration, where materials produced in-house utilized for making other products demanded by customers.

Indeed, the involvement of various tiers within the SC could raise the needs to smoothen the collaboration process. So, companies required developing collaborative communication. Relying on highlighted evidence in the within-case analysis, most companies have shown that they started to improve the efficiency of their SCM by applying digital channels. The novel SCM supports to simplify the complicated process in SC and adding new means to communicate. Nevertheless, they continually develop the existing model. The proposed idea is to consolidate blockchain as a complementary technology for the existing digital SC platform. Thereby, this answering the first research question regarding how blockchain transform the SC in space industry. Blockchain will act as a complementary technology to existing digital SC platforms. In this direction, blockchain perceived to optimize the performance of existing platforms, particularly in term of trust, transparency, traceability and safety.

Blockchain can be adopted in several areas of space industry SC such as digital identity of suppliers, products certification, materials shipping and movement as well as contract management. In a blockchain solution, parties (companies and suppliers) must provide their credential information to be verified and stored as digital identity. The digital identity later serves as an identifier in all transaction. Thus, the advantage is the ability to trust the business partners in the value chain. If new suppliers join, the company should not have any concern about its new partners. Accordingly, blockchain create transparency as parties allowed to manage and control the information passed to blockchain network. Furthermore, concerning products certification, blockchain provides the answer to the problem of counterfeit materials. So, this is relevant concerning the facts that the space industry produces complex products while high-quality materials needed. As an example, when Tier-1 place orders to Tier-5, the company sure that they will receive original parts cause blockchain facilitates to have access to all information related to the orders (i.e. serial numbers of the parts).

In spite of that, the distributed digital ledger allows each party to receive copies of valid and secure information in real-time. That enables companies to have control of the movement of materials. In case problems occur (i.e. missing materials), the company can make smart decisions to solve them.

In the case of materials' shipment, using the example before, both Tier-1 and Tier-5 receive the update of each order. If the orders have to go through an intermediary (i.e. customs authorities) blockchain could address that by reducing the bureaucracy and accelerate the administrative process. Moreover,

blockchain contributes to contract management by generating SC contract, service level contract, procurement contract, and any other contract within SC process. Thus, blockchain helps in diminishing paperwork and reduce time to draw up contracts.

4. Proposition & Managerial Implication

4.1 Proposition

The explanatory model above described how blockchain as complementary technology brings added value processes to the existing space industry SC platform. Following that, through this section, the author would like to propose the type of blockchain technology that might be adopted. The proposal is to implement private-permitted-blockchain. The reasons rely on the natures of network openness and scalability since the space industry classified as complex industry and records many sensitive data. That also reinforced the facts that space technologies are complex, costly and valuable. Most of them are used and beneath the direct supervision of the government. Thus, implementing private-permissioned-blockchain should be proper. The notion of private-permissioned-blockchain is to possess a central authority that restricts the access only to verified parties who perform transactions through the blockchain. They are entitled to append transactions into the blockchain as well as read and update the information.

Private-permissioned-blockchain allows companies to extract commercial value through the implementation of blockchain. The companies in the space industry could represent as principal authorities or collaborate with other business partners to capture and share value. Otherwise, the suppliers benefit from secure data sharing, while gaining access to what information distributed, who they are interacting, and when the information added or the communication happened (B. Carson, 2018). Thereby, the implementation of a blockchain solution for the company and suppliers includes the data sharing between upstream stakeholders (i.e. tier-1 until tier-5), SC data exchanges and administrative documentation.

The possibility is open wide for the blockchain to become a new alternative protocol for trusted data storage, identity and transactions. Blockchain carries benefit in cost reductions such as hiring cost of personnel to develop and manage the database as well as the costs for investment in database. Its decentralized nature causes it possible to store data in each participant inside the blockchain infrastructure. This leads to building trust among participants and increased transparency in the information flow.

When the companies in space industries are ready to adopted blockchain technology into their existing SC platform, they will elicit added values that impacting their business model. The significant impact that should be a highlight is the security and responsiveness of SC. Secure and responsive SC obtains advantages by reducing cost, boosting response time and flexibility in a competitive marketplace. Therefore, the companies are succeeding to accomplish their objective of improving their customer satisfaction. Further, the

value of blockchain that generates secure and responsive SC also adding competitive advantage for the company which make the entry barrier for radical new entrants in the space industry higher, especially in the case of satellites market.

4.2 Managerial Implication

These research findings have several managerial implications. First, the trend in SCM currently inclining to the adoption of digital channels. This trend has changed the way companies communicate with suppliers and control the information flow. The digital channels have proven to ease communication, reduce non-value added activities, reduce SC cost, fostering the relationship between company and suppliers, giving information on material's availability, make demand forecast more accurate, support decision-making as well as provide real-time SC data exchange. However, following all the benefits provided by digital channels, some challenges can hinder its sustainability. The growing dependence on digitalization raising the risk of collapse in the network triggered by cyber-attacks in SC. The UK National Cyber Security Center (2018) mentioned several samples of attack in SCM, namely third party software providers, third party data stores and watering hole attacks. Impacts that may arise from these attacks include the presence of malware with remote access to internal SC system, essential information theft as well as large-scale fraud. Given those facts, managers urged to stay up to date to the information about preventive measures against cyber-attacks and perform risk assessments. That way, the entire supply chain will remain safe and not interrupted. Essentially, SC is in the heart of every industry. So, if SC interrupted, it likely sways the company's productivity. The direct impact affects the internal production process. Ineffective production processes due to interruptions lead to delay in satisfying customer needs, decreasing production rates, losing customers' trust, and the worst condition is the company might fail to compete in the marketplace.

Second, the digitalization of SC perceived as a solution to responsive SC. Companies in the space industry are endeavoring to become competitive by exploiting advanced technology for efficient SCM. To achieve it, companies decided to collaborate with experts in the digitalization of SC to build a secure and responsive platform that mostly dedicated to smoothen the upstream process. Here, SC managers perform a vital duty to promote and encourage internal and external parties to optimize the usage of the platform. The degree to which companies adapt and integrate the digital supply chain is clinging on the participation of all parties in the entire SC. The decision will be considered right on purpose when all have participated in the adoption of the platform.

Besides, although the platform has many positive impacts on the company, in consequence of innovation in technologies development, the existing platform might become obsolete in the future. Thus, SC managers are advised to identify pain points throughout the engagement with the platform and focusing on the parts that need improvements. This thesis discussed the

possibility to combine blockchain technology into the existing digital platforms in space industry SC. That combination presumed to perform efficient solution. Highlighting the added values of blockchain for the space industry SC, managers ought to consider them.

In advance of determining the blockchain strategies, managers prescribe to conduct granular assessments by developing use cases. Thus, they will understand better what are the necessary values for the company and define the approach to capture them. Use cases must be based on several strategies focusing on key characteristics of blockchain technology. The intended characteristics pertain to consensus mechanism, provenance check, an immutable ledger and infrastructure finality (M. Gupta, 2018). Before determining the relevant use cases, managers might respond to several questions such as,

1. Is there any asymmetry in the information collected in the existing platform? If yes, what is the main cause?
2. Does the traceability of information -for example, suppliers' identity, certificate authentication of materials- give benefit to the company?
3. Which information considered important and influence the entire SC process? Is the tamper-proof solution relevant to protect that information?
4. Is it necessary to simplify the access to evaluate the completion of transactions within SC?

Once managers able to respond to these questions and the answers are positive, that will be a decent time to start the deployment of the SCM solution with blockchain technology. Managers later advised to redefine the SCM to become more in-line and determine strategic objective of blockchain solution for SC.

5. Conclusion

This section prepared to conclude the discussion about blockchain technology in space industry SC; the advantage for business practice will be summarized. First is time reduction in multiple complex transactions. As described in the concept of space industry SC, there are several tiers involve. Hence, blockchain technology facilitates a faster collaboration process. Second is cost-effective, a blockchain solution cut the fees in monitoring as all the parties are verified and can be identified by other participants, intermediary process because of the data swapped directly (i.e. in case of global SCM: customs authorities), repetition of effort because the transparency offered by blockchain allows parties to access the distributed ledger. Third is strict security, the tamper-proof feature useful to prevent cyber attacks and fraud. In the private-permissioned-blockchain, it possible to allows only verified suppliers with proof of their digital identity and details of materials supplied to the company (i.e. hardware and materials). Fourth is an improvement in privacy. For permissioned blockchain, parties granted extra access to the details of the transaction (i.e. auditors) because their ID and access privilege checked prior. Fifth is simplified

inspection process through a distributed ledger, every party permits to manages and control the transactions. Lastly, increase operational productivity as blockchain streamlined the process and reduce manual activities (i.e. secured self-billing, automated payment under specific requirement).

Nonetheless, behind all the advantages of blockchain technology, some drawbacks need to be developed. These drawbacks include the immaturity of blockchain, high switching cost as well as the shortage of blockchain expert in the company. Since the nascence of blockchain technology in 2008, many people tried to exploit and advance the use of the blockchain for business scale. But the fact that blockchain still in its infancy stage makes it necessary to be further improved. As a consequence, the processing speed in blockchain infrastructure considered sluggish and require a lot of energy consumption. Whilst, the high switching cost stimulated by shortcoming in the expensive infrastructure.

To overcome that, several technology companies tried to explore the market by offering blockchain as a service (BaaS) with the concept as cloud-based storage (B. Carson, 2018). Also, for the shortage of expert in the company can be surmounted by collaboration with the human resource department to provide special training of blockchain for personnel in charge. This way companies sure that they will have in-house experts.

Eventually, blockchain holds the potentiality to become new promising means for data exchanges despite the drawbacks mentioned above. Blockchain needs to further developed in order to expose its transforming power.

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