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Does Technology Against Corruption Always Lead to Benefit? The Potential Risks and Challenges of the Blockchain Technology

Kibum Kim, Consultant at KPMG, Seoul, Korea

Taewon Kang, Ph.D Candidate at Seoul National University, Seoul, Korea

kkim28@kr.kpmg.com

dream264@snu.ac.kr

Out of various application areas of the recent blockchain technology, this paper examined how this technology could be used to curb corruption and take integrity to higher standards. Possible risk and challenges related to the technology were identified and found that without a well-planned policy, the blockchain technology may not always lead to a socio-economic benefit.

From implementing the blockchain technology as a means of managing the supply chain, we can expect to have a full transparency over the whole supply chain. Also, its application on the public sectors and on under-developed countries has the potentials to root out corruptions and lift those countries out of poverty.

Despite the potential opportunities, this paper found that the blockchain technology is not a panacea that will resolve all corruption issues today. Without considering the data governance and privacy issues, its application on the supply chain may lead to a distorted market structure. Its implementation on the developing or under-developed world will not be realized on a large scale anytime soon due to the resistance of the existing leadership and lack of infrastructure.

Blockchain is still a black box for most stakeholders and, therefore, a holistic and coordinated effort will be necessary. We believe that international organizations are suitable to bringing all stakeholders including the government, business and academia together to come up with an effective policy guideline on the blockchain usage. At the same time, more experiment and innovative use cases should be encouraged and developed from the market side. Entrepreneurs should have the incentives to seize new blockchain-related business opportunities and their continuous efforts will ultimately take integrity to higher standards.

1. Introduction

1.1 Research purpose

A growing stream of research finds a negative relationship between corruption and economic growth. Therefore government and institutions implement various anti-corruption measures to fight against corruption and technology has often been an effective tool of improving integrity. Among various technological innovations, this paper focuses on the recent blockchain technology that arose as an effective way of resolving corruption issues. This paper identified possible risks and challenges related to the technology and found that without appropriate policies, the blockchain technology may not always lead to a socio-economic benefit.

A blockchain is an electronic ledger of digital records that is shared among participants. This technology addresses every transaction's authenticity by confirming the parties involved, the time and date of transaction as well as the contents. If a transaction contains fraud information due to corruption or forgery, it is not validated due to the consensus protocol and, therefore, transaction cannot take place. As such, the blockchain technology can be an effective tool to root out corruptions from having a transparent view on every transaction.

Despite the potential opportunities of the blockchain technology, we find that it is not a panacea that will resolve all corruption-related issues. Blockchain's negative side needs to be examined and the limitations should to be identified prior to its commercial usage. Without considering the potential challenges, the price to pay due to its reserve effect might surpass the potential socio-economic benefit that we expect from eradicating corruption.

1.2 Research question and contributions

This paper examines the potential applications of the blockchain technology as a means of eradicating corruption in three domain areas: supply chain and logistics, government and public sectors, and international trade. Although many papers anticipate the potential opportunities that the technology may bring in our society, this paper focuses more on the challenge and risk factors that needs to be considered before its implementation. A close understanding of its limitations need to be uncovered and appropriate policy measures need to be formulated accordingly in order to maximize the socio-economic benefit of the blockchain technology.

Since the concept of the blockchain first appeared in 2008 and widely spread following the launch of the crypto-currency Bitcoin in 2009, many technical and non-technical papers were published from

both academia and business. Several papers described the technology as a revolution with an immense potential to transform our society just like internet changed the business landscape today.

The blockchain market is growing from the momentum of innovative start-ups and IT giants. Several companies are introducing proof of concepts and solutions that meet the potential demand. Although the current movement is heading towards developing a standardized technology by forming consortiums and partnerships among the blockchain providers, the technology is still being experimented at a wide scale. As the technology is, by itself, transparent, many use cases were being developed as a means of eliminating corruptions around the world. This paper reviews the current stage of technological development through the analysis of various case studies and provides implications on where to go as a next stage. Moreover, this paper examines the blockchain technology from a policy perspective and tries to identify ways of better guiding the technological trajectory. We hope that the technology can end corruptions that run rampant in our society today and ultimately lead to a socio-economic benefit.

From our studies, we conclude that the blockchain technology is a double-edged sword. It may be an effective tool to eradicate fraud, corruptions and bribery from having a transparency. However, it is also important to consider the negative ripple effect of the technology which might hinder sustainable growth. Therefore we conclude that a well-planned policy needs to be developed to maximize the benefits of the blockchain technology usage.

2. Research Background

2.1 Corruption and economic growth

There has been active discussions to identify the relationship between corruption and economic growth. Most studies conclude that, in general, corruption is closely related to low economic growth (Mauro 1995; Mauro 1997; Salinas-Jiménez and Salinas-Jiménez 2007; Goedhuys et al. 2016; Dutta and Sobel 2016). Mauro (1995) identified the relationship between corruption and economic growth based on a cross-sectional national data for the first time. Mauro (1995) measured the degree of corruption of a country based on political stability, legal system, judiciary, and terrorism and named it as the Bureaucratic Efficiency (BE) index. Figure 1 shows the relationship between BE index and GDP per capita growth rate and it shows that as BE index increases, economic growth tends to increase as well. This tendency has been observed in many other studies since this research..
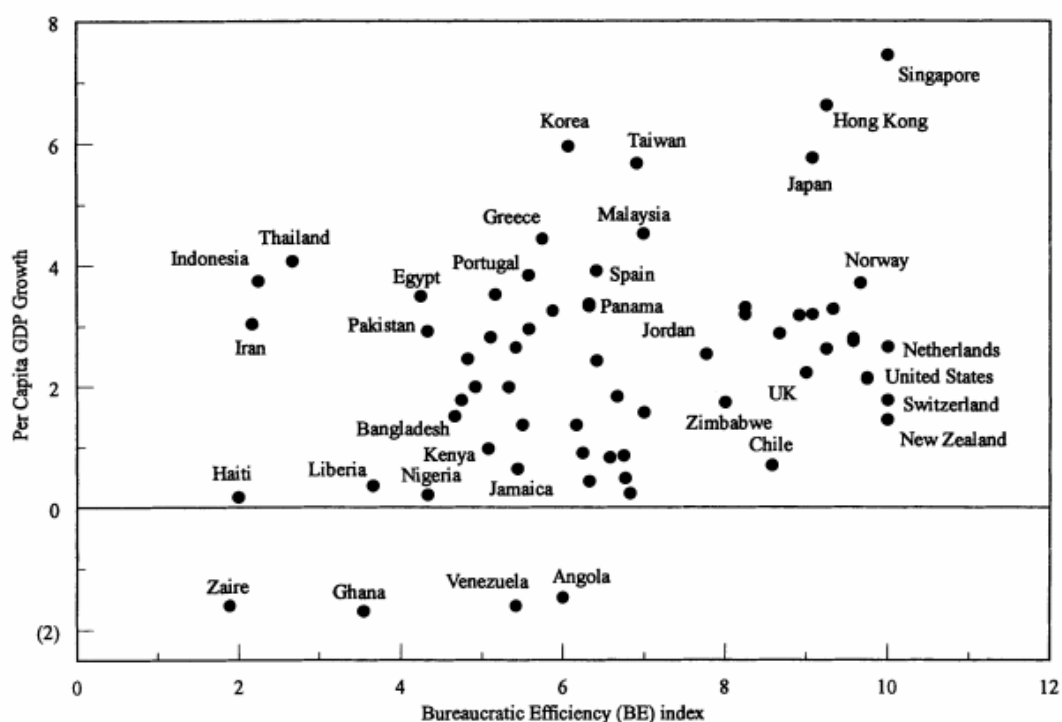
Source: Mauro (1995)

[Figure 1] The relationship between corruption and GDP growth

The direct and indirect effect of corruption on economic growth can be summarized as below. First, as corruption increases, transaction costs and uncertainty increase. Such transaction costs include monitoring costs and enforcement costs to sustain the market. As a result, corruption reduces the domestic and foreign investment (Mauro 1995; Pellegrini and Gerlagh 2004). According to Mauro (1995), public spending for education, healthcare and infrastructure decreases if corruption becomes

widespread. From an empirical study Mauro (1997) finds that corruption seriously affects private investment and ultimately affects growth adversely. Corruption Perceptions Index can be measured from scale 0 (very corrupt) to 10 (very clean) and if a country's corruption index augments from scale 6 to 8, investment consequently increases by 4% and GNP per capita by 0.5%.

Second, corruption inhibits the efficient allocation of resources (Salinas-Jiménez and Salinas-Jiménez 2007). It is very important to optimally allocate and utilize resources in an economy with limited resources (Acemoglu and Verdier 1998). If corruption is widespread, incentives to utilize resources and technologies would be reduced, resource allocation would be inefficient, and the overall vitality of the society would decrease. According to an empirical analysis of 22 OECD countries, corruption has a negative impact on the total factor productivity (TFP) and, therefore, reduces the country's overall technology level (Salinas-Jiménez and Salinas-Jiménez 2007). In addition, Svensson (2005) found that corruption and firm performance are significantly correlated. He argued that in an economy with a high degree of integrity, firm performance is high due to efficient allocation of resources.

Finally, corruption weakens entrepreneurship (Goedhuys et al. 2016; Dutta and Sobel 2016; Anokhin and Schulze 2009). The creative destruction caused by innovation is the driving force of national development (Schumpeter 1934). Therefore, active entrepreneurship is essential for economic growth. Corruption reduces entrepreneurship as it is time-consuming for the entrepreneurs to start a business under a high degree of corruption and uncertainty. In sum, corruption increases uncertainty and transaction costs which ultimately hinder innovations from happening.

2.2 Technology against corruption

Due to the negative impact of corruption on our society, many countries are actively working to eradicate corruption. Countries are introducing various anti-corruption measures including enforced regulations and strengthened monitoring system to detect corruption. Out of various measures, technology has often been used as an effective tool to improve integrity and fight against corruption. In particular, ICT can reduce unnecessary human intervention and make administrative procedure more transparent.

E-government is a representative case that utilized ICT application that helped prevent corruptions on the public sector. E-government provided transparency and better accessibility of government information to the public. Korea is an exemplary country that improved public sector integrity through the e-government. Korea has actively built an e-government system based on the competitive advantage of ICT technology, and as a result, applied e-government system to all public sectors. Based on this experience, Korea is now spreading e-government to various developing countries (Shim and Eom 2009).

This paper examines the recent blockchain technology that emerged as an effective tool to reduce corruption. In the next section, we examine the blockchain technology more in detail.

3. The Blockchain Technology

3.1 What is a blockchain technology?

Blockchain is a database of information distributed over a network of computers rather than located on a single or multiple servers (Figure 2). Since it was first introduced on a paper by Nakamoto (2008), the technology received close attention from diverse industries. Its first and the most famous practical application is the electronic currency known as the Bitcoin.
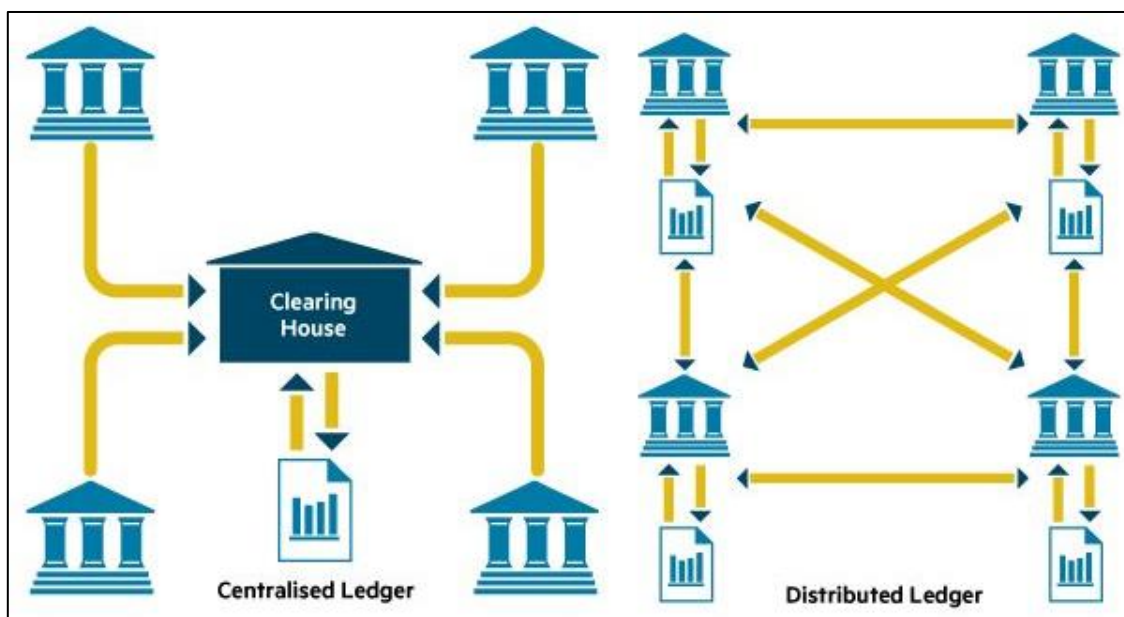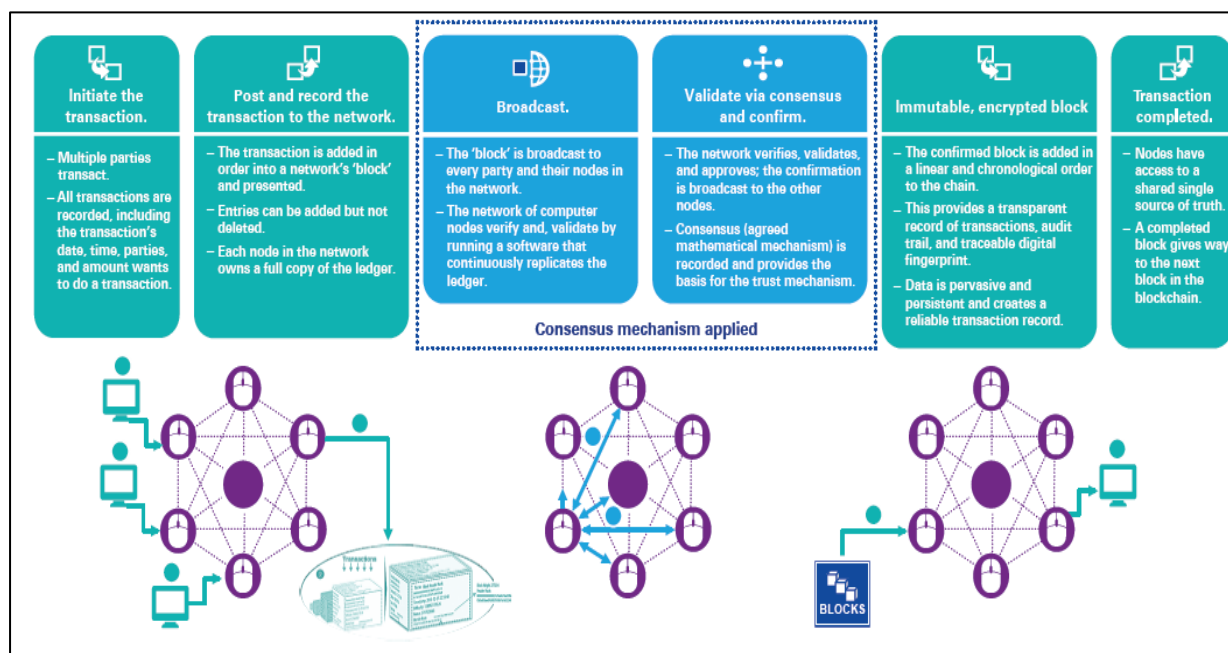

[Figure 2] Introduction of the blockchain technology (Financial Times)

The blockchain technology ranked third among the top 10 emerging technology of 2016 by the World Economy Forum (WEF) and on a recent survey, a majority of experts and executives in the ICT sector expected at least 10% of global GDP to be stored on the blockchain platform by 2025 (Grewal-Carr and Marshall 2016). Other mainstream institutions including the UN, Word Wide Web Consortium, RAND Corporation and IMF explored how the blockchain technology could be utilized as a tool to empower the global communities.

Technically speaking, a block is a current part of the chain which records the history of the most recent transaction on a 'nonce' and once completed it goes into the blockchain as a permanent database. Whenever a block is completed, a new block is generated and then linked as a chain in a chronological order with every block containing a part of the previous block, which si known as a 'hash'. These blocks linked on a chain are distributed over a network which goes through a verification process whenever a new transaction occurs. Unlike traditional transaction where the

trusted third party verifies and executes transactions, some or all of the nodes verify them accordingly to its consensus protocols, and once confirmed, the transaction is executed.

Its consensus protocols can be programmed into various forms. Also, depending on who participates as individual node, blockchain can be developed into a public, private or consortium blockchain. Bitcoin is an example of the public chain where everyone with can participate. For a detailed information on how blockchain works, Figure 3 explains the whole process from initiation to completion of a transaction.

[Figure 3] The process of the blockchain technology (KPMG)

3.2 Key benefits of the blockchain technology

Several benefits of the blockchain technology are highlighted including the reduced transaction cost, speedy process, enhanced privacy and reliability. As a blockchain is a specific type of distributed ledger shared within a network, it is not owned by one person or organization. Therefore, unlike traditional transactions where a trusted third party is needed to verify and certify the transaction, the blockchain technology does not require a middleman that verifies the accuracy or the authenticity of the transaction, thus, reducing its transaction cost.

Another benefit of the blockchain technology is its security. There is a very low risk of manipulation, since it is managed in a digitally distributed format by the network rather than an individual party. The constant reconciliation process within the network guarantees integrity and reliability of the data recorded within the blockchain database. Unless the rules embedded within the protocol allows, it is almost impossible to alter the historical records. At last, blockchain transactions are processed more quickly than traditional data transferring system.

4. Blockchain Application against Corruption

Organizations both in private and public sectors begun exploring the potential applications of the technology. Although most use cases are focused on financial sector, the technology can disrupt various industries and transform the way we conduct businesses and the role parties play (Bindman 2016). Below examines some cases that are used to curb corruptions.

4.1 Supply chain / Logistics

As our world today has become more inter-connected and global, there is an increasing tendency to apply the blockchain technology as a means of monitoring the multiple layers of the supply chain. The supply chain has become more complex and having a transparent visibility across the whole supply chain has become more difficult. As most companies do not have an integrated supply chain management system integrating the whole supply chain, they have a limited or siloed sight on their second or third tier suppliers. It became more difficult to track the flow of raw materials and the distribution channels and, consequently, it has led to various unethical business behaviours ranging from illegal trade, counterfeit products, environment damage, conflicting mineral issues to unethical labours (Badzar 2016; Abeyratne and Monfared 2016).

At the very end of the supply chain, consumers do not have the information on where a final product has gone through across the supply chain (Jørgen and Anders 2016). As an example, the commodities consumers buy contains very little information other than the label addressing the production origin. However, it is difficult for the consumers to know whether some parts of the products were produced by illegal child labour, or within a country where conflicting mineral issues occur. Even though consumers now have more information on products than a decade ago by certifications issued by NGOs, they still lack a strong enforcement mechanism that prevents and monitors illegal behaviours in the market.

Such a lack of transparency in the supply chain or logistics becomes more critical when it comes to pharmaceutical or medical industries in which illegal or fraud medications can lead to fatal consequences (IBM 2016).

In this regard, the application of the blockchain technology on supply chain has the potential to increase supply chain transparency for both suppliers and consumer, and improve contractual coordination (Badzar 2016). The two recent use cases are explained more in detail below.

4.1.1 Food safety

U.S retail giant, Wall-mart, Tsinghua University and IBM in Beijing are testing the blockchain technology to tackle food safety issue in China (Kharif 2016). Thanks to the use of the blockchain technology, consumers can trace back where the pork came from within China, thus certifying and ensuring its quality. The blockchain technology becomes more useful when it combines with the recent IoT technologies such as RFID sensors or QR codes. Without extra manual work to upload information on the blockchain database, the process of certifying the food quality can be automated.

4.1.2 Vendor management

The blockchain technology is also being tested in the mining industry as a means of better securing real-time data generated across the whole supply chain. The end to end supply chain transparency and visibility enables an improved analytics for operational excellence, reduced risk and fastened decision making. BHP billitron, one of the world's largest mining firm, relies on vendors at nearly every stage of the mining process, contracting with geologist and shipping companies. The company is testing the blockchain technology to track material movements of wellbore rock and fluid samples that are being generated from the vendors (Rizzo 2016). From collecting real time data of the vendors on a blockchain, the company plans to conduct quality assessment for its vendors at near real time for better business performance. This will ensure that the vendors comply with the firm's compliance and, thus, improving the quality of the final product. The improved traceability will enable a better management of multiple vendors and production facilities around the world (Kelly 2016). As such, the blockchain application on the supply has the potential to curb out manipulations that some actors within the supply chain attempt. Also, effective oversight and secure supply chain will protect consumers from counterfeit as well as substandard production.

4.2 Public sectors / Government

Blockchain technology has also been examined in various public sectors as well to improve transparency and eliminate corruption. The state of Vermont in the U.S issued a paper that analysed the potential opportunities and risks associated with the blockchain technology (Condos et al. 2016). The idea of publicly tracking public spending using the blockchain technology was also suggested by London Mayoral candidate George Galloway in early 2016. The state of Delaware also announced a new initiatives to embrace the emerging blockchain and smart contract technology. The U.S Postal Service Office of Inspector General (OIG) examined how the blockchain technology could impact the Postal Service's businesses (USPS 2016). The U.K Government Office for Science also published a

comprehensive paper exploring the potential application of the blockchain technology to benefit the public services and the economy (OGL 2016).

The three distinct advantages of the blockchain system, namely distributed architecture, immutability and transparency may help combat fraud and corruption occurring in the public sectors (Pilkington et al. 2016). Blockchain could be used to carry out many functions of traditional regulator and assure the public that the politicians are not squandering around the taxpayer money. Government and financial institutions can use the technology as a means of combating financial crime such as money laundering and tracking any fund transferred for criminal activities such as drugs trade or terrorism. With the use of the technology, every transaction can be recorded without manipulation, making the ultimate destination transparent. Below examines the two use cases that were applied to curb corruptions around the world.

4.2.1 Voting system

Ballot rigging still persists on many parts of the world today. By inaccurate voting for multiple registration, the election result may not always reflect the public opinion but it is subject to manipulation by a corrupted authority. In such circumstances, the blockchain technology ensures that every eligible vote is counted accurately without any manipulation and this can be a huge step towards democracy. Moreover, the technology can transform the traditional paper-based voting system to a digitalized one, offering convenience to the voters in developed countries as well (Foroglou and Tsilidou 2015).

4.2.2 Property & real-estate management

Corruption on the property and real-estate market is another unresolved issue for some countries. As an example, Honduras is notorious for being one of the most corrupted countries in the world, ranking 123rd on the Corruption Perceptions Index by Transparency International. In order to root out the corruptions occurring on land registries, the government of Honduras partnered with a blockchain start-up to develop a system that kept the land record on a transparent and unhackable blockchain platform. Although this project has stalled due to political issues in Honduras (Riley 2015), this type of transparency may keep the government officials supervised from abusing their power while encouraging land owners to officially register their lands on the publicly accessible blockchain network (Brodbeck 2015).

Apart from being transparent, users of the blockchain system could inspect a search for any property records in real-time without any cost. This not only cuts unnecessary waiting time that allows

fraudster to make a move but also provide a more efficient and convenient way of conducting transactions (Campbell 2017; Foroglou and Tsilidou 2015).

4.2.3 Foreign Direct Investment (FDI) / Donation

The blockchain technology has been also reviewed by NGOs and charitable organizations to eliminate the misappropriation of funds by keeping a public ledger of all financial transactions involved in the charitable activities. This would be valuable to international organizations such as the World Bank in tracking where the loans are being spent within the borrowing countries' borders. International organizations that provide FDI to the developing world can track every dollar which will ultimately lead to a better spending. In case of charities, donors will be able to track how their money is spent, the final destination as well as the results generated from the donations.

Such transparent system enabled by the blockchain technology can ultimately lead to a more clean and productive spending alleviating poverty and endemic corruption in the under-developed world. (Pilkington et al. 2016)

4.3 International Trade

As many regulatory compliances need to be met during the process of international trade, the blockchain technology proves to be beneficial when cross-country transaction occurs at a massive scale. Blockchain can make trade finance documentation more efficient by streamlining processes and integrating the database previously spread across multiple parties and databases on a single shared ledger. The paper-based documents between trading parties and banks, more specifically bills of landing, letters of credits are subject to manipulation, loss and fraud (Evry 2015). From the use of the blockchain technology, trading parties can better manage the ownership of documents and eliminate disputes, forgeries and double-spending risks. The use of smart contract can log the change of ownership and automatically transfer payments to ports upon arrival which can lead to a more efficient and transparent way we trade.

5. Risks and Challenges of the Technology

Despite the abundant application areas of the blockchain in combating corruption, it also has various risks and challenges that need to be addressed. Below, we identified 3 major issues that may arise due to its implementation. Without considering them prior to its adoption, the price to pay for this revolutionary technology may surpass the benefit we expect from its diffusion.

5.1 Data governance and privacy

Transparency is considered as a disclosure of information and such information sharing improves the relationship between suppliers and customers by making transaction more efficient (Hart 1995; Fung 2013, Lamming et al. 2001). Such transparency can resolve the information asymmetry between contractors (Akerlof 1970; Fung, 2013), however, we find that too much information sharing among the participants within a supply chain may harm privacy and distort the market structure in an unintended way.

Blockchain applied to manage supply chain may contain valuable data that participants had previsouly not shared. The transparency and traceability of financial or historical data within the distributed ledger may be subject to misuse of those in the upstream of the supply chain. The final manufacturer who did not have information on its 3rd or 4th tier vendors may trace their transaction status and other credential information in real time once blockchain is being adopted at a wide scale. Such information may include inventories, margin, unit cost or bill of materials.

Information sharing may raise the bargaining power of a minority on the upstream of the supply chain. The suppliers in various layers of the supply chain may be subject to vertical integration and in the worst case, they may get a raw deal or pressure to cut price. Transparency in data may stimulate competition among market participants and provide opportunities for new entrants to join the market. This would ultimately improve the industry competitiveness and customer welfare. However, when only a few minorities benefit from making unfair profits, it may harm the fair ground for competition. Moreover, a new form of bribery or corruption between the suppliers may stem from the misallocation of power.

 In order to prevent such side effects from happening, data governance and privacy issue need to be addressed. Otherwise, the blockchain can be used as a tool to abuse one's power and gain dominant control. It is important to pursue transparency in supply chain but, simultaneously, data protection needs to be respected. According to Eric Applewhite from the KPMG, a balance between the two aspects of protection privacy and safety should be the norm, not the exception. Such balance cannot happen without strong leadership to sustain an information sharing culture change (KPMG 2016).

Despite the benefits of data sharing on a blockchain platform, protecting individual company's data privacy and confidentiality should always be high on the agenda.

Since blockchain is deterministic in that the input data and consensus mechanisms are programmed prior to its adoption, a close investigation on data governance, more specifically, who owns the data, what data can be revealed need to be discussed among the participants (EU 2016). The risk factors and limitations should be considered before developing use cases on the supply chain. Already, many checklists or evaluation questionnaires are being developed by research institutes and consulting firms so that companies can understand what blockchain is relevant to the company's context. Companies that will be participating on the blockchain as individual nodes will need to examine the benefits as well as the risks prior to its adoption.

5.2 Resistance from the incumbents

5.2.1 Creative Destruction versus destructive creation

Introducing a new technology to an existing market can be a risky business. It has been said that 80% of the blockchain technology is about the change in business process and 20 percent is related to technology implementation (Mougayar 2015). Therefore, incumbents pay a close attention to the blockchain technology that may disrupt their businesses.

Generally, when a new technology or business enters the existing market, the incumbents either use regulations to defend themselves or strategize to preserve their rent that they previously owned. When Bitcoin first appeared to our world as a crypto-currency, many issues were raised. It has been blamed for distorting the regulated financial market and for bypassing the regulatory scheme of traditional payment system. It is true that Bitcoin is subject to high volatility as it is not backed by a single government or organization. However, raising the entry barrier through regulations only delay the blockchain adoption and restrain innovations to spur.

Similarly, blockchain first appeared as a threatening technology that may substitute trusted third parties including traditional banks and clearing houses. Despite the possibility to replace the role banks play in the market, financial institutions embraced the technology and actively formed consortiums such as the R3CEV to develop proof of concepts and use cases. Through active responses, not only did blockchain offer a significant cost reduction and efficiency, but it enabled revenues to growth through the introduction of new business models and higher-quality service (Zyen 2016). From such active responses of the incumbents, consumers benefited the most from the technology commercialization. Goldman Sachs estimated that the blockchain application in KYC/AML checks alone could save $2.5bn of the $10bn global processing costs in the banking industry (Goldman Sachs

2016). Therefore, in order to benefit the most from the blockchain technology, removing unnecessary regulations is recommended.

5.2.2 Under-developed countries

Applying the blockchain technology in the under-developed countries where corruption and red tape run rampant seems ideal. However, there are many stumbling blocks ahead. First, under-developed country may not have the infrastructure needed for adopting the new technology. Second, most corruptions in the under-developed countries stem from the top management or leadership level and it is unlikely that the blockchain technology will be diffused through the top-down approach (Lielacher 2016). No transformation can succeed unless it is built upon a strong political leadership and commitment ready to support the change process (Pilkington et al. 2016).

Moreover, most blockchain start-ups or IT giants that are developing use cases focus more on lucrative businesses than for the public interests. Even though there are many blockchain cases that were developed in the public sector, it is still rare and gaining strong momentum by a strong leadership is still a challenge. Therefore, international organizations such as the OECD or UN should take an active role in encouraging start-ups to develop more use cases that will root out corruptions and lift the under-developed countries out of the poverty trap.

5.3 Technology-related issues

From the past experience, we find that technology has always been subject to misuse by criminals. Technology is surely a powerful tool that strengthens companies' defences against fraud but at the same it is misused by the fraudster to find areas of vulnerability to penetrate (KPMG 2016). Similarly, blockchain allows an effective solution for detecting frauds but new type of fraud that circumvents the current system appears. As blockchain uses digital signatures to prove identity, transactions can be traced back to cryptographic identities, which are theoretically anonymous. In reality, Bitcoin and similar crypto-currencies using the blockchain technology have been linked to illicit transactions in drugs, weapons, and prostitution. Due to such side effect of the new technology many governments imposed sanctions on its usage due to the concerns over the criminal exploitation (Cognizant 2016). Therefore, blockchain technology can also be viewed as a problem for those hoping to fight crimes and corruption (Nedopil 2016).

6. Discussion & Conclusion

The blockchain technology is surely an innovative technology that has various application areas. This paper reviewed how this technology can be used to curb corruption and achieve the next level of integrity. Despite the potential opportunities, this paper finds that the blockchain technology is not a universal solution that will resolve all corruption related issues we are facing. Without considering the side effects of the technology, the price to pay may surpass the benefit we expect from eradicating corruption. Without considering the data governance and privacy issues, its application on supply chain may lead to a distorted market structure and cause a new type of corruption. Also its adoption to the developing or under-developed world will not be realized on a large scale anytime soon due the lack of infrastructure and resistance of the existing leadership.

Uncovering the potential risks and challenges of the blockchain technology is important to prevent possible side effects from happening beforehand. Blockchain is still a black box for most stakeholders and, therefore, a holistic and coordinated effort will be needed. We believe that international organizations are suitable for bringing all the stakeholders including the government, business and academia together on a roundtable to come up with a feasible policy recommendations and guidelines for the blockchain technology.

At the same time, more experiment and use cases should be encouraged to stem from the free chaotic market. Entrepreneurs should have the incentives to seize new business opportunities and their continuous efforts through trials and errors will ultimately take integrity to higher standards.

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