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The Coming Age of Blockchain Technology in Corporate Governance

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ABSTRACT

This research explores the opportunities hidden in the blockchain technology and smart contracts in the context of corporate governance while also advocates a new way of looking at governance practices in the ever-connecting, automating and digitalizing world by adopting 'Robust Political Economy Framework' to demonstrate that 'human imperfections' are the natural causes of the principal-agent problem. Applying this framework on agency theory, it identifies 'limited rationality' and 'limited benevolence' as the limits of human nature, triggering a certain mindset in corporate managers, which facilitates the aberrant behavior. To deal with such aberrance, it develops two major tools, which are 'de-centralization of powers in decision making and increased transparency and accountability'. It further verifies that these two concepts also form the very core of any governance mechanism aiming at aligning the interests of a principal and an agent. Hence, what makes this framework distinctive is that it can be utilized to keep 'agency costs' under control by monitoring and adjusting the costs and benefits of these two variables. Especially, if the technological developments such as smart contracts and blockchains keep their promise of providing secure automation in governance processes, the framework can be useful in drafting a cost-benefit analysis for the adoption of these new technologies which may not necessarily benefit the performance of companies by 'limiting the human interaction' in decisions while 'increasing the transparency in the operations abruptly'. The latter issues are not the current focus of corporate governance; therefore, this framework will be able to support both the existing and new waves of discussions in corporate governance, changing with the technological developments.

INTRODUCTION

Bitcoin, blockchain hype, blockchain, blockchains, chain of blocks… It seems that these were the latest 'buzzwords' resonating in the ears of technology enthusiasts. But now, these innovations have also started to become 'relevant' in the life of ordinary people with the increasing adoption of this technology in the many other spheres of life. [1] According to one of the leading research centres in Europe, known as the 'UCL Centre for Blockchain Technologies' or 'UCL CBT', this technology is more than an infrastructure for 'crypto-currencies' due to its potential to alter the way today's administrative work gets done. The institution envisions a future where 'Blockchain and Distributed Ledger Technologies' are being widely adopted and integrated into the socio-economic system, transformed completely. Therefore, they are appealing to regulators, industry and academia for the formation of an 'innovative and connected ecosystem' where not only expertise is freely shared but also resources and platforms are easily accessed by these actors.[2] Moreover, in line with the goal of UCL CBT to spread this technology to the lives of ordinary people, they also provide a great input to the literature as to how this technology could be utilised in different sectors. In this regard, 'Market and Finance' and 'Government and Law' are two out of six categories used in their classifications, already implying the potential revolutionary impact of this technology upon the corporate landscape.[3]

In the line with UCL CBT's vision, there is already a hot debate in academia and corporate world regarding the use of 'blockchain technology' in corporate governance, especially hyped after the

[1] Lawrance J. Trautman, 'Is Disruptive Blockchain Technology the Future of Financial Services?' [2016] QR 241. (See Appendix 1 for illustration of the potential adoption paths).
[2] UCL Centre for Blockchain Technologies, accessed on 29.07.2017 on http://blockchain.cs.ucl.ac.uk/about-blockchain/.
[3] *Ibid.*

release of David Yermack's paper on the potential implementation routes of this technology in corporate governance[4]. However, before going through its the adoption in this field, one needs to define the technology. The generally accepted definition of this technology is that 'a blockchain is a sequential database of information that is secured by methods of cryptographic proof, and it offers an alternative to classical financial ledgers.' However, it might be an uneasy definition for those who are not familiar with cryptography and programming. Thus, to put it even simpler, 'the blockchain is an incorruptible digital ledger of economic transactions that can be programmed to record not just financial transactions but virtually everything of value.'[5] It offers a new way of creating, exchanging, and tracking the ownership of financial assets on a peer-to-peer basis. Therefore, what blockchain technology ultimately promises is 'transparency' and 'incorruptibility' in recording the exchange between multiple parties, that can remove 'the agency problem' from certain processes of a company with the help of smart contracts automating the governance rules.

As can be understood, blockchains and smart contracts may achieve to reshape the corporate governance by limiting the human factor in corporate governance of a company by removing the 'human factor' from certain processes while increasing the 'transparency' in its operations. Yet, it is unknown what the lack of human factor in a company and the increased transparency can trigger in the corporate context since especially these issues fall outside the scope of the goal embraced by the traditional corporate governance literature, which is to 'align interests of an agent and a principal'. Hence, the consequences of automation brought by 'blockchains and smart contracts' are unknown. If the agency problem cannot be removed entirely, the focus of corporate governance

[4] David Yermack, Corporate Governance and Blockchains (November 28, 2016). Review of Finance, Forthcoming. Available at SSRN: https://ssrn.com/abstract=2700475.
[5] Don & Alex Tapscott, authors Blockchain Revolution (2016).

needs to be renewed. It needs to understand how companies can strike a balance between removing the agency problem and protecting the privacy within the same company.

Having inspired from this new and difficult dilemma, this research question in this paper was formed as following:

'In what ways may the use of blockchain technology reshape the corporate governance as we know it?'

The motivation behind this question is rather simple as it aims to finds out where and at what cost the technology can be implemented and if there are negative consequences of its adoption, what strategy one needs to follow in addressing these problems.

To be able to answer this question, the research will, initially, start from defining the agency theory to explore its origins. And afterwards, the paper will attempt to adopt a 'framework theory' that can support both the evolution of agency theory and form an understanding of the possible implications of new human-free governance processes in a company. To this end, Pennington's Robust Political Economy theory will be put into a test using the existing literature. If it can be validated, the theory will be able to enlighten the way 'human imperfections' cause the conflict of interests between an agent and a principal and how 'decentralization and increased transparency and accountability' form the core of every governance mechanisms devised to align these interests. In this way, the research could be able identify the atoms of 'agency theory' and 'governance mechanisms', that can be used to analyze the negative and positive effects of the secure automation brought by blockchains and smart contracts.

Upon the formation of this theoretical understanding, the paper will introduce the blockchain technology in Chapter 2 with the motivation to make this technology understandable to readers from all background and especially to legal professional who lack technical knowledge to comprehend the technicalities of this technology. And finally, in Chapter 3, the use of blockchains and smart contracts in the governance processes in this context will be explored and be sampled with practical examples to foresee the possible implications of these developments in horizon. To this end, the research will apply Pennington's reasoning to these technologies to 'ask questions' that can be used by companies to draft a 'cost-benefit' analysis prior to the adoption these technologies in their operations. And eventually, the paper will try to answer the thesis question and process to the conclusion.

Finally, to address the methodological aspect of this paper, one can realize certain limitations present in this paper. Firstly, the research will be relying on second-data, hence, the limited empirical support may be considered as a problematic issue. Nevertheless, for the purposes of this broad topic, the form of data will not cause any problem on its reliability since the theoretical understanding of the issues taking part is the focus rather than their practical implications on the performance of companies. Secondly, this research will not be able to analyze the understanding of the use of blockchains in certain governance processes in detail. The main goal is this paper to predict the future challenges and benefits brought by blockchains and smart contracts in the context of corporate governance from a broad perspective, to map the governance practices affected.

Chapter 1: Theoretical Framework

This Chapter aims at introducing the theoretical framework under which the research will be conducted and the case studies will be analyzed. It will initially introduce the concept of corporate governance under which 'agency theory' will be studied, through which an understanding of how 'the conflict of interest and between an agent and a principal' negatively affect the performance of a corporation and its stakeholders. And secondly, the chapter will present Mark Pennington's Robust Political Economy theory which will be connected to 'agency theory' and provide new insights towards the study of corporate governance in the digitalized world.

1.1. Corporate Governance: Agency Theory

Notwithstanding that 'corporate governance' is not difficult to comprehend as a concept, for many students and even for some scholars, it might be quite problematic to define the term in a simply structured way mostly due to the vagueness and broadness of the term itself[6]. According to OECD, 'corporate governance involves a set of relationships between a company's management, its board, its shareholders and other stakeholders. Corporate governance also provides the structure through which the objectives of the company are set, and the means of attaining those objectives and monitoring performance are determined.'[7] While the Cadbury Report 2012 even more vaguely defines the concept as 'Corporate governance is the system by which companies are directed and

[6] The Associate Editor, 'Theoretical Inquiries in Law' [2015] 16 Theoretical Inquiries L. I.
[7] Organization for Economic Co-operation and Development, 'OECD Principles of Corporate Governance' [2004] 11.

controlled.'[8] However, one another way to define this concept is through identifying its functions and goals as can be found in the definition provided by Khan (2011) below:

"Corporate governance is the broad term describing the processes, customs, policies, laws and institutions that directs the organizations and corporations in the way they act, administer and control their operations. It works to achieve the goal of the organization and manages the relationship among the stakeholders including the board of directors and the shareholders. It also deals with the accountability of the individuals through a mechanism which reduces the principal-agent problem in the organization."[9]

As can be understood, on the one hand, corporate governance is concerned about the relationship of the corporations and the society in which the business activities are conducted. While on the other, it relates to the structure of corporate oversight within a corporation.[10] In the context of latter, the definition also refers to the principal-agent problem which will be the focus of this paper.

Corporate governance is usually studied in the light of certain theoretical frameworks among which 'agency theory' plays an important role in identifying and solving the problems originally stemming from the separation of ownership from control in a modern corporation. Berle and Means (1933) elucidate in what ways such separation could have an impact on the performance of a corporation by using property law as a basis for their theory. They argue that a modern property owner surrenders its wealth to those in charge of the corporation upon the investing in it and in return, he becomes a mere recipient from the profits incurred. This can also be interpreted as that

[8] The Committee on the Financial Aspect of Corporate Governance, 'Cadbury Report' [1992] 2.5.
[9] Humera Khan, 'A literature Review of Corporate Governance' [2011] 25 IPEDR 1.
[10] Thomas J. Courchene, 'Corporate Governance as Ideology' [1995] 26 CBLJ 202.

such an investor simply surrenders its right that the corporation should be operated in its sole interest.[11] Nevertheless, those who are in control of a corporation do not automatically or naturally have the sole interest in running the corporation for the full benefits of its shareholders. There is always a natural clash of interests between the shareholders and the management of a corporation, which is explained by principal-agent relationship, in order words, 'agency theory'.

The theory simply expounds why and how this disparity in the interests of shareholders of a corporation and its management occurs while it also provides insights as to how to align those interests. Regarding this theory, Jensen and Meckling, (1976) two of the most cited scholars as well the pioneers in the field, describe the agency relationship as a type of contract where the principal (shareholder or investor) trusts the agent (managers) with running the corporation on its behalf. However, they argue that this transfer of authority may cause the management of company to take less shareholder-value maximizing decisions in the corporation since they do not act for the best and sole interests of the principal, in other words the shareholders.[12] They claim that if both a principal and an agent are utility-maximers, then there would be a good reason to believe that the agent would not act in the best interests of the principal.

Even without going into technicalities, one may understand how the interests of shareholders and managers differ. For instance, already in 1776, Adam Smith hypothesizes the key dilemma in principal-agent relationship by referring to a metaphor called "other people's money". He argues that the directors in corporations are the managers of the money belonging to other people, hence,

[11] Adolf A. Berle and Gardiner C. Means, 'The Modern Corporation and Private Property' [1933], Transaction Publishers, 3-47.
[12] Michael C. Jensen and William H. Meckling, 'A theory of the Firm: Governance, Residual Claims and Organizational Form [1976] JFE 3-4.

they cannot be expected to have the same 'anxious vigilance with which the partners in a private copartnery frequently watch over their own'.[13] Consequently, he further states that 'negligence and profusion, therefore, must prevail, more or less, in the management of the affairs of such a company'.

However, Adam Smith only looks at the one side of the equilibrium by focusing on the negligence in the management of a corporation. A new perspective could only be inserted into this theory in 1973, by Mitnick adding a new layer to the agency theory by conceptualizing the self-interests and goals of agents or in other words their incentives.[14] He claims that making decisions on behalf of its principal, an agent might be opportunistic to take certain actions due to its self-interests, which may not be beneficial to the principals.

Furthermore, Jensen and Meckling (1976) also contributes to the literature by formulating so-called 'agency costs' which in the most basic sense can be regarded as the costs a principal and an agent need to bear in order to align their interests. One another way to put this is that agency costs are those costs originated from the conflict of interests between an agent and a principal. It is the cost of making sure that an agent will be less opportunistic and more careful in its decisions which ultimately affect the welfare of the principal. To do so, a principal needs to limit the divergences in the interests of itself and its agents by incentivizing them as well as monitoring their activities to prevent any aberrance. In addition, they also categorize agency costs under the three headings below:

[13] Adam Smith, 'The Weath of Nations' [1776] Cannan Edition 700.
[14] Barry M. Mitnick 'Fiduciary Rationality and Public Policy: The Theory of Agency and Some Consequences' [1973] Annual Meeting of the American Political Science Association, 2.

1) The monitoring expenditures by the principal,
2) The bonding expenditures by the agent and
3) The residual cost.[15]

The monitoring expenditures cover, as it could be understood from its name, the cost of a principal's attempt to monitor or restrict the behavior or its agents. This may include, although not limited to, the costs of having a board of directors to supervise the management, issuing of financial statements and employee stock options etc.[16] The bonding expenditures refer to the costs related to agents. It is the costs that an agent takes on himself to limit the agency conflict by even reducing its own personal welfare. For instance, a manager may commit itself to the corporation by agreeing to stay in case of acquisition of the corporation by a third party. In such a case, what the agent promises is preventing him from taking advantage of some potentially better employment opportunities as a result of which it is called 'bonding costs'.[17] And finally, the residual loss simply refers to the costs incurred due to the impossibility of entirely aligning the interests of agents and principals. Therefore, it comprises the costs that could not be prevented by the monitoring and bonding.[18]

Although Jensen and Meckling (1976) clearly categorize different types of agency costs, there are countless ways to refer to similar concepts. For instance, Mitnick (1973) sorts the types of agency

[15] Michael C. Jensen and William H. Meckling, 'A theory of the Firm: Governance, Residual Claims and Organizational Form [1976] 3-4 JFE, 6-7.
[16] Craig A. Depken, Giao X. Nyugen and Salil K. Sarkar, 'Agency Costs, Executive Compensation, Bonding and Monitoring: A Stochastic Frontier Approach' [2013] University of Texas Arlington 11.
[17] *Ibid.*
[18] James S. Ang, Rebel A. Cole and James Wuh Lin, 'Agency costs and ownership structure' [2000] 1 TJF 83.

problems instead of defining them under the labels of 'costs' as 'principal's problem, agent problem and policing mechanisms and incentives'.[19] Yet, ultimately what he refers to is as same as the three types of agency costs aforementioned. Thus, it also must be made clear that only a very small portion of the literature is mentioned for the purposes of this paper. Due to the richness of this area in terms of academic input, only the basics of agency theory could be elucidated.

1.2.Robust Political Economy Theory

What is interesting about agency theory is that it is not only exclusively used in the context of corporate governance. Conversely, many of the pioneering papers in this area were written in the field of political sciences or at least mentions about the cross-applicability of the theory on the areas other than corporate governance. For instance, Ross (1973), Mitnick (1976) clearly refer to the universality of agency issue. Ross states that agency relationship is 'one of the oldest and most common codified modes of social interaction' and 'and agency relationship has arisen between two (or more) parties when one, designated the agent, acts for, on behalf of, or as representative for the other, designated the principal.[20] This easily can be interpreted as that he considers agency theory applicable to different relationships other than the shareholders and managers. Furthermore, Mitnick going further, applies the theory on many actors in the political context from ambassadors

[19] Barry M. Mitnick 'Fiduciary Rationality and Public Policy: The Theory of Agency and Some Consequences' [1973] Annual Meeting of the American Political Science Association, 14-15.
[20] Stephen A. Ross, 'The Economic Theory of Agency: The Principal's Problem' 63 2 AER 134.

to regulatory commissioners and their relationship with the state and public.[21] Thus, his work builds upon what Ross (1973) succinctly discusses.

The papers of Mitnick and Ross aside, what is noteworthy is the work of Pennington (2011) who provides a fresh perspective to the use of agency theory by adopting the theory in the context of political sciences and further simplifying the theory. Following the footsteps of his predecessors, he claims that the use of agency theory is not limited to manager-shareholder relationship, conversely, it could be applied to what he calls 'the mother of all principal-agent problem' implying the relationship of politicians and public.[22]Since there is what Meckling (1976) would refer as a contractual relationship between public and politicians by the transfer of authority from the former to the latter, there is an obvious agent-principal relationship between these actors. In fact, one could reasonably believe that agency problems between politicians and citizens are even more aggravated than those in the corporate context since elected politicians tend have less supervision and monitoring especially in the centralized political systems.

Moreover, Pennington in another work where he expounds his Robust Political Economy theory,[23] although he does not refer to agency theory explicitly, hypothesizes the reasons why policy-makers ('decision-makers in the context of political and economic institutions') tend to fail in their policies. He claims that two human imperfections, namely the problem of limited benevolence and limited rationality, cause policy-makers to make wrong decisions, misallocate given recourses and

[21] Barry M. Mitnick 'Fiduciary Rationality and Public Policy: The Theory of Agency and Some Consequences' [1973] Annual Meeting of the American Political Science Association, 18-23.
[22] Mark Pennington, 'Principal-Agent Theory and the Welfare State' [2011] CATO.
[23] It is worth noting that the theory was already existent in the literature (see Boettke and Leeson, 2004), however, Pennington gives it its current practicability.

display rent-seeking behavior.[24] The former imperfection merely refers to the self-interest of policy-makers as humans who are utility-maximizers for themselves rather than for others. The latter, on the other hand, is about that policy-makers have limited rationality. Therefore, they are not expected to make completely rational decisions especially in a context of considerable uncertainty and imperfect information, causing their policies to fail. For instance, many governments take initiatives to form 'business clusters' and make investments into developing the necessary infrastructure for such projects, and eventually they end up wasting the public resources by failing to make right choices based on micro-economic aspects of such projects.[25] Thus, Pennington asserts that the success of a political institution formed by policy-makers and its policies are contingent on its ability to address human imperfections successfully. In the line with this, he introduces the quality of 'robustness', which is used as a label for the institutions which can address human imperfections effectively. Hence, if an institution could effectively and efficiently reduce the effects of those human imperfections, it would be deemed to be a 'robust institution', thus, it would be expected to make more reliable decisions and perform better.[26]

[24] Nick Cowen, 'Introduction: Symposium on Robust Political Economy' [2016] Critical Review 28:3-4 422.

[25] Philippines and its experience with Special Economic Zones can be given as example. See Toshiyuki Kono and Kazuaki Kagami, The Structure and Functions of Special Economic Zones. in Jürgen Basedow and Toshiyuki Kono (eds), *Special Economic Zones* (Mohr Siebeck 2016) 71.

[26] Mark Pennington, 'Robust Political Economy' [2011] 27 4 CATO 8-11.

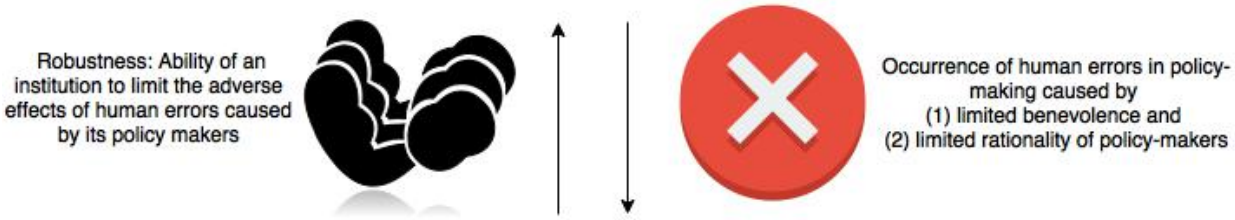

Diagram 1

Considering Pennington's theory, one may also realize that human imperfections are not limited to policy-makers but natural to all individuals. Therefore, his analysis on human behavior could also be utilized in other fields, one of which could be the corporate governance and agency theory. However, to show this, one needs to look at what causes the conflict of interests between an agent and a principal. As shown before, Jensen and Meckling (1976), Berle and Means (1933) and Adam Smith argue that the conflict of interest between an agent and principal originates from the 'self-interest' inherent in the former. Although they see self-interest as a human imperfection, they do not refer to 'limited rationality' directly.

On the other hand, some of the more contemporary authors believe that limited rationality and conflict of interests are highly relevant concepts. According to Chugh, Bazerman and Banaji (2005), 'the conflict of interest is not limited to explicit dishonesty. Rather, unconscious acts of ethically questionable behavior are more prevalent, more insidious, and as such, more in need of attention.' They claim that limited rationality is another human imperfection causing decision-makers to act unethically since 'they are psychologically motivated to maintain a stable view of a self that is moral, competent, and deserving, and thus, immune from ethical challenges. Because individuals view their immunity as more powerful than the situation (moral, competent) and view

any gains incurred as appropriate (competent, deserving), this view is a barrier to recognizing and addressing conflicts of interest'.[27] Many other authors such as Robennolt and Sternlight (2013)[28], De Cremer (2009)[29], Bazerman and Tenbrunsel (2012)[30] also agree on the effects of limited rationality on recognizing and addressing conflicts of interest. Thus, even when a principal is completely stripped of its self-interests, it can still involve in self-benefitting behavior without even realizing it. Hence, the occurrence of conflict of interests is inevitable as long as there is a human factor in the operations of a company. Besides, if individuals indeed suffer from 'limited rationality,' then it is only logical to assume 'limited rationality' will increase the frequency of negligent behavior as well as the risk that these actors act on their selfish-desires without giving much consideration to the negative effects of their behavior.

As can be understood, the focus on 'self-interest' or in other words 'limited benevolence' as the source of the conflict of interests between an agent and a principal seems to leave the paint unfinished without referring to 'limited rationality'. These two-human imperfection have their fair share in developing conflict of interests between an agent and a principal; and without eliminating them, it is impossible to align their interests completely. Therefore, this paper suggests that

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[27] They call this phenomenon 'bounded ethicality' and view it as an extension of limited rationality. See Dolly Chugh, Max H. Bazerman and Mahrazin R. Banaji, Bounded Ethicality as a Psychological Barrier to Recognizing Conflicts of Interest. Moore, D., Cain, D., Loewenstein, G., & Bazerman, M.H (*Eds*.), *Conflicts of Interest: Problems and Solutions from Law, Medicine and Organizational Settings*. (Cambridge University Press 2005) 90.

[28] Jennifer K. Robbennolt and Jean R. Sternlight, 'Behavioral Legal Ethics' [2013] 45 Ariz. St. L.J. 1107.

[29] David De Cremer, Psychology and Ethics: What It Takes to Feel Ethical When Being Unethical. David De Cramer (*ed), Psychological Perspectives on Ethical Behavior and Decision Making. (IAP 2009)* 3.

[30] Max H. Bazerman and Ann E. Tenbrunsel, 'Blind Spots: Why We Fail To Do What Is Right And What To Do About It' [2012] 22 accessed on 16.08.2017 at http://press.princeton.edu/chapters/s9390.pdf.

Pennington's analysis of human imperfections could be adopted to cover both 'self-interest' and 'limited-rationality' as the triggering factors behind the occurrence of the conflict of interests and the desire to act on them. In this way, a better foundation for the agency problems originated from these conflicts, could be built.

Pennington also discusses that limited rationality is even more prominent under a certain degree of uncertainty and imperfect information.[31] In the line with his reasoning, it could be expected that the higher the information asymmetries between and agent and a principal are, the more room there would be for an agent to act for its own benefit. Hence, it would be important to add 'information asymmetries' into equilibrium as an aggravating factor for the negative effects of 'human imperfections' in developing conflict of interests between an agent and a principal.

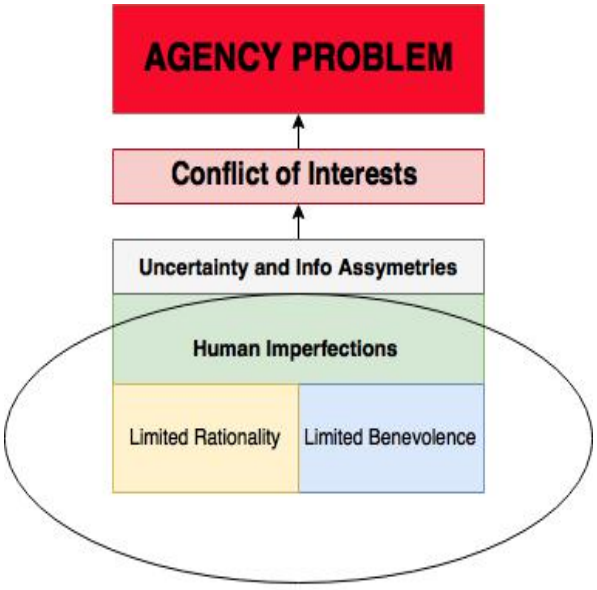

Diagram 2

[31] Mark Pennington, 'Robust Political Economy' [2011] 27 4 CATO 8.

Furthermore, Pennington's reasoning in his Robust Political Economy theory may also provide insights into 'controlling the conflict of interests between an agent and a principle' if the atoms of the conflict is 'limited benevolence and limited rationality'. As mentioned previously, Pennington conceptualizes two mechanisms that could tackle with the human imperfections leading policy-makers to make wrong decisions[32]and later these are clarified by Moberg. Hence, understanding how the negative effects of human imperfections could be useful in analyzing the corporate governance mechanism aiming at aligning the interests of an agent and a principal.

The first of these mechanisms was the de-centralization of the powers of the decision-makers (policy-makers in the context of political institutions). Pennington argues that when we have multiple actors making decisions, 'we facilitate a process of trial-and-error learning that minimizes the consequence of any particular error while in a centralized system the decisions taken may have far-reaching consequences.'[33] By the same token, in decentralized decision-making, since actors would have less responsibilities, they could accommodate the needs of actors surrounding them more easily in their-decisions, which could ultimately deal with the consequences of the limited rationality problem.[34] Besides, the hierarchy of decision-makers in a decentralized system, may serve as a system of checks-and controls, which could reduce the adverse effects of the limited benevolence.[35]

[32] *Ibid* 9.
[33] *Ibid.*
[34] Vuk Vukovic, 'Robust Political Economy. Classical Liberalism and the Future of Public Policy' [2011] EEP 225.
[35] Lotta Moberg, 'The Political Economy of Special Economic Zones' [2014] Journal of Institutional Economics, 15-16.

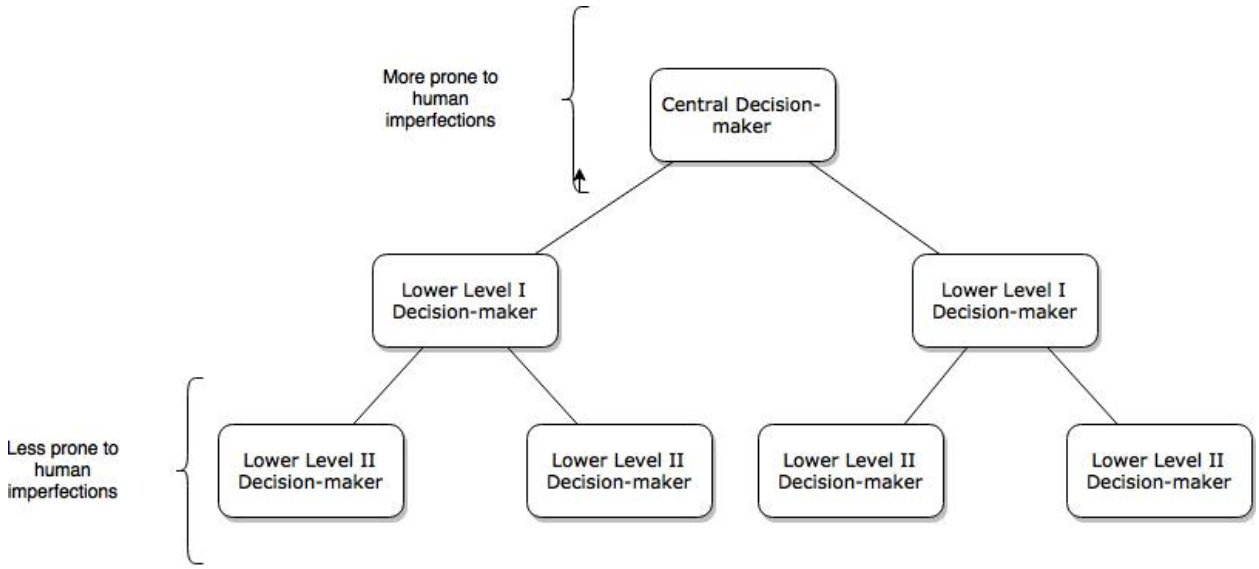

Diagram 3

Furthermore, the second mechanism mentioned by Pennington was originally referred as 'exit option' through which those who are affected by the opportunistic decisions can end their relationship with the decision-maker.[36] Pennington claims that 'if people are acting opportunistically, the capacity to exit from relationships with these actors provides a disciplinary check on potentially self-interested behavior.'[37]However, he does not clarify how this exit option could be operative. In this regard, Moberg (2014) gives insights as to how this mechanism could be functioning in the context of a political or an economic institution. She indicates that if the 'accountability and transparency' are increased in decision-making process, the limited benevolence could be tackled since the decision-makers would face accountability for their selfish behavior. Furthermore, if they are aware of the consequences of their activities, they would show more caution in their actions and dealings with third parties while also making more rational

[36] Mark Pennington, 'Robust Political Economy' [2011] 27 4 CATO 9.
[37] *Ibid.*

choices to be re-elected. Thus, at least in a political context, public would have an exit option by not-electing the same politicians or also in some extreme cases by prosecuting and impeaching them.[38] However, to guarantee this kind of exit, it is an absolute necessity to have 'accountability and transparency' for the activities of politicians.[39]

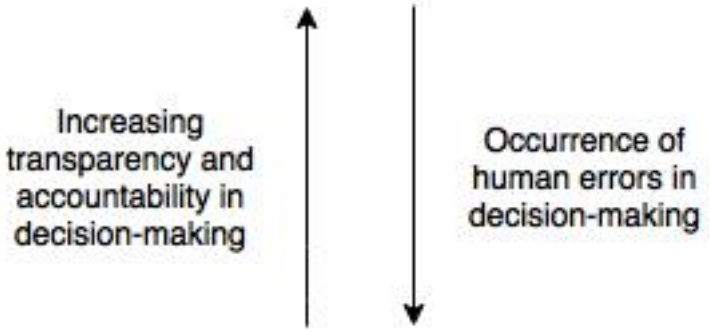

Diagram 4

As can be understood, none of these two mechanisms are specific to dealing with human imperfections in a political context, understanding the logic behind these mechanisms could be helpful in developing right corporate governance mechanisms dealing with the conflict of interests caused by the human imperfections. In fact, it is not difficult to see these already present in the modern corporate governance practices used in dealing with the agency problem. To illustrate, monitoring mechanisms in a company provides 'increased transparency and accountability' for the actions of an agent, ultimately reducing the effects of limited benevolence and limited rationality

[38] Vuk Vukovic, 'Robust Political Economy. Classical Liberalism and the Future of Public Policy' [2011] EEP 224.
[39] Lotta Moberg, 'The Political Economy of Special Economic Zones' [2014] Journal of Institutional Economics, 10-12.

by making sure that decision-makers in a corporation act ethically and more carefully.[40]The separation of management from directors and leaving major decisions to be taken by the shareholders or the hierarchical structures in companies can also be given as examples. These mechanisms decentralize decision-making and therefore allow parties to have more room for trial-and-error learning and act more logically under load of less responsibilities, reducing the effects of limited rationality. At the same time, such decentralization creates a system of checks-and-controls for abhorrent behavior by increasing transparency in the company with the superiors and principals acting as monitors. In fact, even giving performance-based pay or similar incentives to managers is about using the mechanism of 'accountability' to deal with 'lack of benevolence' as it increases their exposure to the results of their own actions. Considering one only has the most 'transparent information' about its own doings, performance-based incentives certainly act as a checks-and-controls mechanism in the context of corporate governance.

In a nutshell, it seems that Pennington was successful at identifying the atoms of agency theory and the corporate governance mechanisms dealing with the agency problem. His arguments seems to explain the very basic core of the issues faced in corporate governance. Thus, its adoption in literature could broaden our understanding of agency theory and help us understanding the logic of current corporate governance mechanisms and developing new ones.

[40] Dimitru-Nicusor Carausu, 'Monitor and Control in Companies: An Agency Theory Approach' [2015] 2 JPAFL 47.

Future of Corporate Governance

The desired and undesired effects of human factor in a company will always be present as long as humans continue to involve in the decision-making in the operations of the company. And some of these undesired effects will perpetuate the occurrence of conflict of interests between the shareholders and managers. However, with the current developments in technology, there may be opportunities for companies to deal with 'the negative effects of human imperfections' in certain governance processes used in running the company.

Some of the most discussed technologies in the context of corporate governance are blockchains and smart contracts, considered to have the capacity to create immutable systems that can automate some of the current governance practices. However, if the automation of certain corporate governance practices is an attainable goal, one could wonder how it could affect the development of the scholarly work in the field of corporate governance. As mentioned before, Khan (2011) asserts that one of the main functions of corporate governance is to 'deal with the accountability of the individuals through a mechanism which reduces the principal-agent problem in the organization'. However, without the human imperfections, and therefore, the conflict of interests, a company would not have a principal-agent problem in the processes where this technology adopted.

However, before understanding the possible implications of automation of corporate governance for companies and the literature, one needs to understand the technical development behind this technology to see whether it can keep its promises. Thus, in the next chapter, the technology of blockchains and smart contracts will be introduced.

Chapter 2: The Blockchain Hype

2.1. A New Era: Blockchains

Who could had imagined that a cosy Christmas day in 1990 could have become a line separating the past and the future. This was the day Sir Tim Berners-Lee officially made his code for a new 'information management' system available to public, whose conceptual and architectural design were outlined in a paper written by him previously in 1989. It was the 'World Wide Web' (hereinafter: The Web), born from a paper and grew to connect billions of people all around the world. It enabled ordinary people to access information and interact with each other through a network of computers known as the 'Internet.' [41] This breakthrough technology made the 'frictionless transfer of information' possible for everyone beyond the limits of location and time.[42]

Resembling the disruptiveness of the Web, now the world has been attesting to a new technology, thought to have altered the course of future once more[43]. Interestingly, this technology was also introduced in a paper very much like the Web, written by an unknown author operating under the alias 'Satoshi Nakamoto' in 2008. In his paper, he set up the foundational rules for the design of the first crypto-currency known as Bitcoin, working on an algorithmic network. However, Nakamoto did not only made the peer-to-peer electronic cash system operative in 2009 but he also, regardless of his intention, opened a new door to the future with

[41] Susannah Fox and Lee Rainie, 'The Web at 25 in the U.S.' [2014] PRC 1-2.
[42] Katya Malinova and Andreas Park, 'Market Design with Blockchain Technology' [2016] University of Toronto 1.
[43] Lawrance J. Trautman, 'Is Disruptive Blockchain Technology the Future of Financial Services?' [2016] QR 241.

his algorithmic network design, known as Blockchain technology.[44] He added a new dimension to 'the frictionless transfer of information' by enabling 'the frictionless transfer of value' on the network of computers.[45]

Furthermore, Blockchain technology did not remain static, it continued to evolve by especially accommodating 'smart contracts' in its very design as evidenced by Ethereum.[46] Hence, Blockchain technology can accommodate programs, allowing the technology to be implemented in more complicated areas rather than exclusively in the peer-to-peer electronic cash transfer. According to the World Economic Forum, this technology can found its use in areas including, but not limited to, facilitating global payments, issuing syndicated credit or securities, collateral management, regulatory and compliance activities and proxy voting.[47]

As can be understood, Blockchain technology can be adopted in many areas,[48] but this paper will be focusing on the use of the technology specifically in the context of corporate governance, which was hyped after the release of a paper by Yermack (2015). He elucidates the changing roles of corporate actors with the application of Blockchain technology in the matters concerning corporate governance and suggests the way this technology could be further implemented in many corporate matters, such as corporate book-keeping, stock issuance, shareholder meetings

[44] J.H. Witte, 'The Blockchain: A Gently Introduction' [2016] RCM 2.
[45] Katya Malinova and Andreas Park, 'Market Design with Blockchain Technology' [2016] University of Toronto 1.
[46] 'A decentralized platform that runs smart contracts: applications that run exactly as programmed without any possibility of downtime, censorship, fraud or third party interference.' (see Alan Cunningham, 'Decentralization, Distrust & Fear of the Body – The Worrying Rise of Crypto-law' [2016] 13 SCRIPTed 235 236.
[47] World Economic Forum, 'The Future of Financial Infrastructure: An Ambitious Look at How Blockchain Technology Can Reshape Financial Services' [2016] 46-119.
[48] Lawrance J. Trautman, 'Is Disruptive Blockchain Technology the Future of Financial Services?' [2016] QR 241. (See Appendix 1 for illustration of the potential adoption paths).

etc.[49] It is interesting to see how he envisions the future of corporate governance shaped by such a new technology, replacing the decades old corporate practises.

Therefore, the goal of this chapter will be initially conceptualising Blockchain technology and subsequently to see its potential applications in the context of corporate governance. By looking at these applications, the paper will be analysing their positive and negative effects on the governance in the light of the agency theory with an aim to understand whether these uses of Blockchain technology will be able curb with the agency problems corporations face.

2.2. Blockchain Technology and Smart Contracts

Blockchain and Bitcoin

As mentioned previously, the brainchild of Bitcoin was Satoshi Nakamoto who matured and bundled several already-existing technologies to create a peer-to-peer electronic cash system.[50] Therefore, it was not the function of Bitcoin, but it was its algorithmic network design that came to be known as Blockchain.

Fundamentally, a blockchain can be described as 'a (distributed) ledger or, more simply, a chronological database of transactions recorded by a network of computers. The term "Blockchain" refers to these transactions being grouped in blocks, and the chain of these blocks forms the accepted history of transactions since the inception of the blockchain.'[51] These blocks

[49] David Yermack, 'Corporate Governance and Blockchains' [2015] Rof.
[50] Satoshi Nakamoto, 'Bitcoin: A Peer-to-Peer Electronic Cash System' [2008] 1.
[51] Gareth W. Peters and Eftathios Panayi, 'Understanding Modern Banking Ledgers through Blockchain Technologies: Future of Transaction Processions and Smart Contracts on the Internet of Money' [2014] arXiv 1409-1451.

are 'validated by linking ownership of transacting parties to so-called public keys (to prove ownership, users use both their public and a private key), which can be thought of as (anonymous) identifiers' and 'validation of transactions occurs via so-called proof-of-work protocols where multiple parties compete to validate for a fee'.[52] Besides, it is important to note that a blockchain is not just an incorruptible digital ledger of economic transactions that can be programmed to record exclusively financial transactions, it has capacity to record virtually anything of value.[53]

However, these types of definitions are not easily comprehensible for those who are new to the Blockchain hype. Hence, understanding the design and working principles of Bitcoin could provide a better picture of the technology behind this peer-to-peer cash electronic system. For an average user, Bitcoin is simply a computer program allowing the user to access its Bitcoin wallet through which it can send and receive bitcoins. All these transactions processed since the inception of Bitcoin are distributed on the network through a public ledger (database of transactions) called the 'blockchain', which is available to public. By providing a complete history of all transactions freely, the system allows users ('nodes') to verify the validity of every transaction. This process of verification or procession of the transactions by the nodes is known as 'mining' in return of which processing node is rewarded with bitcoins. Hence, users of Bitcoin are incentivized to complete transactions by using certain specialized hardware that can solve complex mathematical problems.[54]

[52] Katya Malinova and Andreas Park, 'Market Design with Blockchain Technology' [2016] University of Toronto 1.
[53] Don Tapscott and Alex Tapscott, 'Blockchain Revolution' [2016].
[54] Ronald A. Glantz, 'Primer: Bitcoin' [2014] Pantera Capital 1-2.

To send bitcoins, a user needs a private key, automatically produced by the system upon the initial registration, and is only known to this specific user. This key operates as an online signature by allowing the user to spend its bitcoins. Besides, every user also has a public key which is available to the public, hence can be considered as an anonymized name for the user. By going through a cryptographic process, this public key also provides a Bitcoin address for users. Thus, the sender needs to know the Bitcoin address of the receiver to be able to transfer any amount of bitcoin. It is also essential to realize that for each transaction the sender creates a new Bitcoin address by using its public key, thus one may say that the Bitcoin address is like an invoice number.[55]

To illustrate how a Bitcoin transaction works in action, the following transaction can be given as an example. 'A' (sender) would like to pay its car purchase from 'B' (receiver). To do so, A requests Bitcoin address of B to which it intends to send the necessary amount of bitcoin from its own bitcoin wallet. Once A announces this transaction to the system, it signs it with its personal private key. Subsequently, this information is published on the public ledger, meaning that anyone on the network can view (1) the amount desired to be transferred, (2) A's public key and (3) B's Bitcoin address.[56]

At this point, miners get involved in the process, by verifying these individual transactions and putting them in blocks on the Blockchain in return for bitcoins. What miners do is they initially determine (1) the authenticity of A's signature by checking her public key and (2) the sufficiency

[55] David Yermack, 'Corporate Governance and Blockchains' [2015] Rof 7.
[56] J.H. Witte, 'The Blockchain: A Gently Introduction' [2016] RCM 2-3.

of A's balance and ultimately create a cryptographic[57] transaction hash[58] number (or mathematical identifier) for this transaction to be incorporated into a block. Once enough transactions (around 2000 per block[59]) are verified and hash numbers are created, they are bundled in a block, which takes around 10 minutes.[60]

Eventually, using the hashes in the block, miners aim at creating one single hash for the block. This 'block hash' subsequently is combined with the hash from the previous block to create one single hash, which is used to solve a complex mathematical puzzle named 'proof-of-work'[61]. Another important point to see is that since new block hashes are attached to the preceding hashes, the information of the transactions in these hashes can be traced back to the first block

[57] 'The Blockchain uses cryptography to secure its transactions. Cryptography is "the art of creating and using methods of disguising messages, using codes, ciphers, and other methods, so that only certain people can see the real message.' (see Michael A. Froomkin, 'The Metaphor Is the Key: Cryptography, the Clipper Chip, and the Constitution' [1995] 143 U. PA. L. REv. 709, 713).

[58] 'A hash key is any fully-defined function which takes an alpha- numeric sequence (i.e., a string of letters and numbers) of arbitrary length and reduces it to one of predefined finite length.' (see J.H. Witte, 'The Blockchain: A Gently Introduction' [2016] RCM 2.).

[59] Llew Claasen, 'Which is better for Bitcoin's scalability — a Bitcoin Unlimited hard-fork or a Bitcoin Core soft-fork?' [2017] Medium.

[60] Larissa Lee, 'New Kids on the Blockchain: How Bitcoin's Technology Could Reinvent the Stock Market' [2016] 12 Hastings Bus. L.J. 101.

[61] Proof-of-Stake is started to be used as an alternative to Proof-of-Work in newer generations of Blockchains, allowing the users with more tokens to be allowed to mine more than those with less experience to increase security. This is introduced as a solution the problems faced in Proof-of-Work-based systems where (1) each new block transaction requires more transaction power while the reward given to miners diminish and (2) is prone to 51% attacks. (see Robin Bracke and Lei Zhou, 'Distributed Ledger Technology: Reinventing Your Business' [2015-2016] VBS 9.

created, making the system 'incorruptible' because of one needs to modify all preceding blocks to make a change on the ledger, limiting the incentives to cheat due to the costs involved.[62]

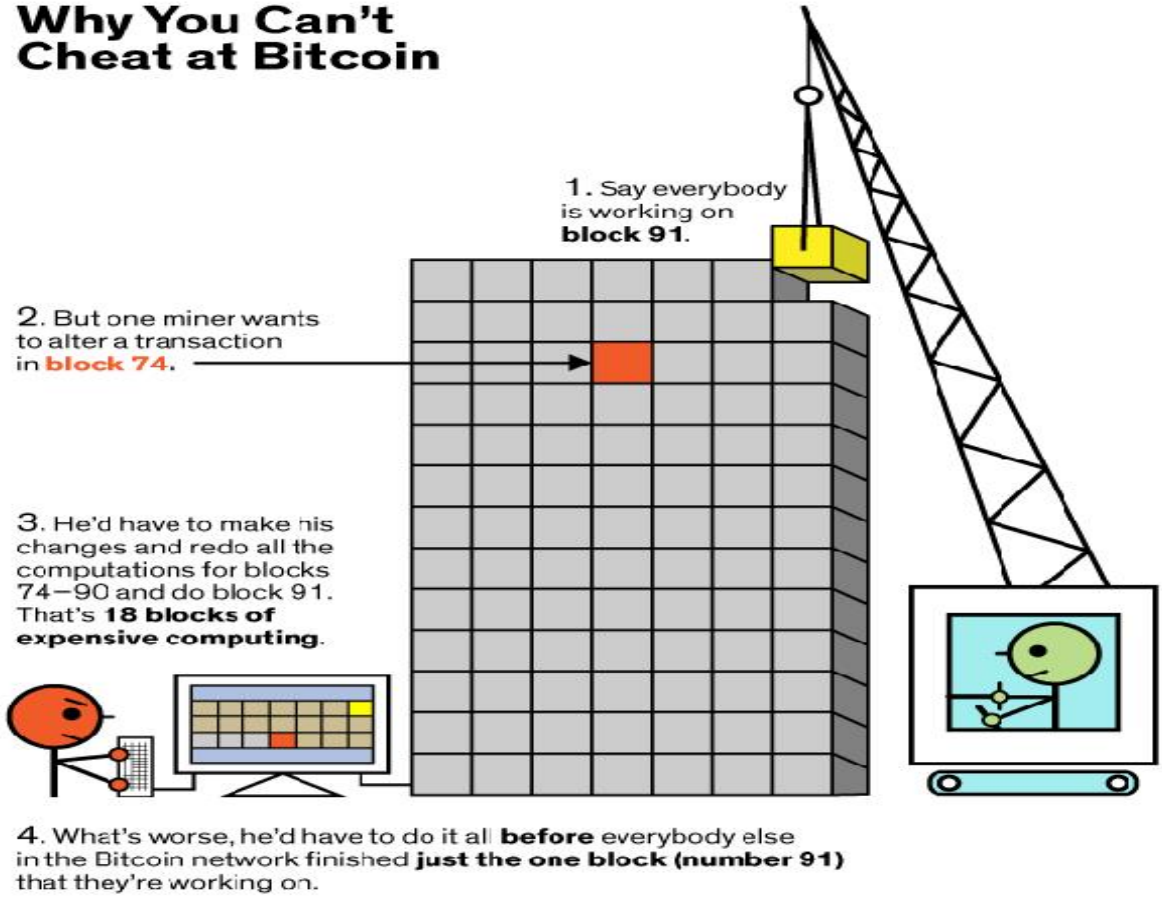

Diagram 5[63]

Once a block is ready, miners simply compete for combining the hashes from all pervious hashes and the hashes included in the block to create one single hash, which can be compared to a complex mathematical problem. Finally, whoever miner solves this puzzle the fastest, it is

[62] Larissa Lee, 'New Kids on the Blockchain: How Bitcoin's Technology Could Reinvent the Stock Market' [2016] 12 Hastings Bus. L.J. 90-104.
[63] David Yermack, 'Corporate Governance and Blockchains' [2015] Rof 46.

rewarded with bitcoins by the system while the money transfer is also successfully completed from A to B. [64]

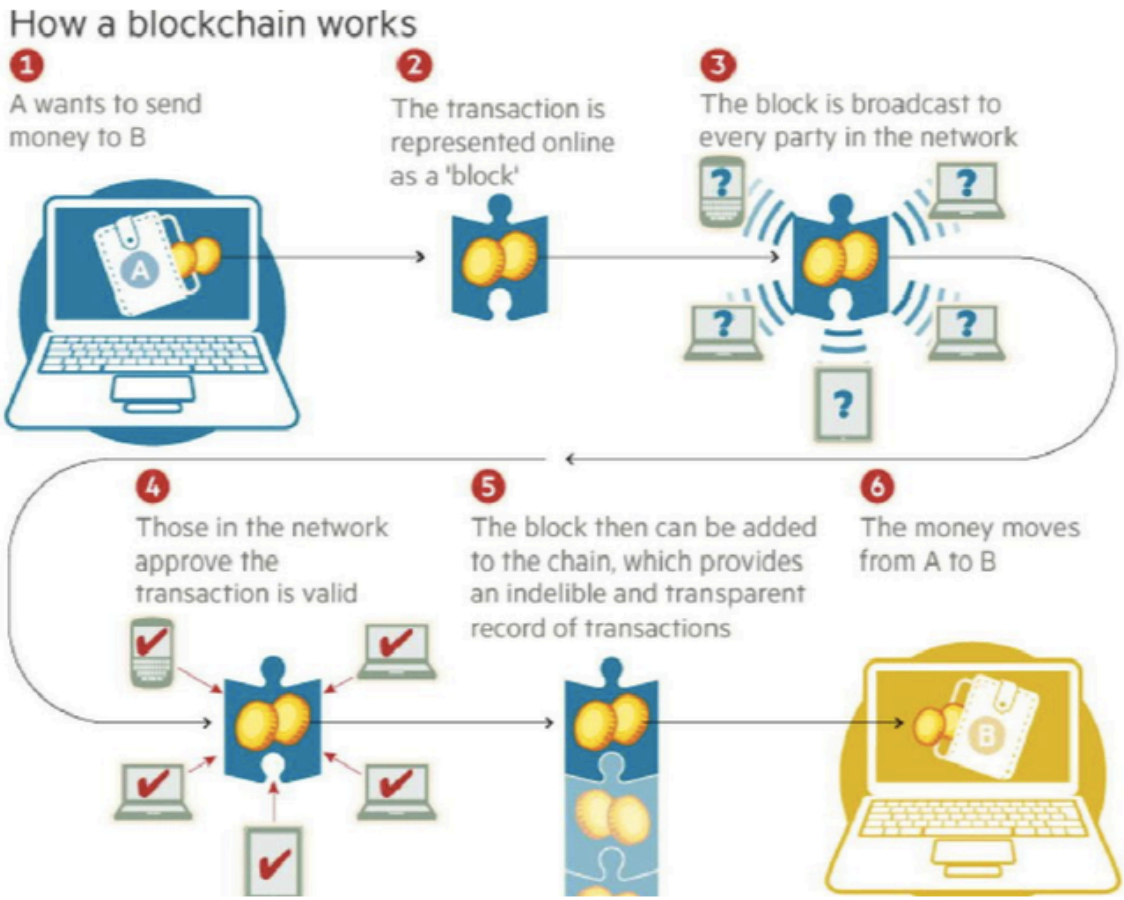

Diagram 6[65]

[64] Larissa Lee, 'New Kids on the Blockchain: How Bitcoin's Technology Could Reinvent the Stock Market' [2016] 12 Hastings Bus. L.J. 90-100.

[65] Michael Crosby, Nachiappan, Pradhan Pattanayak, Verma Sanjeev and Vignesh Kalyanaraman, 'Blockchain technology' [2016] SCETTR University of Berkeley 7.

Characteristics of Blockchain Technology

As can be understood, there are certain features of the algorithmic network design of Bitcoin, shared by all other Blockchain platforms. Hence, such platforms usually share the following 5 features:

i) **Privacy:** As a built-in function in a platform, users (nodes) are never identified publicly while all transactions are completely transparent and traceable.[66]

ii) **Immutability:** Once transaction is processed entirely, it cannot be modified. This is achieved by the linkage of every transaction record to the previous transactions in the form of blocks.

iii) **Standardized rules:** There are same standardized rules which need to be followed to process a transaction, which can be seen as the foundational basis for 'smart contracts'.

iv) **Distributed:** Every transaction can be seen on a distributed database and be validated by every partaking nodes contingent on the uniform rules.[67]

v) **Decentralized:** There is not a trusted 'central authority'; e.g., a bank, to verify each transaction. Instead of this trust element, Blockchain-powered platforms use partaking nodes to verify transactions by following an incentive-based approach while the platform is entirely open to public interested in participating. Such platforms heavily rely on 'proof' to determine whether a transaction is authentic. If a node can prove the authenticity of the transaction, it is validated while the node is rewarded in

[66] Marc Pilkington, 'Blockchain Technology: Principles and Applications' UoB 11.
[67] Willl Martino, 'The first scalable, high performance private blockchain' [2016] Kadena 2. (see Appendix 2).

return.[68] Decentralization also increases the level of privacy which is another characteristic of blockchain since both ideas go hand by hand.[69]

Smart Contracts

Smart contracts represent a characteristic of the second-generation distributed ledger technology after the release of Bitcoin, built upon the 'standardized rules' feature ingrained in the blockchain technology.[70] A smart contract is an agreement whose execution is automated usually through 'a computer running code that has translated legal prose into an executable program.'[71] For instance, a smart-house that locks the doors if the mortgage debt is not paid on time can be given as an example as the contract between the bank and the mortgagor is automatically executed upon the breach of the contract terms. As can be understood, there is also no reliance on the third parties such as state for the execution of the contract, it is completely 'automatic'.[72]Or even a simpler example of this can be found in vending machines where one can get soda automatically after the insertion of the required amount of money.[73]

Smart contracts run on a blockchain-platform, allow the storage of program code and increase the level of functionality other than the regular transfer of assets. They have ability to codify

[68] Larissa Lee, 'New Kids on the Blockchain: How Bitcoin's Technology Could Reinvent the Stock Market' [2016] 12 Hastings Bus. L.J. 92.
[69] Primavera De Flippi, 'The Interplay between decentralization and privacy: the case of blockchain technologies' [2016] 7 JPP 2-5.
[70] Willl Martino, 'The first scalable, high performance private blockchain' [2016] Kadena 2.
[71] Max Raskin, 'The Law and Legality of Smart Contracts' [2017] 1 GLTR 305 309.
[72] *Ibid* 306.
[73] *Ibid*.

financial agreements on a blockchain platform and to guarantee their execution.[74] Considering many blockchains operate on a decentralized fashion without having a central authority to trust, it provides solution to a major problem in terms of execution of contracts since without such a strong third party it is challenging to have such contracts executed. Besides, such contracts would also offer efficiency by reducing the need for manual labour in the business processes.[75]

On a blockchain-powered platform, 'smart contracts self-execute the stipulations of an agreement when predetermined conditions are triggered.'[76] Parties to a contract sign it by using their online signature (e.g. the private key in Bitcoin, although it does not have smart-contract functionality) and deploy it to the distributed ledger. Once the stipulations of the agreement are met, the required action is automatically triggered. For instance, a smart contract can automatically enforce the payment of a service or good after the delivery of such good or service. On the other hand, in case of a non-payment, the program could directly start the proceedings to recover the good or suspend the service concerned without needing a third party.[77] Currently, Ethereum provides this functionality, which is why it is considered as the new generation for the Bitcoin technology.[78]

[74] World Economic Forum, 'The Future of Financial Infrastructure: An Ambitious Look at How Blockchain Technology Can Reshape Financial Services' [2016] 46-119.
[75] Reggie O'Shields, 'Smart Contracts: Legal Agreements for the Blockchain' [2017] 21 N.C. Banking Inst. 177 178.
[76] Institution of International Finance, 'Getting Smart: Contracts on the Blockchain' [2016] 2.
[77] Reggie O'Shields, 'Smart Contracts: Legal Agreements for the Blockchain' [2017] 21 N.C. Banking Inst. 177 179.
[78] Alan Cunningham, 'Decentralization, Distrust & Fear of the Body – The Worrying Rise of Crypto-law' [2016] 13 SCRIPTed 235 236.

Public vs. Private blockchains

One important distinction that needs to be made in the context of Blockchains is the differentiation between 'private and public blockchains'.[79] These concepts fundamentally differ in terms of the level of decentralization and anonymity within a blockchain-powered platform.[80] So far, all previous definitions and explanations given regarding blockchains were explanatory for public blockchains since they represent the pure idea of such peer-to-peer networks as envisioned by Nakamoto.[81] Hence, one can think of Bitcoin when it comes to public blockchains which are open to anyone who would like to join to the network without any required permission from a central authority or a third party. Therefore, they are de-centralized and allowing its users to remain anonymous.[82]

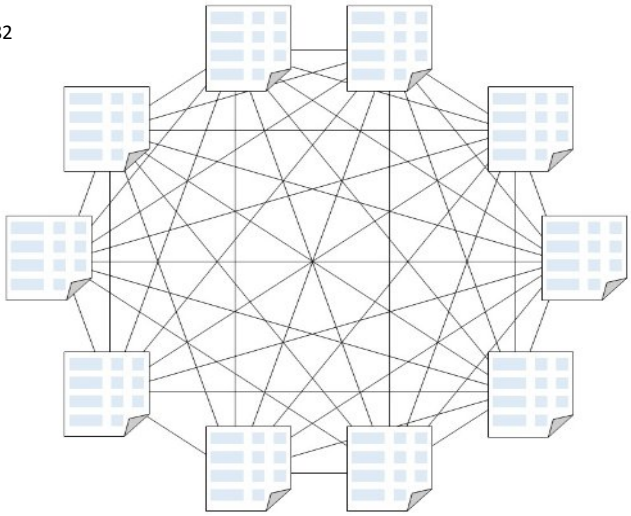

Diagram 7[83]

[79] Robin Bracke and Lei Zhou, 'Distributed Ledger Technology: Reinventing Your Business' [2015-2016] VBS 4-5.
[80] Marc Pilkington, 'Blockchain Technology: Principles and Applications' UoB 11-13
[81] Satoshi Nakamoto, 'Bitcoin: A Peer-to-Peer Electronic Cash System' [2008] 1.
[82] Marc Pilkington, 'Blockchain Technology: Principles and Applications' UoB 11-13
[83] Tori Adams, 'Making Blockchain Safe for Government: Merged Mining and Government Chains' [2016] Linkedin.

On the other hand, there are also private blockchains, which simply rely on the distributed ledger technology, while they have a central authority whose role is to authorize those who would like to join to the network and to gain access to the distributed ledger. Participants need to be authorized and their identity would at least be known to this central authority. Hence, one can argue that private blockchains is exact opposite of public blockchains while both simply share the technology of distributed ledgers. [84]

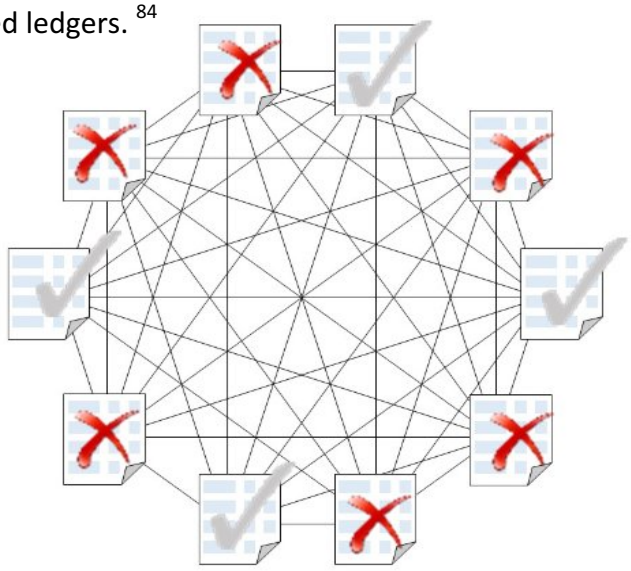

Diagram 8[85]

Furthermore, decentralization and anonymity can come at different levels. A private blockchain can have a group of entities managing the blockchain, hence one cannot argue that there is one single central authority in the system. Besides, those platforms offering a mixture of features from private and public blockchains also exist, called hybrid blockchains.[86] One interesting example of this is the private blockchains using miners from an outside chain; e.g. a public chain

[84] Marc Pilkington, 'Blockchain Technology: Principles and Applications' UoB 11-13
[85] Tori Adams, 'Making Blockchain Safe for Government: Merged Mining and Government Chains' [2016] Linkedin.
[86] Marc Pilkington, 'Blockchain Technology: Principles and Applications' UoB 11.

that accommodates the former through 'merged mining' and 'blockchain anchoring'. By making use of these protocols, a private blockchain can employ the miners of a public blockchain without the miners of latter being member of the former and having access to private information in the private blockchain, boosting the security in the blockchain. [87]

Sidechains

One important functionality of blockchains that shall be noted is their interoperability.[88] By side chains or side-chaining to an existing 'main chain', tokens from the former to latter or vice-versa can be transferred.[89] For example, currently, a side chain connected to Ethereum side chain can Transfers tokens from the main chain and convert them to its own tokens while also these tokens can be transferred back to Ethereum chain after conversion as in e.g. Dollar-Euro conversion.[90]

[87] A better understanding of these concepts can be found in Appendix 3 and Tori Adams, 'Making Blockchain Safe for Government: Merged Mining and Government Chains' [2016] Linkedin.
[88] Giulio Prisco, 'Vitalik Buterin Reviews Chain Interoperability Schemes in New R3 Research Paper' [2016] accessed on 22.07.2017 on http://www.nasdaq.com/article/vitalik-buterin-reviews-chain-interoperability-schemes-in-new-r3-research-paper-cm727637.
[89] Marc Pilkington, 'Blockchain Technology: Principles and Applications' UoB 22.
[90] Jeff Coleman, 'What is side chain'

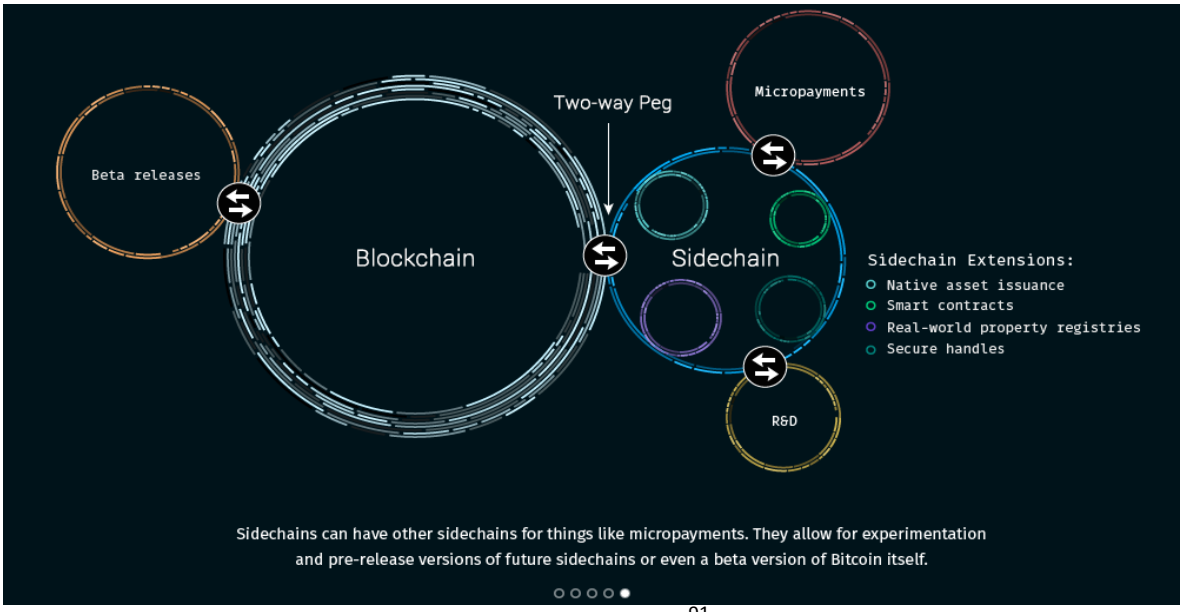

Diagram 9[91]

As can be seen in the illustration above, sidechains with different functionalities (e.g. smart contracts which are not supported by the main chain shown) can be connected to the main chain among which tokens can be transferred. In this way, the level privacy, centralization and functionality can be controlled under sidechains. This also means that personal private blockchains can also be connected to larger public blockchains with this kind of protocol.[92]

[91] Blocksteam.com, accessed on 22.07.2017 on https://blockstream.com/technology/.
[92] For more information see Adam Back, Matt Corallo, Luke Dashjr, Mark Friedenbach, Gregory Maxwell, Andrew Miller, Andrew Poelstra, Jorge Timón, and Pieter Wuille, 'Enabling Blockchain Innovations with Pegged Sidechains' [2014] Blockstream 3-21.

Limits and Future of Blockchains

Both private and public blockchains have their uses as they answer to certain needs of its users, ranging from anonymity to essential identification of its users to increased security. However, this technology is not yet error-free and the limits of this technology need to be studied.[93] Yet, with the speed of development in this technology, it seems that they will certainly be resolved soon. Then, it will be a time where blockchains will adopted virtually operation that requires a ledger keeping. And ultimately, this research anticipates a future where all individual blockchains will be inter-operative and linked to each other, forming an invisible ecosystem of blockchains.

[93]Neither the limits of blockchains nor the solutions to them are within the scope of this paper, nevertheless, a summary of this subject can be found in the Appendix 3.

Chapter 3: Blockchain-powered Corporate Governance

3.1. From Bitcoin to Corporate Governance

Having introduced the technology behind the blockchains and smart contracts, now this chapter will be exploring the potential uses of blockchains in the context corporate governance, which was previously studied by the pioneer in the field, Yermack (2015), who identifies the potential adoption paths of blockchains in corporate governance.[94] He elucidates the solutions offered by the implementation of Blockchain technology in the matters concerning corporate governance while also expounding the changing roles of corporate actors coming with this. He argues that blockchain offers a great deal of increased accuracy, efficiency and transparency in corporate voting, share ownership and record-keeping, replacing the decades old corporate practises.[95] Therefore, he claims that the use of blockchains will reduce corporate waste and misbehaviour noticeably.[96]

Furthermore, after the exploring the potential uses of blockchains in corporate governance and testing those claims on the already-in-use blockchain-powered companies or platforms, the paper will try to predict the possible future of blockchains in this context and show that the Pennington's theory can be useful in responding the challenges coming with the adoption of this technology in corporate governance.

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[94] Bradley Fink, 'Blockchain Comes To Corporate Governance With AST Proxy Voting' [2017] accessed on 30.07.2017 at http://www.nasdaq.com/article/blockchain-comes-to-corporate-governance-with-ast-proxy-voting-cm791465

[95] David Yermack, 'Corporate Governance and Blockchains' [2016] Working Paper No. w21802 NBER (This paper was initially published in 2015 while it was subsequently updated in 2016 and 2017).

[96] Bradley Fink, 'Blockchain Comes To Corporate Governance With AST Proxy Voting' [2017] accessed on 30.07.2017 at http://www.nasdaq.com/article/blockchain-comes-to-corporate-governance-with-ast-proxy-voting-cm791465

3.2. Securities on Blockchain

Some of the first enthusiasts of blockchains were stock exchanges, which was not surprising. The stock exchanges we know have not changed the model they have been using for over 400 years when the Dutch East India Company became the first publicly-owned company and a central register was needed to track the transfer of its shares on the secondary market. Today, to put it very simply, when certain shares are sold on a stock exchange, an investor relies on a third party working as a 'stock transfer agent' for the stock market concerned to change the names of the seller with the buyer on the shares. Hence, this reliance on a third party in a centralized system increases the costs for transactions including administration charges, transfer fees and expenses originated from potential failures originated from the single point of failure.[97] While also in this old model, there are apparent transparency issues caused by the information asymmetries leading to market advantages, forged securities and systemic counter party risks.[98]

Diagram 10[99]

[97] Transfer agents are the only responsible parties for any failure. Due to their singularity, the checks and controls over their actions are much more limited than a system where responsibilities are distributed to more parties.

[98] Jess Desjardins, 'The Blockchain Could Change the Backbone of the Stock Market' [2017] accessed on 31.07.2017 at http://www.visualcapitalist.com/blockchain-backbone-stock-market/.

[99] *Ibid*.

However, the problems inherent in the old model of stock exchanges can be cured by the introduction of blockchain-run platform using automated smart contracts to complete all actions without requiring human effort in its processes. And the currently available technology already allows a company to issue 'digital securities' processed on a distributed ledger. So that, shares, debt instruments and virtually any other type of securities can be issued on a distributed ledger where the transactions can be executed and confirmed.[100] Since this would allow public to monitor transactions more effectively, there would be a greater level of transparency in ownership while also the execution and settlement would be cheaper due to the non-existence of a need to rely on a third party for the execution of transactions.[101] In short, blockchain technology could promise the transfers of securities to be observed in a real-time basis while the transactions costs are reduced markedly, which can be translated into efficiency and security.

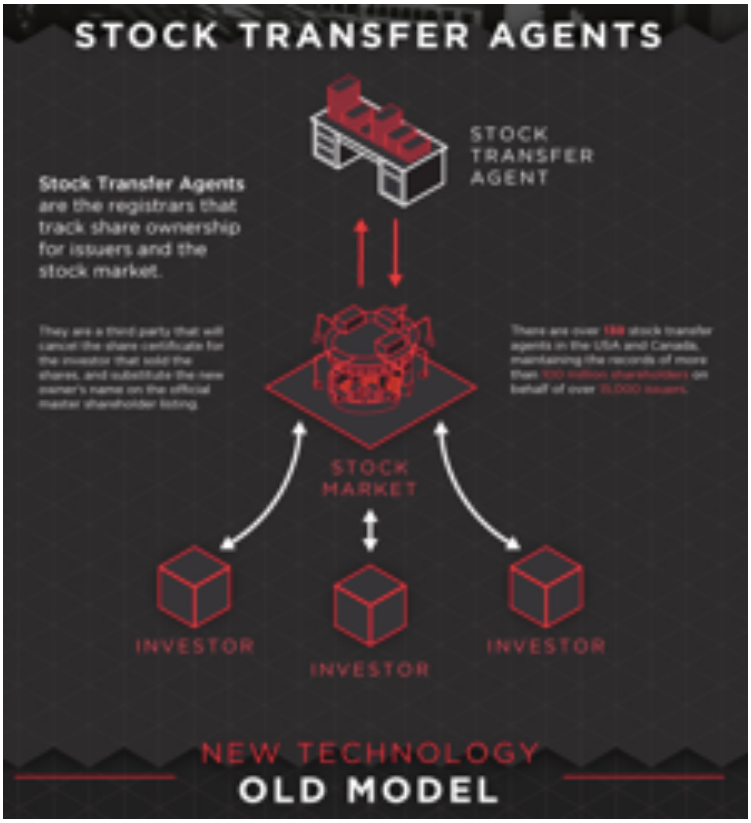

Diagram 11[102]

[100] Christoph Van der Elst and Anne Lafarre, 'Bringing the AGM to the 21st Century: Blockchain and Smart Contracting Tech for Shareholder Involvement' [2017] European Corporate Governance Institute (ECGI) - Law Working Paper No. 358/2017 15.

[101] Cost-efficiency only applies to public blockchains. In case there is an incumbent third party in private blockchain or the nodes are paid for executing the transactions, they will face higher level of costs than the traditional public blockchains .

[102] Jess Desjardins, 'The Blockchain Could Change the Backbone of the Stock Market' [2017] accessed on 31.07.2017 at http://www.visualcapitalist.com/blockchain-backbone-stock-market/.

Practical Examples

Traditional stock exchanges have already been experimenting with the blockchain technology and NASDAQ, the Australia Securities Exchange, the Tallinn Stock Exchange, London Stock Exchange[103] and the Korea Stock Exchange are the pioneers in this front.[104] Nevertheless, these institutions due to the recordkeeping and disclosure requirements of SEC[105] and their own securities commission for the public companies, do not seem utilizing all perks of blockchain technology. Currently, the use of blockchains focus on the issuance of securities for private companies and targeting institutional buyers who require less protection by the securities commission.

For instance, NASDAQ's Linq blockchain allows private companies to record the transfer of shares owned by founders, early investors and employees.[106] This platform enables its customers to digitally record the ownership of the company, therefore, reduces the settlement time used for the delivery of shares and eliminates the need for 'traditional paper shares'. In fact, the NASDAQ public statement suggests that the adoption of this technology in public markets could reduce the standard settlement time from three days to 10 minutes since the payment and exchange of shares could be processed almost simultaneously without any reliance on a third party to approve these transactions. Furthermore, the system also allows investors and issuers to download and upload

[103] See Anna Irrera and Jemima Kelly 'London Stock Exchange Group tests blockchain for private company share' [2017] accessed on 01.08.2017 at https://www.reuters.com/article/us-lse-blockchain-idUSKBN1A40ME.

[104] NextChange, 'How these 6 stock exchanges are getting on board with blockchain' [2016] accessed on 01.08.2017 at https://nexchange.com/article/8637.

[105] A summary of SEC Regulations can be followed at https://www.sec.gov/pdf/annrep01/ar01marketr.pdf.

[106] Kevin Petrasic and Matthew Bornfreund, 'Beyond Bitcoin: The blockchain revolution in financial services' 2016 accessed on 01.08.2017 at http://www.the-blockchain.com/docs/Beyond%20Bitcoin%20-%20The%20blockchain%20revolution%20in%20financial%20services.pdf

necessary documents necessary for the transactions.[107] It is also important to note that this platform is already operative and 'Chain.com' was the first company, which recorded its issuance of shares to a private investor on the platform.

In the same token, the Australia Securities Exchange also plans to fully implement a similar system, which will be decided in August 2018. However, the Exchange makes clear that they will also be adopting a 'private blockchain' unlike in Bitcoin. Yet, they claim that settlement risk exposure[108] will still be reduced by 99%, hence the systemic risk and capital costs will be lowered significantly.[109]

Furthermore, blockchains do not only attract stock exchanges, there is also an increasing demand from individual companies to employ blockchains in their activities. For example, Overstock.com had a keen interest in blockchains and therefore it opted to create its own blockchain to record its shares. Hence, it invested in the company named 'tzero' which became its majority-owned of subsidiary, to create a blockchain-powered platform through which it could issue its shares. And ultimately, Overstock.com became the first company in the history to issue and record its preferred shares on a blockchain trading system[110]. This is also important to note that, this issuance of shares

[107] Nasdaq.com, 'NASDAQ LINQ Enables First-Ever Private Securities Issuance Documented with Blockchain Technology' [2015] accessed on 01.08.2017 at http://ir.nasdaq.com/releasedetail.cfm?releaseid=948326

[108] Settlement risk, to put it simply, means that the party you are dealing with will not pay you after you transferred the good or service you sold. For more information see: http://www.investopedia.com/terms/s/settlementrisk.asp

[109] Jamie Redman, 'ASX Defends Blockchain Research Initiative in the Light of Criticism' [2016] accessed on 01.08.2017 at https://news.bitcoin.com/asx-defends-blockchain-research/

[110] It is important to see that the shares issued were private securities which cannot be traded on exchanges.

was also pre-approved by the SEC in the US, thus there is an already existing legal approval from the regulators.[111]

As can be understood from the given examples, the use of blockchain in the context of securities is currently limited to 'private blockchains' and focuses on private securities which cannot be circulated freely as a result of the dense regulation in the secondary market. The already existing blockchain platforms have a centralized body which executes the transactions instead of individual nodes in a public blockchain. Therefore, there are still 'trust issues' hidden in the design of these platforms while they provide certainly higher levels of disclosure and speed. Even in its basic form, this private block-chain powered platforms are simply a step up from our 400-years-old traditional stock-exchange model.

Yet, there are also interesting examples where 'public blockchains' are operated for the issuance of securities to the public. To illustrate, 'DCORP' is a virtual venture capital company or also known as Decentralized Autonomous Organization (DAO)[112], which is another use of blockchains that will be introduced later, running as a side-chain on Ethereum public blockchain. The company started its operations with a 'Initial Coin Offering' on Ethereum through which they sold the shares of the company to the Ethereum users who paid for the coins (representing the shares of the company)) with their Ether (Ethereum tokens). The amount of Ether they paid by investors were converted into the special DCORP coins at a pre-specified rate and subsequently the investors were given access to the DCORP side-chain where they act as shareholders by having certain voting

[111] Tzero, 'Overstock.com Announces Rights Offering Including Blockchain Shares On T0 Platform' [2016] accessed on 01.08.2017 at https://tzero.com/news/2016/12/14/overstockcom-announces-rights-offering-including-blockchain-shares-on-t0-platform

[112] DAO is an organization running through smart contracts, or simply a virtual company.

and ownership rights.[113] Hence, we are already at a point where blockchain and smart-contracts are being implemented on public channels. Nevertheless, the 'Wild West' of ICOs seems to have come to an end as we know them on July 25, 2017 when the U.S. Securities and Exchange Commission announced that ICO tokens qualified as 'securities' and therefore they now officially became subject to federal securities law.[114] Thus, although now there is more legal certainity in regards to such 'shares', it is unknown what will be the future implications of this development for the adoption of blockchains in the secondary markets for the use of non-sophisticated investors. It seems that as the stock exchanges already doing, Ethereum DAOs may target accredited investors or change their strategy to act as crowdfunding projects as their access to the public is much more limited than before since only private placements with very limited liquidity will be allowed.[115]

Blockchain-Powered Securities Platforms and Corporate Governance

The use of both private and public blockchains used in the context of securities exchange promises to increase 'transparency in the transfer of securities and to provide 'efficient execution and settlement for the transactions.' These improvements, nevertheless, do not occur in isolation, in fact they have potential to alter the dynamics between managers and investors as well as companies and the regulators.[116]

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[113] DCORP company website, accessed on 01.08.2017 at https://www.dcorp.it/#about

[114] Tanzeel Akhtar, 'SEC Weighs In on ICO Tokens as Securities; Ether Still Labeled "Currency"' accessed on 04.08.2017 at https://bitcoinmagazine.com/articles/sec-weighs-ico-tokens-securities-ether-still-labeled-currency/.

[115] Private placements cannot be offered to public while they cannot be sold. See SEC 'Private Placement Exemption' section 4(a)(2) accessed on 04.08.2017 at https://www.sec.gov/info/smallbus/qasbsec.htm#npo

[116] Mark Calderon, Ferdisha Snagg and Claire Harrop, 'Distributed ledgers: a future in financial services?' [2016] 31(5) J.I.B.L.R. 246-247.

In terms of the effect of blockchains on the corporate level, one can see that blockchain technology allows investors to see the transactions in real-time regardless of the use of private or public blockchains through a distributed ledger. Even when only limited actors can access to a blockchain, the 'increased transparency' will at least improve the circulation of information for those permitted while in a public blockchain the transparency of transactions will be maximized. What this means is that the activities of the parties holding securities of a company will be disclosed to the market. Even when their names are kept completely 'anonymous' or only disclosed to the governmental agencies, the transfers of securities and public keys of investors will be more transparent than what today's stock exchanges offer.[117]Therefore, the managers, institutional investors, activist shareholders, parties preparing for a hostile take-over will be hesitating to make any move that will easily arouse suspicion. Consequently, such platforms will be improving corporate governance by preventing the opportunistic behavior of these actors who would prefer complete secrecy.[118] This means that blockchains may reduce the agency problem in companies by providing a constant monitoring of the holdings of the managers and insiders who have the control over the company decisions while their 'accountability' for these actions will make sure that they act 'more benevolently and rationally'

One interesting feature of blockchains is that they may increase transparency in the market itself, rather than within the companies as in disclosure rules which requires the release of identity for shareholders after reaching a certain stake of ownership in a public company and other insider

[117] David Yermack, 'Corporate Governance and Blockchains' [2016] Working Paper No. w21802 NBER 16.
[118] *Ibid*.

ownership by managers and officers.[119] The current approach of regulations simply discloses those running and controlling the company rather than their intent. Besides, even when the insiders are disclosed, insider trading is not necessarily committed by the insiders. Therefore, the current disclosure rules do not seem provide effective solutions in preventing insider trading. However, if public blockchains could be used in securities market, the transparency of the entire market, even with anonymity, could be useful to track the intents of parties transparently and prevent insider trading.[120]

Yet, 'increased transparency and exposure to accountability' is not the only effect produced using blockchains and smart contracts in tokenization of shares, but one can also clearly see the elements of 'decentralization' in the power the managers had over the securities of a company. It is an empirically supported fact that especially back-dating of their stock option awards, stock option exercises and charitable gifts of stock for certain financial profits and tax benefits. However, when securities are entered on a distributed ledger operated on a blockchain-powered platform, the time-stamp over shares or other securities will not be able to be rewritten or changed, completely removing the problem of 'backdating' in corporate processes.[121] Hence, blockchains and smart contracts promise decentralizing the decision-making power of managers over securities by allowing secured online platforms to record the changes in securities of the company to deal with 'limited benevolence' problem faced in this specific process.

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[119]The shares owned by officers and directors of a company and other shareholders owning over 10% of the company qualify as insider ownership. See Christoph Kaserer and Benjamin Moldenhauer, 'Insider Ownership and Corporate Performance – Evidence from Germany' [2005] 21 CEFS TUM 3-5.

[120] Pulak Prasad, 'Moving Towards Transparency of Ownership and Control: A Case Study' [2002] The Fourth Asian Roundtable on Corporate Governance 3-4.

[121] David Yermack, 'Corporate Governance and Blockchains' [2016] Working Paper No. w21802 NBER 23.

However, as attested from the lack of operational public blockchains in the given examples, one realizes the current regulations do not allow the use of public blockchains and blockchains targeting the non-sophisticated investors except in Ethereum ICOs which, nevertheless, also came to an end. This is mainly caused by the fact that this technology is perceived to be highly disruptive in terms of regulations. For instance, The UK[122] and the EU[123] have already been preparing for any potential disruption in the market and planning how they could address issues such as the level of privacy and anonymity while it can be argued that the US is one step ahead with its move regarding DAOs. It seems that regulators especially try to answer, 'which actors shall be allowed in blockchain-powered securities platforms', 'who shall be executing the transactions (public nodes, government or any trusted third party)'[124], ''what the level of anonymity shall be', 'how the currently existing mandatory disclosure rules and tax systems can be replaced'[125], 'how consumer protection issues, security risks and conflict of laws etc. could be dealt with'. It seems that without addressing these issues, public markets may never be able to exploit blockchains completely. Yet, these issues are far beyond the scope of this paper.

[122] See UK Government Chief Scientific Adviser, 'The Distributed Ledger Technology: Beyond Blockchain' [2015] UKGCSA accessed on 02.07.2017 at https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/492972/gs-16-1-distributed-ledger-technology.pdf.

[123] See ESMA, 'The Distributed Ledger Technology Applied to Securities Markets' [2016] Discussion Paper.

[124] Mark Calderon, Ferdisha Snagg and Claire Harrop, 'Distributed ledgers: a future in financial services?' [2016] 31(5) J.I.B.L.R. 246-247

[125] Andrea Miglionico, 'The Impact of FinTech on Securities and Secured Transactions: what is new in the financial industry?' [2016] 31(12) J.I.B.L.R.

What this paper aims to shed light on is that blockchains increase 'transparency' in the securities market and expose market actors to 'accountability' regardless of being public or private and promises to reduce the agency problem or even remove it by completely automating the process of the transfer and execution of securities from the hands of managers through 'decentralization'. Therefore, it seems that Pennington's argument that 'decentralization and increased transparency and accountability' can limit the negative effects of 'human imperfections' from the certain operations of a company, is directly supported by the goal behind the use of blockchains in securities. Yet, what is fascinating is that if the transfer and issuance of securities can be automated completely, what would be the complete picture of its consequences? Considering there will be no human factor coming with human imperfections, neither the agency problem in administrative side of securitization process, the literature's focus on the agency problem would become obsolete. In this case, it would be more reasonable to explore 'the optimal level anonymization for investors and the level of transparency for companies and the protection of anonymity from third parties.'

3.3. Blockchain eVoting

The fact that securities can be represented on a distributed ledger also offers also some other solutions that can be utilized in the context of corporate governance. The simplest and already existing mechanism in this sense is the use of blockchains to record the votes during virtual shareholder that redefines the concept of 'annual shareholder meetings' or 'AGM'.[126]

[126] Finextra.com, 'Nasdaq hails Estonian blockchain pilot for proxy voting' [2017] accessed on 06.08.2017 at https://www.finextra.com/newsarticle/30027/nasdaq-hails-estonian-blockchain-pilot-for-proxy-voting/blockchain.

To put it simply, blockchains can be used to create online platforms where shareholders make proposals or vote for the proposals within a pre-determined period. To do so, such platforms distribute online coins (or shares) to the eligible shareholders, allowing them to access to the voting platform where they can vote. In this way, the votes can be recorded in a safer, cheaper and faster way while also some of the specific problems faced in the AGMs such as inexact voter lists, incomplete distribution of ballots, and chaotic vote tabulation could be addressed by the introduction of streamlined procedures and the help of 'smart contracts'.[127] Besides, by digitalizing AGMs, companies may also increase the shareholder turnout in the decision-making by not requiring any physical attendance and motivating them to vote with the increased transparency, speed and accuracy in voting.[128]

Practical Examples

One of the earliest examples of the blockchain technology adopted in corporate voting comes from Estonia, allowing its citizens registered on its online residency platform to vote remotely on virtual shareholder meetings.[129] To be able to use the system, shareholders in publicly-owned companies listed on NASDAQ's Tallinn Stock Exchange, need to have an initial registration at the e-residency platform run by the government. Upon the registration, they allowed to access to the e-voting platform where shareholders can view information about AGMs and vote before and after the

[127] Marcel Kahan and Edward B. Rock, 'The Hanging Chads of Corporate Voting' [2008] 96 GLJ 1227-1281.

[128] Christoph Van der Elst and Anne Lafarre, 'Bringing the AGM to the 21st Century: Blockchain and Smart Contracting Tech for Shareholder Involvement' [2017] European Corporate Governance Institute (ECGI) - Law Working Paper No. 358/2017 17.

[129] The system was announced by NASDAQ on 12.07.2017, see Nasdaq.com, 'Nasdaq's Blockchain Technology to Transform the Republic of Estonia's E-residency Shareholder Participation' accessed on 06.08.2017 at http://ir.nasdaq.com/releasedetail.cfm?releaseid=954654.

meetings[130], transfer their voting rights to a proxy, monitor the proxy and review previous meetings.[131]

However, as can be understood, the already operative Estonian E-voting platform uses private blockchain technology where only shareholders on the E-residency platform are allowed to access, shareholders do not vote anonymously while most importantly the nodes executing the transactions on the blockchain are government approved.[132] In fact, a similar platform was also used in the Estonian and Norwegian national elections (Estonian and Norwegian I-Voting System) as well. Yet, the centralization of the system by government was highly debated as it made the platforms concerned vulnerable to DDoAs[133] Attacks.[134] Furthermore, it must be noted that it is technically the first example of the use of blockchains[135] in a matter concerning secondary markets and publicly-owned companies as most of the focus of blockchains is private securities market.

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[130] This feature of the e-voting allows shareholders to cast their votes even before and after a meeting and therefore provides increased flexibility in terms of time constraints.

[131] Business.nadaq.com, 'Is Blockchain the Answer to E-voting? Nasdaq Believes So' accessed on 06.07.2018 at http://business.nasdaq.com/marketinsite/2017/Is-Blockchain-the-Answer-to-E-voting-Nasdaq-Believes-So.html.

[132] Finextra.com, 'Nasdaq hails Estonian blockchain pilot for proxy voting' [2017] accessed on 06.08.2017 at https://www.finextra.com/newsarticle/30027/nasdaq-hails-estonian-blockchain-pilot-for-proxy-voting/blockchain.

[133] 'A Distributed Denial of Service (DDoS) attack is an attempt to make an online service unavailable by overwhelming it with traffic from multiple sources. They target a wide variety of important resources, from banks to news websites, and present a major challenge to making sure people can publish and access important information.' See Digitalattackmap.com, 'What is a DDoS Attack?' accessed on 06.08.2017 at http://www.digitalattackmap.com/understanding-ddos/.

[134] Ahmed Ben Ayed, 'A Conceptual Secure Blockchain-Based Electronic Voting System' [2017] 9(3) IJNSA 1-3.

[135]There are also other examples of such platforms (e.g. Abi Dhabi Securities Exchange). However, they have similar features to Estonian system. Therefore, they will not be dealt in this paper. For more information see Richard Kastelein, 'Abu Dhabi Securities Exchange Launches Blockchain eVoting' [2016] accessed on 06.08.2017 at http://www.the-blockchain.com/2016/10/18/abu-dhabi-securities-exchange-launches-blockchain-evoting/.

Blockchain eVoting and Corporate Governance

To look at the benefits of eVoting in detail, firstly, it can be observed that corporate eVoting may improve accuracy of elections by improving the reliability in the outcome of close corporate elections, increasing 'transparency' in the voting process and 'decentralizing' the power of management to affect the results in close elections. The literature argues that there has been a constant problem in vote tabulation in the close elections where is always a dispute regarding 'when the polls are closed and whether all votes are counted'.[136] Moreover, the empirical data shows that close elections tend to result in favor of the management disproportionately, which may indeed support the previous argument.[137] Besides, such data could also point out the effects of the last-minute lobbying carried out by the management which may obtain highly accurate information about the outcome of the voting while it is going on. Hence, eVoting could indeed improve the accuracy and precision of vote tabulation, reducing the potential negative effect of human imperfections inherent in managers on close corporate elections and therefore the agency problem. Managers, in such a system, have less room for selfish decision-making and acting irrationally in their actions, as a result of the decentralization of their power in controlling the process of voting.

Secondly, eVoting could also deal with what is known as 'Empty Voting,'[138] which is to simply put the act of borrowing the voting shares to influence the election outcome. This, as can be

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[136] *Ibid*.

[137] Yair Listokin, 'Management Always Wins the Close Ones' [2008] AMER 159-184.

[138] 'Empty voting is a practice favored by some activist hedge funds to boost their voTing power in a company without putting much money. The SEC wants to determine whether it is being used to inappropriately influence corporate voting results.' See Stephen Taub, 'SEC to address "Empty Voting"' [2010] accessed on 08.08.2017 at http://www.institutionalinvestor.com/Article/2639251/Search/SEC-to-Address-Empty-Voting.html#.WYsCC8Z7GqA.

understood, is a highly questionable conduct as it affects the 'democratic aspect of elections' by separating the ownership of shares from the voting rights, hence, the limiting the adverse effects of the election on the voting party. This exposes other shareholders to a higher risk since a party engaging in empty voting votes without being subject to its consequences while other shareholders are. This, currently, may not be an illegal activity,[139] it is still disconcerting for the other shareholders who can be negatively affected if the empty voting is used to harm the company or to benefit from the consequences of certain election result. Since, eVoting platforms require online share registration and identification of the shareholders, there would be increased transparency. Thus, the transfer of shares to a suspicious party, could act as a warning mechanism to alert the management and other shareholders for a potential 'empty-voting'.[140] In fact, if the relationship between the management and an actor with 'full empty-voting' power is not transparent, the 'empty-voter' could be considered as the 'hidden owner' of the company,[141] which could have enough power to steer the managers to act in a certain way that may not be value-maximizing for the other shareholders. This could create an 'agency problem' and under a blockchain-powered and transparent securities platform, this problem in the gray-area of law and practice, could be dealt with.

eVoting promises to improve speed, transparency and accuracy of voting in corporate decision-making though 'decentralizing' the power of certain actors to affect the election outcomes, which

[139] SEC has been already trying to understand how it can address the empty voting issue since 2010 and its stance is still not clear at the moment. See Stephen Taub, 'SEC to Address Empty Voting' [2010] accessed on 18.08.2017 at http://www.institutionalinvestor.com/Article/2639251/Search/SEC-to-Address-Empty-Voting.html#.WZavZMZ7GgQ.

[140] David Yermack, 'Corporate Governance and Blockchains' [2016] Working Paper No. w21802 NBER 29.

[141] Henry T. C. Hu and Bernard Black. 'Empty Voting and Hidden (Morphable) Ownership: Taxonomy, Implications, and Reforms' [2006] 3(61) TBL 1011.

could possibly attract more shareholders to cast their votes and increase the shareholder involvement from the perspective of corporate governance.[142] Therefore, a much modern relationship between the shareholders and the management could be established by the utilization of this technology, which could certainly lower the agency costs in a corporation while improving the trust between the parties in this context[143].

As can be understood, this particular use of blockchains and smart contracts also utilize 'increased transparency and accountability and decentralization elements' to reduce the agency problem in voting process of a company by eliminating the human factors which also lead to 'the conflict of interests between shareholders and managers'. If this technology could be developed into better functioning samples and adopted by companies, it may completely remove the human factor from the voting process. Van der Elst and Lafarre (2017) even discuss the possibility of removing 'physical AGMs'[144] as a practice in companies by allowing shareholders to vote over a certain time span on blockchain-powered online platforms. Yet, it does not mean that removing human interaction can reduce the agency costs in a company where the physical interaction between shareholders and management may also be value maximizing.[145]For instance, in physical AGMs, the shareholders of a company have a chance to confront the management with unexpected questions to expose them to 'accountability' without letting them to give a strategic and fabricated

[142] Ibid 27.

[143] Christoph Van der Elst and Anne Lafarre, 'Bringing the AGM to the 21st Century: Blockchain and Smart Contracting Tech for Shareholder Involvement' [2017] European Corporate Governance Institute (ECGI) - Law Working Paper No. 358/2017 25.

[144] In many countries today, AGMs are required to be physical even when companies make use of online voting platforms. See *Ibid*.

[145] Icsa.org.uk, accessed on 18.08.2017 at https://www.icsa.org.uk/assets/files/marketing/essays/Runner-Up-essay-2017.pdf.

answer, which shows the importance of human interaction for the functioning of a public company.[146]

Therefore, even when the agency problem can be removed from the process of voting, eVoting platforms simply leaves the literature with newer questions. Among many, some of these could be as following: 'To what extent, does a company need the physical human interaction between shareholders and management during the voting process? and how could the desired level of interaction be injected into the company's decision-making process?', 'Is it absolutely necessary to have a physical AGM?', 'Is it important to disclose the position of management, possessing the most transparent information about the operations of the company?', 'Shall eVoting platforms share tentative results during an on-going voting and how it could affect the election results?', 'Could tentative results drive shareholders to irrational decision-making when voters are anonymous?'…

3.4. Blockchain Accounting

The concept of modern accounting can be traced back to Luca Pacioli's work 'The Collected Knowledge of Arithmetic, Geometry, Proportion and Proportionality', published in 1474. In his work, Pacioli describes 'the double entry accounting system, debits and credits, and the trial balance', which are the still the **backbones** of our accounting principles in the 21st century. However, the adoption of the blockchain technology in accounting may be a major shift in the history of accounting. [147] Blockchains allow a single ledger of transactions to be distributed to

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147 James Overnden, 'Will Blockchain Render Accountants Irrelevant?' [2017] Accessed on 07.08.2018 at https://channels.theinnovationenterprise.com/articles/will-blockchain-render-accountants-irrelevant.

permitted participants in real-time, make the double entry accounting system obsolete and limit the occurrence of disparity between multiple ledgers. Therefore, one can clearly see that blockchain accounting has potential to lower the costs tremendously by eliminating the need for bookkeepers or auditors by projecting the company transactions in real-time basis.[148]

Practical Examples

When it comes to practical examples of blockchain accounting, one realizes that there is not any noticeable platform offering such service. Yet, many accounting firms and researchers introduce their own conceptualizations of a working blockchain accounting system to the literature. Among many, it seems that there are two distinct examples of blockchain accounting, which can be discerned by the level of third party reliance.

The first these is the accounting system conceptualized by Deloitte**,** introducing a private blockchain platform where the transactions between companies are recorded simultaneously on a single ledger rather than multiple ledgers for multiple companies while the access to this blockchain ledger is given to the companies, banks, tax authorities and auditors.[149] As illustrated below, such system could record the transactions of multiple companies at once, hence eliminating the need for four time entry in a usual double-entry accounting while also making the dealings securer by the constant monitoring of other actors such as courts, banks and tax authorities. With the increased reliability, running costs of a company could significantly lowered.[150]

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[148] David Yermack, 'Corporate Governance and Blockchains' [2016] Working Paper No. w21802 NBER 29.

[149] Deloitte, 'Blockchain Technology: A game-changer in Accounting?' [2016] 2 accessed on 07.08.2017 at https://www2.deloitte.com/content/dam/Deloitte/de/Documents/Innovation/Blockchain_A%20game-changer%20in%20accounting.pdf.

[150] *Ibid*.

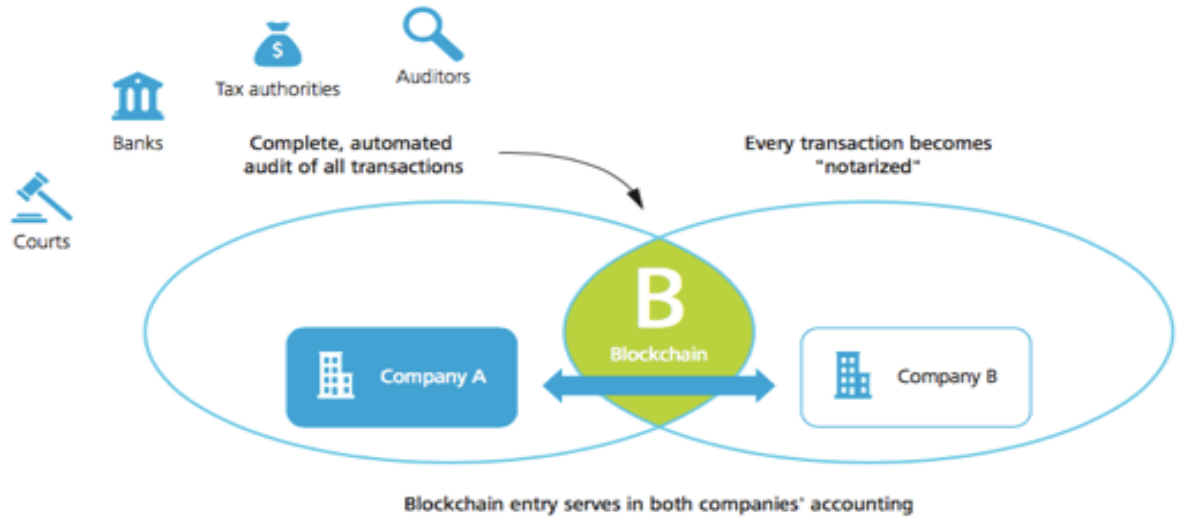

Diagram 12[151]

It is not difficult to see that these mechanisms mentioned may redefine the roles of auditors and accountants which is positioned in the center of all transactions between all companies. On the other hand, the literature concentrates on a different mechanism where the roles of auditors and accountants are minimized. Borrowing from Yermack (2016), Byström (2016) hypothesizes that if companies voluntarily discloses all their transactions on a blockchain, with a permanent time stamp on each transaction, the firm's entire ledger would be available instantly. Therefore, the need for an auditor to prepare balance sheets and income statements would be obsolete since such information would be available to the allowed actors including shareholders in real-time basis. Hence, on a blockchain-powered platform where a company records its transactions and balances, there would be no need for an auditor tasked with giving opinion regarding the accuracy of financial statements. [152] In this way, considering it is almost impossible to alter a previously entered data on a blockchain, a trust relationship between companies and its shareholders could be

[151] *Ibid*.
[152] Hans Byström, 'Blockchains, Real-Time Accounting and the Future of Credit Risk Modeling' [2017] Lund University Working Paper 2016:4 3-5.

established instead of the current mistrust model where auditors are needed to monitor the financials of the companies. Nevertheless, both Yermack (2016) and Byström (2017) do not provide any clarification in terms of the technological infrastructure of their design. For instance, questions such as which parties allowed to the blockchain or what the level of 'anonymity' shall be maintained are left unanswered.

Blockchain Accounting and Corporate Governance

To concentrate on the design of the blockchain accounting platform proposed by Deloitte, one easily recognizes that this design especially addresses multiple levels of agency problem in the triangular relationship between a company, its shareholders and its auditor. One of the problems in this context arises from the mistrust of the shareholders towards the auditor, as an extension of the trust problem between an agent and a principal. Ironically, although an auditing firm partly eliminates the agency problem between the management and shareholders of a company, it also creates a new agency problem between itself and the shareholders. Since an auditor technically is chosen or appointed by the management, there is no reason for shareholders to trust their auditor with an open heart. Nevertheless, if blockchains could be adopted in corporate accounting and all transactions between two parties are recorded in a single distributed ledger with automation of the process, it could increase 'transparency and reliability' of accounts tremendously by 'decentralizing' the power of management to record the transactions to a computerized system and the power to alter these accounts to an auditing firm and certain other government institutions. This would not only deal with the agency problem between the shareholders and management, but also the one between the shareholders and the auditing firm. Nevertheless, the later agency problem can only be solved if all transactions are recorded by computerized systems without the

involvement of 'human factor' and if the power possessed by auditing firms to alter the accounts are regulated properly.[153]

On the other hand, the second proposal seems to deal with agency problems much more radically by eliminating the involvement any third party in the accounting to remove the agency problem in the process of accounting. It promises to 'decentralize' the power of management to record and alter the accounts to a computerized system that enters each transaction on a distributed ledger automatically. In fact, this also would eliminate the need for auditors, which is another agency problem as mentioned in the previous paragraph. Ultimately, this proposal would allow a company to have more 'transparent, dynamic and accurate financial data', which would be more reliable for the shareholders while also the value of the company can be reflected upon the share prices much fairly.[154]

As can be understood, if blockchains and smart contracts could be utilized to remove 'human imperfections' from the accounting process, it could remove the agency problem entirely. One can even put this into perspective better in the context of the famous Enron case where the accounting reports were altered by executives to increase the share prices of the company before selling their own shares.[155] If the accounting process was 'transparent' and 'decentralized in the form of automation', the human imperfections which steered these executives to act 'selfishly' and 'irrationally' could be controlled before leading them into this scandal. Therefore, there would be

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[153] Deloitte, 'Blockchain Technology: A game-changer in Accounting?' [2016] 2 accessed on 07.08.2017 at https://www2.deloitte.com/content/dam/Deloitte/de/Documents/Innovation/Blockchain_A%20game-changer%20in%20accounting.pdf.

[154] Hans Byström, 'Blockchains, Real-Time Accounting and the Future of Credit Risk Modeling' [2017] Lund University Working Paper 2016:4 5.

[155] See Investopedia.com, 'Agency Theory' accessed on 18.08.2017 at http://www.investopedia.com/terms/a/agencytheory.asp/.

no reason to mistrust the financial data of companies without the human factor in them. Even though such revolutionary technologies remove the 'agency problem' in accounting process, it still does not eliminate in the decision-making process before a transaction while it also confronts the corporate governance with new questions and issues. Since especially, both given proposals increase the transparency at different levels, one naturally wonders the optimal and beneficial level of transparency of accounts to third parties. While complete transparency seems to deal with agency problem, it does not mean it reduces the agency costs as it may expose the strategy of a company to third parties who can benefit from, increasing the agency costs. In fact, even when transactions are processed anonymously, it is not impossible to tract the IP address of transacting parties. For instance, police have already devised a system tract IP addresses on Bitcoin system[156]Therefore, if these aspects of the technology cannot be improved, corporate governance will need a better understanding of the effects and desired level of transparency in accounting.

3.5. Virtual Companies

The next step in digitalization of companies seems be the virtual companies existing without the constraints of physical borders, which can technically be achieved by merging the aforementioned mechanisms, e-Voting, real-time auditing and tokenization, altogether on a blockchain. In such a case, corporate governance as it is known could be completely irrelevant since such a company would run on the smart contracts carrying out the wished of human shareholders by automatically

[156] John Bohannon, 'Why Criminals Can't Hide Behind Bitcoin' accessed on 18.08.2017 at http://www.sciencemag.org/news/2016/03/why-criminals-cant-hide-behind-bitcoin.

executing the terms of a contract.[157] Yet, as it will be shown in the already operative examples of such platforms, below, that neither the current technological development nor the regulators are ready to have this paradigm shift any soon.

Nevertheless, there is a difference between private and public companies as they are organized differently, which affects the adoption of blockchains in different organizations. Since public companies can be listed on stock exchanges, they come with stringent conditions and regulations[158] due to need to protect the shareholders from the negligent and selfish behavior of the officers and directors of the company as it is the same reason behind the adoption of corporate governance mechanisms in the public companies. Thus, it would be reasonable to assume that the digitalization of private companies will occur much faster than public ones.

Practical Examples

To start with operative examples in the context of digitalization of private companies, Otonomos[159] comes forward as an interesting service provider which offers its customers to incorporate a private company in 5 common law jurisdictions by the click of a button online. And upon the formation of a company for its customers, the company also allows its customers to access to a dashboard where each shareholder can control its wallet of shares and transfer them among the shareholders, attend at virtual shareholder meetings and see the online book-building. Hence, Otonomos clearly provides its users all the three functionalities mentioned before. Yet, it seems that blockchain book-

[157] Ey.com, 'Building blocks of the future' [2016] accessed on 07.08.2017 at http://www.ey.com/gl/en/services/assurance/ey-reporting-building-blocks-of-the-future#item1.

[158] See the difference of UK Public and Private companies, accessed on 07.08.2017 at http://council.lancashire.gov.uk/documents/s46513/Appendix%20A.pdf.

[159] See the company website, accessed on 07.08.2017 at https://www.otonomos.com.

building functionality on the dashboard is not a match for the conceptualized models previously mentioned since Otonomos booking-building function is not as sophisticated as the aforementioned blockchain accounting mechanisms where every single detail is recorded instead of just the move of shares or the raised capital.

However, the actual paradigm shift in the legal industry will come when the digitalized public companies will take off. One of the earliest examples of such companies are found on the Ethereum public blockchain, which allows its users to codify corporate governance rules (quorum, notice period, matters of unanimous consent, casting votes, transfer of shares, real time book-keeping etc.) and run them autonomously the with the help of smart-contracts.[160] Such online associations are currently known as 'Decentralized Autonomous Organizations' or 'DAOs' which simply mimic what one could called 'public companies' by having the capacity to issue shares, pay executives and employees, authorize budgets, make corporate decisions and virtually anything a company does. The only difference is that this organization is not incorporated in any jurisdiction and usually does not have a physical existence. It is run by the power of computers connected in the blockchain network.[161]

As can be understood 'DAOs' was expected to completely revolutionize the conventional concept of a company since it did not require a physical address[162] (unlike incorporated public and private

[160] Michael Milnes, 'Blockchain: A Tech Trend for Business Lawyers in 2016' [2016] Accessed on 08.08.2017 at https://www.linkedin.com/pulse/blockchain-tech-trend-business-lawyers-2016-michael-milnes.

[161] Robert Donald Leonhard, 'Corporate Governance on Ethereum's Blockchain' [2017] 9 Accessed on 08.08.2017 at https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2977522.

[162] Mark Fenwick, Wulf A. Kaal and Erik P. M. Vermeulen, 'The "Unmediated" and "Tech-driven" Corporate Governance of Today's Winning Companies' [2017] 45 accessed on 07.08.2017 at https://ssrn.com/abstract=2922176.

companies),[163] physical attendance and incorporation and was not subject to those stringent and onerous requirements to be able to sell shares to public. Therefore, many bloggers, legal scholars and simply blockchain-enthusiasts were very excited to experience these changes and write about it. Yet, it seems that this 'DAO hype' may have been taken a hard hit from the U.S. Securities and Exchange Commission on July 25, 2017 after it finally published its long-waited decision regarding the 'freely circulated DAO tokens (shares) on the online platforms'. Now, all DAO's issuing 'shares or tokens' will be subject to the rules of SEC. Therefore, DAOs will need to be incorporated, follow financial disclosure rules, hold AGMs and more.[164] Nevertheless, it would be unreasonable to disagree with SEC's decision, since public investors need protection originating from their limited knowledge in securities market and assessing the performance of companies. Incorporation, financial disclosure, physical attendance is some of the main instruments of SEC to make sure that companies are run as they claim to be running to improve the trust element between shareholders and management.

In the light of this, it is hard to see how they will differ from physical companies. Eventually, they might just become physical companies that employ the above-mentioned 'E-voting, online securitization and virtual book-keeping' mechanisms on a public blockchain unless governments are ready to explore the opportunities hidden in technological developments. If the advantages of incorporation, financial disclosure and physical attendance can be substituted in virtual companies by using different mechanisms, then there would be no reason for governments to take a negative stance on these developments.

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[163] Requirements for the incorporation of UK Public and Private companies, accessed on 07.08.2017 at http://council.lancashire.gov.uk/documents/s46513/Appendix%20A.pdf.

[164] This decision was taken after a cyber-attack perpetrated on a DAO. For more detail see SEC, Release No. 81207 / July 25, 2017. Accessed on 06.08.2017 at https://www.sec.gov/litigation/investreport/34-81207.pdf.

Virtual Companies and Corporate Governance

As it has been already covered, blockchain voting, tokenization of shares and real-time auditing address diverse issues in the context of corporate governance, specifically the agency problems. In that regards, one may argue that the concept of a virtual company is a bundle of these instruments. However, one needs to understand the motivations behind this digitalization in order to see in what sense it can produce a different effect on the corporate governance than these individual instruments.

Virtual companies can almost be seen as reaction to the agency problems in a modern company and which encodes the governance rules on smart contracts, to prevent human errors in the processes of the company. According to the original white paper elucidating DAOs, the reason behind this automation of the governance rules was that 'people do not always follow the rules and (2) people do not always agree what the rules require'.[165] It seems that the white paper simply makes use of the human imperfections, as defined by Pennington, in explaining the reasons behind the conflict of interests between shareholders and corporate agents.[166] Therefore, it can be assumed that virtual companies ultimately aim at addressing the agency problem by increasing the 'transparency' in corporate operations (e.g. real time bookkeeping, increased shareholder involvement by streamlining the voting process), lowering the information asymmetries and 'decentralizing' the powers of management and distributing them to 'automated systems' in order to make sure that they would be more hesitant to act on self-interest. In other words, virtual

[165] Christoph Jentzsch, 'Decentralized Autonomous Organization to Automate Governance' [2015] white paper 1.

[166] Michael C. Jensen and William H. Meckling, 'A theory of the Firm: Governance, Residual Claims and Organizational Form [1976] 3-4 JFE, 6-7.

companies aim at minimizing human errors caused by natural human imperfections in corporate processes, consequently the agency problem by making.

Yet, one shall not be led into thinking that they make companies run more efficiently and effectively. Better corporate governance is not a sufficient condition for companies to perform better and human interaction is not necessarily a bad thing. It seems that virtual companies and all other blockchain-powered corporate governance mechanisms studied are better at completely removing the human interaction and agency problem from certain processes of a company than reducing the agency costs. There are many examples where human interaction may be good for companies, thus these mechanisms may unexpectedly increase the agency costs if they are not devised without giving consideration to the human interaction in a company.

For instance, corporate engagement with institutional shareholders which may occur in the form of private negotiations with the management,[167] is shown to contribute to the liquidity of the company's stock and reduce the information asymmetries by acting as an oversight over the management.[168]Nevertheless, under a virtual company of complete transparency and democratic decision-making, as promised by the use of blockchains and smart contracts, institutional shareholders would be deterred to engage in corporate decision-making through informal channels. This may increase the agency costs if the benefits of virtual company with the perceivably reduced scale of agency problem, is less than the benefits of this kind of human interaction.

[167] DB Advisors, 'Corporate Engagement by institutional Shareholders' [2009] accessed on 14.08.2017 at https://www.db.com/cr/de/docs/DBAdvisors_CorpEngagement_090113.pdf.
[168] Nancy Huyghebaert and Cynttia Van Hulle, 'The Role of Institutional Investors in Corporate Finance' [2004] XLIX Tijdschrift voor Economie en Management 695.

Conversely, in a system without transparency and decentralization of power from managers, one could also argue that institutional investors could engage in insider trading with the superior information they hold (in comparison to other shareholders) due to their closer ties to the management.[169] Therefore, there needs to be an understanding of the necessary level of 'transparency and decentralization' in specific operations of a company to make sure that they operate efficiently and effectively with the desired level of human interaction.

Overall, even when virtual companies can eliminate the agency problem in a certain process, they do not necessarily benefit their shareholders maximally. Companies need human interaction, thus is need for scholars to seek an understanding of the relationship between the human interaction in certain governance practices and the overall performance of companies. In this regard, the use of Pennington's identification of 'human imperfections' and the role of the 'decentralization and increased transparency and accountability to address these issues' can be used as a guide to understand human behavior in a company in order to conceptualize its positive sides while reducing the effects of the negative ones.

[169] Jennifer Hill, 'Institutional Investors and Corporate Governance in Australia' [2008] Legal Studies Research Paper No. 08/37 The University of Sydney, 21.

CONCLUSION

The main goal of this research was to demonstrate how blockchains could be devised in the context of corporate governance and how this could affect the corporate landscape.[170] What this technology promises is to 'solve the principal-agent problem' in certain corporate processes of a company by automating the governance rules on smart contracts and running them on immutable platforms.[171] Having analyzed the features of the existing and proposed blockchain platforms, the research could indeed observe this effect in the working examples of blockchain-run platforms offering solutions for 'the issuance and transfer of securities, corporate voting and accounting', although there is still room for improvement before a mass adoption.

Nevertheless, removing the agency problem from the equation by automating certain corporate governance rules is not an isolated development, it puts other issues under the spotlight, two of which are 'the level of beneficial human interaction' and 'the effect of transparency on performance of a company'. Especially when these automated governance mechanisms are bundled as a virtual company, the interaction between shareholders, management and other stakeholders becomes very minimal in these processes concerned while the transparency of company's operations become extremely high. However, the research in the field of corporate governance focuses on resolution of the agency problem, thus, there has not been a complete framework that could respond to the perpetuating agency problems in some governance processes alongside the reduced human interaction and lack of corporate privacy in others.

Hence, the second goal of this paper was to set a framework clarifying the impact of 'human factor' and 'transparency' on corporate governance, which could be used to design mechanisms in solving

[170] Satoshi Nakamoto, 'Bitcoin: A Peer-to-Peer Electronic Cash System' [2008] 1.
[171] David Yermack, 'Corporate Governance and Blockchains' [2015] Rof 34.

the existing agency problems while also addressing the risks associated with the automation of governance. In the line with this, the research attempted to adopt Pennington's Robust Political Economy theory to address these issues by making use of his successful observations on the human behavior in decision-making and the basic logic behind the governance mechanisms aiming at resolving the principal agent-problem.

When Pennington's theory put into test by the traditional literature on the agency theory, it was clear that his concept of 'human imperfections' could be justified as the sources of the conflict of interest between an agent and a principal, the scale of which is worsened in a context of uncertainty and information asymmetries. Besides, his theory also consolidates the understanding of the sources of this conflict by addressing both 'limited rationality and limited benevolence' of the human nature.

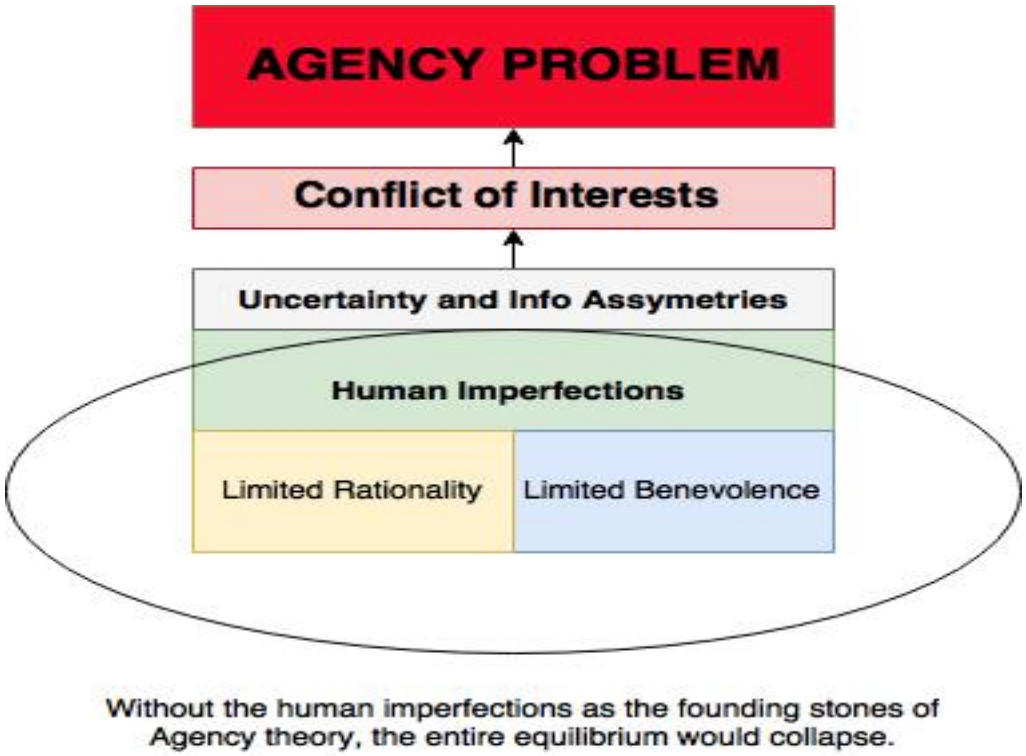

Diagram 13

Confirming this, the research could validate that all corporate governance practices, ranging from the use of blockchains in certain processes to already existing governance practices, devise these two theoretical mechanisms in dealing with the agency problem. These were 'decentralization of control in decision-making and the increased transparency and accountability', which were hypothesized by Pennington and Moberg as the solutions towards the elimination of the negative effects of human imperfections from the decisions of agents. Thus, it could come to a conclusion that Pennington's arguments were useful in elucidating the causation triggering the elimination of the agency problem in a company through smart contracts and blockchains.

In the light of the theory, the research could establish that it was the radical adherence of the blockchain technology to 'the utmost transparency with increased accountability and complete decentralization in decision making', removing the agency problem in certain processes of governance while also reducing the human interaction in companies. Besides, it could also plainly explain how lack of privacy in the operations of a company could cause other market actors to benefit from such information for their-self-interests. Hence, it could be anticipated that the cost of embracing 'transparency, accountability and decentralization' without a cost-benefit analysis may be higher than its benefits due to the change in the reduced human involvement and increased transparency of corporate actions. By understanding the consequences of these variables, companies can come up with better governance strategies embracing blockchains and smart contracts and they can reduce the agency costs to financially beneficial levels by adjusting them.

In a nutshell, this paper could demonstrate that human imperfections will not be eliminated altogether in the operations of a company any soon while the future technologic developments

are promising in removing such human imperfections in certain areas of corporate governance. Hence, it can be expected that the future discussions in corporate governance will evolve differently with a focus on the importance of 'physical human interaction' and 'corporate privacy' in a company rather than the traditional concentration on 'aligning the interests of an agent and a principal'. Considering these topics will need to co-exist more-or-less equally as a part of the literature, the adoption of Pennington's understanding of human imperfections and notions of 'decentralization and increased transparency and accountability' could be a step towards this renewed focus of corporate governance as his reasoning could be used to analyze both the 'causes and cures' of the agency problem and the results of automation under a single framework.

Finally, to address the potential development of this research, it is important to acknowledge that it had a very broad focus since the use of blockchains in corporate governance is a very new phenomenon. Hence, the future research in this field could address each of the specific corporate governance mechanisms studied more in detail to see the dynamics automation alters in the specific examples. Further, it could also study the importance of human interaction in the corporate decision-making with a goal to seek a substitute for such interaction within the technological developments.

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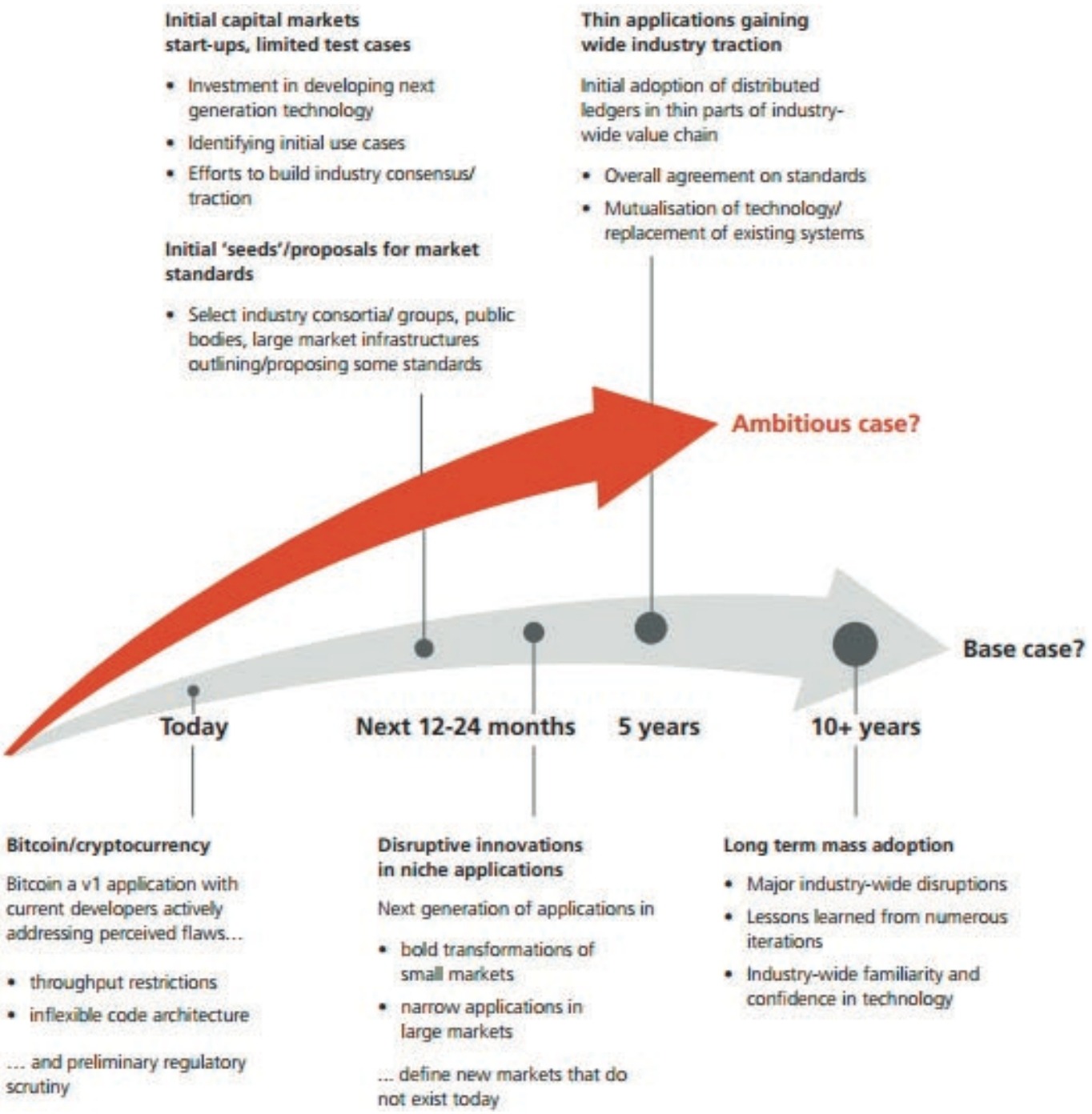
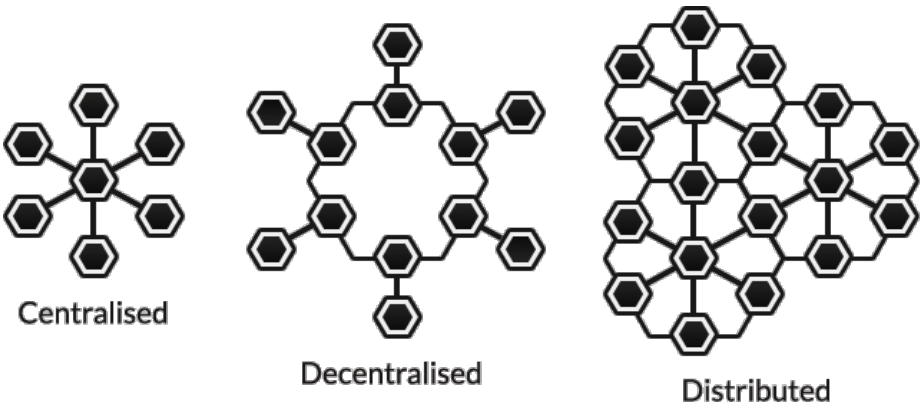
Appendix

Appendix 1



Appendix 2



Bracke and Zhou (2015-106)

Appendix 3

Limits of Blockchains

Limits of Public Blockchains

Redundancy is one of the main limits faced by all distributed ledgers, yet especially for public blockchains that may be hosting millions of nodes. Although public ledgers increase the security on a blockchain platform by adding competition to the mining, it might be redundant and costly for certain organizations that would like to make use of blockchain technology. Bitcoin was a move against the distrust against the centralized payment systems, however its technology eventually became a useful instrument for many different actors ranging from banks to government organizations. For instance, it is highly possible that a bank may see a distributed public ledger not useful since it continues to remain as intermediary in the equilibrium. Banks or governments also may not be willing to share its every dealing; therefore, a completely public ledger may have limits in terms of use for the actors with different needs.[172] Besides, it should not be forgotten that the transition from high centralized systems to decentralized systems will not happen in a day, therefore private and hybrid forms of blockchain may be useful in the initial stage as at least they are not entirely decentralized, thus the information in circulation and the number of participating nodes can be controlled at ease.

Scaling is the second limit found in the design of public blockchain, frequently referred in the literature. In a public blockchain like Bitcoin, the public ledger grows exponentially faster than the number of miners, increasing the required storage and computational power for the transactions as each transaction is linked to the previous transactions. As mentioned before, it already takes around

[172] Saifedean Ammous, 'Blockchain Technology: What is it good for?' LAU 4-5.

10 minutes of immense CUP use to process one block in Bitcoin.[173] Considering Visa processes 24 thousand transactions per second while Bitcoin handles just 2000 per block (meaning each 10 minutes), the scalability issue seems to be obvious at this stage.[174]

Yet, as there is a current demand to solve this scalability issue, there are many research focusing on this issue. Particularly, the University of Sydney seems to curb this problem with their new project at the development stage, Red Belly Blockchain. According to the researchers at the university, their blockchain allegedly achieved to process 400 thousand transactions per second on a network of 100 computers, even outdoing Visa.[175] Hence, technology seems to be curbing this problem, while at the very moment private blockchain might be useful for those who do not want to experience scalability problem on their processes.

Regulatory hurdle is another problem blockchain platforms are facing or will be facing in the future. Public blockchain without a centralized authority operates in every part of the world beyond the limits of any jurisdiction and are already notorious for being hard to monitor and regulate. There is already an inclination towards regulation by several jurisdictions, only problem is that currently it is technically burdensome to do so.[176] Yet, one can see the regulations on the horizon. Besides, for the heavily regulated industries like finance, the adoption of this technology may also be slow due to this ambiguous regulatory future as well as the lack of technical capacity to transfer current rules to a blockchain.[177]

Irreversibility of transactions is another issue that needs to be addressed, constituting a limit to the use of blockchain. Although blockchain technology reduces the human error to the lowest possible level by making use of the increased computational memory and power. Yet, hypothetically human errors are not eliminated and in a blockchain system to reverse a block containing error (e.g. fraudulent transaction or a mistake), all history of blockchain needs to be modified, requiring 51% of the processing power of the network. This means that more than half of the mining power is needed to amend the blockchain concerned, which might be impossible depending on the number of nodes involved.[178] For instance, it is hard to imagine a governmental land registry using a public chain where the incumbent governmental institution could not modify

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[173] Larissa Lee, 'New Kids on the Blockchain: How Bitcoin's Technology Could Reinvent the Stock Market' [2016] 12 Hastings Bus. L.J. 101

[174] Massimo Mortini, 'From "Blockchain hype" to a real business case for Financial Markets' [2016] BU and Banca IMI 4.

[175] Maria Monash, 'University of Sydney Builds New Blockchain Able to Process 400,000 Transactions/Sec' [2017] accessed on 21.07.2017 on www.coinspeaker.com/2017/07/05/university-sydney-builds-new-blockchain-able-process-400000-transactions-sec/?lipi=urn%3Ali%3Apage%3Ad_flagship3_feed%3B3AtmtDOTRjSc%2Fnli4KkxsA%3D%3D

[176] Primavera De Flippi, 'The Interplay between decentralization and privacy: the case of blockchain technologies' [2016] 7 JPP 2-5.

[177] Saifedean Ammous, 'Blockchain Technology: What is it good for?' LAU 4-5.

[178] Garby Gabison, Policy Considerations for the Blockchain Technology Public and Private Applications' [2016] Citation: 19 SMU Sci. & Tech. L. Rev. 327 330.

its own blockchain. At least, the implementation of a public blockchain by such institutions after the centuries of centralized decision-making will not be easy. [179]

And finally, **security issues** are other limits inherent in public blockchain. The 51% problem that mentioned previously may come as a security breach known as '51% Attack'. As mentioned before, to process new blocks in a blockchain, more computation power is needed for every new block but also there are less tokens to be mined after each block. For instance, in Bitcoin, while mining comes with its reward in the form of bitcoins, in a certain period, there will be no Bitcoin to be mined[180], hence the incentive to mine will be diminishing gradually in case that the value of Bitcoin will also reach a plateau. In such a case, the number of miners will drop, allowing some miners to reach that infamous 51% computational power in the system and be able to 'manipulate the blocks'. Hence, the name 51% Attack refers to 'the risk of having a maliciously intended agent or group of agents who dominate the aggregate computational power available in the distributed network – they could, therefore, manipulate the addition of new blocks by consistently leading the confirmation process.'[181] For instance, in 2014, one of the mining pools, 'Ghash.io' reached almost 50% of the computational power in Bitcoin.[182] Although they publicly acknowledged they would act ethically, this showed that 51% attacks were more plausible that it was thought before. Yet, it must also be stated that in all likelihood, such attacks are considered to be too costly to perform.[183]

Furthermore, to avoid 51% Attack problem, platforms such as Ethereum introduced proof-of-stake protocols instead of proof-of-work, which allows those with more tokens to mine more. Hence, to have a 51% attack, a miner would need 51% of all token existing in the system. For instance, in a reputable crypto-currency platform like Ethereum, a miner owning 51% of the tokens would never attack the system since it would lose the most with the plummeting market value of the coins [184]

Limits of Private Blockchains

When it comes to private blockchains, one can easily understand that they do not pose any practical limits in terms of scaling, redundancy of intermediaries. They are not as at risked as public blockchains due to regulatory obstacles as well as irreversibility of transactions since there is a third party (e.g. central authority) managing the chain. Yet, the idea of Private Blockchains is contradicting Nakamoto's initial goal.[185] He wanted to get rid of trust element in transactions by removing the third parties from all transactions while private blockchains are managed by a central

[179] *Ibid*.

[180] Some also argue that in case there will be no Bitcoin to be mined, the system may introduce transaction free for the processing of each block. (see Evan Faggart, 'What Happens to Bitcoin Miners When all Coins are Mined?' [2015] Bitcoinnews.)

[181] J.H. Witte, 'The Blockchain: A Gently Introduction' [2016] RCM 4.

[182] Pete Rizzo, ' Ghash.io: We Will Never Launch a 51% Attack Against Bitcoin' accessed on 22.07.2017 on http://www.coindesk.com/ghash-io-never-launch-51-attack/.

[183] Investopedia, 'Proof of Stake' accessed on 22.07.2017 on http://www.investopedia.com/terms/p/proof-stake-pos.asp

[184] Ibid.

[185] Satoshi Nakamoto, 'Bitcoin: A Peer-to-Peer Electronic Cash System' [2008] 1.

authority. Hence, one can argue that there are inherent security risks in private blockchain-powered platforms.[186]

From the perspective of users, it is indeed a trust issue as blocks can be manipulated by the central authority if they are processing the transactions instead of miners. However, even when miners are tasked with processing the blocks, since there will not be many miners, the blockchain will be prone to 51% Attacks if the blockchain continues to use proof-of-work protocol. This issue certainly is the biggest downside of private blockchains. However, there are proposed solutions for this issue. Firstly, mining can be outsourced to trusted companies functioning as auditing companies (it would create new business).[187] And secondly, as mentioned before, two blockchains can be connected to each other and their blocks can be processed simultaneously. In this regard, 'merged mining' and 'blockchain Anchoring' are two separate protocols that can achieve this goal.[188] By making use of these, a private blockchain can use the miners of a public blockchain without the miners of latter being member of the former and having access to private information in the private blockchain, boosting the security in the blockchain.

[186] Willl Martino, 'The first scalable, high performance private blockchain' [2016] Kadena 5.
[187] Jeff Garzik, 'Public vs. Private Blockchains' [2015] 14.
[188] *Ibid*, 15-18