RICARDIAN CONTRACTS

Bridging the Gap Between Smart Contracts and Traditional Contracts

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PREFACE

Abstract:
This thesis will analyze the development of smart contracts and what is the next step of evolution of this disruptive technology. The focus of the thesis is to follow and understand the development of a hybrid form of contract which is both machine and human readable, i.e. Ricardian contract. This thesis will explore the topic from the point of view of necessity of smart contracts and the need to make its use widespread and how Ricardian contract can achieve the same. The basis of this solution is that Ricardian Contract solves the legal enforceability question of smart contracts. The structure of the thesis is built upon the elements of Ricardian contracts, connecting legal agreements to standardized code. An exploration will also be conducted from the point of view of the current usage of Ricardian contracts by companies such as OpenBazaar in their decentralized marketplace platform, comparing it with existing systems such as Amazon.

Keywords:
Legal technology - Contract automation - Smart contracts - Ricardian contracts - Hybrids contracts

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LIST OF ABBREVIATIONS

1. TPL - Trustless public ledger
2. IFTTT - If This, Then That
3. IOT – Internet of Things
4. EVM - Ethereum Virtual Machine
5. PKI - Public Key Infrastructure
6. IACCM - International Association of Contracts and Commercial Management
7. DAML - DARPA Agent Markup Language
8. DAO - Decentralized Autonomous Organizations
9. AI – Artificial Intelligence
10. OSS – Open Source Software

INTRODUCTION

"Every new thing creates two new questions and two new opportunities"

Jeff Bezos, CEO Amazon

Disruptive technology is part of human lives now. Every aspect of human life has been disrupted ever since the advent of internet, and even more so with blockchain and smart contracts. Blockchain has created several opportunities ranging across industries, at the same time it has also raised several important questions. Over the past couple of years, many industries like Insurance, Supply Chain Management, Finance, and Healthcare have started heavily leaning towards utilizing blockchain technology. Briefly introducing the concept of blockchain, which is basically a ledger of transactions. Blockchain technology organizes digital records of transactions into discrete chunks (blocks), and then maintains a chronological list of those blocks (the chain). In simple terms, *A chain of blocks: a blockchain*.[1] This technology can restructure online exchanges and reduce issues such as corruption, fraud, mistakes making it a very reliable online tracking system.[2]

Blockchain and smart contracts are two different technologies but are intrinsically linked, so to say currently, one cannot exist without the other. Smart contracts are blockchain enabled computer protocols that authenticate, enable, monitor, and implement the negotiation and performance of a contract.[3] It is based on blockchain technology. A Smart contract is captured in code, which automatically performs the obligations, as per what parties have decided to set into an agreement.[4] It is important to note here that once the smart contract code gets uploaded into the blockchain, the only way the action can be dictated is by the logic that is inserted in the code, making it immutable.[5] Most recently smart contracts are gaining popularity because of the emergence of blockchain technology and the emergence of cryptocurrency.[6]

The main aim of the creators of blockchain was to make a contractual relationship more efficient and economical with potentially fewer opportunities for error, delay or dispute as it is deployed on

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[1] James Grimmelmann, 'All Smart Contracts Are Ambiguous' (2019) 1 Penn Journal of Law and Innovation (Forthcoming), <https://ssrn.com/abstract=3315703> accessed 15 April 2019

[2] Philippa Ryan, "Smart Contract Relations in e-Commerce: Legal Implications of Exchanges Conducted on the Blockchain", (Technology Innovation Management Review, 2017) 5, <http://www5.austlii.edu.au/au/journals/UTSLRS/2017/24.pdf > accessed 13 April 2019

[3] Alan Morrison, 'Blockchain And Smart Contract Automation: Introduction and Forecast', (PWC, 20 March 2016) <http://usblogs.pwc.com/emerging-technology/blockchain-and-smart-contract-automation-an-introduction-and-forecast/> accessed 13 April 2019

[4] Hsiao J, 'Smart Contract on the Blockchain-Paradigm Shift for Contract Law' [2017] 14 (10) US-China L Rev 685

[5] William Rode, 'Blockchain for non-techies: 3. Smart contracts', (Hackernoon, 11 July 2017) <https://hackernoon.com/blockchain-for-non-techies-3-smart-contracts-104f77277297> accessed 22 May 2019

[6] Huu Nguyen, Scott Bailey, "Use of Artificial Intelligence for Smart Contracts and Blockchains" (Squire Patton Blogs, April 2018) <https://www.squirepattonboggs.com/en/insights/publications/2018/04/use-of-artificial-intelligence-for-smart-contracts-and-blockchains> accessed on 28th May 2019

to a trustless public ledger i.e. TPL.[7] There can be three components governing the complete technology, i.e. blockchain, which is the register where smart contracts are stored and crypto-property is recorded. Secondly, the crypto property, which is the value that is transferred. And lastly, the smart contract, which sets all the conditions and consequences for the transfer of crypto property.[8]

It would be criminal to discuss smart contracts without touching upon, Nick Szabo's[9] definition of smart contract which defines it as -

"*a smart contract is a computerized transaction protocol that executes the terms of a contract. The general objectives are to satisfy common contractual conditions (such as payment terms, liens, confidentiality, and even enforcement), minimize exceptions both malicious and accidental, and minimize the need for trusted intermediaries. Related economic goals include lowering fraud loss, arbitrations and enforcement costs, and other transaction costs."*[10]

The main inspiration behind these contracts is that it can be represented in code and be executed by computers[11], unlike traditional contracts established through speech, written words, or actions, smart contracts are algorithmic, self-implementing and self-enforcing computer programs.[12] Vending machine is one of the very first example of smart contract which has been used over and over again as to explain how a smart contract works. The functioning of the machine is as simple as that the machine is computerized in order to avoid third-party interaction wherein it is programmed in a way that, if the conditions are met, and if the money is inserted then it will dispense the product automatically without the need for any human intervention.[13]

Another example of a smart contract can be illustrated by the following example –

[7] Hsiao J, 'Smart Contract on the Blockchain-Paradigm Shift for Contract Law' [2017] 14 (10) US-China L Rev 685

[8] Jaccard Gabriel, 'Smart Contracts and the Role of Law' (2018) 1< https://ssrn.com/abstract=3099885> accessed 13 April 2019

[9] Nick Szabo, developed the phrase and concept of "Smart Contract", <https://en.wikipedia.org/wiki/Nick_Szabo> accessed 22 May 2019

[10] Nick Szabo, 'Smart Contracts: Building Blocks for Digital Markets' (1996) <http://www.fon.hum.uva.nl/rob/Courses/InformationInSpeech/CDROM/Literature/LOTwinterschool2006/szabo.best.vwh.net/smart_contracts_2.html> accessed 1 April 2019

[11] Eliza Mik, 'Smart Contracts: Terminology, Technical Limitations and Real-World Complexity' (2017) 1, < https://ssrn.com/abstract=3038406 > accessed 13th April 2019

[12] Kristian Lauslahti, Juri Mattila & Timo Seppälä (2017). "Smart Contracts – How will Blockchain Technology Affect Contractual Practices?" ETLA Reports No 68. < https://pub.etla.fi/ETLA-Raportit-Reports-68.pdf> 1, accessed 13 April 2019

[13] Eliza Mik, 'Smart Contracts: Terminology, Technical Limitations and Real-World Complexity' (August 2017) 1, < https://ssrn.com/abstract=3038406 > accessed 13 April 2019

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Starting Balance in the contract = Take Money From A.
Update Starting Balance = Take Money From B.
Record outcome of the bet as per received signal.
If ( Outcome = 'Team X wins' ) { Send Money To A }
Else { Send Money To B }
```

Image Source - Hacker noon[14]

Initially, smart contracts were developed keeping in mind only a limited set of transaction especially in relation to financial instruments. But with changing times and lack of trust amongst people, the need of an autonomous body grew stronger and the emphasis of removing a third- party in transactions became more relevant. Understandably, there is a movement towards more parties entering into smart contracts with the intention of enforcing the obligations by code. Hence, what started as a niche phenomenon in such areas as financial derivatives and prediction markets, is now set to change the not only the financial as well as entire legal landscape resulting in "revolutionizing" commerce.[15] Before getting swept into the development of this new technology, it is important to emphasize here that traditional contract system which has been in place since middle ages is not something that can be replaced overnight and is better suited to deal with all the uncertainty transactional relationships bring along with them. Despite the potential of smart contract, there is a challenge that commercial relationships which have several layers of obligations, it is difficult to convert these into codes.[16] Hence revolutionizing the contract system along with the commercial sphere will not happen overnight and it must be one step at a time.

Problem Statement

One of the major issues the legal fraternity is brought face to face with currently is the issue of legal enforceability of smart contracts. The great many potential of smart contract falls on its face without the same having any legal validity. A scenario where the best of features from the traditional contracts can be taken and incorporated to smart contracts without it losing the essence of being machine readable agreements is the question this thesis tries to explore. Contracts are difficult to understand and even more so, to manage given the volume that is involved. Despite that, they are also currently the backbone of an efficient business operation and come with a solid backing of legal jurisprudence. But the time is right to utilize the principle of "*code is law*"[17] which

[14] Oscar W, 'AI Smart Contracts—The Past, Present, and Future' (Hackernoon, 21 November 2018) <https://hackernoon.com/ai-smart-contracts-the-past-present-and-future-625d3416807b> accessed 15 April 2019

[15] Sergey Grybniak, "Advantages and Disadvantages of Smart Contracts in Financial Blockchain Systems" (Hackernoon, 28 December 2017) < https://hackernoon.com/advantages-and-disadvantages-of-smart-contracts-in-financial-blockchain-systems-3a443145ae1c> accessed on 13 April 2019

[16] Hsiao J, 'Smart Contract on the Blockchain-Paradigm Shift for Contract Law.' (2017) 14(10) US-China L Rev 685

[17] Samer Hassan, Primavera De Filippi "The Expansion of Algorithmic Governance: From Code is Law to Law is Code" (2017) 5 < https://ssrn.com/abstract=3117630> accessed 20 May 2019

uses and extends the wisdom of legal and coding experts[18] combined, developing a model which works for people and machines, is what the thesis tries to elaborate on.

Research Question

To move ahead from the discussions regarding functioning of smart contract and its enforceability, this thesis will focus on the need for a hybrid model or Ricardian contract and examine its structure in comparison with smart contract and traditional contracts.

The **central research question** of the thesis is to answer

"Can a hybrid model like Ricardian contract, bridge the gap between smart contract and traditional contract?

That being the common question of the thesis, this thesis will also delve into various other questions and sub questions i.e. "why is there a need for a hybrid model?", comparative analysis of Ricardian contract with smart contract and traditional contract, how can a hybrid model like Ricardian contract help in widespread usage of smart contracts? How to codify prose of the contract?

Structure

This thesis begins with a brief introduction to smart contracts and blockchain technology. In the introduction, briefly touching upon the functioning of smart contracts, its current usage in various industries and the legal enforceability issues surrounding smart contracts. The thesis begins with analyzing what the current position is vis-à-vis in terms of usage of smart contracts and what the future of smart contract is, bringing in the question of the need for a hybrid form like Ricardian contract.

In the third chapter, elaborating further on Ricardian contract and its salient features, the elements of Ricardian contract, and how does Ricardian contract solve the problem of codifying prose by converting terms into both machine readable and human readable contracts. Then the thesis delves into the comparative analysis of smart contracts and Ricardian contract.

In the fourth chapter, this thesis closely looks into the evolution of smart contracts and if Ricardian contracts are the future of blockchain. This thesis puts forward the proposition that Ricardian contract is the future of blockchain-based legal agreements. Taking the discussion further to question such as, how a hybrid model like Ricardian contract can help in widespread usage of smart contracts.

In the last chapter before conclusion, this thesis explores into practical aspects of usage of a hybrid model like Ricardian contract and the at the existing models of Ricardian contracts being successfully used by companies, with a comparative analysis of Amazon's centralized model vis-à-vis Open Bazaar's decentralized Ricardian contract model being used in its online marketplace

[18] James Hazard, Helena Haapio "Wise Contracts: Smart Contracts That Work for People And Machines" (2017) 5 <https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2925871> accessed 20 May 2019

and if in future, a decentralized market place will be more popular using Ricardian contract and blockchain.

Methodology

In order to answer our central research question, this thesis will focus on research of existing international legal as well as available technical literature on smart contracts, Ricardian contract and blockchain technology. In order to explain both smart contract and Ricardian contract this thesis will take the help of technical and diagrammatic representation of both the technologies. But without losing focus, the main criteria will be to explore more of the legal aspect. The technical aspects of the technology will be only to the extent to explain how the technology works. Methodology used will include comparative analysis to draw a comparison between the two models of contract as well as to make a comparison between an existing Ricardian contract model being used by an online marketplace and the traditional model followed by another e-commerce company. Overall, a blended approach of analytical and comparative methodology will be used by the thesis in order to answer the research questions of raised.

Objective

With the widespread use of blockchain across industries, it has become increasingly important to look at usage of smart contracts in business. There is an ongoing debate as to whether smart contracts are contracts in the real sense at all[19], with some authors not being inclined towards smart contracts due to its lack of legal enforceability. This thesis will only touch upon this debate. However, the focus of this thesis is to look at the hybrid form of contract which brings together the best of traditional contract and smart contract, i.e. Ricardian contracts.

[19] David B. Black, "Blockchain Smart Contracts Aren't Smart And Aren't Contracts" (Forbes, 4 February 2019) < https://www.forbes.com/sites/davidblack/2019/02/04/blockchain-smart-contracts-arent-smart-and-arent-contracts/#70ad4d1d1e6a> accessed 13 May 2019

CHAPTER 2

THE NEED FOR A HYBRID FORM OF SMART CONTRACT

Humans are at that point of time in history where their lives are being swept away by application of technology in all spheres. Day in and day out they are being introduced with new game changing technologies even before they can adopt to the existing newer technologies. Never in history have humans been as reliant on technological support and artificial intelligence as they are today. Regulators have been left as spectators as technologies evolve at a pace where it goes on to the next step even before regulators can reach to stakeholders with their questions on how to regulate such technology. Keeping in mind the recent technological development, especially the development vis-a-vis the legal industry, it will not be wrong to say that the emergence of smart contract is one of the most significant contribution to the legal sphere in recent times.[20]

The basic characteristics of a smart contract are: *First*, smart contracts are drafted using source code use on computers, they can be standardized and executed at nearly no cost hence to decrease the marginal cost of contracting. *Second*, for party valuing certainty, there will be no room for ambiguity of contract interpretation but to execute the contract. So once the contracting parties have agreed to be bound by a clause, the smart contract's code, immutably binds them to that clause without the possibility of breach. *Third*, smart contracts are designed on a decentralized format.[21]

Making an observation as to at how smart contracts can help, especially in managing contracts, a reference can be made to the International Association of Contracts and Commercial Management (IACCM) survey of their corporate members (numbering 12,000 at the time of the survey, now 50,000 globally), which estimated that the current pitfalls of contracting lead to value erosion of 9% or more across commercial sectors.[22] There were several pitfalls observed, but not all of the pitfalls identified by the IACCM could be resolved by self-executing contracts. But even if half the total of 4.5% is considered, this still results into a very huge number in dollar terms when applied to the size of the business that is present in more complex contracts. This makes self-implementing contracts in sectors such as energy, petrochemicals, shipping, real estate, public

[20] Jaccard Gabriel "Smart Contracts and the Role of Law" (2018) 3 < https://ssrn.com/abstract=3099885> accessed 13 April 2019

[21] David Petersson "How Smart Contracts Started and Where They Are Heading" (Forbes, 24 October 2018) <https://www.forbes.com/sites/davidpetersson/2018/10/24/how-smart-contracts-started-and-where-they-are-heading/#4137e10c37b6> accessed 14 April 2019

[22] Cummins T, "Commercial agility and creativity through contract simplification" (IAACM, 29 March 2016) <http://media.swissre.com/documents/Presentation_Tim_Cummins.pdf> accessed 22 May 2019

utilities, infrastructure and commercial insurance, a very important solution for business transactions.[23]

2. Current application of Smart Contract

Currently several business transactions are being be coded into a blockchain through smart contracts. Smart contracts are computer coded agreements that use digital property, cryptocurrency, digital reputation, and then mathematical logic to self-execute, self-enforce, and self-regulate making the code free from any kind of modifications.[24] Smart contracts are constantly evolving and few examples of current application of smart contracts include voting, management, supply chains, healthcare and real estate[25]. Below are few examples discussed in detail:

2.1.1 Insurance Sector

The current problem with insurance policies is that the claims process can take weeks or even months to be paid, they are severely bogged down due to the time factor. The process is still majorly manual and requires a large degree of human intervention which ends up adding huge administrative costs, and higher premiums for customers. This problem can be eased if these insurance policies can be automated by writing them into a smart contract. Applying IFTTT, when the conditions of the smart contract change in an insured event, for example in the event of any natural disaster, the claims process gets triggered immediately. In the insurance sector, the application of blockchain technology has been explored through investments from both big and small companies, active interest from consultancy firms. In 2016, B3i, the first blockchain-centred insurance consortium was created.[26]

2.1.2 Supply Chain Management

This sector is predicted to benefit the most out of smart contracts. Smart contracts can be used record ownership rights as items progresses in the supply chain, showing a clear chain of ownership at each stage. With the help of IoT sensors, products can be tracked from producers to warehouses, warehouses to manufacturers, and from manufacturers to suppliers. The customer can track the product at each stage and in case if an item is delayed or lost, making it the perfect online tracking mechanism. If any stakeholder involved in the supply chain fails to meet the terms of the

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[23] Rory Unsworth, "Smart Contract This! An Assessment of the Contractual Landscape and the Herculean Challenges it Currently Presents for "Self-executing" Contracts" (2019) 10 < https://doi.org/10.1007/978-981-13-6086-2_2> accessed 22 May 2019

[24] Wulf A. Kaal, Craig Calcaterra, "Crypto Transaction Dispute Resolution (2017) 1 U of St. Thomas (Minnesota) Legal Studies Research Paper No. 17-12, < http://dx.doi.org/10.2139/ssrn.2992962> accessed 13 April 2019

[25] David Petersson "How Smart Contracts Started and Where They Are Heading" (Forbes, 24 October 2018) <https://www.forbes.com/sites/davidpetersson/2018/10/24/how-smart-contracts-started-and-where-they-are-heading/#4137e10c37b6> accessed 14 April 2019

[26] Tom Bobrowski, "Blockchain and Smart Contracts for Insurance: Is the Technology Mature Enough?" https://www.the-digital-insurer.com/blockchain-and-smart-contracts-for-insurance-is-the-technology-mature-enough/ (The Digital Insurer) accessed 14 April 2019

contract, for instance if a supplier did not send a shipment on time, or if a supplier did not disburse payment on time to its workforce, it would be clear for all the parties to see the same and act accordingly.[27]

2.1.3 Healthcare

"According to a study conducted by IBM, around 16% of healthcare executives are determined about their plans to implement blockchain solution in their work this year, while around 56% expected to adopt blockchain by the year 2020."[28]

The future of blockchain in health tech looks bright especially with pilots such as drug traceability, which can be one example of how smart contracts can revolutionise the healthcare industry. Patient, health payer and drug manufacturer can enter into smart contracts and use blockchain platform to ensure encryption which can only be authenticated by either of the above parties. The health payer will reimburse drug manufacturer when patients order prescription drug as per the patient's health plan. This payment is triggered by the smart contract when conditions agreed upon previously are met. Such smart contract between the consumer and the drug manufacturer guarantees that a certain amount of payment is transferred from the consumer to the drug manufacturer. The system can be structured in a way that the providers have contracts set up with payers so that every time a patient receives care (a doctor's visit, a medical procedure, etc.), an entry is created in the blockchain. This ensures drug traceability and also convenience for health payer as well as patients.[29]

2.1.4 Employment Contracts

A smart employment contract can bring complete transparency between employer and employee as employees know exactly what is expected of them and the compensation they will receive for their work and hence everyone involved is in the same page as to all the conditions under the agreement. Wages can be paid through the contract itself, with requirements that specified hours be logged into the system before pre-determined funds are transferred into the employee's account. This smart employment contract can also be redrafted to reflect any changes such promotions and changes in responsibilities. The overall progress of employee's professional growth can also be tracked using this smart contract.[30] Despite not being used major businesses currently; this is an area to look out for future opportunities of smart contract.

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[27] Laura Cox, "5 Applications of Smart Contracts" (Disruption Hub) <https://disruptionhub.com/smart-contract-uses/> accessed 14 April 2019

[28] Mayank Pratap, "Blockchain in Healthcare: Opportunities, Challenges, and Applications" (Hackernoon, 8 August 2018) https://hackernoon.com/blockchain-in-healthcare-opportunities-challenges-and-applications-d6b286da6e1f Accessed 14 April 2019

[29] Mayank Pratap, "Blockchain in Healthcare: Opportunities, Challenges, and Applications" (Hackernoon, 8 August 2018) https://hackernoon.com/blockchain-in-healthcare-opportunities-challenges-and-applications-d6b286da6e1f Accessed 14 April 2019

[30] Huges Brown, "Smart Contracts: Here Are the Practical Applications of This Exciting Blockchain Technology" (Entrepreneur Europe, 24 September 2018) < https://www.entrepreneur.com/article/320467> accessed 14 April 2019

In order to understand Ricardian contracts, the first step is to understand the platforms that support smart contracts as below.[31]

2.2 Platforms for Smart Contracts

To better understand the technicalities of the smart contract platforms, a distinction must be first made between *public and private blockchain*.

The main intention behind all these smart contract platform is common, i.e. to offer decentralized peer to peer network, where all participants have access to copy of the ledger and every change to the ledger has to go be agreed amongst all participants.[32] The main distinction between public and private blockchain is the element of permission. Permission as to who can participate in the blockchain network, execute, the consensus protocol and maintain shared ledger.[33] And this is also a major drawback is the large-scale consensus that must be achieved in the shared ledger. More specifically, to achieve consensus, each node in a network must solve a complex, resource-intensive cryptographic problem called a proof of work to ensure all are in sync.[34] Another major drawback is the public nature of the blockchain, which results into lack of privacy for transactions. A few examples of public blockchain platforms are Bitcoin, Ethereum, whose main aim is to increase and protect the user's anonymity.[35]

On the other hand, in case of private blockchain, it is a permissioned blockchain, which means that there is a restriction on participation and on the access to copy of ledger, and the transactions. These platforms are more commonly used by enterprises and are also referred to as 'Enterprise Blockchain' as the businesses involved want to control who can write and read data on this blockchain. Hence, the intention here, unlike a public blockchain, is to not control the anonymity of participants. In case of permissioned blockchain, the identity of participants is not anonymous in order to define rules about what data they can commit to the ledger and what data they can

[31] Emanuel Regnath, Sebastian Steinhorst, "Samoan: Smart Contracts in Natural Language", 3, <https://www.researchgate.net/publication/328815776_SmaCoNat_Smart_Contracts_in_Natural_Language> accessed 22 May 2019

[32] Sloane Brakeville, Bhargav Perepa,"Blockchain basics: Introduction to distributed ledgers" (IBM, 18 March 2018) <https://developer.ibm.com/tutorials/cl-blockchain-basics-intro-bluemix-trs/> accessed 12 May 2019

[33] Jayachandran Praveen, "The difference between public and private blockchain" (IBM, 31 May 2017) <https://www.ibm.com/blogs/blockchain/2017/05/the-difference-between-public-and-private-blockchain/> accessed 12 May 2019

[34] Jayachandran Praveen, "The difference between public and private blockchain" (IBM, 31 May 2017) <https://www.ibm.com/blogs/blockchain/2017/05/the-difference-between-public-and-private-blockchain/> accessed 12 May 2019

[35] Demiro Massessi, "Public Vs Private Blockchain In A Nutshell", (Medium, 12 December 2018) <https://medium.com/coinmonks/public-vs-private-blockchain-in-a-nutshell-c9fe284fa39f> accessed 12 May 2019

consume from the ledger.[36] There are many options for a private or enterprise blockchain, the most commonly used platforms include Hyperledger, R3 Corda and Quorum.[37] The fundamental factor to decide the type of platform depends on the solution the blockchain provides.

Let's consider two examples of public and private blockchain in order to understand the various smart contracts platform.

2.2.1 Ethereum

Ethereum is said to be the '*gold standard*' of smart contracts[38]. It is a blockchain based open software platform which gives developers the ability to build and deploy a decentralized application. Ethereum, on the other hand, allows people to run different programs on its EVM, irrespective of the language, if there is enough memory and time. EVM makes it easier to create blockchain apps. With Ethereum it is possible to develop thousands of applications on one platform instead of having to build a completely new application for each of the application. Ethereum is revolutionizing the decentralization because with the help of Ethereum, any centralized service can be decentralized.[39]

The very first release of smart contracts in Ethereum platform was for the purpose of giving parties that do not have a relationship of trust, a way to enter into an agreement, where the confidentiality of transaction can be maintained and the whole transaction can be verified by all the parties.[40] Ethereum showed the world how the blockchain can evolve from a simple payment mechanism to something far more meaningful and powerful.[41]

2.2.2 EOS

EOS is a blockchain-powered smart contracts protocol for the development, hosting and execution of decentralized applications.[42] EOS Blockchain aims to become a decentralized operating system

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[36] Abdul Wahab, "Consensus Protocols of Distributed Ledger Technology" (Medium, 20 October 2018) <https://medium.com/@wahabjawed/consensus-protocol-of-distributed-ledger-technology-c61526490e60 > accessed 12 May 2019

[37] Demiro Massessi, "Public Vs Private Blockchain In A Nutshell", (Medium, 12 December 2018) <https://medium.com/coinmonks/public-vs-private-blockchain-in-a-nutshell-c9fe284fa39f> accessed 12 May 2019

[38] Michael Mulders, "Comparison of Smart Contract Platforms" (Hackernoon, 5 March 2018) <https://hackernoon.com/comparison-of-smart-contract-platforms-2796e34673b7>, accessed 15 April 2019

[39] Which Are The Top 5 Smart Blockchain Based Smart Contract Platforms? (Krypto Graphie, 2018) <https://www.kryptographe.com/top-5-smart-blockchain-based-smart-contract-platforms/> accessed 15 April 2019

[40] Marley Gray, Craig Hajduk "Anatomy of a Smart Contract" (GitHub, 17 April 2017) < https://github.com/Azure/azure-blockchain-projects/blob/master/bletchley/AnatomyofASmartContract.md> accessed on 22 May 2019

[41]Ameer Rosic, "What is Cardano Blockchain?" (Blockgeeks, 2018) <https://blockgeeks.com/guides/what-is-cardano/> accessed 12 May 2019

[42] Stephen O'Neal, "EOS Community Is Challenged After Node Announces Financial Rewards for Votes", (Coin Telegraph, 5 December 2018) <https://cointelegraph.com/news/eos-community-is-challenged-after-node-announces-financial-rewards-for-votes> accessed 12 May 2019

which can support industrial-scale decentralized applications.[43] It was launched in June 2018 as OSS (open-source software), and is said to be fast, with zero transaction cost and fees for users. Unlike Ethereum, EOS is said to counter scalability issues as it can support millions of users. Another difference of EOS from other blockchain platforms is that it doesn't use proof-of- work concept and employs a method referred to as delegated proof-of-stake. Instead of depending upon mining, this platform places reliance on delegates to make new blocks.[44]

2.2.3 R3 Corda

The Corda platform was built in 2016, consists of an OSS project, Corda. It has a set of standards, network parameters and associated governance processes, which combined together define the global Corda Network.[45] Corda platform enables issuance, transfer and redemption of cash-like liabilities denominated in real-world currencies where regulation allows the facilitation of such transfer. Corda platform aims to solve the existing problem of managing contracts between firms, individuals, enterprises which have a relationship of trust, but just not enough trust to share their records.[46] The Corda platform is being used heavily by various players in the insurance sectors, i.e. Swiss Re, MetLife to name a few and in India, thirteen local insurers have developed a life insurance project with Cognizant using Corda platform as well.[47]

2.2.4 Hyperledger fabric model

Hyper Fabric framework is a platform for the development of blockchain based products. Hyperledger Fabric came into the existence due to collaboration of Digital Asset and IBM's and their first hackathon.[48] It is a private and permissioned blockchain system which means unlike, in Permissionless (or public network) systems that allow unknown identities to participate in the network.[49] Hyperledger fabric is playing a major role in food supply, fine art, insurance, aviation and accounting sectors, including interesting projects such as food source tracking, enterprise operation management and compilation of insurance data.[50]

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[43] Ameer Rosic, "What is EOS Blockchain: Beginners Guide" (Blockgeeks, 2018) <https://blockgeeks.com/guides/eos-blockchain/> accessed 15 April 2019

[44] EOS Platform—What You Should Know, (Medium, 4 July 2018) <https://cryptodigestnews.com/eos-platform-what-you-should-know-58da830d2aa8> accessed 12 May 2019

[45] Richard Gendal Brown, "The Corda Platform: An Introduction" (Corda, 2018) <https://www.corda.net/content/corda-platform-whitepaper.pdf> accessed 19 May 2019

[46] Richard Gendal Brown, "The Corda Platform: An Introduction" (Corda, 2018) <https://www.corda.net/content/corda-platform-whitepaper.pdf> accessed 19 May 2019

[47] Nicky Morris, "R3's Corda dominates insurance sector" (Ledger Insights, May 2018) <https://www.ledgerinsights.com/r3-corda-blockchain-insurance/> accessed 19 May 2019

[48] Hyperledger, <https://www.hyperledger.org/projects/fabric> Accessed 19 May 2019

[49] Shashank, "Hyperledger Fabric – A Platform for Business Solutions" (Edureka, 22 May 2019) <https://www.edureka.co/blog/hyperledger-fabric/#Hyperfabric>, accessed 19th May 2019

[50] Five Hyperledger Blockchain Projects Now in Production, (Hyperledger, 30 November 2018) <https://www.hyperledger.org/blog/2018/11/30/six-hyperledger-blockchain-projects-now-in-production> accessed 19 May 2019

2.3 Limitation of Existing Smart Contracts

The relationship between smart contracts and legal contracts is not a simple one[51] which is the basis of the limitations of smart contract. As observed in the above examples of various platforms that host smart contracts, programming languages codify smart contracts. As easy it is for coders and developers to write and develop this, it is that difficult for lawyers or someone not trained in the programming language. So, businesses cannot rely on smart contracts given that current business processes are subject to compliance requirements involving auditing by humans in natural language.[52]

Secondly, the above platforms for developing smart contracts are mostly still on public blockchains like Ethereum or Cardano. This is a challenge for business as there are issues such as corporate secrets and data privacy involved. Even though this is changing and permissioned blockchains are now starting to be used more frequently.[53] Further, as the execution of contracts is on an unalterable blockchain, this makes it unfavourable for business. Businesses operate in real-world environments and must react to evolving circumstances. As contractual agreements often change, smart contracts not offering such kind of flexibility is a crucial limitation, difficult to ignore[54].Whereas on the other hand, contracts drafted in natural language are flexible which is the main factor why businesses are heavily dependent on it.

As most parties cannot always predict the future of an agreement, there is an option for the parties to incorporate commercial customs into their agreement and unnecessary negotiations can be avoided in a stage where parties have not yet reached consensus on some areas. This brings more efficiency to the contracting process. By eliminating this flexibility, smart contract imposes costs that are more severe and inflexible than the ones they sought to solve at the very beginning.[55] Writing and debugging codes are both difficult and complicated process. Whereas the advantage of vague and ambiguous natural language is that it is cheaper and faster to negotiate and write down. Hence this flexibility has proven to be good[56].

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[51] J.G. Allen, *Wrapped and Stacked:* "Smart Contracts and the Interaction of Natural and Formal Language", [2018] 14 EUR REV CONTRACT L 307

[52] Sarah, Rothie, How Ricardian Smart Contracts Enable Blockchain Adoption, (Coin Central, 30 August 2018) <https://coincentral.com/ricardian-smart-contracts/> accessed 22 March 2019

[53] Robby Houben, Alexander Snyers, "Cryptocurrencies and blockchain" (TAX3 committee study, 30 August 2018) <https://coincentral.com/ricardian-smart-contracts/> accessed 22 March 2019

[54] Sarah, Rothie, How Ricardian Smart Contracts Enable Blockchain Adoption, (Coin Central, July 2018) <http://www.europarl.europa.eu/cmsdata/150761/TAX3%20Study%20on%20cryptocurrencies%20and%20blockchain.pdf> accessed 22 March 2019

[55] Jeremy M. Sklaroff, "Smart Contracts and the Cost of Inflexibility", [2017] 166 University Of Pennsylvania Law Review 264, <https://pdfs.semanticscholar.org/0783/0f2f209fcf5ad916848448baacdbfb78fe7c.pdf> accessed 22 May 2019

[56] James Grimmelmann, 'All Smart Contracts Are Ambiguous' (2019) 2 Penn Journal of Law and Innovation (Forthcoming), <https://ssrn.com/abstract=3315703> accessed 15 April 2019

As Levy[57] explains the characteristics of legal contracts in her article, "*As such, it can be both operationally and socially beneficial to leave some terms underspecified; vagueness preserves operational flexibility for parties to deal with newly arising circumstances after an agreement is made and sets the stage for social stability in an ongoing relationship*.[58]

Smart contracts currently cannot deal with commercially complex scenarios and codes will fail to embed all possible answers to all possible questions. Hence, there are numerous limitations to the freedom of smart contracts.[59] The crucial problem is also, what happens when the outcomes of the smart contract and demands of law are completely opposite sides of spectrum? Imagine, for a moment, if an insurance holder who is not satisfied with the blockchain-based rejection of a payout, how will such issues be tackled if the question regarding the legal background of smart contract is not solved. These parties must have access to legal jurisdictions so that the legality of the respective blockchain-based decisions can be scrutinized effectively. It is only if the law can suspend or on the other hand recognize technology-based self-executing contracts or find a hybrid solution tackling these limitations, future of smart contracts can only then be seen as a part of reality in business operations.[60]

2.4 Future of Smart Contracts

The only way to fully understand a new technology is to be one step ahead of what the current solution, the aforesaid technology provides. Keeping the above proposition in mind, its crucial to analyze the evolution of smart contract which has already been discussed in the previous sub-sections i.e. discussing surrounding current usage of smart contracts to development of smart contract platforms to the issues surrounding legal enforceability of smart contracts. Exploring the question of the past, present and the future of smart contract, brings us to what next smart contracts has to offer. The evolution of smart contract, a technology developed way before bitcoin gain popularity, came into existence with the aim targeting the dubious role of intermediary and how to remove them from the system started as early as in 1995.[61] But the complete utilization or

[57] Karen E. C. Levy, "Book-Smart, Not Street-Smart: Blockchain-Based Smart Contracts and The Social Workings of Law" [2017] 7, Engaging Science, Technology, and Society <https://pdfs.semanticscholar.org/d9bf/0c9d82d0ffe44bb493c9b2f4ed41bafaf035.pdf> accessed 22 May 2019

[58] Jeremy M. Sklaroff, "Smart Contracts and the Cost of Inflexibility", [2017] 166 University Of Pennsylvania Law Review 264, <https://pdfs.semanticscholar.org/0783/0f2f209fcf5ad916848448baacdbfb78fe7c.pdf> accessed 22 May 2019

[59] Martin Von Haller Gronbaek, "Blockchain 2.0, Smart Contracts And Challenges (June 2016) <https://www.twobirds.com/en/news/articles/2016/uk/blockchain-2-0--smart-contracts-and-challenges> accessed 14 April 2019

[60] Florian Möslein, "Legal Boundaries of Blockchain Technologies: Smart Contracts as Self-Help?" <https://ssrn.com/abstract=3267852> accessed 16 April 2019

[61] David Petersson, "How Smart Contracts Started And Where They Are Heading", (Forbes, 24 October 2018) < https://www.forbes.com/sites/davidpetersson/2018/10/24/how-smart-contracts-started-and-where-they-are-heading/#9e616e337b63> accessed 13 April 2019

evolution of smart contracts actually took place only after bitcoin imploded into the scene.[62] Especially with Ethereum's first implementation.

With passage of time and development of various smart contract platforms as discussed above, the list of such platforms is on a rise. In 2019, the smart contract is set to become smarter[63] with businesses exploring the possibility of using big data and IoT in combination with blockchain technology. Some of the recent example of these developments can be noticed in projects such as the project by IBM and Maersk group. The technology giant and shipping giant are collaborating to create a global shipping platform with blockchain technology. To tackle the problem of large volume of data, the companies realize the need to develop new type of smart contracts.[64] It is safe to say that the future of smart contract will be the convergence of big data, artificial intelligence and machine learning combined with blockchain and smart contracts. With introduction of AI, computers can learn from the smart contract flows and the data, which is most the vital element. This data can successfully guide as to the points where things can go right and wrong from past records. IOTA, Ocean Protocol, and SingularityNet[65] have already started exploring AI as a service solution.[66]

But, if Bitcoin had its impact on 2017, and 2018 had smart contracts written all over it,[67] from the looks of it, 2019 seems to be heading towards the direction of Ricardian contract leaving its mark[68]. As the future of smart contract cannot exist without it evolving into more of a hybrid smart contract, in the next section this aspect of the research question is analyzed.

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[62] David Petersson, "How Smart Contracts Started And Where They Are Heading", (Forbes, 24 October 2018) < https://www.forbes.com/sites/davidpetersson/2018/10/24/how-smart-contracts-started-and-where-they-are-heading/#9e616e337b63> accessed 13 April 2019

[63] Craig Sproule, "As smart contracts get smarter, the rules of development will change" (Venture Beat, 18 February 2018) < https://venturebeat.com/2018/02/18/as-smart-contracts-get-smarter-the-rules-of-development-will-change/> accessed on 13 April 2019

[64] Craig Sproule, "As smart contracts get smarter, the rules of development will change" (Venture Beat, 18 February 2018) < https://venturebeat.com/2018/02/18/as-smart-contracts-get-smarter-the-rules-of-development-will-change/> accessed on 13 April 2019

[65] Francesco Corea, "The convergence of AI and Blockchain: what's the deal?" (Medium, 1 December 2017) <https://medium.com/@Francesco_AI/the-convergence-of-ai-and-blockchain-whats-the-deal-60c618e3accc> accessed on 13 April 2019

[66] Andrew Ancheta, SingularityNET Delivers Blockchain AI To Domino's Pizza (Crypto Briefing, 1 May 2019) <https://cryptobriefing.com/singularitynet-delivers-blockchain-dominos-pizza/> accessed on 13 April 2019

[67] Craig Sproule, "As smart contracts get smarter, the rules of development will change" (Venture Beat, 18 February 2018) < https://venturebeat.com/2018/02/18/as-smart-contracts-get-smarter-the-rules-of-development-will-change/> accessed on 13 April 2019

[68] Chirag Bhardwaj, "Blockchain Technology Trends in 2019 and Beyond" (Appinventiv, 22 May 2019) <https://appinventiv.com/blog/top-blockchain-technology-trends/> accessed 22 May 2019

2.5 Why Ricardian contract is need of the hour?

> *Blockchain will be to transactions, what the internet was to communication – what started as a tool for sharing information will transform industries, once its adoption is widespread.*[69]

Currently Smart Contracts can function in the below spectrums:

- The contract can be written entirely in code.
- The contract can be entirely be in code with a separate natural language version (human readable)
- Split model i.e. a contract divided into parts wherein the code incorporates by reference the terms master agreement drafted in natural language.
- A natural language contract with a part of encoded performance e.g. the payment mechanism.[70]

Smart contracts seem to provide enormous potential benefits in future in terms of reducing transaction costs and increasing security, and given the technology is in such a nascent stage, disputes can and will arise. Hence, there is a need to move away from a preconceived notion that usage of smart contracts will get rid of disputes completely, especially with the existing traditional legal system. Further, it can be said the intersection of contract law and code will create new areas of potential dispute.[71]Without existing precedence, dealing with these new disputes will be an uphill task.

Some of the legal issues that have been asked by legal scholars for a long time now include:

- Whether smart contracts are legally binding?
- What is the resolution if the smart contract suffers from coding errors?
- If the split model of contract in code and natural language master agreement is in place, what happens if there are discrepancies in both the versions?
- How will smart contracts deal with subsequent changes of law or regulation that may make performance of the Smart Contract illegal?

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[69] Chris Chelvan, "New blockchain-based smart legal contracts for Australian businesses" (CSIRO) <https://www.csiro.au/en/News/News-releases/2018/New-blockchain-based-smart-legal-contracts> accessed 12 May 2019

[70] "Arbitrating Smart Contract disputes" (Norton Rose Fulbright, October 2018) <https://www.nortonrosefulbright.com/en/knowledge/publications/ea958758/arbitrating-smart-contract-disputes> accessed 12 May 2019

[71] "Arbitrating Smart Contract disputes" (Norton Rose Fulbright, October 2018) <https://www.nortonrosefulbright.com/en/knowledge/publications/ea958758/arbitrating-smart-contract-disputes> accessed 12 May 2019

- How to resolve issues arising with performance of Smart Contracts based on an inaccurate data feed.[72]

One major challenge surrounding smart contract enforcement is, what is the result when the performance of smart contract is tied to a subjective standard. Just like vending machine relies on mathematical calculations to check if you have inserted enough money, a smart contract's code relies on deterministic and precise logic to execute its instructions. Unlike, commercial contracts which uses language such as "reasonable" or "best endeavors" to provide flexibility. In presence of these subjective standards it is difficult to translate the same into code or reduce it into a formula. Due to lack of this flexibility which is desirable to parties in a contractual relationship, it is very less likely that smart contracts will replace traditional contracts.[73] Therefore, a new spectrum that exists beyond the above is required in order to deal with legal issues that arise because, for now the society does not exist in a system where "*code is law"*.[74]

CHAPTER 3

SALIENT FEATURES OF RICARDIAN CONTRACT

Contracts are slowly starting to communicate in a very non-traditional way unlike before to new audiences and new areas. The earlier concept of contracts with its elements and strict conditions is no longer untouched due to changing contexts in which contracts are used. There is a paradigm shift now from traditional contracts which was based more on text to be read, now to more visualized contracts, i.e. contracts with embedded images seeking to supplement text and enhance contract readability and usability, which was not the case when contracts were initially introduced to businesses. The way contracts could be generated in near future might be though prose objects[75] and guided interviews, be it in the form of a text-only contract, visualized contract, smart or intelligent contracts, or hybrids of these.[76]

Creation of a hybrid form of contract which is readable by both machines and humans is the answer, to releasing the true potential of smart contract. Only after this gap is bridged, it might lead to more widespread adoption and usage of smart contracts.

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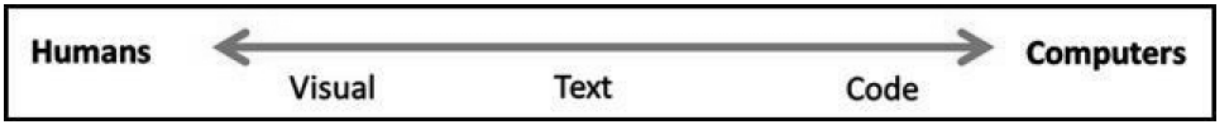
[72] "Arbitrating Smart Contract disputes" (Norton Rose Fulbright, October 2018) <https://www.nortonrosefulbright.com/en/knowledge/publications/ea958758/arbitrating-smart-contract-disputes> accessed 12 May 2019

[73]Taylor Vinters, "Smart contracts: a boon or bane for the legal profession?" (Lexology, September 2018) <https://www.lexology.com/library/detail.aspx?g=f16551a7-e974-41d2-ba45-37e2dc7f6e41> accessed 12 May2019

[74] Taylor Vinters, "Smart contracts: a boon or bane for the legal profession?" (Lexology, September 2018) <https://www.lexology.com/library/detail.aspx?g=f16551a7-e974-41d2-ba45-37e2dc7f6e41> accessed 12 May2019

[75] Prose Objects – This term was coined from Ian Grigg's paper on "Ricardian contracts" *See,* Ian Grigg, "The Ricardian contract" (1996) <http://iang.org/papers/ricardian_contract.html> accessed 2 April 2019

[76] James Hazard, Helena Haapio "Wise Contracts: Smart Contracts That Work for People And Machines" (2017) Pg. 5 <https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2925871> accessed 20 May 2019



Source- Ease of Human/Computer Readability: Visual-Text-Code Continuum[77]

The above image shows us how contracts appear along the range of the ease (or difficulty) of human/ machine readability. Ricardian contracts can provide for graphical user interface to text-only contracts as well as to smart and other code-based contracts, thereby helping the preparation of truly human-readable contracts.[78] The Ricardian contract model is for the purpose of digitally traded assets, described as *"contract between an issuer and a holder"*. Wherein each participant in this system of trading have their own set of trading rules, represented by any type of value. The main components consist of legal text, parameters, and a signature chain which is digitally signed by the issuer.[79]

The transaction in this system includes the hash of the contract which was issued and the asset transferred which was used to secure claims as well as prevent changes in the contract claims.[80] A Ricardian contract stores contract details in a machine and human readable format is a huge solution to the long ongoing debate of enforceability of smart contracts and also fills the gap between legislation and computers via cryptography.[81] This thesis will further discuss the above in the following chapter, but first step is analyzing the definition of Ricardian contracts.

3.1 Defining "Ricardian contracts"

[77] Helena Haapio, Daniela Plewe, Robert deRooy, "Contract Continuum: From Text to Images, Comics, and Code" (2017). In Erich Schweighofer et al. (Eds.), Trends and Communities of Legal Informatics. Proceedings of the 20th International Legal Informatics Symposium IRIS 2017. Österreichische Computer Gesellschaft, Wien 2017, Pg. 415 (ISBN 978-3-903035-15-7) <http://dx.doi.org/10.2139/ssrn.2928604> accessed on 20 May 2019

[78] James Hazard, Helena Haapio "Wise Contracts: Smart Contracts That Work for People And Machines" (2017) Pg. 5 <https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2925871> accessed 20 May 2019

[79] Emanuel Regnath, Sebastian Steinhorst, "SmaCoNat: Smart Contracts in Natural Language" (2018) 3, <https://www.researchgate.net/publication/328815776_SmaCoNat_Smart_Contracts_in_Natural_Language> accessed on 22 May 2019

[80] Emanuel Regnath, Sebastian Steinhorst, "SmaCoNat: Smart Contracts in Natural Language" (2018) 3, <https://www.researchgate.net/publication/328815776_SmaCoNat_Smart_Contracts_in_Natural_Language> accessed on 22 May 2019

[81] Dalmas Ngetich, "Ricardian Contracts: Why Integration will Phase out Vulnerable Smart Contracts" (New Economy, 11 January 2019) <https://newconomy.media/news/ricardian-contracts-why-integration-will-phase-out-vulnerable-smart-contracts/> accessed 22 May 2019

Ricardian contract was first introduced by Ian Grigg[82] in 1995.

Grigg defined it as "*a single document that is a) a contract offered by an issuer to holders, b) for a valuable right held by holders, and managed by the issuer, c) easily readable by people (like a contract on paper), d) readable by programs (parsable like a database), e) digitally signed, f) carries the keys and server information, and g) allied with a unique and secure identifier*."[83]

Ricardian contract was originally introduced as a part of the Ricardo payment system. Ian Grigg, who is a finical cryptographer and the man behind this new type of legal document, is also considered as one of the pioneers of financial cryptography. He developed this new concept to digitize a legal contract or any financial instrument or asset.[84]

As discussed earlier, smart contracts are also machine-readable contract, or set of instructions that control and direct the upcoming actions and events. Smart contracts act as contracts to provide trust during an exchange in blockchain process. These contracts can be used to exchange money, shares, property, and other assets on the internet. And the obligations between two parties can be defined and executed through computer code.[85] In order to tackle the issue of the obligations being in code, Ricardian contract can be used.

Ricardian contract can also be described as a document which defines a type of value for issuance over the internet. It identifies the issuer, being the signatory, and any terms and clauses the issuer finds necessary to be added, can be inserted in the document, to make this a strong contract. The Ricardian contract which has to be both machine and human readable, is formatted as a text file. This file provides convenience to reader as the same can be easily read, whether displayed or printed. The programs can also be converted into internal forms for the purpose of searching, name-value pairs. This can include a different section for each type of contract, such as bond, share, currency, etc. [86]

Further sections included can describe, in program-parsable terms, usage of decimal points, titles, and symbols.[87] This can be illustrated by the following image as below:

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[82] Ian Grigg, "Pioneer in Financial Cryptography and Inventor of the Ricardian contract. A renowned financial cryptographer who has been active in this space since 1995, Ian is inventor of both Ricardian contracts and triple-entry accounting" <https://eosalliance.io/ian-grigg/> accessed 12 May 2019

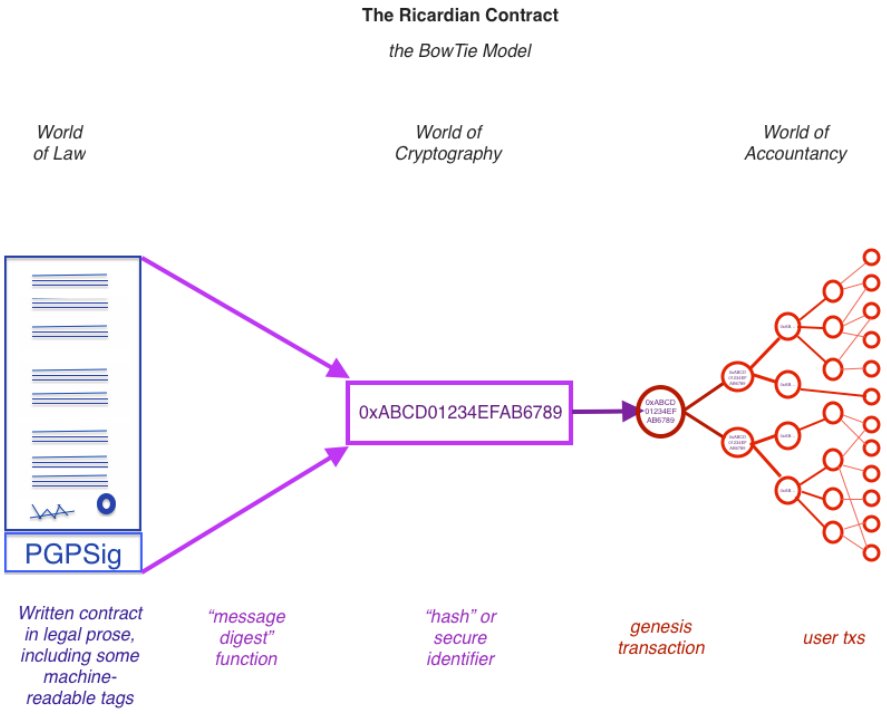
[83] Ian Grigg, "The Ricardian contract" (1996) <http://iang.org/papers/ricardian_contract.html> accessed 2 April 2019

[84] Alam, Iftikhar, "What are Ricardian contracts? A Complete Guide" (101 Blockchains, 28 December 2018) <https://101blockchains.com/ricardian-contracts/> accessed 16 April 2019

[85] Alam, Iftikhar, "What are Ricardian contracts? A Complete Guide" (101 **Blockchains**, 28 December 2018) <https://101blockchains.com/ricardian-contracts/> accessed 16 April 2019

[86] Ian Grigg, "Guide to Ricardian contracts" (WebFunds Project) <http://www.webfunds.org/guide/ricardian.html> accessed 12 May 2019

[87] Ian Grigg, "Guide to Ricardian contracts" (WebFunds Project) <http://www.webfunds.org/guide/ricardian.html> accessed 12 May 2019



Source – Ian Grigg, Ricardian contract[88]

Breaking down the components of Ricardian contract, it consists of three essential parts which ensure that the contract is fully automated and legally enforceable, i.e. *parameters*, *code and prose*.[89] The element of parameters consists of the factors that are specific to the contract, for example, it can be deal points like prices, dates, timelines, quantities, currency etc. A deal point is a fluid notion since any part of a contract can become a perilous negotiation issue in any particular transaction. But the point is that any aspect of a contract can fit into at least one of these three categories of conditions mentioned. Smart contracts fulfil the role of the code part and hence the guiding force behind the strong movement development of platforms such as Hyperledger, Corda, and Ethereum.[90] The smart contract template in Ricardian contract model will therefore combine two separate parts, the legal contract prose part and the executable smart contract code part. The legal prose which is written in natural language includes parsable parameters. These parameters are used as configuration for a standardized, fixed executable code, whose behavior is only

[88] Ian Grigg, "Guide to Ricardian contracts" (WebFunds Project) <http://www.webfunds.org/guide/ricardian.html> accessed 12 May 2019

[89] James Hazard, Helena Haapio "Wise Contracts: Smart Contracts That Work for People And Machines" (2017) Pg. 5 <https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2925871> accessed 20 May 2019

[90] James Hazard, Helena Haapio "Wise Contracts: Smart Contracts That Work for People And Machines" (2017) Pg. 5 <https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2925871> accessed 20 May 2019

controlled as per the given parameters.[91] The machine-readable contract layer can express the entire agreement in computer code, but the whole agreement will not have the same level of machine functionality. The machine-readable layer is also where the modularized nature of contract building can be most readily seen and understood.[92]

3.2 The "Machine - Readable Contract Layer"

The crucial elements of a blockchain layer includes network, transaction, blockchain, trust, application and security layer. All the elements of this layer are equally important, but the application layer is most crucial as this layer which contains the smart contract.[93] This is also the layer where the machine-readable contract layer can be inserted.

There are five broad requirements for smart contract templates:

1. Editing: Methods to create and edit contracts, including contract prose and parameters. In a practical system of transacting, most editing will consist of order-entry, filling in parameters or overriding specific prose, this can be done in transaction system, such as electronic payment systems and web interfaces.[94]

2. Transmission: Blockchains, including Bitcoin, Ethereum, Corda and Hyperledger, all of them have attracted attention and development efforts for their fraud-reduction aspects. Current systems of payment also provide secure pathways for transmission of parameters and other key/values.[95]

3. Stamping: these are the protocols for legal execution of smart legal agreements which can be with or without signatures. Signature can be done by conservative methods, including by signing a full text or even a hash of the full text. It is, however, much more efficient and reliable to use the cryptographically assured methods of Blockchains and payment systems. In such circumstance, prose objects rely on the code platform for signature.[96]

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[91] Emanuel Regnath, Sebastian Steinhorst, "SmaCoNat: Smart Contracts in Natural Language" (2018) 3, <https://www.researchgate.net/publication/328815776_SmaCoNat_Smart_Contracts_in_Natural_Language> accessed on 22 May 2019

[92] Thomas D. Barton, Helena Haapio, Stefania Passera, James G. Hazard, "Successful Contracts: Integrating Design and Technology", (2019) 63 < https://link.springer.com/chapter/10.1007/978-981-13-6086-2_3, 72> accessed 22 May 2019

[93] Ioannis Karamitsos, Maria Papadaki, Nedaa Baker Al Barghuthi, "Design of the Blockchain Smart Contract: A Use Case for Real Estate" (717) (2018) JIS <https://www.scirp.org/journal/PaperInformation.aspx?PaperID=85741> accessed on 22 May 2019

[94] James Hazard, Helena Haapio "Wise Contracts: Smart Contracts That Work for People And Machines" (2017) Pg. 5 <https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2925871> accessed 20 May 2019

[95] James Hazard, Helena Haapio "Wise Contracts: Smart Contracts That Work for People And Machines" (2017) Pg. 5 <https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2925871> accessed 20 May 2019

[96] James Hazard, Helena Haapio "Wise Contracts: Smart Contracts That Work for People And Machines" (2017) Pg. 5 <https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2925871> accessed 20 May 2019

4. Binding: Methods to bind the parameters or deal points of a contract and its corresponding smart contract code to create a smart legal contract, i.e., a legally enforceable smart contract.[97]

5. Enforceability: Methods to make smart legal contracts available in forms acceptable according to laws and regulations in the appropriate jurisdiction. [98]

Keeping the above requirements in mind, Ricardian contracts can provide us with a contract layer in smart contract templates. This contract layer will rely on a three-layer design: First, there are simple, recognizable icons that can be clicked on to reveal a plain language version of the relevant text. If additional information is required, the full text is available. The structure includes the so-called legal code layer, the version which can be read by lawyers and lastly, then a machine-readable version, i.e. the key terms inserted into a format which the software systems, search engines, and other kinds of technology can understand.[99]

So, if there exists a legal agreement between parties in question, the same can be programmed as a Ricardian contract. In case there is any additional instructions regarding execution of the event in question, that can also be part of Ricardian contract too. Some of the essential elements that maybe included could be in form of IFFT clauses, i.e. parties involved in the transactions, validity of the contract, addition of exceptions and limitations etc. [100]As seen in the image below, the Ricardian contract contains natural language which is human readable. So, bringing together the Ricardian triple model of parameters, prose and code,[101]Taking the example live contracts, they can be changed after the execution of an event. For example, taking into considering a sale of car between two parties, one clause can be about contacting an authority that can confirm if the seller is the actual owner of the vehicle. Using, IFFT function, if such information is updated, you can add it to the Ricardian contract, making a new version of the contract. This way the Ricardian contract can execute different events and will move towards a logical conclusion based on the outcome of each event.[102]

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[97] James Hazard, Helena Haapio "Wise Contracts: Smart Contracts That Work for People And Machines" (2017) Pg. 5 <https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2925871> accessed 20 May 2019

[98] James Hazard, Helena Haapio "Wise Contracts: Smart Contracts That Work for People And Machines" (2017) Pg. 5 <https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2925871> accessed 20 May 2019

[99] About The Licenses – Creative Commons <http://creativecommons.org/licenses> accessed on 22 May 2019

[100]Alam, Iftikhar, "What are Ricardian contracts? A Complete Guide" (101 Blockchains, 28 December 2018) <https://101blockchains.com/ricardian-contracts/> accessed 16 April 2019

[101] In a nutshell: Ian Grigg's Ricardian contracts and digital assets prehistory (Bit on blocks, 22 November 2016), <https://bitsonblocks.net/2016/11/22/in-a-nutshell-ian-griggs-ricardian-contracts-and-digital-assets-prehistory/> accessed on 22 May 2019

[102] Alam, Iftikhar, "What are Ricardian contracts? A Complete Guide" (101 Blockchains, 28 December 2018) <https://101blockchains.com/ricardian-contracts/> accessed 16 April 2019

Source- Commonaccord.org[103]

Solving the issue of legal enforceability of smart contracts, Ricardian contract can be used as a binding legal agreement. As a result of which, this can be used in courts by parties to bind each other for the obligations agreed to in the Ricardian contract. Lawyers can draft such terms and conditions which both parties understand and are in consensus with and sign the document. Then theses terms and conditions can be further converted to hash functionality, which can in turn be used by software on the blockchain platforms such as R3 Corda[104], which is actively pushing for usage of Ricardian contract.[105]

Some other additional benefits of Ricardian contracts include the feature that they are secure in nature as they use hidden signatures and signing of the contracts takes place through private keys. Later, the hash of the agreement is used to attach that hidden signature to the contract. Ricardian contracts also offer protection to parties in an agreement who do not have equal bargaining power from a party with upper hand who is more susceptible to changing the terms in the agreement during the execution unilaterally. Hence, once the agreement is finalized the same cannot be modified unilaterally making it extremely secure.[106] Further, when the signature of the issuer is

[103] Jurij Lampic, "Ricardian contracts: A smarter way to do smart contracts?" (Schönherr, 2019) <https://www.schoenherr.eu/publications/publication-detail/ricardian-contracts-a-smarter-way-to-do-smart-contracts/> accessed 12 May 2019

[104] <https://www.r3.com/corda-platform/> accessed 12 May 2019

[105] Alam, Iftikhar, "What are Ricardian contracts? A Complete Guide" (101 Blockchains, 28 December 2018) <https://101blockchains.com/ricardian-contracts/> accessed 16 April 2019

[106] Marc-Olivier Archambault, "Introduction to Ricardian Contracts" (EOS Canada, 18 May 2018) <https://www.eoscanada.com/en/introduction-to-ricardian-contracts> accessed 22 May 2019

added to the contract, it creates a legible and binding agreement about the information described in the document. This also makes it possible to track the parties involved with the help of the private key and hold them accountable.[107]

Hence, summarizing, the characteristics of Ricardian contract can be seen below.

3.3 Characteristics of Ricardian contract

The characteristics for a Ricardian contract can be listed as below[108]:

1. Human parsable;
2. Printable document;
3. Program is parsable;
4. All versions i.e. displayed, printed, parsed are manifestly equivalent;
5. Signature of the Issuer;
6. All relevant information is present in one single document, including signature and parties. This, along with the *manifestly equivalent* characteristic above, results into the *Rule of One Contract*;
7. It can be represented as a legal contract;
8. It can be identified securely, wherein the securely means any attempt to distort the linkage between a reference and the contract is not feasible;
9. It is supported by financially capable PKI (such as OpenPGP[109]);
10. Extensible – It can interpret bonds, shares, loyalty, etc.;
11. It can identify legal issuer (signer of contract) and issuance server;
12. Cannot be changed by anyone except legal issuer or other parties of the contract;
13. Verifiable in nature;

[107] Alam, Iftikhar, "What are Ricardian contracts? A Complete Guide" (101 Blockchains, 28 December 2018) <https://101blockchains.com/ricardian-contracts/> accessed 16 April 2019

[108] Ian Grigg, "Guide to Ricardian contracts" (WebFunds Project) <http://www.webfunds.org/guide/ricardian.html> accessed 12 May 2019

[109] OpenPGP - OpenPGP is the most widely used email encryption standard. It is defined by the OpenPGP Working Group of the Internet Engineering Task Force (IETF) as a Proposed Standard in RFC 4880. OpenPGP was originally derived from the PGP software, created by Phil Zimmermann, < https://www.openpgp.org/ > accessed 12 May 2019

14. Permissionless – The contract can be created and used by anyone without requiring allocations in controlled spaces.[110]

Having analyzed the elements of Ricardian contracts now the next step is to make a comparative analysis of all the three forms of contracts to get a better perspective of where the characteristics of each format stand currently in terms of viability and advantages.

3.4 Smart Contracts Vs Ricardian contracts V Traditional Contracts: Comparison Table[111]

Characteristics	Smart Contract	Ricardian contract	Traditional Contracts
Purpose	Execute the terms of an agreement	Record the terms of an agreement as a legal document	A framework for parties to legally bind parties into performing legal obligations
Flow	Automate actions on the blockchain-based applications	It can also automate operations on the blockchain-based applications	There is no automation involved
Validity	It is not a legally binding document	It is a legally binding document or agreement	It is a legally binding in nature
Versatility	Cannot be a Ricardian contract	Any Ricardian contract can be a smart contract as well	Can be converted into Ricardian Contract for the human readable contract layer
Readability	Smart contracts are machine-readable but not necessarily human-readable	Ricardian contracts are both machine-readable as well as human readable	Only human readable

Ricardian contract will be a hybrid form of contract which will combine characteristics from both the other formats. This can be helpful in bridging the gap between traditional contracts and existing smart contracts. Using text and code, wherein the text will clearly specify the smart contract code

[110] Ian Grigg, "Guide to Ricardian contracts" (WebFunds Project) <http://www.webfunds.org/guide/ricardian.html> accessed 12 May 2019

[111] Ian Grigg, "Guide to Ricardian contracts" (WebFunds Project) <http://www.webfunds.org/guide/ricardian.html> accessed 12 May 2019

with which it is associated, and the parties should have full visibility into the variables that is passed on to the smart contract, how they are defined and how the transaction events will trigger execution of the code.[112] Once Ricardian contracts are widely adopted, its evolution could mean that soon companies will move towards smart contracts usage in larger scale. The use of smart contracts is unlikely to render the legal profession obsolete. But there is no doubt that, it will definitely change the way contracts are recorded and implemented in comparison with how it is done currently.[113] In the next chapter this thesis looks into how the role of lawyers will change with changing nature of contracts. Also exploring another important hypothesis that Ricardian contract is the future of blockchain-based legal agreements.

CHAPTER 4

RICARDIAN CONTRACT - FUTURE OF BLOCKCHAIN-BASED LEGAL AGREEMENTS

4.1 Changing nature of Contracts

Mainstream contracting practices have gone towards more deeply complex ways with advent of technology. Whereas technology has evolved exponentially, the legal and contracting framework of many branches of commerce has not. The format of complex commercial contracts remains the same as it was 30 years ago, mainly formatted like a book, with long, impenetrable texts which are frequently subject to litigation in Courts.[114]

From the time the traditional contracts have been in use, they have been referred to as documents "written by lawyers for lawyers"[115], be it documenting simple transactions or complex transactions, contracts have gradually become into lengthier, inaccessible prose dominated by the goal of ensuring certainty and saving parties from losing in courts.[116] At the end, legal ideas and natural

[112] Stuart D. Levi, Alex B. Lipton, Arps Skadden, "An Introduction to Smart Contracts and Their Potential and Inherent Limitations" (Harvard Law School Forum on Corporate Governance and Financial Regulation, 26 May 2018) < https://corpgov.law.harvard.edu/2018/05/26/an-introduction-to-smart-contracts-and-their-potential-and-inherent-limitations/> accessed 22 May 2019

[113] Sarah Rothie, "How Ricardian Smart Contracts Enable Blockchain Adoption" (Coin Central, 30 August 2018) <https://btc-investor.net/ricardian-smart-contracts/> accessed 14 April 2019

[114] Rory Unsworth, "Smart Contract This! An Assessment of the Contractual Landscape and the Herculean Challenges it Currently Presents for "Self-executing" Contracts" (2019) 10 < https://doi.org/10.1007/978-981-13-6086-2_2> accessed 22 May 2019

[115] Helena Haapio, Thomas D. Barton, "Business-Friendly Contracting: How Simplification and Visualization Can Help Bring It to Practice", *In*: Jacob, Kai/Schindler, Dierk/Strathausen, Roger (Eds.), "Liquid Legal – Transforming Legal into a Business Savvy, Information Enabled and Performance Driven Industry" (Springer International Publishing, 2017) 371– 396 < https://doi-org.tilburguniversity.idm.oclc.org/10.1007/978-3-319-45868-7_24> accessed 22 May 2019

[116] Thomas D. Barton, Gerlinde Berger-Walliser, Helena Haapio, "Visualization: Seeing Contracts for What They Are, and What They Could Become" [2013] 19 JOURNAL OF LAW, BUSINESS & ETHICS 47

language has ended up dominating the implementation of contracts, resulting into less friendly, maybe even less useful documents, that diverted attention from the ongoing planning, implementation, and governance aspects of the transactions. With respect to users of commercial contracts, there is hardly any interest of readers to read these lengthy complicated documents filled with legal jargons, and even less understand them adequately. As mentioned before, the main aim of the contracts is now solely based on avoiding legal liability rather than providing guidance toward performing contractual responsibilities as the system remains complex and prone to litigations in courts.[117]

This classical concept of contracts is changing and expanding faster than it can be processed by companies, regulators, stakeholders, With multiple smart contract platforms coming out with their various models to move towards decentralized systems. The arrival of new technologies presents us with important questions and challenges about the future of contracting, as well as about traditional legal practice within both legal departments and law firms, calling for a new quality of co-operation between business and their lawyers[118] and as well as new roles played by coders with businesses looking to incorporate smart contracts into their business operations.

Some changes that have occurred in the traditional contracting includes,

1. "Documents" have been transfigured into modules of information that can be aggregated and retrieved by individual user query;
2. "Written" is being supplemented by visualization, hyperlinks, and most importantly well as computer code;
3. "By lawyers" is becoming a group of builders that include users, information designers, and coders; and
4. "For lawyers" have become a broad set of potential users, both humans and machines, each of which interfaces differently with the agreement across its lifecycle.[119]

4.2 Future of hybrid models like Ricardian contracts

The future of legal agreements being envisioned currently is a future where agreements such as contractual relationships are recorded and automatically managed without error, where anybody can transact seamlessly for any contractual purpose without friction. As more and more business

[117] Thomas D. Barton, Gerlinde Berger-Walliser, Helena Haapio, "Visualization: Seeing Contracts for What They Are, and What They Could Become" [2013] 19 JOURNAL OF LAW, BUSINESS & ETHICS 47

[118] Rory Unsworth, "Smart Contract This! An Assessment of the Contractual Landscape and the Herculean Challenges it Currently Presents for "Self-executing" Contracts" (2019) 10 < https://doi.org/10.1007/978-981-13-6086-2_2> accessed 22 May 2019

[119] Thomas D. Barton, Helena Haapio, Stefania Passera, James G. Hazard, "Successful Contracts: Integrating Design and Technology", (2019) 63 < https://link.springer.com/chapter/10.1007/978-981-13-6086-2_3, 72> accessed 22 May 2019

move towards models where parties to contracts collaborate to maintain accurate, shared records rather than maintaining their own independent and inconsistent systems which require extensive reconciliation processes to ensure consistency,[120] the role played by Ricardian contracts, which is also being referred to as "*Blockchain's Killer Application*"[121] will be crucial.

Using simpler models like the Ricardian contract, it will be easier and convenient to solve so numerous problems including, reducing transaction costs, preventing disputes by making the system decentralized and cutting the middleman, and help hence achieve business goals. Ricardian contracts approach automation of contract from a different perspective, a perspective which will potentially benefit issuers of financial instruments, parties to derivatives and banks, which will eventually transform the way law is practiced. The reason why Ricardian contracts might be the real killer application for blockchain is because there are enormous advantages of making contracts both machine readable and human readable, i.e. financially, organizationally, and relationally.[122]

Understanding these potential gains requires a clear evident efficiency gain and genuine personnel engagement with the tools that make such gains possible. The examples of the same are not difficult to imagine, for example, activities such as payments, could be self-executing like that of a smart contract, upon software-verified satisfaction of specified contractual conditions. These self-executing provisions offer obvious and dramatic efficiency gains, but more modest code can enhance a broad range of human activity.[123]

Coded provisions can supply a wealth of immediately available, flexibly configurable information to assist in human problem solving. Virtually any parameter embedded within contract coding can be automatically updated and rendered into human-readable for real-world events that currently unfold. As the use of IoT and sensors grow at exponential levels, for example, the loading, transport, and delivery of goods can be tracked automatically, making it huge impact on the supply chain management industry.[124] Real life potential problems which occur in live environment, can be flagged promptly, at the same time managers can also be alerted to a risk, and fallback options made immediately visible before even the risk escalates. The coding may even prevent the problem from arising at the first place. Text instructions for implementing various tasks under an agreement

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[120] Richard Gendal Brown, "The Corda Platform: An Introduction" (Corda, 2018) <https://www.corda.net/content/corda-platform-whitepaper.pdf> accessed 19 May 2019

[121] Mark van Rijmenam, "Why Ricardian contracts, not Smart Contracts, are Blockchain's Killer Application" (Medium, 13 May 2019) <https://vanrijmenam.nl/ricardian-contracts-blockchain-killer-application/, accessed 20 May 2019

[122] Thomas D. Barton, Helena Haapio, Stefania Passera, James G. Hazard, "Successful Contracts: Integrating Design and Technology", (2019) 63 < https://link.springer.com/chapter/10.1007/978-981-13-6086-2_3, 72> accessed 22 May 2019

[123] Thomas D. Barton, Helena Haapio, Stefania Passera, James G. Hazard, "Successful Contracts: Integrating Design and Technology", (2019) 63 < https://link.springer.com/chapter/10.1007/978-981-13-6086-2_3, 72> accessed 22 May 2019

[124] Freddie Roberts, "Delivering the goods: 8 examples of IoT transforming supply chain" (Internet of Business, 14 November 2016) <https://internetofbusiness.com/8-real-life-examples-iot-supply-chain/> accessed 22 May 2019

can be sent automatically at the appropriate time, to the appropriate person, within an organization. Once coded, this enhanced contract implementation requires little or no additional investment of time or money. And all this can be made effective when the smart contract template is drafted by lawyers and then coded by programmers.[125]

Finally, even after their completion, coded contracts could continue to contribute. The code provides an electronic record of operations that can facilitate ongoing refinement throughout a business. Data detailing past transactions generate historical information that can be readily mined, aggregated, and analyzed in response to diverse queries throughout an organization. The other added benefit of creating machine-readable contracts is that it has another possible use that can contribute to standardization and fairness assurances currently wherein companies spend a huge amount of money for contract management tools. Once digitized, fully completed contracts may be uploaded and archived in databases. There, then these contracts may be mined analytically in various ways, generating transparent information about transacting practices and creating records for all the transactions. The easy availability of most-common practices can be helpful to ensure that contract negotiations proceed within at least conventional boundaries.[126]

Contracts play a very important role, but their implementation is not fully utilized majorly because they are seen from the perspective of the legal industry. Moving beyond the understanding of contracts solely as documents written by and for lawyers, potential roles played by designers and coders can be appreciated who now can play important role in building contracts. This can result into contract not just being a process anymore but also a product.[127]

The role of lawyer will accordingly also change, as a lawyer's involvement in smart contracts is unlikely to be limited to drafting. Once regulator start getting involved into how to regulate applications such as Ricardian contracts, these projects will need the help of legally-trained professionals to ensure that the development of the hybrid form of contracts stays within regulatory confines.[128] New blockchain based protocols such as OpenLaw[129]are already seeking lawyer's assistance in the negotiation and execution of legal agreements, as well as the integration of smart contracts to automate certain aspects of the written contract. In this platform, a user only needs to

[125] Jenny Harrison, "How IoT in Logistics Revolutionizes the Supply Chain Management" (Transmetrics) <https://transmetrics.eu/blog/iot-logistics-revolutionizes-supply-chain-management/> accessed 22 May 2019

[126] Thomas D. Barton, Helena Haapio, Stefania Passera, James G. Hazard, "Successful Contracts: Integrating Design and Technology", (2019) 63 < https://link.springer.com/chapter/10.1007/978-981-13-6086-2_3, 72> accessed 22 May 2019

[127] Stefania Passera, Helena Haapio "Transforming Contracts from Legal Rules to User centered Communication Tools: a Human-Information Interaction Challenge" (Communication Design Quarterly, April 2013) 2 <https://stefaniapassera.com/wp-content/uploads/2016/08/2013_communication-designquarterly_passera_haapio.pdf> accessed 12 May 2019

[128] Taylor Vinters, "Smart contracts: a boon or bane for the legal profession?" (Lexology, September 2018) <https://www.lexology.com/library/detail.aspx?g=f16551a7-e974-41d2-ba45-37e2dc7f6e41> accessed 12 May2019

[129] "Introducing OpenLaw" (Medium, 25 July 2017) < https://media.consensys.net/introducing-openlaw-7a2ea410138b> accessed 20 May 2019

fill in a standard form to generate a smart contract that is incorporated into the written agreement. In future, smart contracts ability to create immutable records on the blockchain may also be used to assist notaries in proving provenance and authenticity of documents. Across various commercial firms, the combination of smart contracts and blockchain technology may be used to provide a secure and effective platform for storage and accessibility of information purpose. Hence, legal process such as document discovery can be streamlined to make the system more efficient.[130]

CHAPTER 5

EXISTING MODELS OF RICARDIAN CONTRACT

5.1 Current usage of Ricardian contract

As observed throughout the discussion of this thesis, businesses are slowly leaning towards the next step of evolution of smart contracts, i.e. Ricardian contracts. Recently, some blockchain based technologies have started supporting Ricardian contracts, like Block. One[131] which is one of such open source software publishing firm which has recently come out with its Ricardian contract for EOS[132]. The new EOS Ricardian contract and the introduction of a new type of digital agreement raised many eyebrows as well as interest in this topic[133] and a discussion ensued on how Ricardian contracts can help with legal enforceability of smart contracts.

Ricardian contracts are also being used in different forms by some projects including the decentralized marketplace OpenBazaar[134] and the R3 Corda system[135]. However, some companies are developing the concept further. For example, SciDex [136] is building a blockchain-based protocol called the Ricardian Adaptive Smart Contract protocol, i.e. RASC. The Ricardian element will provide for a legible contract document, which can be audited by humans. The adaptive element of the protocol will be that the contract in question can be changed as per changing circumstance. As a result, amendments or rewrites can be incorporated to newly agreed terms as a response to emerging or unpredictable situations. And lastly, the smart contract mechanism will provide automation of the agreement. This protocol can be of great help in industries such as trading to ensure compliance with the requirement for legal documentation to support the transaction. The system also allows for input from oracles nodes which can verify real-life

[130]Gary Tse, "Smart contracts: a boon or bane for the legal profession?" <https://www.taylorvinters.com/article/smart-contracts-a-boon-or-bane-for-the-legal-profession> (Taylor Vinter, 24 September 2018) accessed 20 May 2019

[131] <https://block.one/>

[132] Omar Faridi, "Block.one releases Ricardian contracts for EOS" (CryptoInsider) <https://cryptoinsider.com/block-one-releases-ricardian-contracts-for-eos-dapp/> accessed 16 April 2019

[133] Alam, Iftikhar, "What are Ricardian contracts? A Complete Guide" (101 Blockchains, 28 December 2018) <https://101blockchains.com/ricardian-contracts/> accessed 16 April 2019

[134] <https://openbazaar.org/>

[135] <https://www.r3.com/corda-platform/>

[136] <https://www.scidex.co/>

occurrences that influence the execution of the agreement. [137]One such example of usage of this protocol is in the SciDex Marketspace, which is a decentralized exchange for scientific data. Users in this marketspace can access a collection of scientific data, as well as monetize their own contributions. For example, in this marketspace, companies can access meteorological and soil quality data available on the platform and can also put out a call to action, asking for contributors to provide data that may be available to them. The transactions involving data exchange are governed by RASC protocols which represent the real-life agreements agreed between the parties over the use of the data.[138]

Another such project which applies the principle of Ricardian Contract is BOSCoin[139]. BOSCoin implements what it calls "*trust contracts*". These are contracts are designed in such a way that it can be read and used by both humans and machines. They are developed using a language that is intentionally engineered not to be Turing-complete.[140] Turing-complete programming brings in an enormous amount of flexibility for the purpose of developing algorithms. But on the downside, at times it can lead to unintended consequences like that of the notorious hack of the DAO[141].

Another company, Kadena[142] has developed a smart contract programming language, Pact. Pact code is readable by humans and can be written directly onto a blockchain.[143] Hence as It is executed directly on the ledger and is stored in a human-readable format as an immutable transaction Pact smart contracts can be openly verified by anyone.[144]

5.2 Moving towards Decentralized online marketspace

Blockchain has stormed the business world and is claiming its stake in one industry after another. One such industry where there are a lot of opportunities for blockchain to replace the old centralized system is the world of e-commerce or online marketplace. This decentralized system

[137] Reuben Jackson, "Filling in the Missing Piece of Smart Contracts" (Nasdaq, 15 August 2018) <https://www.nasdaq.com/article/filling-in-the-missing-piece-of-smart-contracts-cm1007966> accessed 23 May 2019

[138] Reuben Jackson, "Filling in the Missing Piece of Smart Contracts" (Nasdaq, 15 August 2018) <https://www.nasdaq.com/article/filling-in-the-missing-piece-of-smart-contracts-cm1007966> accessed 23 May 2019

[139] <https://boscoin.io/>

[140] "How Ricardian Smart Contracts Enable Blockchain Adoption" (BTC Investor, 30 August 2018) <https://btc-investor.net/ricardian-smart-contracts/> accessed 14 April 2019

[141] Osman Gazi Güçlütürk, "The DAO Hack Explained: Unfortunate Take-off of Smart Contracts" (Medium, 1 August 2018) < https://medium.com/@ogucluturk/the-dao-hack-explained-unfortunate-take-off-of-smart-contracts-2bd8c8db3562> accessed on 25 May 2019

[142] <https://kadena.io/en/>

[143] How Ricardian Smart Contracts Enable Blockchain Adoption" (BTC Investor, 30 August 2018) <https://btc-investor.net/ricardian-smart-contracts/> accessed 14 April 2019

[144] Vivienne Chen, "Safer, Smarter Contracts with Pact" (Medium, 20 February 2019) <https://medium.com/kadena-io/safer-smarter-contracts-with-pact-e86b9ccaca9f> accessed 23 May 2019

of blockchain has the potential of producing a new kind of business which will revolutionize majority of industries. This technology helps to create a new business model which is built on technology, rather than people or top management. There is not a certain individual who receives profits of its own, nor does anyone make any decisions based on emotion or self-preservation which is crucial for sectors such as recruitment.[145] The prospect of blockchain completely revolutionizing the centralized marketplace to a completely decentralized system is not far from reality especially with companies like OpenBazaar[146] in picture. E-commerce giant Amazon[147] is already in a battle with IBM and Oracle with its own *"blockchain-as-a-service"* offering.[148] In this chapter this thesis will make a comparison between the decentralized model of OpenBazaar and Amazon, to analyze how Ricardian contract models can bring more efficiency, manage risks and minimize disputes[149] compared to centralized system such as Amazon.

Let's start the comparison by looking at the image below which describes the current status vs. how blockchain will change the system of online marketplace in future.

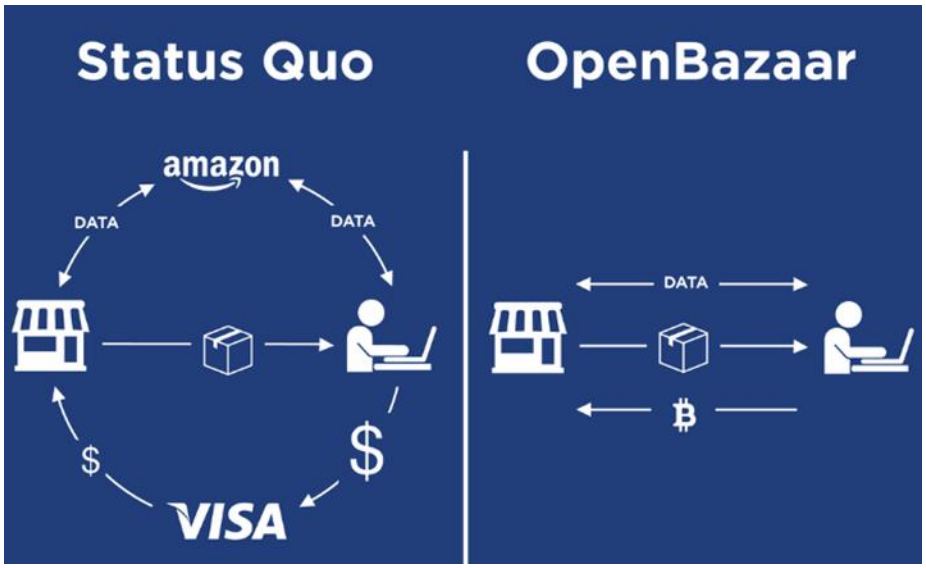

Image Source - OpenBazaar[150]

[145] Anton Cherkasov, "Centralized Giants Move To the Decentralization—Here Is Why" (Hackernoon, 15 May 2018) < https://hackernoon.com/centralized-giants-move-to-the-decentralization-here-is-why-a8c35ce1cbf9> accessed 13 May 2019

[146] <https://openbazaar.org/>

[147] <https://www.amazon.com/>

[148] Darryn Pollock, "Amazon & Microsoft's Move to Blockchain: Centralized Companies Into Decentralized Ecosystem", (Coin telegraph, 12 May 2018) < https://cointelegraph.com/news/amazon-microsofts-move-to-blockchain-centralized-companies-into-decentralized-ecosystem> accessed on 22 May 2019

[149] "Ricardian contracts in OpenBazaar" (GitHub) <https://gist.github.com/drwasho/a5380544c170bdbbbad8> accessed 22 May 2019

[150] "What is OpenBazaar" (OpenBazaar, 2018) < https://openbazaar.zendesk.com/hc/en-us/articles/208020193-What-is-OpenBazaar-> accessed 13 May 2019

5.3 OpenBazaar

OpenBazaar is a project which is not essentially new anymore as it has been in the picture 3 years now. It is basically open source project which created a decentralized network for peer to peer commerce (P2P) online using cryptocurrency. This platform does not have any fees or restrictions. In other words, Openbazaar[151] is an open source marketplace. As per the description provided by CB Insights[152], OpenBazaar is a new way to trade online. Users can connect directly with other users by running a program on their own computer systems and take part in P2P trading.

OpenBazaar is the world's first and only fully decentralized marketplace, which means it connects people directly and securely to each other via a peer-to-peer network, rather than through a centralized website, like other online marketplace players which are ruling the e-commerce space such as Alibaba, Amazon, or eBay. There's no big company behind the scenes that can act as a gatekeeper, collect data, or restrict transactions for anyone.[153] It started as a fork of a hackathon project called Dark Market in 2014. And it quickly became an entirely different platform with a different vision for making trade free for everyone, everywhere, and not focused on the dark web. And now, it is changing the way online commerce works. By connecting its users directly to one another it requires no middlemen. And the variety of products available ranges from clothes, music, to local foods, rare items, and even short-term rentals. And all the services available comes with no transaction fees.[154]

Let's look at the functionalities OpenBazaar described on their website as below. The description provided by OpenBazaar breaks down the contract into 4 stages:

Stage 1: Listing/Vendor Offer

i. The Vendor lists what is for sale (physical item, digital content, services etc.)
ii. There are some prior steps regarding Moderator selection that won't be elaborated on in this article

Stage 2: Stage 2: Buyer Order

i. The Buyer sends an order to the Vendor
ii. The Vendor acknowledges the order, sending a digital signature that will serve as a Vendor authentication of the order (prevents attackers from making fake ratings of the Vendor)
iii. Buyer funds the multi signature escrow address

[151] <https://openbazaar.org/> accessed on 22 May 2019

[152] OpenBazaar (CB Insights) <https://www.cbinsights.com/company/openbazaar> accessed on 22 May 2019

[153] "A true P2P marketplace. No fees. No restrictions. Welcome to OpenBazaar" (Coinisseur, 20 April 2019) <https://www.coinisseur.com/a-true-p2p-marketplace-no-fees-no-restrictions-welcome-to-openbazaar/> accessed on 22 May 2019

[154] "A true P2P marketplace. No fees. No restrictions. Welcome to OpenBazaar" (Coinisseur, 20 April 2019) <https://www.coinisseur.com/a-true-p2p-marketplace-no-fees-no-restrictions-welcome-to-openbazaar/> accessed on 22 May 2019

iv. Order processing time begins: 1-3 days to ship the item

Stage 3: Vendor Order Confirmation

i. The Vendor confirms to the Buyer that the order has been processed and the item has been shipped
ii. Gives the Buyer any shipping related data, for physical goods
iii. Gives the Buyer a download address and password, for digital content
iv. Gives the Buyer any relevant data to perform the service
v. Sends partially signed transaction releasing funds from the multi signature escrow address to the Vendor (still requires Buyer to sign after receiving the item)

Stage 4: Buyer Receipt

i. Buyer acknowledges that the item, content, or service was delivered/performed
ii. Signs a transaction releasing funds from multi signature escrow
iii. Makes a rating and review of the Vendor, sends the transaction summary to the Vendor and Moderator for storage. [155]

OpenBazaar extends the utility of the Ricardian contract, which acts as act as a ledger of the transaction or trade flow between the contracting parties. The ultimate version of the Ricardian contract, which contains a completed and digitally signed record of the execution of the contract, is called a trade receipt. The functionality of trade on OpenBazaar, is whenever there is a trade on OpenBazaar, there is a Ricardian contract created to track the legitimacy of the agreement that has been signed by both parties. This brings added security that neither of the parties is getting scammed, and that in the case of fraud, an aggravated party would have legal records to plead his case in a court of law.[156]

5.3.1 Payment system of OpenBazaar

There are 3 types of payments that Open Bazaar offers, i.e. Direct payments, Moderated payments, Offline payments.

a. *Direct Payments* – In this type of payment, buyer sends coins to the vendor and both parties are online. There is only one fee paid and the buyer pays it on top of the price of the item.
b. *Moderated Payments* – In this case, buyer selects a moderator and payment goes into escrow. There are two fees paid, one is paid by the buyer when they fund the escrow and the other is taken out of the total amount in escrow when funds are released. In case there is no dispute and funds are released to the vendor, then effectively the vendor has paid the

[155] "Decentralized Reputation in OpenBazaar" (OpenBazaar, 8 October 2015), <https://openbazaar.org/blog/decentralized-reputation-in-openbazaar/> accessed 22 May 2019

[156] Marc-Olivier Archambault, "Introduction to Ricardian contracts (EOS Canada, 18 May 2018) <https://www.eoscanada.com/en/introduction-to-ricardian-contracts> accessed 22 May 2019

second fee, since they receive the total in the escrow minus the cost of the fee. 2 out of 3 parties are needed to release funds from a moderated order, hence, if 1 of the parties is unresponsive and doesn't release funds then the other party will be forced to open a dispute with the moderator. [157]

c. *Offline Payments* – In this type of payment, the vendor is offline. If a moderated payment is made by a buyer to an offline vendor, then it is the same as a regular moderated payment. But if a direct payment is made to an offline vendor, then the payment is temporarily held in an escrow account that either buyer or vendor can pull from. The order can be accepted or rejected if the vendor comes online. If they accept and fulfil the order, then they receive the payment and receive the funds minus a coin fee. If the vendor does not become online again (or they reject the offline order when they come back online), then the buyer pulls the funds back, and they receive the funds minus a coin fee. Out of the three payments, doing an offline payment means one party will be paying an extra coin fee, so it's better for the vendor to be online for orders if possible.[158]

5.4 Amazon

Often claimed to be the largest online retailer in the world, Amazon's online marketplace is completely centralized. Amazon provides a platform for retailers to sell their product and consumers buy their goods directly from Amazon's platform. Products sold through Amazon's partner retailers are often uncommon items or those with a higher purchase price, and the inventory is kept in the company's large network of warehouses.[159]

The products offered to buyers through Amazon's online storefront comes with a "*small markup".* Amazon does not charge a fee for its retailer partners to list items for sale but does retain a portion of the sales price as commission. Amazon does have various other services such as the Prime services, its own streaming service etc. Amazon is in control of all the services offered, it is involved in collecting data from user histories, it is involved in charge of the logistics being the item bought being timely delivered. Consumers mostly visit the company's site assuming its products are less expensive and readily available for purchase and shipping.[160]

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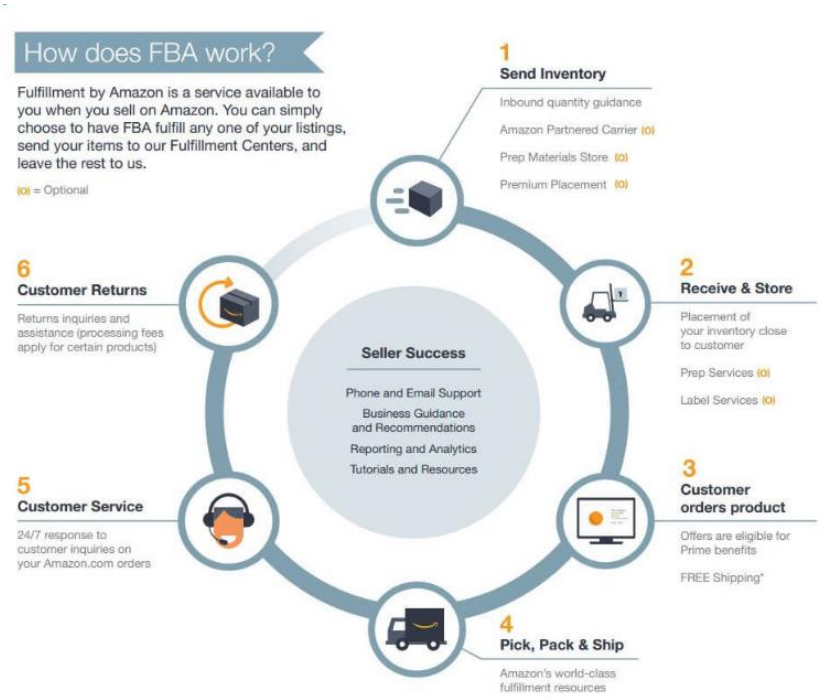
[157] "OpenBazaar Buyer Guide - What to expect in this decentralized marketplace", (OpenBaazar, 1 November 2017) <https://openbazaar.org/blog/openbazaar-buyer-guide-what-to-expect-in-this-decentralized-marketplace/> accessed 22 May 2019

[158] "OpenBazaar Buyer Guide - What to expect in this decentralized marketplace", (OpenBaazar, 1 November 2017) <https://openbazaar.org/blog/openbazaar-buyer-guide-what-to-expect-in-this-decentralized-marketplace/> accessed 22 May 2019

[159] Andrea Marchiotto, "What are the key differences between Amazon and Alibaba?" (Medium,24 November 2018) < https://medium.com/@IndianaStyle/amazon-and-alibaba-key-differences-how-to-win-part-two-2e8d3070b989> accessed 22 May 2019

[160] How does Amazon Work: A Look into Amazon Business Model and Revenue Analysis, (Verve Logic, 24 May 2019) < https://www.vervelogic.com/blog/how-does-amazon-work-a-look-into-amazon-business-model-and-revenue-analysis/> accessed 24 May 2019

The below image is the breakdown of how Amazon's centralized network functions.



Source - How the Amazon Supply Chain Strategy Works[161]

Having looked at the major functionality of both Amazon and OpenBazaar, the next step is to make a comparative analysis between the two.

5.5 OpenBazaar Vs. Amazon

Comparing OpenBazaar and Amazon, the main points of difference lies in the network created by both the models. In one hand, OpenBazaar is decentralized, the whole system functions since the user's data collection in its own computers without the data being shared with anyone else in the network or reposing trust on any other third party. It simply is a peer-to-peer (P2P) network connecting the users of the platform directly, unlike Amazon where the information is stored in the cloud of Amazon servers, users must depend on Amazon to control their orders, and transactions.[162]

Secondly, the mode of payment is also a major point of difference. In OpenBazaar, the mode of payments can be direct, moderated or offline, but the currency will be bitcoin. Buyers have the option to fund their internal OpenBazaar wallet with a variety of coins in one of 3 cryptocurrencies that each user chooses upon setup: Bitcoin, Bitcoin Cash or Zcash. Unlike Amazon which doesn't

[161] Tara Johnson, "How the Amazon Supply Chain Strategy Works" (Tinuti, 25 July 2018) <https://www.cpcstrategy.com/blog/2018/07/amazon-supply-chain/> accessed 23 May 2019

[162] "OpenBazaar Buyer Guide - What to expect in this decentralized marketplace", (OpenBaazar, 1 November 2017) <https://openbazaar.org/blog/openbazaar-buyer-guide-what-to-expect-in-this-decentralized-marketplace/> accessed 22 May 2019

use bitcoin as payment method and is dependent on more traditional method of payment such as cash, cards, PayPal etc.

Thirdly, the flow of transactions is completely different in both the models. Amazon's model includes more complicated logistics involved as its uses, "Amazon-to-buyer" sales approach[163] and not peer-peer sale. The method of communication in both the platforms also differ as in Amazon directly don't communicate with the seller but communicate through Amazon. Whereas in OpenBazaar, the users directly communicate with each other and this comes with a slight disadvantage as the users are spread across the world and the communication might not always be in real-time. Lastly, as already mentioned, there are no transaction fees involved in OpenBazaar, even though each cryptocurrency network used might have such fess compared to Amazon where there is a markup involved between Amazon and the seller.[164]

OpenBaazar is not very commonly used marketplace yet and the reason why it is still not being used in a widespread manner is due to various drawbacks, i.e. cryptocurrencies are not currently legalized everywhere. It is still undergoing a lot of development such as multi wallet, offline ordering and messaging, IPFS protocol and the technology behind it i.e. blockchain is also constantly changing. With respect to reputation as well, Amazon is almost a household name now but not a lot of people are aware of the existence of OpenBazaar.[165]

But as companies like Amazon, eBay, Netflix etc. are looking to embrace the model and technology behind OpenBazaar. In near future, companies might move beyond the existing payment and contract structure backed by credit cards towards a more self-executing structure.[166] If Ricardian contracts become a part of such systems, this cold result into more and more lawyers embracing the idea, understanding and the functionality behind the technology.

[163] Tara Johnson, "How the Amazon Supply Chain Strategy Works" (Tinuti, 25 July 2018) <https://www.cpcstrategy.com/blog/2018/07/amazon-supply-chain/> accessed 23 May 2019

[164] "OpenBazaar Buyer Guide - What to expect in this decentralized marketplace", (OpenBaazar, 1 November 2017) <https://openbazaar.org/blog/openbazaar-buyer-guide-what-to-expect-in-this-decentralized-marketplace/> accessed 22 May 2019

[165] "OpenBazaar: Why it hasn't Steamrolled Amazon and eBay?" (Medium, May 2019) <https://medium.com/@cryptoshoppe/openbazaar-why-hasnt-it-steamrolled-amazon-and-ebay-6d6e2c34471a> accessed 22 May 2019

[166] Rob Knight, Mattereum panel at the Internet of Agreements conference. (Medium, 6 April 2018) <https://mattereum.com/upload/iblock/06c/mattereum_slides.pdf> accessed 25 May 2019

CONCLUSION

In the light of the analysis of the central research question, *"whether a hybrid model like Ricardian contract bridge the gap between smart contracts and traditional contract"*, it can now affirmatively be answered that Ricardian contract will indeed bridge the gap between smart contract and traditional contracts resulting into widespread usage of smart contract application.

Summarizing the thesis, which began with the introduction into the world of blockchain technology and smart contracts. Followed by detailed analysis of the current usage of blockchain in various industry. It was important to understand the perspective of how widely the technology is being currently used. Moving on to the various platforms of smart contracts and the difference between types of smart contract platform and how these platforms are segregated into permissioned and permissionless blockchains. The thesis further discussed the limitations of smart contracts, especially the lack of legal enforceability of smart contracts and its impact on lack of widespread usage of smart contracts in various industries so far. Briefly discussing the future of smart contracts when used in combination with IoT and AI and how this can be revolutionary for business operation and touching upon why we need a hybrid mode.

Next part of the thesis mainly answered our central research question by introducing the concept of Ricardian contracts with several diagrammatic representation and a more detailed description of how it functions and the important characteristics of the same. It was observed that smart contracts have proven to be less flexible due to the presence of coding language, which demonstrates their inability to adapt to changing circumstances and revised choices of parties involved in a contract.[167] Additionally, this results into creation of more inefficiency and costs as smart contracts are not open ended in nature.[168] Hence, the solution offered is a hybrid model which can be read and interpreted by both humans and machines giving us the flexibility of the existing traditional contracts which contain natural language. Making a comparative analysis of Ricardian contract, smart contract and traditional contracts give us more clear perspective of the complete paradigm of the points of difference between the three.

Chapter 4 of the thesis discussed, why Ricardian contract is the future of blockchain based smart contract and this explanation is divided into two parts. In the first part, the changing nature of contracts is analyzed, as this change has serious repercussions on the functioning of the whole legal industry, including lawyers, paralegals, administrative officials who work in an environment where the very nature of contract execution is changing. Unlike the previous understanding of the

[167] Martin Von Haller Gronbaek, "Blockchain 2.0, Smart Contracts And Challenges (June 2016) <https://www.twobirds.com/en/news/articles/2016/uk/blockchain-2-0--smart-contracts-and-challenges> accessed 14 April 2019

[168] Jeremy M. Sklaroff, "Smart Contracts and the Cost of Inflexibility", [2017] 166 University Of Pennsylvania Law Review 264, <https://pdfs.semanticscholar.org/0783/0f2f209fcf5ad916848448baacdbfb78fe7c.pdf> accessed 22 May 2019

execution of contracts which was text based and more theoretical in nature, smart contracts and hybrid models of contracts are different to a large extent. More and more contractual relationships are now being governed by visual based agreements which uses pictures and graphs as methods of representation and some businesses are also exploring smart contract options to increase efficiency and save costs. This can truly be achieved by Ricardian contracts, at least on paper till more pilot projects are taken up by companies to test the same. The second part of the chapter explores the future of such hybrid models of Ricardian contract and emphasizes on why legal contracts should no longer be made by and for lawyers only. It makes a pertinent observation that with smart contract and Ricardian contract, coders will have a bigger role to play in creation of contracts or more and more lawyers will lean towards learning coding. But even without lawyers learning to code, the presence of smart contracts in business operation no longer means that the role of lawyers will be completely circumvented. In fact, there will be more opportunities for lawyers who will play an important role in creation of Ricardian contract templates. The prose part of the machine-readable contract layer will be the domain of lawyers. But soon, more emphasis will be on the automation of parts of a legal agreement than packing an agreement with legal jargons.

In the last chapter before conclusion a comparative analysis was made between an existing well established centralized and decentralized online marketspace. The purpose behind this comparative analysis was to point out efficiency and inefficiency in both the systems and if the decentralized model which functions on the hybrid Ricardian contract system is more desirable to be used in future and why it has not completely taken over centralized models despite offering features such as no third party intervention, no transaction costs, more secure transactions, secure data to name a few. It has also been observed that companies like the likes of Amazon, PayPal are indeed mulling over the possibility of implementing smart contract in their operations.

This thesis aimed to discuss legal aspect of Ricardian contracts which several papers debating the legal enforceability of smart contracts have merely touched upon. This thesis fields Ricardian contracts as the best alternate to the legal enforceability questions surrounding smart contracts. It is important to include here that there is crucial limitation of this research that as currently the exploration of hybrid implementation of smart contracts is in its nascent stages, not a lot of studies have yet focused on the several questions surrounding its scalability.[169] There are several questions that can and will arise once there is a more widespread usage. The main motivation of this thesis was to introduce the reader to this new developing paradigm of a hybrid model of smart contract, moving beyond the debate of legal enforceability of smart contracts. It is time to move on from the question of legality of smart contract and find alternate hybrid models such as Ricardian contract to increase widespread usage of smart contract application, explore how smart contract solution can be made workable in the existing contractual structure paradigm.

[169] Carlos Molina-Jimenez, Ellis Solaiman, Ioannis Sfyrakis, Irene Ng, Jon Crowcroft, On and Off-Blockchain Enforcement Of Smart Contracts (arXiv e-prints, 2 May 2018) 6 < https://arxiv.org/abs/1805.00626> accessed 13 April 2019

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