

Blockchain-based Technology in the Coffee Supply Chain Trade: Case of Burundi Coffee

Vinesh Thiruchelvam^{1,2}, Alexandre Shaka Mughisha¹, Maryam Shahpasand^{1,2}, Mervat Bamiah²

¹Asia Pacific University of Technology & Innovation

²Prince Sultan University, Saudi Arabia

dr.vinesh@apu.edu.my

Abstract—Blockchain is a decentralised database, encrypted tamperproof digital ledger technology that allows all network participants to trust each other and interact. This trust is initiated due to the automated verification of the transactions by every node in the network through cryptographic algorithms without any third-party interference. Previous literature identified that traceability, visibility, transparency, and security of operations across the supply chain are challenges to the traditional Coffee Supply Chain (CSC). These challenges raised from inaccuracy regarding manual processes and the involvements of several intermediaries throughout the overall CRC process. Considering these aspects, there is a need for an automated system that enables accurate, secure real-time cost-effective supply chain which facilitates a fair CSC trade. Based on the results of the quantitative questioner conducted on all Burundi coffee actors, this study proposed the Technology Acceptance Model (TAM) base Blockchain technology to be deployed in the Burundi Coffee industry.

Index Terms—Blockchain Technology; Supply Chain; Coffee Supply Chain; Technology Acceptance Model.

I. INTRODUCTION

Coffee is a favourable drink around the globe with diverse flavours and well-known brands. It has its own economic advantages as it provides foreign income and has a significant share in the overall economy for several developing countries [1]. According to the International Coffee Organization, in 2016 alone, people around the world consumed more than 150 million kilograms of coffee bags [2].

Despite the Coffee significance still, its supply chain has several challenges such as fragmented production, climate change, and market instability. Not to mention the emerging digital transformation whereby innovative technologies such as the Internet of Things (IoT), Big Data, and Cloud Computing have been implemented across other industries to enhance the transparency and traceability in supply chain processes, yet not being utilised by coffee industry [3].

Coffee Supply Chain (CSC) comprises of complex network relations between roasters, traders, processors, and farmers [4]. It involves information about product, stakeholders, and cost among others. This information requires multi-tier data gathering, rating, and intelligence for analytics. The first tier identifies the supply chain stakeholders, also assess and trace to the source. Whereby the second tier enables the suppliers to communicate with customers and share data to meet transparency requests [4]. Other tiers involve the analysis and traceability among others.

However, tracing the origin of products across complex supply chain requires transparent and tamper-proof metadata infrastructure which have to be trusted by all parties as well

as to be adaptable to changing environments and regulations [5]. Current CSC has unfair ecosystem which impacts the coffee producers in the form of fluctuation in the market NYC and the rising price from the intermediaries.

This study focuses on the coffee sector as it is crucial to the Burundian economy, due to its high employability and the profits from coffee exports, as well as a vital source of foreign exchange revenue. The contribution of the study will be as developing a blockchain application model for the CSC trade as a solution for the sustainable coffee industry.

Next section identifies Burundi's coffee industry. Section III discusses CSC challenges. Section IV presents Blockchain technology for CRC. Section V. describes the research methodology. Section VI defines the proposed model. Section VII discusses the results. Finally, Section VIII concludes the study.

II. BURUNDI'S COFFEE INDUSTRY

Coffee sector is vital for Burundi (located in East Africa) economy since it facilitates employment of farmers and earnings of foreign exchange from exports [6]. Burundi is leading the African countries of the average share of Coffee export value as shown in Table 1 [7]. However, despite the increased production of coffee, still, its failure in the supply chain has created an imbalance in the CSC industry [8].

Table 1
The African Countries Average Share of Coffee Export

Country	Coffee share in % of GDP		Coffee share in % of export value	
	1990	2015	1990	2015
Uganda	3.3	1.5	92.1	17.9
Burundi	5.3	1.3	80.6	35.6
Ethiopia	1.1	1.2	44.0	18.9
Rwanda	3.2	0.8	75.2	9.4
Togo	1.1	0.5	6.6	1.6
Cote d'Ivoire	2.6	0.3	9.2	1.0
Kenya	2.4	0.3	20.0	3.6
Tanzania	1.9	0.3	24.2	3.0
Guinea	0.2	0.3	0.8	0.8
Central African Republic	0.7	0.2	8.5	4.1

III. COFFEE SUPPLY CHAIN CHALLENGES

The supply chain is considered as structured manufacturing whereby raw material is processed into finished goods to be delivered to customers [9]. It is a complex process that requires time and efforts. Moreover, it involves many intermediaries such as suppliers, providers, and customers as shown in Figure 1 [10].

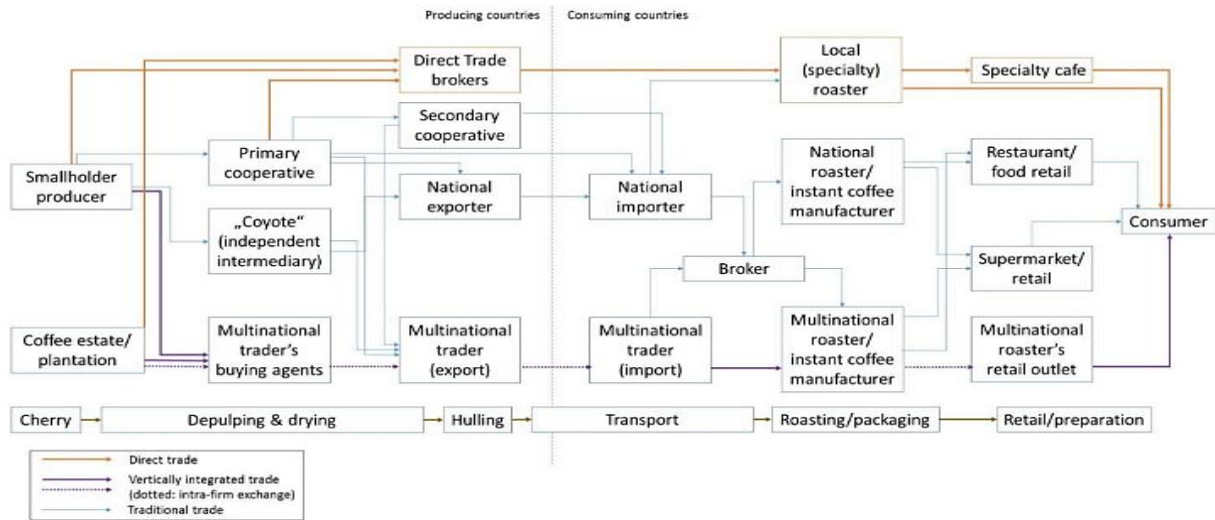


Figure 1: The Illustration of Coffee Supply Chain

Coffee is considered the second largest traded commodity in the world with a market share of over \$100 billion. As worldwide Coffee demands continue to increase due to the increasing daily demands of consumers, still its supply chain faces challenges as follows [1]:

- Location challenge: farmers who are in remote areas which makes it hard to maintain production sustainability for millions of coffee farmers.
- Social challenges: ageing farmer communities, young farmers migration to the cities, as well as the poverty of harvesters.
- Economic challenges: include expensive resources, low productivity, plant ageing, lack of market information, poor direct market access.
- Market crises challenge: the majority of developing countries depend on agricultural commodities; therefore, they are vulnerable to any crisis in international markets. Currently, the coffee industry has more than 25 million farmers and families just depending on a single commodity [11].
- Environmental challenges: include soil erosion and degradation, changing weather conditions among other factors [12].
- Time and cost Challenges: current CSC is complex, costly and time-consuming. It takes days to perform payment between manufacturers and suppliers, or between customers and vendors. Moreover, contracts must be managed by lawyers and bankers that need time and money.
- Traceability Challenge: coffee transactions cannot be traced back to suppliers which makes the defects difficult to eliminate.
- Friction Challenge: many intermediaries and several communications to the third party in between.
- Transparency Challenge: traditional CSC processes includes procurement, manufacturing, storage, and distribution. It comprises several relationships such as suppliers, subcontractors, and customers. Additionally, it has an internal association function which uses its systems to track coffee products and maintain its services. These factors increase the friction and decrease in transparency [13].

The coffee industry in Burundi is experiencing the same challenges affecting its supply chain. Figure 2 illustrates the current process and actors for Burundi CSC.

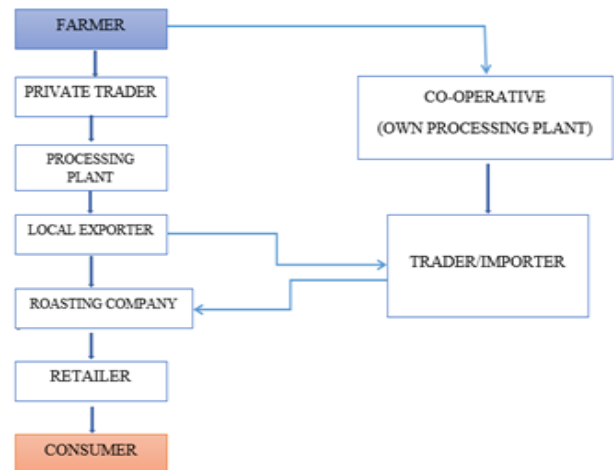


Figure 2: Current process and actors for CSC in Burundi

IV. BLOCKCHAIN TECHNOLOGY FOR SUPPLY CHAIN

Supply chain success relies on its ability to assist businesses in saving costs, faster delivery, shorter manufacturing time, and better inventory management. Organizations aim to optimise the efficiency and effectiveness of its supply chain management. Efficiency refers to conducting best practices within available resources, whereby effectiveness focuses on the outputs and how well organisations meet the demands of stakeholders to gain their satisfaction [14].

Blockchain as a decentralised distributed, digital ledger which records transactions in a series of blocks as scattered copies over multiple digital devices (nodes) [15]. It increases transparency and efficiency since all transactions data are available to anyone who is on the network. Blockchain has an embedded smart contract that triggers actions automatically. For example, in a CSC a delivery transaction recorded on the blockchain can trigger payment.

The blockchain is secure whereby each new block of transactions is linked to the previous ones in a tamperproof manner. Additionally, nodes are updated regularly. A blockchain can serve internal and external entities. It can be

used in the CSC for various reasons such as self-executing contracts to automate chain management. It enables transactions recording and product progression from the manufacturing process to delivery.

CSC information including amount, date and time of each payment is visible whereby personal information is not which preserves confidentiality, reliability, and integrity. Every entity in blockchain has to agree on each transaction to be valid including payment, storing, transport or delivery.

The blockchain is immune which means that transactions made cannot be falsified such as inventory records, storage conditions, delivery times and dates, among other verified and saved transactions in the blocks. All copies of the transactions are finality. Furthermore, Blockchain enables smart contract which is stored in the block and functions specifically as programmed. This protects from fraud since the smart contract receives the input from the files (ledger) and trigger an event [16].

Blockchain enables transfer of payments automatically to any part of the world, in contrast with a traditional supply chain that depends on traditional banking which is costly and time-consuming. Each of the Coffee production stages can be recorded using the Blockchain technology. These records are tamperproof, inalterable and permanent, as well as it can be traced to the source. Blockchain enables real-time monitoring of the operation's progress and data verification [17]. Several Blockchain solutions have been used in industry for CSC such as:

Bext360: which uses a mix of mobile applications, Blockchains, and robots for tracking the overall supply chain process from production to delivery for increased transparency, traceability and profitability [18].

Crypto N' Kafe (CNK): a global decentralised blockchain ecosystem that utilises smart contract to improve the efficiency of the overall CSC service delivery while preserving trust and transparency between the involved parties [19].

Starbuck: a coffee industry leader is integrating Blockchain in its CSC as a Pilot Program for traceability [20].

As per the analysis of previous literature and observing industry trends the author proposed the integration of blockchain technology in Burundi CSC. The blockchain is the most suitable solution since it enables CSC traceability, transparency and security of operations. The decentralised nature of blockchain makes it an ideal solution for massive-scale processing systems based on scaling.

V. METHODOLOGY

This study methodology is based on a quantitative analysis approach. A questionnaire was sent using online Google Doc. for a sample size of 66 respondents representing the Burundi coffee industry. The sample size was selected based on the target populations (coffee producers and consumers). Furthermore, the target population included 167 producers and 36 companies. The selected survey sample contains 66 respondents based on a calculation including marginal error for determining the sample 10% and confidence level of 95%.

However, only 49 responses out of 66 have responded with the rate of 74.2%. Furthermore, SPSS 24.0 tool was used for data analyses. The questionnaire comprised of 20 questions. Figure 3 shows the respondent types. It is observed that producers were with the highest percentage 61% and traders were the least with 6%.

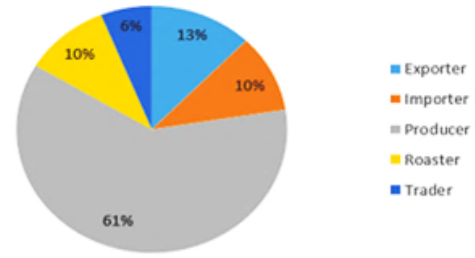


Figure 3: Respondents types and rates

Figure 4. shows the overall cross tabulation between the type of involved actors in CSC and their awareness of sustainability. Producers 100% related coffee sustainability with social, economic, and environment, traceability, and supply chain. Producers were the only actors in the industry to acknowledge sustainable supply chain 100% and premium price 96.7% for the sustainable coffee industry. The exporters 100% related sustainability with social, economic, and environmental considerations, 83.3 %traceability and premium price, sustained supply chain at a rate of 66.7%.

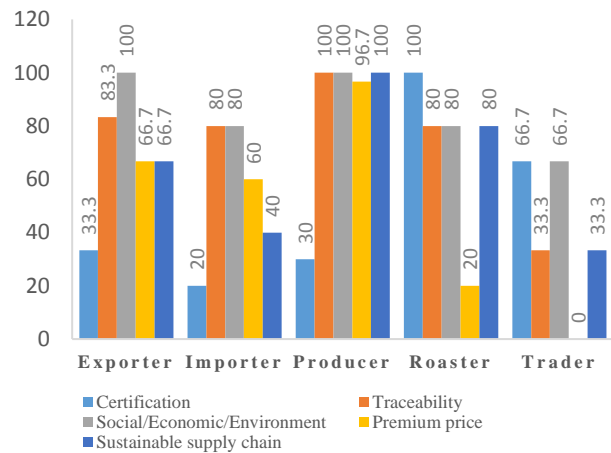


Figure 4: Factors impacting Burundi sustainable coffee industry

Roasters related the coffee sustainability with certification 100% traceability, social, economic, environment, and supply chain at the same rate of 80%. Traders related sustainability with social, economic, environment, and certification equally 66.7%, however, they were the only ones who did not consider premium price among other actors.

Other questions feedbacks assisted in understanding the respondent's expectations regarding the coffee they produce, sell, purchase or consume. Majority of respondents wanted to gain more information about the origin of the coffee, its destination and its producers 12.4% wanted to learn about the reliability of the sources and the suppliers. Whereby 2.4% wanted to know about market access, the pricing of coffee, and the sustainability.

It is observed from 98% respondents' feedbacks that their awareness of coffee distribution and provenance traceability is lacking. Whereby, 97.96% of the respondent stated the importance of transparency for guaranteeing the reliability of information shared by CSC actors. Moreover, the visibility factor is rated by 93.88% as important in CSC to maintain its sustainability and control. Furthermore, 97.96% agreed that technology assists in making the coffee industry more sustainable. The respondents' have agreed that technology can assist in solving the current coffee sustainability problem.

Based on the overall analysis conducted that respondents expect to gain greater access to market, suppliers and producers, premium pricing for their coffee for getting a sustainable supply chain. Considering the level of expectation from the technology, the respondents aim to gain higher traceability, transparency, visibility in the coffee industry as well as enhancing the connectivity in the CSC.

VI. PROPOSED MODEL

This study proposes the Technology Acceptance Model (TAM) based Blockchain technology to be deployed in the Burundi Coffee industry supply chain. The Blockchain technology enables the CSC entities to use the blockchain system to be connected directly in the network to receive the required information without involving intermediaries which save time, cost and efforts besides increasing the sustainability of the system. The proposed framework is shown in Figure 5.

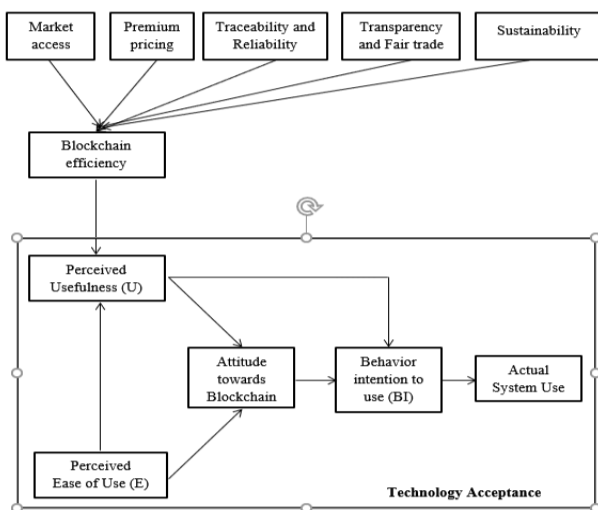


Figure 5: Blockchain acceptance model derived from TAM

VII. RESULTS AND DISCUSSION

It has been determined through the conducted questioner that there is lack of adoption of certification in the coffee industry. The researcher, therefore, recommends the use of the coffee certification as evidence of the sustainability of the produced coffee. Greater emphasis needs to be for this certification as it offers guidance and a better life for the coffee farmer families regarding fair and direct trade, sustainable farming, as well as improved economic, social and environmental production and protection.

Based on the data analysis findings, it was determined that the actors from the Burundi coffee industry require the technology to be adopted in the supply chain to get a more significant market access, higher pricing, sustainability, and traceability to increase the fair trade and transparency in the supply chain for the benefit of the coffee producers/farmers.

The researcher recommends the adoption of the proposed blockchain model for the Burundi coffee industry. This is primarily because TAM based Blockchain model is a hybrid model which will restrict the supply chain network to be limited to certain actors from the industry. Any farmer or coffee producer having access to join the CSC network and potentially get involved in the transactions will be validated before being part of the network. This will ensure the

authenticity of who is on the network. Moreover, the proposed model will benefit from the significances of blockchain to ensure fair trade, security, sustainability, transparency and traceability of CSC.

VIII. CONCLUSION

Burundi Coffee industry is still lacking technological adoption. This study proposes the adoption of Blockchain in CSC to streamline the supply chain process by digitisation and automating its processes such as payment and auditing of the inventory and current assets to ensure fair trade and pricing for all stakeholders. The adoption of Blockchain will make the CSCC process transparent, also will ensure that every transaction is documented from the initial phase of purchasing from farmers to the end process of selling it to customers. The adoption of Blockchain offers increased transparency, greater sustainability, and scalability, better safety, and security, fair trade and price equality for the Burundi Coffee industry. Blockchain through its smart contracts can eliminate costly delays and paper waste.

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