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THE ECONOMIC ASSESSMENT OF BLOCKCHAIN IN WORLD'S LOGISTICS AND SUPPLY CHAIN

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ABSTRACT

Selama beberapa dekade terakhir, lingkungan perdagangan global dan manajemen rantai pasokan semakin kompleks. Integrasi teknologi baru sangat penting untuk mendukung tren pertumbuhan dan kompleksitas ini. Proses pengurusan bea cukai merupakan potensi hambatan dalam lingkungan perdagangan dan manajemen rantai pasokan negara akibat operasi yang rumit, banyaknya dokumen, dan kurangnya transparansi. Faktor-faktor ini menyebabkan pengelolaan waktu yang tidak efisien, risiko dokumen yang hilang, dan ketidakefisienan dalam penanganan keuangan. Penelitian ini mengeksplorasi potensi integrasi teknologi Blockchain, dengan menggunakan *smart contacts* sebagai infrastruktur dasar, untuk meningkatkan efisiensi keseluruhan dari proses pengurusan bea cukai. Temuan menunjukkan bahwa penerapan teknologi Blockchain dapat meningkatkan produktivitas sistem dengan meningkatkan pengelolaan waktu, mengurangi kemungkinan penanganan dokumen yang salah, dan meningkatkan aliran keuangan. Selain itu, penelitian ini juga menunjukkan bahwa biaya implementasi awal berdampak signifikan terhadap titik impas adopsi Blockchain. Sementara itu, peningkatan biaya pemeliharaan tahunan dan biaya platform memiliki dampak minimal dan dapat diimbangi dengan perbaikan di area lain, seperti peningkatan keamanan.

Over the past few decades, the global trade and supply chain management environment has become increasingly complex. Integrating new technology is essential to support these trends of growth and complexity. The customs clearance process is a potential bottleneck in the trade environment and the nation's supply chain management due to its intricate operations, numerous documents, and lack of transparency. These factors lead to inefficient time management, the risk of missing documents, and financial handling inefficiencies. This research explores the potential of integrating Blockchain technology, using smart contracts as the underlying infrastructure, to enhance the overall efficiency of the customs clearance process. The findings demonstrate that implementing Blockchain technology can improve the system's productivity by enhancing time management, reducing the likelihood of document mishandling, and improving financial flow. Additionally, the research indicates that the initial implementation cost significantly impacts the break-even point for Blockchain adoption. At the same time, increases in yearly maintenance and platform fees have a minimal effect and can be offset by improvements in other areas, such as enhanced security.

1. INTRODUCTION

1.1. Background of Study

The globalization of logistics has led to a more intricate supply chain system that extends across various countries and involves many stakeholders, such as manufacturers, suppliers, logistics providers, and financial institutions.

Effective management of these supply chains is essential for businesses and companies to stay competitive. Nonetheless, traditional supply chain processes that involve manual documentation management, offline payment, and manual manifest verification frequently encounter high human resources and inefficiencies caused by a lack of transparency, prolonged payment cycles, and the potential for fraud and human errors. These problems can exacerbate the country where it is located as a hub of the region's logistics and relies on import-export activities as the main economic driver. There are various challenges in the current supply chain system. First, the inefficiency of customs clearances and payments which are typically slow, cumbersome, and prone to errors and fraud. Processing clearances and payments can take days or even weeks. According to the World Bank, clearing customs takes approximately seven days due to the extensive documentation required, leading to company operation problems for suppliers and disrupting the entire supply chain. Second, real-time visibility into

transactions is necessary for companies to track payments and manage their finances efficiently. Third, adopting the digital payment system as a payment facilitator is intricate for every public sector due to its complex back-end infrastructure and system integration.

As a result, blockchain technology has gained recognition for its unique features, including decentralization, distributed ledger technology (DLT), and smart contracts that securely, transparently, and immutably record transactions. Validated by a network of nodes and immutable once recorded, blockchain is ideal for enhancing transparency, security, and efficiency in various industries, including supply chain management.

1.2. Objective

The primary objective of this research is to analyze current inefficiency in traditional supply chain operations and payments. Secondly, to explore the possibility of deploying Blockchain technology in the customs clearance process and acting as a means of payment in logistics through a mixed-methods approach, combining qualitative and quantitative models. Thirdly, to recommend the appropriate and comprehensive recommendations for integrating blockchain technology into current supply chain systems. From this, the research's main question is "How do Blockchain technologies improve a nation's logistics and customs clearance operations."

2. LITERATURE REVIEW

This section aims to provide a detailed overview of the existing research and theoretical frameworks and modelings regarding the use of blockchain technology in supply chain management, especially in payment processes and customs operations. This chapter will discuss the key concepts, economic evaluation, challenges, potential recommendations, and modeling framework of blockchain technology in supply chain systems.

2.1. Economic evaluation on supply chain finance and blockchain

Supply chain finance (SCF) emerged around the 2000s, initially focusing broadly on financial management within supply chain processes by integrating logistics, supply chain management, collaboration, and finance. Recently, SCF has been more precisely defined as financial solutions designed to optimize working capital in a company's supply chains, using financial instruments, practices, and technologies to enhance working capital and liquidity for business partners. SCF connects buyers, suppliers, and funders to provide short-term credit, reduce financing costs, and improve business efficiency (Waseem A., Changsha H., Asaad A., 2018).

When integrating blockchain technology into SCF, using the cost-benefit model proposed by Dello Iacono, Reindorp, and Dellaert (2015) and scenario planning for traditional, smart contract, and IoT solutions, the analysis shows that blockchain enhances the overall net benefit for stakeholders, especially in SCF, through increased efficiency in invoice and payment processing. Suppliers benefit if the increase in working capital outweighs platform and maintenance fees. The net benefit of using an IoT platform is around 25% higher than traditional methods, while smart contracts offer nearly 20% higher benefits due to high maintenance and infrastructure costs (Figure 1). The primary recommendation is to set platform fees below the break-even point to incentivize the adoption of blockchain technology (Patara P., 2019).

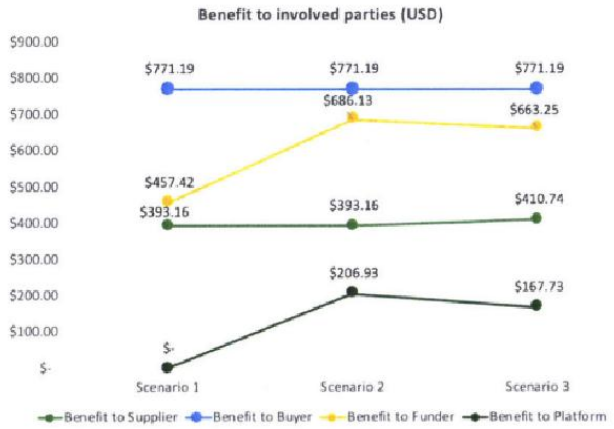

Figure 1: Benefit to stakeholders (Patara P., 2019)

2.2. Blockchain Technology

Blockchain technology with a distributed ledger technology as an underlying infrastructure is a decentralized data structure that maintains a finite growing list of records, which are shared among all network members. It not only allows the insertion of new entries into the database but also ensures that all members have a distributed and immutable data system. Additionally, blockchain is exemplary for implementing smart contracts, which are computer protocols that automatically execute and enforce agreements based on predefined conditions. When these conditions are met, smart contracts can automatically initiate transactions without intermediaries providing faster transactions, more transparency, and more traceability.

One area where blockchain can significantly impact is the Know Your Customer (KYC) process. Typically, KYC requests can take almost a month to complete using standard industry measures. According to Omran et al. (2017), blockchain could eliminate the need for the KYC process, as credit ratings and supplier evaluations would be stored and cryptographically secured on the blockchain. These benefits suggest that blockchain technology has the strong potential to disrupt existing supply chain finance solutions, particularly in invoice processing efficiency and transaction handling processes. (Swan, M. 2015)

In addition, one study suggests that Blockchain technology can effectively alleviate cross -border transactions and its underlying payment infrastructure. The cross-border fund transfers within Asia, particularly in Southeast Asia, suffer from significant inefficiencies which include vertiginous transaction fees, exposure to high foreign exchange settlement costs, and prolonged settlement times. Blockchain technology will enable financial transactions in local currencies, which being said, requires only one execution through a unified platform. This unique specification minimizes foreign exchange risks that would otherwise arise from processing payments across multiple platforms. (Yupawadee S., 2016).

2.3. Traditional customs operations

Studies suggest that there might be multiple inefficiencies in the traditional customs operations which handle paperwork manually and payment is usually done via bank transfer or manual fiat currency payment. The potential slackness is in the low utilization rate of patrol and inspects officers when conducting goods declaration and clearance operations, contracting issues such as loss of historical contract information and contract-law enforcement that can lead to illicit activities, and the current technology may not be able to cope with an increasing amount of information from the growing global economy. This issue can be alleviated to some lower degree by introducing technology such as Blockchain or other technology that can faster the operations can securely collect and store a large amount of information. (Puneet J. 2018).

3. RESEARCH METHODOLOGY

3.1. Data and Knowledge Preparation

For the insights and knowledge collection, the author conducted the interview process to obtain necessary information and insights on related topics of interest. The interviewees are chosen based on their experiences and perceptions of the specific knowledge which represents a range of companies, including commercial banks, central banks, and blockchain-related firms. Ethical considerations, including informed consent and confidentiality, will be upheld throughout the interview process for all participants. The list of interviewees is provided in Table 1.

No.	Date	Topic	Position	Company / Organization
1	July 9, 2024	Customs overall procedure	Technical Officer	Royal Thai Customs
2	July 9, 2024	Customs clearance operation, process, and challenge	Director	Royal Thai Customs
3	July 10, 2024	Blockchain-based solution	Senior Auditor	Central Bank of Thailand
4	July 15, 2024	Smart contract technology	Senior Analyst	Central Bank of Thailand
5	July 23, 2024	Customs clearance operation, process, and challenge	Senior Technical Officer	Royal Thai Customs
6	July 24, 2024	Smart contract technology	Product Analyst	TTB Bank

Table 1: Lists of interviewees

For the quantitative data reference in this research, which will be used as a primary base case scenario for the modeling part, the author used the open data source along with numerical value from academic articles which provide comprehensive and diverse data sources pertinent to the research objectives. The open source for this research took strong ethical consideration by enforcing the Data Ethical Framework such as the data will not include sensitive information and traceable data, and adherence to data usage policies. The list of open source and type of data used is provided in Table 2.

No.	Date used	Data	Article source
1	July 21, 2024	Blockchain app deployment cost	CLEVEROAD
2	July 21, 2024	Blockchain app additional deployment cost	CLEVEROAD
3	July 21, 2024	Percentage of the cost associated with each deployment	APPINVENTIV

Table 2: Lists of data source

3.2. Operation Analysis

The As-Is flowchart of Customs clearance operation involving the traditional operation with manual documentation and payments is being analyzed to identify inefficient gaps. Note that this flowchart is roughly the overall design of the system when Blockchain is integrated. It conveyed neither a full customs process nor a complete operation. The author identified many limitations within the flowchart as described as follows. First, customs clearance documentation involves a lot of physical paperwork such as customs manifest, paper invoice, and declaration of hazardous goods. Based on the interviews, The customs officers generally require significant time for paperwork processing such as checking all the relevant information on the manifest or finding the previous paper manifest to verify the current manifest. This, in turn, creates a waste of time for most Customs officers to handle the paperwork process and consume a high amount of human resources. Second, used manifests and documents are stored in physical warehouses with little or inefficient protection. This leads to insecure documentation potentially compromising the integrity and confidentiality of sensitive information. For instance, paper manifests can be susceptible to fraud through unauthorized edits if there are no prior records of that manifest's history details. Third, bank guarantee letters are typically used for high-value transactions where the seller seeks assurance from the buyer. These documents ensure that the seller receives payment once the goods reach their destination. However, in some cases, the letter does not ensure the quality of the goods shipped. Even if the goods are defective, the seller will still receive payment as long as the letter of credit conditions are fulfilled. Although both the seller and buyer attempt to ensure the quality before and after the goods arrive at the final

destination. There are still some cases that this issue can arise, and it leaves the gaps for potential problems in the future.

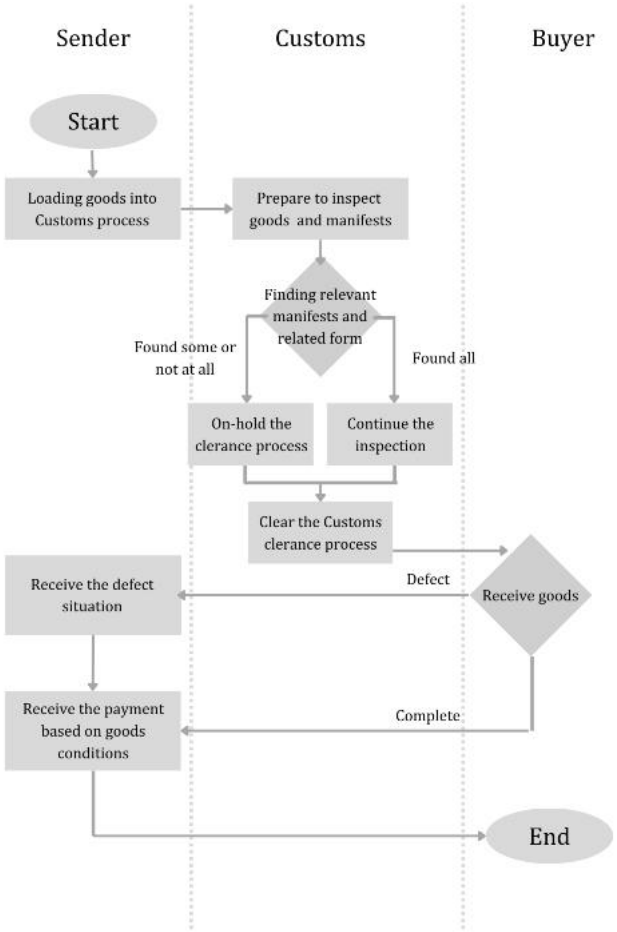

Figure 2: As-Is flowchart for traditional customs clearance operations

3.3. Technology Analysis

Blockchain technology, also known as Distributed Ledger Technology (DLT), operates as a decentralized system for processing and storing data across interconnected nodes. Data is grouped into blocks, which are sequentially linked to form a chain. Each block undergoes encryption and includes a hash value derived from the previous block, ensuring data accuracy and integrity. This decentralized storage method eliminates the need for intermediaries, reducing the risk of counterfeiting and enabling automated transactions through smart contracts. When a transaction order or update is requested, it must be verified and agreed upon by all network members, or a majority, through a consensus process. This ensures secure, reliable, and tamper-resistant data management.

Nonetheless, Blockchain still processes certain risks that need to be addressed before implementing in any project. The specific risks that have potential impacts on operation when implemented along with customs operation are shown below.

Type of risks	Explanations
Document and Manifests Security	The decentralized system of Blockchain stores the data and information in each block and can be accessed if the requester has what is known as a "Hash" value. This creates a significant data leak if the unique hash value is in the wrong hands. Strong measurement of security needs to be strictly enforced
Network connection	The network inside the Blockchain requires each customs or related organization to synchronize and connect inside the network. Lack of collaboration and management between each country's customs creates high risks for system operations and leads to inefficiency

Table : Risks associated with Blockchain when implemented along with customs operation

3.4. Economic Evaluation Modeling

To summarize the modeling process, to quantify the value before and after implementing the blockchain in the customs clearance process, many non-quantifiable economic parameters such as risks associated with non-physical loss need to be translated to quantify parameters. The base case model has been developed to set the baseline threshold to see how the system behaves at the initial. The main objective of the equation is to see how long the system reaches the break-even point. After that, we add the other factors parameter with deviations to see how the model behaves in the system in the long run by using simulation techniques. Finally, we can see the trend result on how blockchain will benefit and reach a break-even point in the system by plotting a line graph. The final result will not give the exact number or value on specific questions such as how many days the Blockchain will reach the margin point or how much we need to invest in Blockchain but rather on general trends, insight, and potential gaps on how the Blockchain will perform in the long-run system such as Blockchain will ever reach the margin point and beat the set-up cost and maintenance cost in the long run.

First, we set up the break-even point equation before implementing Blockchain and after implementing Blockchain as in Equation 1. The left-handed equation illustrates the total economic benefits on the condition before implementing Blockchain and the right-handed equation displays the total economic benefits on the condition after integrating Blockchain. Then we set the system to see the difference between 2 equations. This process will tell us how long the cost of implementing Blockchain will exceed the traditional operation.

$$Cinitial + B * Cdocument + B * Cfraud$$

Equation 1: Economic evaluation of traditional Customs procedure,

$$Cinitial + B * Cmaintenance + B * Cplatfee$$

Equation 2: Economic evaluation when integrating Blockchain into customs procedure

Lastly, we obtained the total economic opportunity cost between traditional customs operations and when integrating blockchain technology by simulating around 40 times. A point worth noting is that the break-even point for the blockchain will offset the opportunity cost from the traditional approach based on the initial assumption is approximately 30-35 years as shown in Figure 3, which is to say we need to use Blockchain around 30 years to be worth the investment with no other factors interfere.

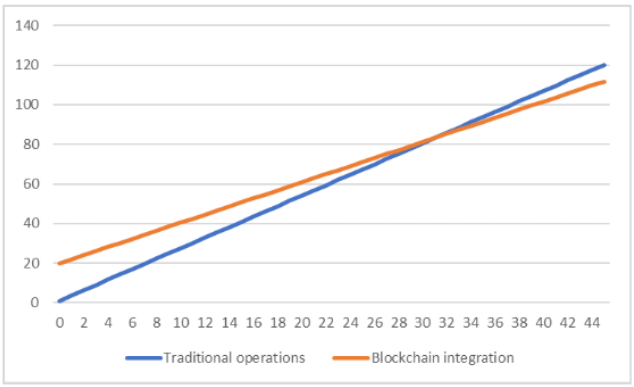

Figure 3: Simulation result of net economic opportunity cost between two scenarios

4. RESULTS AND FINDINGS

4.1. Findings

Based on the in-depth interview session, the new to-be flowchart integrating Blockchain technology as the foundation infrastructure has been developed to facilitate the customs clearance operations as shown in Figure 3. There are three main differences between the as-is and to-be flowcharts as follows, first, the Blockchain will facilitate the documents and manifests storing process from physical to digital at the customs inspection step. This integration will reduce the considerable time for document processing for customs officers and alleviate the potential risk of document loss. Second, the smart contract will be used rather than the physical contract. This change will affect the payment term between the related parties by triggering the smart contract when all the conditions in the initial are met ensuring that performance-based will be enforced thus reducing human error and fraud. For instance, the buyer and the seller or related parties can initiate a smart contract based on specific agreed conditions. This smart contract is designed to automatically execute certain actions such as payment and fund transfers when all the initially agreed conditions are met. If every condition outlined in the smart contract is met, the payment to the seller is processed automatically. This automation significantly reduces the need for human processing, ensuring a more efficient and transparent transaction process. Third, blockchain technology will facilitate the payment process. Typically, the buyer provides a letter of credit (LOC) to the seller or related parties as a guarantee of payment once specific conditions are fulfilled. Both parties' banks, then, are involved in the process. The potential problem is that the LOC only specifies general conditions without addressing the quality of the goods. Consequently, even if the supplier ships defective goods, they still receive payment from the bank if the LOC conditions are met. The implemented smart contract in blockchain will reduce the need for these intermediaries and ensure the specific conditions are fully met. This, in turn, greatly reduces intermediaries' fees and diminishes the chance when payment is made without goods delivery.

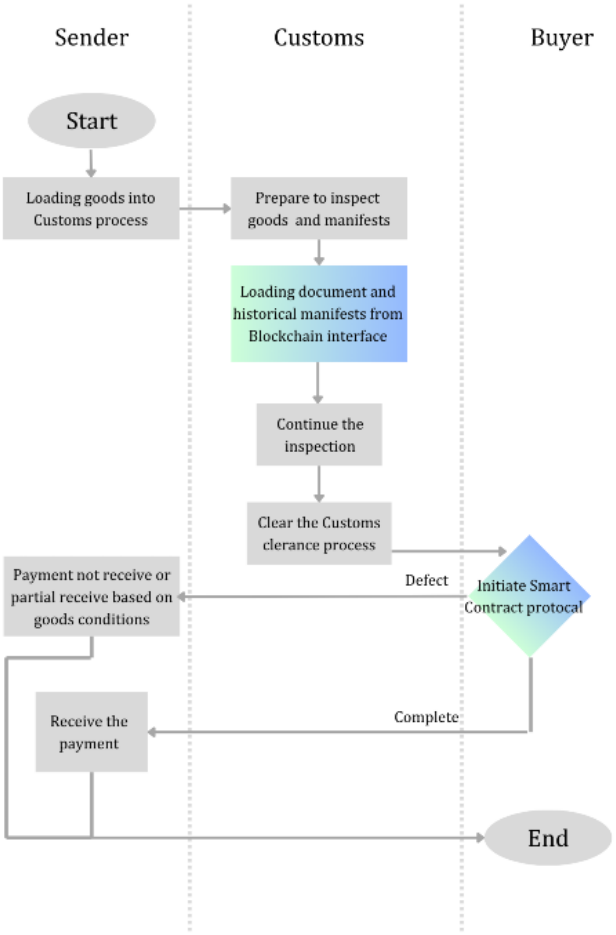

Figure 5: To-Be flowchart when integrating Blockchain into customs clearance operations

Furthermore, the result from the system simulation on the net economic benefits of integrating Blockchain into traditional customs operations and interview sessions yields three key findings. First, the result analysis when the initial set-up cost decreases by half yields an interesting outcome. The duration to reach the break-even point was shortened by nearly 75% to around 14 years as illustrated in Figure 6. Technically the deduction of

the initial set-up fee cannot be reduced by half like in the assumption. This outcome shows the tendency to considerably shorten the duration of the break-even point when implementing Blockchain if the government or related parties can reduce the initial set-up cost for Blockchain by any amount.

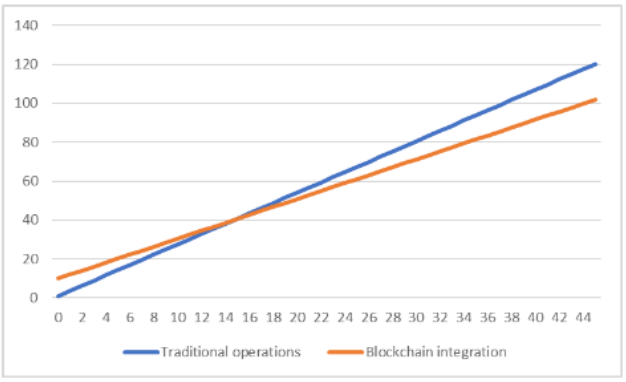

Figure 6: Parameter tuning result from the deduction in the initial set-up cost variable

Second, when we set the maintenance fee to be double, the duration of the total economic break-even point widened as expected but not significant. The result shows that the break-even point has gone up around 6 years as displayed in Figure 7. This suggests that an increase in yearly maintenance fee does affect the duration to offset the investment but is not significant enough to conduct the flooring price strategy (forcing the fee to not increase above a certain number by offset with another cost or actions).

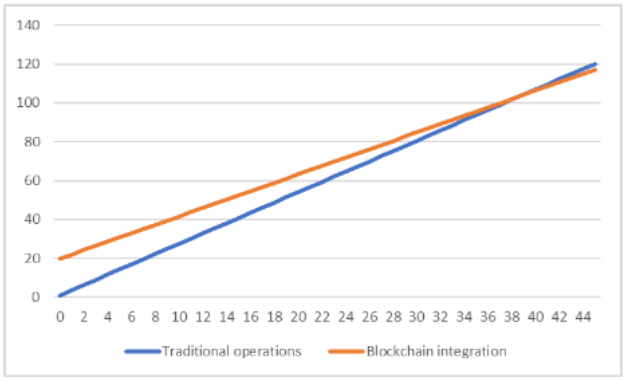

Figure 7: Parameter tuning result from the increment in maintenance fee

Third, when we set the platform fee to be increased by double ratio, the result analysis shows that it increased the break-even point just slightly by a couple of years as shown in Figure 8. This shows a strong correlation between the yearly platform fee and the duration of the break-even point that it does not affect significantly. This suggests that if the increase in the platform fee yields other features or is offset by other drawbacks, the investment in the platform fee should be considered. For instance, if the company offers a stronger cyber security system with an additional yearly platform fee, this offer should be considered since the increase in the likelihood of cyber-attack prevention can considerably off-set the increase in platform fee which just slightly increases the duration of break-even point by a small amount.

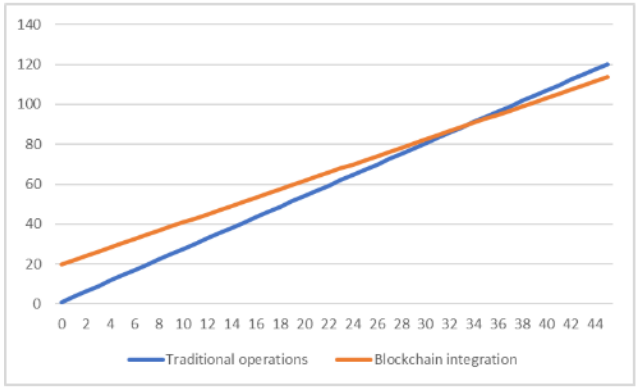

Figure 8: Parameter tuning result from the deduction in platform fee

4.2. Discussion

From varying the parameters in the simulation model along with in-depth interview sessions from various industries, we can see three potential gaps that need to be addressed. First, based on the result of the simulation, we see that the maintenance cost of Blockchain is variable and plays a significant factor that affects the duration of the break-even point. If the implementor can lower the maintenance cost by a small amount, it will help reduce the overall total cost and make the break-even duration considerably shorter. This maintenance cost consists of various measures to ensure that the system runs continuously and smoothly. Partnering with appropriate and having decent Blockchain maintenance knowledge, can help reduce regular maintenance costs. Second, the initial set-up cost for implementing Blockchain as the foundation technology is tremendously high as seen in the interception in the final simulation result graph. According to the interview, this initial setup cost tends to be lower as the technology grows more advanced. Waiting at the right timeline to implement Blockchain might be more appropriate than implementing it right away since the initial set-up cost cannot be much lower and few actions can be done here. The important factors to consider when to start implementing Blockchain might be the size of the budget, the project's objectives, the break-even point timeframe, related partners, and readiness for technology adoption. Lastly, the acceptability of the new technology poses a significant challenge to all related parties which can be particularly intricate for customs officers. Related countries' customs departments must implement blockchain and approve documents and manifests inside the system's interface which requires multiple approvals and tremendous time. Additionally, each country's customs department needs to link inside the same Blockchain

network which can lead to interoperability problems or connecting different blockchains.

5. CONCLUSIONS

5.1. Conclusion

In summary, there has been significant growth in technology research making access to new technology easier than ever before. Various technologies can contribute to the nation's growth, especially in the logistics area where it plays a remarkable role in the country's economic growth. Integrating blockchain technology into customs clearance operations and national logistics systems offers significant potential for improving efficiency, transparency, and security logistics operations. Blockchain's unique feature of a decentralized and immutable ledger can simplify the complex customs clearance process by consolidating all the paperwork process, minimizing the time lead between the payment transactions, and preventing fraud. Furthermore, tts also enhanced traceability and accountability of the information between related parties, especially between each customs country. However, due to its long timeframe to reach its break-even investment point of around 30 years, there are a few limitations and challenges that need to be addressed before implementing the technology such as acceptance between each party, project budget allocation, and readiness between parties to adopt new technology. These limitations can be overcome with enough coordinated efforts and collaboration among governments, private sectors, and technology providers to ensure that Blockchain technology can provide smooth operation and help transform nations's customs and logistics, leading to a more efficient and transparent global trade environment.

5.2. Recommendation

Based on the author's analysis, in-depth interview sessions with experts in various fields, and analysis results from the model. Three potential recommendations will be made to address the potential gaps in the implementations in the future as well as to ensure smooth transitions between traditional operation to blockchain integration.

1. Due to its unique feature of a decentralized system which requires all parties inside the network to join together, when implementing Blockchain at the beginning phase, training and meetings with all related parties, as well as the technologies company, must be held regularly, especially at the beginning phase to ensure that all the members fully understand their specific roles and responsibility. This includes the Customs officers who will use the Blockchain interface system extensively during the clearance processes. A step-by-step guide needs to be conducted in the training and regular feedback meetings should be held as needed.
2. The acceptance of Blockchain implementation is considered another challenge when fully executed, each node inside the Blockchain network needs to connect to another's customs country to share and exchange the information. This might create reluctance and possibly incorporate other countries' customs to utilize the feature in the Blockchain fully. It is highly recommended that each customs country connects the customs from various countries and discuss the possibility of cooperation to ensure the Blockchain will be used at its full capacity.
3. The fixed cost of system maintenance and cyber security measurement to ensure the continuity of Blockchain operation will be a tremendous challenge in customs's budget management. The maintenance cost will steadily increase as time goes by and create a high deficit in the budget. Each customs board of executive and related departments needs to fully prepare and discuss the source of the budget to allocate to this portion.

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