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Transforming Cross-Border Payments by leveraging Blockchain Technology

Master Thesis

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We have written this Master Thesis independently. Any ideas or data taken from other authors or other sources have been fully referenced.

Table of contents

Table of Figures

List of Tables

Abstract

Cross-border payments play a significant role in the global economy. As per Bank of England estimate, the value of cross border payments is expected to increase to $250 trillion by 2027. However, the cross-border payments space has been facing persistent challenges, especially in terms of the cost, speed and transparency. In this thesis the traditional cross border payment models are critically compared among themselves and also with the existing blockchain based models. After the assessment, it was found that traditional models fall short in areas where blockchain models excel. Conversely, the blockchain based models have weakness in areas where traditional models do well. From this assessment and other considerations, a new cross-border payments model based on blockchain and smart contracts while still relying on financial intermediaries is proposed, analysed and evaluated. On analysis, it was found that the proposed model can be more effective than both traditional and other prevailing blockchain based models provided the risks are effectively managed.

Introduction

Globalization has been remarkable for many countries. It has helped increased trade with other nations, attracting foreign direct investment (FDIs) to developing nations, providing them new business opportunities, markets and access to new technology. For the society, global trade has improved the standard of living by increasing per capita income and lowering the consumer prices (Erixon, 2018). Cross border payments form the backbone of the system that enables international trade by facilitating settlement of financial obligations and contracts between corporations that engage in international trade. (Saiz et al., 2023). There is no formal definition for cross border payments, but international organization such as world bank define cross border payments as the international transaction between countries, involving exchange of one currency for another (Central Bank Digital Currencies…., 2021).

Cross-border payments can be divided into two categories: wholesale and retail payments. Wholesale payments also referred to as large value payments often involve settlement of transaction between financial organisations such as banks, business corporations and financial markets (Wandhöfer, 2022) and the retail payments are transactions between non-financial corporations, business and its customers, personal transfer between family and friends living in different counties (Bindseil and Pantelopoulos, 2022). Immigration of around 281 million individuals was estimated to be 3.6% of the global population contributing to remittance of 702 billion USD in 2020 (World Migration Report, 2022).

The Cross-border payment industry is growing at the rate of 6-7% year on year and is expected to reach roughly 2.5 trillion USD in revenue by the year 2025 (Denecker et al., 2019). This growth is vastly dependent on robust international payment systems. The existing challenges in the cross-border payment technology can be a hurdle in the growth of international trade and e-commerce. This increase in volume of cross border payments requires attention to meet the capacity it demands. The most prominent inefficiencies of the current cross-border payments system are high cost of transfer, longer settlement time, lack of transparency in pricing (Bindseil and Pantelopoulos, 2022). The focus to improve the above-mentioned inefficiencies are also backed by the G20 countries (Dong, 2021). This has generated interest among researchers, students and various international bodies including financial stability board to come up with new models and processes to improve the existing cross border payment systems. Blockchain technology has been recognised as a viable

candidate to propose new payment methods because of its features such as decentralization, immutability, transparency of transaction, fast processing, accessibility, security and reliability (Arora and Makani, 2021), (Zheng et al., 2017) and (Taherdoost, 2022). Blockchain has also found its application in business areas such as supply chain, health care etc. The research in the domain of blockchain based cross border payments mostly focus on describing its potential benefits, but there is a gap in existing research, as they do not bring about a comprehensive comparative analysis of blockchain based models and traditional models. There is also not much research available proposing solutions to overcome the deficiencies of blockchain based models.

The aim of this thesis is to propose a novel blockchain-based conceptual model for cross-border payments, to effectively tackle the inefficiencies in the existing cross-border payment systems. This thesis illustrates the flow-of-funds and Architecture diagrams to provide a clear representation of the new blockchain-based model. To achieve this aim, existing literature is reviewed to gauge the current state of the cross-border payment industry, understand the characteristics of an efficient payments system, derive an evaluation framework for evaluation of various cross border payment implementations and propose a new model based on these findings. Considering the broad nature of the cross-border payments, the scope of this article is restricted to the remittance of retail cross border payments, which although of low value are more in frequency. The solutions proposed can also be implemented for wholesale payment systems and may also be a blueprint for the startups looking to develop blockchain based solutions for cross border payments.

This paper in addition to Introduction, is divided into various sections, namely: Literature review where through review of existing literature is carried out, followed by Section 3 on Research and Methodology, Section 4 on Results and Discussion and finally Conclusion under Section 5.

Keywords: Cross-border payments, Blockchain, Remittances, Cryptocurrency, CBDCs.
CERCS: S180, Economics.
S181, Financial science.

1.Literature Review

In this section, existing research in cross-border payment systems is reviewed to gain insights into current implementations and identify the existing challenges. Furthermore, research on blockchain technology, its features and current applications in cross border payments is also examined. Existing research on characteristics of an efficient payment system are also reviewed.

1.1. Cross border payments: current implementation models and challenges

Bech and Hancock (2020) have defined a payment system as a combination of procedures, instruments, and regulations that facilitate funds transfer between individuals or groups. The payment system includes both the participants involved in the transaction and the entity responsible for managing the process. Payments between parties from different jurisdictions, which require a foreign exchange and are subject to the rules and regulations of the corresponding jurisdiction, are referred to as cross-border payments (Shirakami et al., 2020). Bindseil and Pantelopoulos (2022) in their study point out that cross border payment systems can be divided into two types retail and wholesale cross border payments. Retail payments generally refer to transactions made by consumers and businesses for the purchase of goods and services. Although each payment is typically for a small amount, the overall volume of these payments is high. In contrast, wholesale payments involve transactions between financial institutions, such as settlements for securities and foreign exchange trades, interbank funding transactions, and payments to central counterparties. These payments are typically of high value and require settlement on a specific day and sometimes at a specific time (Schwarcz, 2021). In the current cross border payment landscape, the payments can be segregated into traditional models (banks, money transfer operators, Fintech) and the more recent block-chain based models (Dong, 2021). These are explored in the following sections.

Bank transfer. Cross border payment, through the banks, involves the customer's visit to his bank (physically/online) with a request to initiate the transfer. The payment is initiated by the sender's bank. When the sender and the recipient are customers of different banks, the funds are transmitted through intermediate banks known as correspondent banks. SWIFT messaging system is used to facilitate payment messages communication between these banks. Correspondent banks are akin to agents and play an important role in providing access to global financial services to the customers of domestic banks (Correspondent Banking, 2016).

A typical cross-border payment involves multiple such banking relationships to provide cross-border payment service to its customers. As the transaction chain lengthens, the cost and time required to settle the funds also prolong (Claussen & Pedersen 2022). This results in lack of transparency, especially with respect to transaction status, fees and settlement time. Presence of centralized intermediaries also heightens the settlement risk as there is a risk of correspondent banks not being able to fulfil the obligations (Park, 2018). Further, the operating times of the banks differ in different jurisdictions (sometimes due to the difference in time zones) adding to the delay in settlements (Auer, et al., 2021). The process-flow is highlighted in the Figure 1.

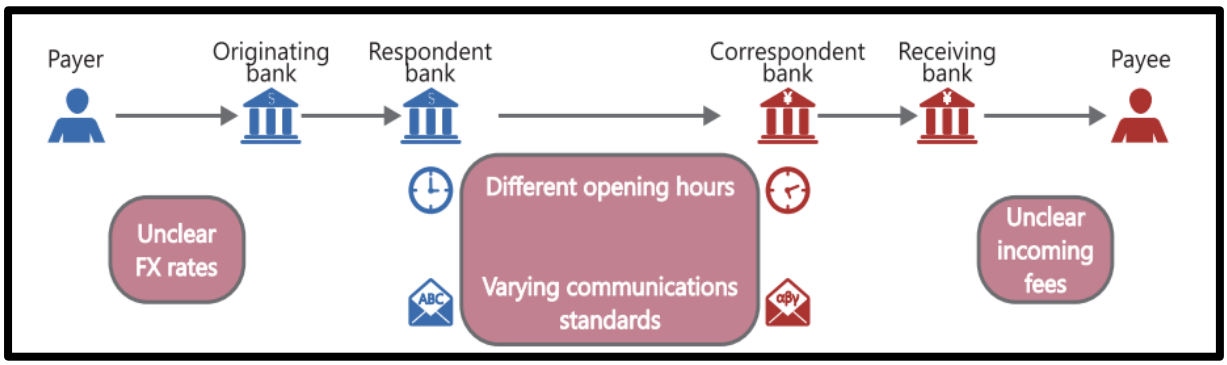

Figure 1. Typical Cross-border Payment transaction flow for Bank transfers
Source: (Multi-CBDC arrangements…, 2021)

Money transfer operators (MTOs). MTOs are organisations that offer payment transfer services at their physical outlets without needing a bank account either via direct cash or digital payment methods. This makes the service highly attractive to users who have no access to bank accounts and those that wish to send and receive direct cash. Some prominent examples are Western Union and MoneyGram. Cash is handed over by the sender to the agent at the MTO store and the money is made available to the recipient at the destination country against an identification or some unique code (Claussen & Pedersen, 2022). This model also is faster than banks due to the way it operates.

Fintech transfers. Fintechs are financial entities similar to MTOs, but they provide online services and do not have agents or physical outlets. As most of the offerings are online, they accept payments from the payer through an online channel like debit, credit card, and interbank payments, unlike traditional MTOs that accept cash pay-in and pay-outs. The customer initiates the transaction on the web platform or Mobile Wallet by making a payment and the recipient is paid out by the FinTech's partner bank in the destination country either for a fee or through prior arrangements such as pre-funding (Claussen & Pedersen, 2022). In

case the same entity has operations in both source and destination, then the settlement can happen in its own books as a closed-loop system. But in other cases, they rely on corresponding banking networks and the foreign exchange transactions are settled in the books of a bank. (The Future of Money…, 2022).

The challenges that hinder the efficiency of cross border payments in general are discussed by various researchers. Zetzsche (2022) and Bindseil and Pantelopoulos (2022) in their research discuss these challenges which include high costs, low processing speed, limited access to the services, lack of transparency, liquidity and prefunding. Ishrat (2020) in his research studied the high costs and has claimed that this usually arise due to transaction fees, account fees, foreign exchange fees, and liquidity costs Additionally, Sergeev et al (2021) studied the operational costs that results from several checks that are required to be employed to tackle complex anti-money laundering (AML), Combating the Financing of Terrorism (CFT), sanction screening, and know-your-customer (KYC) checks. Depending on the origin and destination jurisdiction, as the intermediary chain grows these checks must be performed at each of the correspondent banks before processing the payments, further increasing the cost and time required to settle cross-border payments. Sloboda (2017) studied the issues related to cross border payment speed and found that they are the manifestation of strict regulatory checks such as AML, CFT, and KYC along the chain of intermediaries also hinder the speed of cross-border payments. The limited overlap of business hours across the time zones increases the time required to process cross-border payments. As more intermediaries are involved, more time is required to complete compliance checks, leading to slow settlement speeds. Dong (2021) in his study also refers to similar problems highlighted by other authors we have discussed so far, and he also points out the efficiency that can be gained with blockchain technology.

1.2. Blockchain technology and its application in cross border payments

Blockchain as a technology was theorized by Satoshi Nakamoto in 2008 and implemented in 2009 (Monrat and Schelen, 2019). Since then, there has been vast research to find its application in different industries. Swan (2015) defines Blockchain technology as a decentralized, distributed ledger that records transactions in a tamper-resistant and transparent manner. Nuttah et al. (2023) describes blockchain as a chain of blocks ordered chronologically, where each block is a container of data. The study conducted by (Monrat and Schelen, 2019) and (Aste et al.,2017) highlight the following characteristics of blockchain: Decentralization, persistency, anonymity, auditability.

The authors (Dattani and Sheth, 2019) and (Ratha et al.,2022) describe in their study various types of block chain systems. Permissionless or public blockchain are one which provide access to everyone as long as they adhere to blockchain rules. Permissioned or private blockchain are not available to everyone, they usually belong to a certain individual or organization that manage the permission and authorization to access and verify add transaction to blocks. These characteristics make blockchain optimal when applied to different domains such as: healthcare, voting, trade finance, Government payments and cross border payments. Research to find blockchain's utility in different business domains continue to increase (Monrat and Schelen, 2019), (Aste et al., 2017). The study by (Saripalli, 2021) identifies the benefits of application of blockchain technology to Government related payments. The study conducted by (Vazquez et al., 2021) describes benefits and risks of various blockchains such as Bitcoin, Ethereum and Ripple. The study by (Ganne, 2018) also highlights the importance of blockchain and its application in different business areas also bringing out some important limitations related to blockchain based cross border payments models such as Bitcoin based model, in terms of cost, speed scalability and network congestions. Flow of funds for Bitcoin and other crypto currency-based models are described below.

Bitcoin based models. "Bitcoin is a peer-to-peer cash system where exchange happens directly between the parties involved without the involvement of a trusted third party." (Satoshi Nakamoto, 2008). The network operates like a non-reversal cash-like transaction system i.e., without any central authority. Users can download the open-sourced bitcoin wallet and start receiving bitcoin from other's wallet. In order for a transaction to be completed, the proposed transaction should be inserted in the blockchain i.e., decentralized database. For the transaction to be inserted, consensus needs to be arrived at by the nodes. For consensus to be arrived, the node that mined the transaction should demonstrate a solution to a cryptographic puzzle i.e., Proof of Work (POW). (Sun Yin et al., 2019) (Nguyen and Kim, 2018).

Other cryptocurrency backed models. Inspired by the potential of the blockchain technology, several projects came up to facilitate cross border payments. In such models, cryptocurrency is used as a back-end to facilitate remittances (Reinventing Remittances…, 2017). One of the most notable blockchain-based cross-border payment Network is Ripple, which uses its native XRP token to facilitate near-instant cross-border payments between financial institutions (Qing Deng, 2018). Ripple proposed a model which involves using a crypto currency XRP as a bridge currency. The sender transfers money by converting it into

XRP token and the recipient converts it into local currency by selling the XRP (Qing Deng, 2018).

There has been innovation in recent years in the field of cross border payments, like e-money. The study by (Grifoli et al., 2021) and (wu et al., 2021) focus on the innovation seen in cross border payment field as e-money and mobile payment, E-money is becoming a significant player in the payments industry, and its main difference from cryptocurrencies is that it offers claims that can be redeemed for their full value in currency whenever requested. These include private players like Alipay, WeChat, and M-Pesa etc. The authors identify 4 issues with e-money such as Liquidity risk, default risk, market risk, foreign exchange risk.

As is evident, adequate research work was conducted on identifying the problems of cross border payments in various traditional models such as those pertaining to banks and other financial entities. Current research also describes the potential of blockchain and crypto currencies and informs blockchain as a possible solution to various problems. However not much research was seen in actually proposing a model that can act as a blueprint for implementing blockchain solution to cross border payments.

This paper aims to suggest such a model basing on the findings of a comparative analysis of traditional models and existing blockchain based models. The comparative analysis is carried out using an evaluation framework described in the following section.

1.3. Characteristics of efficient cross border payment system

The study conducted by (Khiaonarong, 2003) says that efficiency of payment system can be classified into two categories technological and economic efficiency. Technological efficiency focuses on adoption of new technology in computing and networking domain to benefit in operational performance such as speed and automation of monotonous tasks. Economic efficiency deals with management and allocation of resources in operations related to payment and settlement to have economic benefits in terms of cost in operations and price for the services offered to the customers. In the study conducted by (Masihuddin et al., 2017) suggest the following to be the characteristics of an efficient payment system: integrity and authorization, confidentiality or privacy, availability and reliability. the study conducted by (Abrazhevich, 2001) and (Asokan et.al., 1997) highlights that a payment is efficient if it has the following features anonymity, applicability, authorization type, convertibility, ease of use (usability), efficiency, interoperability, reliability, scalability, safety, traceability, and trust. Based on the review of existing literature, an efficient payment system should include following characteristics:

a) Transaction fee – The cost incurred to transfer funds through model should be minimal (Neuman & Medvinsky, 1995), (Coutinho et al., 2023).
b) Transaction Time – The system should settle the payments instantly (Neuman & Medvinsky, 1995), (Coutinho et al., 2023) (Bezovski, 2016).
c) Transparency – The pricing should be available at the time of initiation, and payment status should be available until settlement is completed (Abrazhevich,2001) & (Asokan et al.,1997).
d) Safety – The transaction should be safe from financial loss and potential risks (Gregor, 2003).
e) Access – The payment system should be accessible to everyone (Neuman & Medvinsky, 1995).
f) Prefunding – The system should not require any pre-funding, as system should have instantaneous settlement. (Neuman & Medvinsky, 1995), (Abrazhevich, 2001) & (Asokan et al.,1997).
g) Scalability – The system should be able to adapt to the volume and demand for payments and should perform efficiently (Abrazhevich, 2001).
h) Volatility – The value transfer through the payment system should not depreciate until settlement (Gregor, 2003).
i) Compliance compatibility – The Payment system should be compliant to rules and regulation of all jurisdiction (Gregor, 2003).

The issue of privacy and confidentiality is more a legal issue than a technological one. The regulation of the data brokerage industry requires a legislative solution. This paper will use the efficiency criteria discussed by the authors in the above section to draw an evaluation criterion to evaluate both traditional and blockchain based cross border models in the upcoming section of the paper.

2. Methodology and Data

2.1. Methodology

Comparative analysis of traditional and existing blockchain based models of cross border payments carried out using the evaluation framework detailed in Table 1. The Evaluation framework is derived from the characteristics of the efficient payment system as reviewed during the literature review. The findings of the comparative analysis would be

used to propose a new model. The new model would then be evaluated using the same evaluation framework.

Table 1

Evaluation frame work for assessment of cross border payment models

Characteristics	**criterion**	**Assessment Grade**
Transaction fee	Percentage of transaction amount	+, if < 1% 0, if 1% to 3% -, if >3%
Transaction time	Time taken for the funds to reach the recipient	+, if settled instantly 0, if settled on same day -, if settlement takes days
Transparency	Extent to which the transaction status and fees information are available to sender before initiating payment.	+, if full and accurate information disclosed 0, if inadequate disclosure -, if partial disclosure
Safety	Extent to which the Risk of financial loss are managed	+, if all risks mitigated 0, if some risks exist -, if multiple unmanaged risks.
Access	Extent to which the Restrictions (KYC, digital ID etc.) or roadblocks in accessing the payment system is removed or managed.	+, if permissionless 0, if permission required but criteria is lenient -, if permission required with strict KYC procedures
Prefunding	Requirement of additional liquidity in single or multiple currencies for prefunding the payments	+, if No pre-funding required 0, if pre-funding required but has liquidity risk -, if Prefunding and liquidity risk exist
Scalability	Ability to handle increasing volume	+, if High 0, if Reasonable -, if Low
Volatility	Extent to which value of transaction does change before the transaction is completed.	+, if Low 0, if Reasonable -, if High
Compliance Compatibility	System should be able to handle regulatory requirement	+, Compatible 0, Not fully compatible -, Not Compatible

Source: compiled by authors

For traditional models: Bank transfers, Money Transfer Operators (MTOs) and FinTechs are considered. For blockchain based models, Bitcoin based and Ripple (crypto currency based) are considered. For the newly proposed model, Polygon Network is considered. The selection of these models is based on the criteria of market share (Greene and David 1984) (Fernandez et al, 2021). Currently banks, FinTechs and MTOs have a majority market share in the cross-border payments. Within the blockchain based models, Bitcoin Network in general has the highest Market Capitalization and Ripple Network have the highest market share in based cross border blockchain payments. Polygon is the Layer 2 network of Ethereum blockchain with highest market capitalization. (coinmarketcap.com, 2023).

Following steps are carried out to conduct the research: Data Collection, Analysis of the data with reference to evaluation framework, Comparative analysis, Analyse the findings, propose a new model as solution and assess the new model as per the conceptual framework. For the purpose of reference, a transaction amount of $200 is considered.

The data required to be collected as per the framework involves both quantitative and qualitative data. The quantitative data is analysed using statistic measures as per the applicability. The formulas used for calculation of Transaction fee and Transaction time of the proposed model are derived and described in the subsequent Discussion section. On the other hand, the qualitative data is subject to manual review technique. It involved the following steps: (Golder et al., 2014)

(a) Preliminary screening of documents was done through reading of the titles and abstracts.
(b) Subsequently the content of the papers was quickly scanned for presence of relevant content.
(c) The papers containing the relevant contents were read in detail and relevant data is collected as per the assessment framework along with concise process flow of each payment model.

2.2. Data collection

Quantitative data pertains to transaction cost and transaction speed. Quantitative data for traditional models is collected from The World Bank, Remittance Prices Worldwide database containing 122,055 transaction details for Banks, MTOs and MTO-Online from 2016-Q2 to 2022-Q3, following was the representation in percentage, Banks 18%, MTOs 46%, and MTO-Online was 36%. The world bank data is very comprehensive and includes data from 215 countries. Following data is extracted for each transaction: settlement time and

cost taken to complete transaction. Secondary data is preferred over primary data source considering the resource constraints and indications from literature review that transparency with respect to pricing and time could be an issue with financial institutions. The relevant data is extracted for the purpose of analysis. The total cost to send $200 is calculated as percentage average of all fees and charges such as fee charged by financial institution, foreign exchange conversion fee and foreign exchange margin applied. The transaction time is calculated on the frequency of variable speed actual over the total transactions of an institution and represented in percentage.

Quantitative data for blockchain models is directly sourced from the blockchain explorers as the data is accessible to anyone. Considering that the blockchain is relatively emerging domain, recent data i.e., 3 months (January 2023 to March 2023) is collected for the purpose of analysis. Dune Analytics tool is used to filter and extract the data from blockchain.

Exploratory data gathering technique is used for collecting data for qualitative points as it is well suited for studies involving innovative environment (Iansiti et al., 2004) (Adner et al., 2010). This data is primarily sourced from analysis of documents and research papers database published by various International Organizations such as International Monetary Fund (IMF), World Bank and Bank of International Settlements (BIS), Financial Stability Board (FSB) and various central banks in addition to scientific literature. Additionally, data related to blockchain models is sourced from the white papers, research papers and reports from respective blockchain explorers. The documents are interpreted within the context of the data points of the conceptual framework. (Bowen, 2009). Rationale for restricting the sources only to the above-mentioned international organizations and central banks is as follows: (Bowen, 2009)

(a) The focus is on the quality of the documents chosen rather on the quantity. The authors are the experts in the respective fields and tone of the documents is free of agenda and based on facts or objective findings.
(b) The choice of the sources for documents ensured that there is no bias as these international organizations do not represent any particular financial institutions.

3. Results and discussion

This section is divided in two parts, in the first part the findings of comparative analysis of existing cross border payment models are discussed, which is performed using the evaluation framework discussed in the previous sections. The seconds part will introduce a

new conceptual process model for cross border payments using the inputs from the comparative analysis previously mentioned.

3.1. Comparative analysis

Transaction fee. Analysis of the data collected from the World bank remittances database was carried out to arrive at the global average cost for banks, MTOs and Fintechs. This showed that for transferring $200, the average transaction cost charged by the banks was found to be the highest at 10.5% and MTO-online (FinTech) is found to be lowest at 4.8%. Traditional MTOs charged an average of 6.4%. On the other hand, analysis of the bitcoin blockchain data for the period January 2023 to March 2023 showed that the average transaction fees are $1.67, irrespective of the amount or total value of the transaction. The transaction fee is much lower than the traditional payment methods. Ripple network however has the lowest fees with only a few cents i.e., almost zero fees. Therefore, the evaluation of blockchain based models is "+". Considering the very high cost on comparative basis, the evaluation for banks, MTOs and Fintechs is negative i.e., "-".

Transaction time. Upon data analysis, it has been observed that bank transfers involved the highest transfer time. A majority of the bank transfers (around 62%) took around 2-5 days to reach the beneficiary. On the other hand, a significant portion of the transactions undertaken by MTOs and Fintechs (MTO-Online) took less than an hour to settle. Below figure 2 illustrates the performance of the each of the traditional payment models with respect to the transaction time.

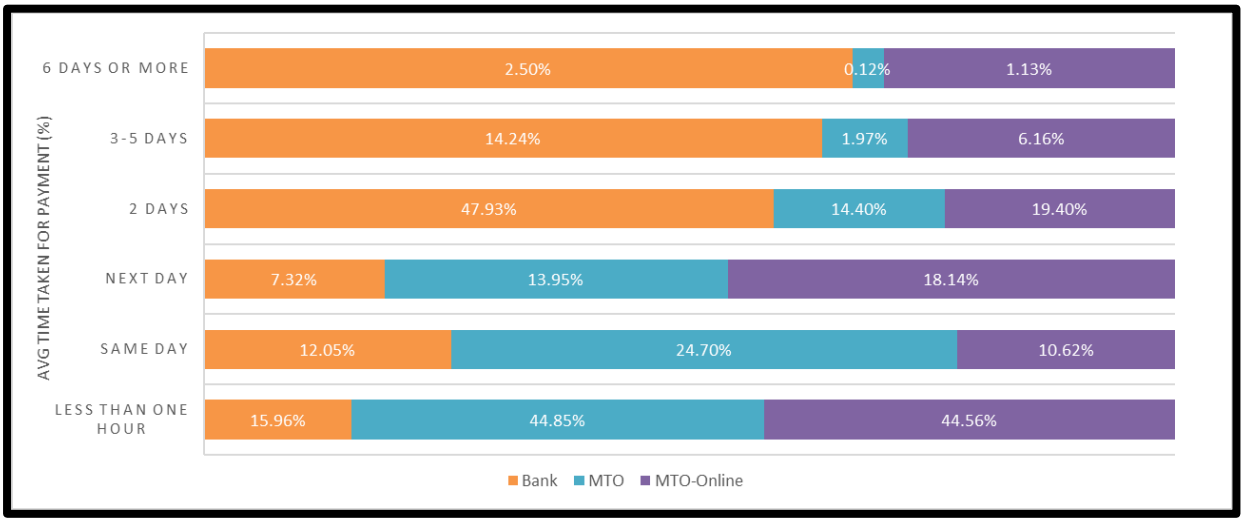

Figure 2. Average time required for traditional model to send $200

Source: Compiled by authors

On the other hand, for the bitcoin network, the average transaction confirmation time is 85.13 minutes. However, on further analysis, it is found that nearly 70% of the transactions get confirmed with an hour. And the rest of the transactions completed within 10 hours. Compared to MTOs and Fintechs, the percentage of transactions completed within one hour is higher. While MTOs and Fintechs took more than one day for around 30% and 45% of the transactions respectively, none of the bitcoin transactions took more than ten hours. Same day payments at MTOs and Fintechs usually pertain to closed loop systems where payer and payee must have account with the same service provider (Cross-border Retail Payments, 2018). For the ripple network, the transaction confirmation is real-time i.e. instantaneous. Therefore, while the evaluation for the banks is negative, the evaluation for MTOs and Fintech is reasonable. And for Bitcoin and ripple, the evaluation is positive.

Transparency. In the traditional models, the transaction involves flow of funds through multiple intermediaries such as correspondent banks and hence the transparency in terms of cost and status of transaction is very limited. (Enhancing Cross-border Payments, 2020). Customers often find it difficult to trace the funds i.e., predict when the funds would be available to the recipient and also to know how much payment would cost before sending it. In many cases, other MTOs and Fintechs also rely on banks and their correspondent relationships at least in part (Cross-border Retail Payments, 2018). On the other hand, the transaction details (costs, fees) of Bitcoin or other crypto based models such as Ripple are openly available for the public to view. Therefore, while the evaluation for traditional models is negative, the evaluation for blockchain based models is positive.

Safety. Banks and other financial institutions such as MTOs and Fintechs are regulated entities and bound by the domestic compliance requirements. Therefore, customers have complaints or recourse mechanisms. However, the traditional models are exposed to settlement risk, exchange rate risk and liquidity risk as the settlement is not real-time. (Cross-border Retail Payments, 2018) (The Future of Money…, 2022). Around a third of the transactions are exposed to foreign exchange settlement risk (Glowka and Nilsson, 2022).

On the other hand, the settlement for bitcoin and other crypto currencies such as ripple XRP is near real-time and therefore there is no settlement risk. However, they do not fall under the ambit of the regulatory compliance and hence there are no customer protection mandates such as compliant mechanisms or any other recourse mechanisms. Therefore, vulnerable to frauds and malicious activities. (Decrypting Financial stability risks…, 2022) (Chimienti et al., 2019). Considering the above safety and risk aspects, the traditional

models are evaluated as reasonable, while the blockchain based models are evaluated as Negative.

Access. Access to cross border payments require an account with the bank. Anyone with adequate KYC can open a bank account to access the global payments at bank. However, KYC, data issues and lack of Digital IDs is resulting in lack of access to a transaction account to around 31% of the adults worldwide, especially in the developing countries where a large chunk of remittances are sent. (Targets for Addressing…, 2021) (The Global Findex Database…, 2018). On the other hand, to receive funds in bitcoin or any crypto currency such as XRP, the recipient needs to download an open-source wallet in his mobile phone and share his wallet address details with the sender, as such removing any access barriers. Traditional models are therefore evaluated as Reasonable, while the blockchain based models are evaluated as positive.

Prefunding and liquidity issues. Traditional models require maintaining idle cash balances in different foreign currencies based on forecast of customer's demand (Cross-border Retail Payments, 2018). Netting can reduce the costs involved but netting efficiency is reduced because of the fact that there are different messaging formats between the intermediaries and also different time zones. This adds to the liquidity costs (Cross-border Retail Payments, 2018). Even though the forex markets operate 24/7, there have been instances of intraday flash crashes in the exchange prices during the "witching hours". This results in liquidity issues. (The sterling 'flash event'…, 2016) On the other hand, in blockchain based models, there is no necessity of pre-funding as the Bitcoin or a cryptocurrency act as a bridge currency. There could, however, be issues due to lack of adequate liquidity at the destination for converting bitcoin/crypto currency to local currency (Buenaventura, 2017). In view of above, the traditional models are assessed as Negative, while the blockchain based models are assessed to be Reasonable.

Scalability. From technology perspective the traditional models are scalable as they rely on centralized systems such as Core banking System which can be scaled with some enhancements and server capacity upgrades (Fakhrudin et al., 2019). On the other hand, Bitcoin scalability when measured in terms of throughput is restricted to around 3-4 transactions per second (Sanka and Cheung, 2021). However, new scaling techniques Layer 2's such as Lightening Network are being worked upon by the bitcoin community to increase the scalability. (Makarov and Schoar, 2022). The scalability of some other crypto backed projects such as Ripple is on the higher side as they rely on consensus mechanism which is different from that of Bitcoin's Proof of Work (PoW) consensus mechanism (Eklund and Beck, 2019).

In view of above, considering the current developments, the traditional models could be assessed as Positive, while bitcoin as negative and other crypto backed models as Positive.

Volatility. Traditional models are backed by stable fiat currencies and are therefore not exposed to volatility risk. However, on the other hand, bitcoin and other crypto backed models are exposed to the volatility of the underlying asset. The difference between futures and spot prices can go as high as 60% p.a. and vary over time (Schmeling et al., 2023). While the Volatility of the Bitcoin decreased over the years, it is significantly higher than other financial assets (Decrypting Financial stability…, 2022). Therefore, Positive Assessment is given for traditional models, while Negative assessment is given for blockchain based models.

Compliance compatibility. In general, there is no single centralized entity responsible to ensure compliance to extant Government and regulatory instructions such as those related to Know your customer (KYC) and Anti-Money Laundering. As a result, unlike the traditional financial institutions, the crypto based models usually take place without any formal supervision or regulatory checks and balances (Decrypting Financial stability…, 2022). Global standards or regulations required to safe guard the payments using Bitcoin or crypto are currently non-available, leading to regulatory gaps and enhanced risks (Bains et al., 2022). Lack of global standards, conduct regulations and safeguarding rules make the assessment negative for Bitcoin and crypto backed models. The Traditional models can be assessed as positive as regulations are clearly defined.

Overall assessment and findings. The traditional and blockchain based models are evaluated as per the conceptual framework and the overall assessment is summarized in the Table 2 below.

Table 2

Overall assessment of traditional and blockchain models.

	Banks	MTOs	FinTech	Bitcoin	Other Crypto based
Transaction Fee	-	-	-	+	+
Transaction Time	-	**0**	**0**	+	+
Transparency	-	-	-	+	+
Safety	**0**	**0**	**0**	-	-
Accessibility	**0**	**0**	**0**	+	+
Pre-Funding	-	-	-	**0**	**0**
Scalability	+	+	+	-	+
Volatility	+	+	+	-	-
Compliance	+	+	+	-	-

Source: Compiled by authors

The comparative analysis reveals certain interesting findings. One of the most important findings is that the Traditional models fare poorly where blockchain models excel and vice versa. For instance, Traditional models rank low on Transaction fee while the blockchain models rank high. Same is the case with some other characteristics such as transaction Speed, Transparency and pre-funding. At the same time, traditional models score better in Compliance and Volatility characterises where blockchain models fare poorly. Moreover, it is observed that Traditional models are better at scalability compared to Bitcoin. Safety, however, is concern in all the models. However, comparatively, banks and other traditional models fare better in safety aspect. Considering these findings, a new model is proposed that attempts to leverage the benefits of blockchain technology without compromising on the benefits offered by the traditional models.

3.2. Proposed model based on smart contracts

Basic premise. Based on the comparative assessment carried out so far between the traditional payment models and blockchain based payment models, it can be inferred that blockchain based models enhance the transaction speed and reduce the transaction costs among other things but gets compromised on volatility and regulatory compliance. Therefore, the features of the proposed model should not only uphold the efficiency with respect to Cost and time but also with respect to volatility and regulatory compliance.

Tokenization of fiat currency. Further analysis on the reason behind the issues related to volatility and regulatory compliance suggests a single cause i.e., presence of a cryptocurrency as a bridge asset. It is the presence of this cryptocurrency that leads to volatility and regulatory issues. Therefore, the alternate model should strive to process the transaction on blockchain without using any cryptocurrency (Bitcoin or ripple etc.) as a bridge currency. In view of this, the proposed model involves replacing cryptocurrency with non-volatile and fully compliant fiat currencies. Fiat currencies are tokenized and onboarded on to the blockchain so as to enable peer-to-peer transactions of such fiat tokens.

Pre-funding and smart contracts. However, removing the cryptocurrency from the transaction reintroduces old challenge. Crypto-currency acting as a bridge currency eliminates the need for any pre-funding, which is one of the pain points of traditional payment models. By removing it, the problem gets re-introduced as liquidity now needs to be arranged by the participating banks to facilitate the payments in different currencies at

different locations. The alternate model needs to address this problem. Towards this end, it is proposed to incorporate Automated Market Maker (AMM) into the proposed model. AMM refers to the set of smart contracts deployed on the public blockchain that enable anyone to provide liquidity for facilitating the trade or cross border payment transaction in our case. AMM protocols allow traders to exchange one crypto asset for another automatically on a blockchain based on a peer-to-pool model (International banking and financial…, 2021). In other words, the liquidity can be provided by anyone with idle cash and earn fees in return. This frees the capital from stressed banks/financial institutions from maintaining pre-funding and at the same time can enable banks/financial institutions to earn a return for providing liquidity.

Choice of blockchain. Currently there are around 30 public blockchains (coingecko.com). Considering that cross border payments could involve large volume of low value transactions as well, it is important to choose a highly scalable blockchain for the alternate model. This blockchain should also support smart contracts for deploying AMM. Ethereum is the most popular blockchain with the highest market cap among the blockchains with smart contract facility(coingecko.com). However, the transaction fee is relatively higher with lesser scalability. Several Blockchains have come up as an additional layer on top of the Ethereum blockchain to address these issues. Among them, Polygon blockchain is the most used with highest market cap with a Total value locked as high as $7.7 billion (coingecko.com, April 09, 2023). Considering this, the Polygon blockchain has been chosen as the preferred blockchain for the Alternate Model.

The alternate model proposed in on the above premises. This alternate model would be subsequently assessed to know the know how it fares when compared to other models. Functional Architecture of the Proposed Model. The proposed model envisages enabling a smart-contract layer on top of the base blockchain layer. Smart contract refers to the piece of code that is executed by the blockchain transaction validators before the transaction are confirmed. In other words, the smart contracts contain all the logic and instructions that are required to successfully carry-out the payment. This logic thus contains aspects related to payment mandate, currency exchange through liquidity pools, transaction fees and also any KYC/AML/Sanctions related checks. When all these pre-defined conditions are met, the transaction gets executed. Figure 3 illustrates the suggested Architecture. The polygon blockchain is the base layer which acts as a decentralized data to execute and store all the transactions. Smart contract layer contains the logic and only those transactions which are in line with the logic gets approved. Application/Interface layer is used by the banks or other

regulated financial institutions to interact with the blockchain. These institutions can submit the transaction proposals to the blockchain on behalf of their customers.

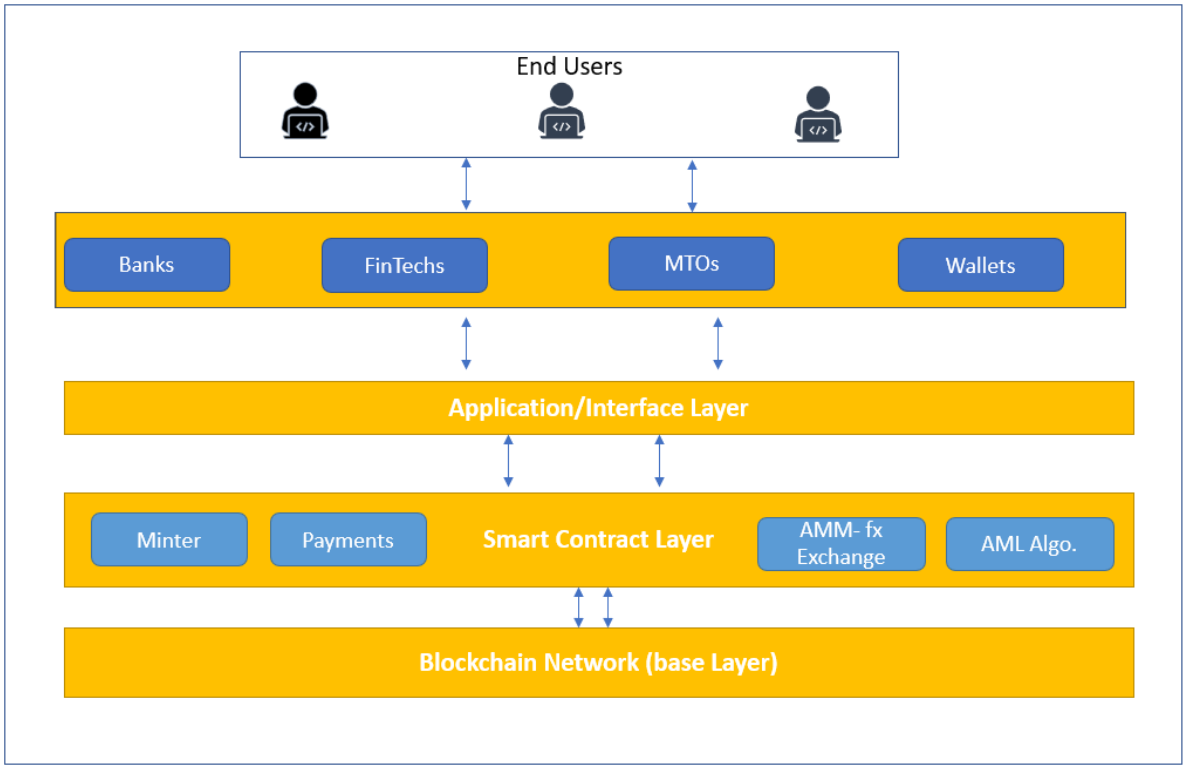

Figure 3. Architecture of the Proposed Model

Source: Compiled by authors

Actors involved – participants and components of the model

Banks and other regulated institutions. These are the institutions that have developed an interface to interact with the blockchain. These institutions receive the payment mandate from their customers and carry-out three specific activities. First, as when they receive the payment instruction, they debit their customers account in fiat and mint equal amount of fiat tokens on the blockchain using the MINT-BURN smart contract. Second, the minted tokens are sent to the customers wallet or sent to the blockchain for currency conversion and subsequent transfer to the beneficiary. Third, they can use their idle cash in different fiat currencies and add currency-pair liquidity using the Liquidity Pool smart contract and earn a part of the transaction fees.

End-Users. Customers of the banks or financial institutions who developed an interface to interact with the blockchain. Customers have access to the blockchain wallet and

they control the movement of funds to and from out of that wallet. The wallet contains fiat tokens minted by their bank and they can use such tokens to initiate cross-currency payments.

Decentralized Exchanges (DeX). These are the decentralized exchanges which facilitate cross-currency swaps. Unlike centralized exchanges, there is no centralized intermediary to be trusted. All the rules of the exchange are written as smart contracts. Such smart contracts include AMM smart contract and Liquidity Pool smart contract which enables the banks and other financial institutions to provide/withdraw liquidity. The smart contract can rely on the currency conversion pricing oracle to obtain the current inter-bank exchange rate.

Flow of funds – transaction flow. Customers initiate the transaction by issuing a payment mandate to their bank or financial institution. It could be done in the same way as they do for domestic payments using various channels such as branch, internet banking or Mobile App. The bank/financial institution then does the usual KYC/AML related and other regulatory checks as per the usual practise and debits the customer's account, mints the fiat tokens on blockchain and credits the customers blockchain wallet. Customer can then initiate the transfer or the bank on behalf of the customer can submit the transaction proposal to the blockchain. The validators of the blockchain validate the transaction as per the smart contract. The AMM smart contract does the currency conversion as per the liquidity available in the liquidity pools and per the current inter-bank exchange rate. Once the validation is successful, the transaction is completed and added to the decentralized ledger. The beneficiary's wallet is thus credited. The beneficiary can send the tokens to his bank's blockchain wallet with a request to withdraw the tokens as fiat currency in his bank account as and when necessary. The funds flow is illustrated in the Figure 4.

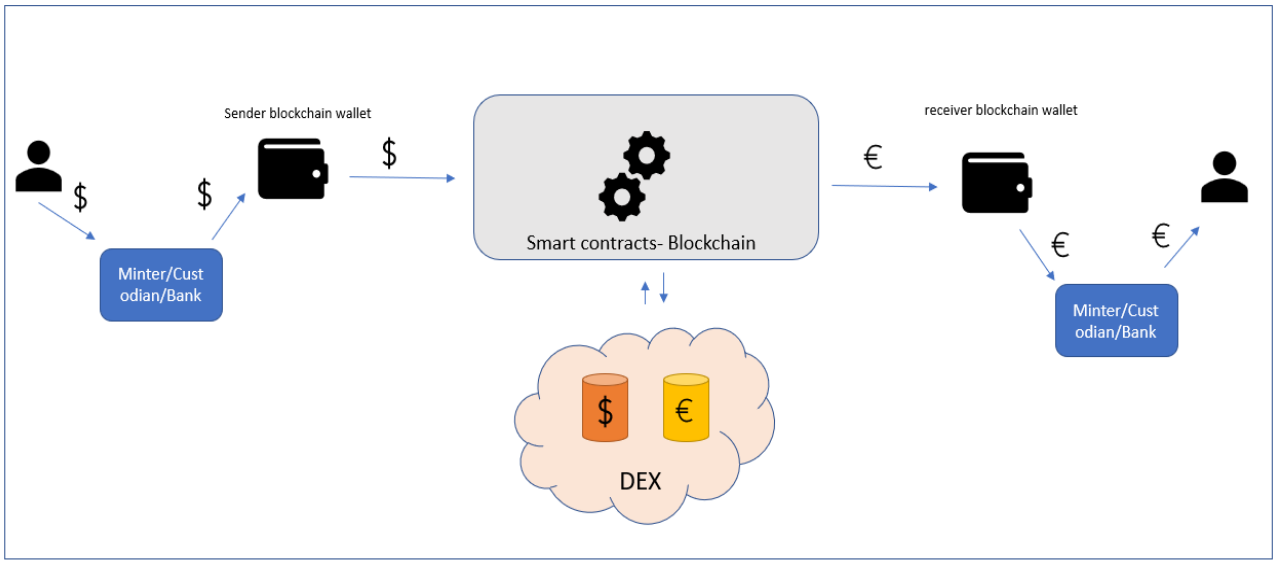

Figure 4. Flow of funds proposed in the alternate Model for USD-Euro pair

Source: Compiled by authors

3.3. Assessment of the model

Transaction fee. The blockchain chosen is public blockchain and as such is free for anyone to access the network. The banks/financial institutions do not incur any overhead or maintenance cost to access the network. The network however charges a transaction fee for every transaction. For every single cross border payment, a maximum of four transactions needs to be submitted:

1. MINT - The sending bank minting the fiat tokens – MINT transaction
2. TRANSFER - The actual funds(tokens) transfer from sender to recipient wallet
3. SWAP -Currency conversion through the DEX AMM.
4. BURN - The recipient the transferring the fiat tokens form his wallet to that of the recipient bank for releasing the fiat in the bank account.

Total payment transaction cost is therefore the sum total of the all the above four transaction costs. The first three transactions are submitted to the blockchain and blockchain charges a network fee. Network fee is the fee charged by the blockchain validators to post the transactions and update the decentralized ledger. AMM charges are charged by the Decentralized exchanges (DEX) and is a fixed amount. The AMM charges go to the Liquidity providers who facilitate the currency conversion. Therefore, the average transaction cost can be calculated using the below formula.

$$\textit{Average Transaction Cost} = 3 \times (\textit{Average Network fee per transaction}) + \textit{DEX fee per transaction} \quad (1)$$

While the fees charged by the DEX is fixed, the fees charged by the blockchain network is a variable. 90 days network fee data is collected as sample i.e., from January 2023 to March 2023 to analyse the network fee. The data is sourced by querying the polygon blockchain decentralized ledger using the blockchain analyser tool – Dune Analytics. As per the analysis of the data, the network fee varies with a range from USD 0.01748 to USD 0.093. The average network fees are USD 0.043. The data is illustrated through Figure 5.

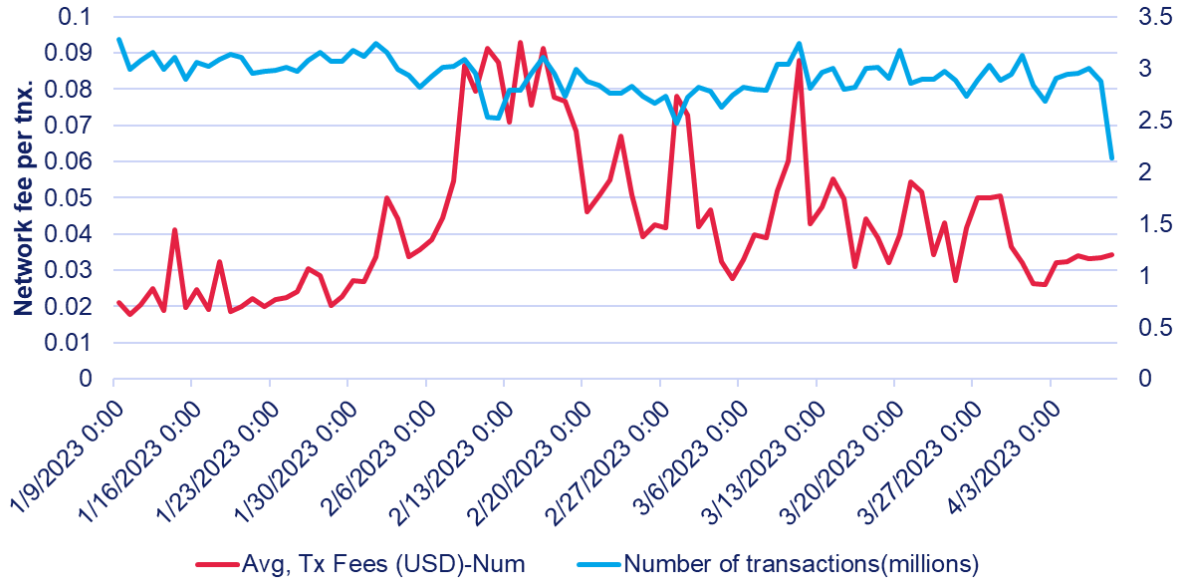

Figure 5. Average cost of network fee per transaction

Source: compiled by authors

To arrive at the DEX fee, data is collected from top five DEX in the blockchain space. The data is illustrated in Figure 6. The fees range from 0.04% to 0.30%. Taking a conservative approach, the maximum fee which is also the mode i.e., 0.3% can be taken as the reference fee for the purpose of evaluation.

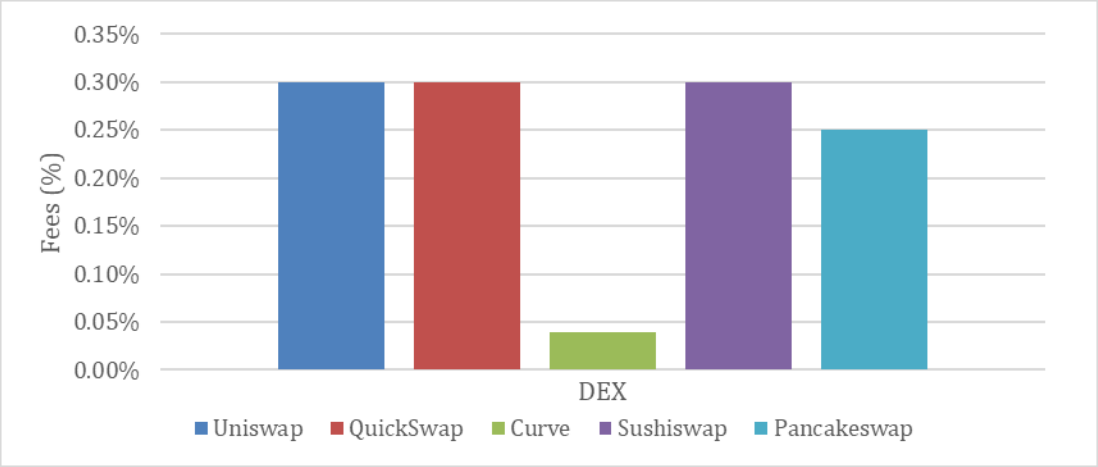

Figure 6. Fees charged by various DEXs

Source: compiled by authors

Using equation (1), the average transaction cost is calculated below.

Average Transaction Cost = 3 × (0.043) + 0.3%

= 0.3% + USD 0.13

~ 0.3%

The average transaction cost of the proposed model is 0.3% which is considerably less compared to traditional banking models and also that of bitcoin for a transaction amount of $200. Therefore, the evaluation is Positive (+).

Transaction time estimation. Overall, the payment transaction involves four sub transactions as explained in the previous section. All these transactions execute sequentially in an automated manner. Therefore, the transaction time can be calculated using the below formula.

Average Transaction Time = 4 × (average transaction completion time) (2)

To arrive at the transaction completion time on blockchain, three months data (January 2023 to March 2023) on the Polygon data is collected as sample and analysed. Data is collected by querying the blockchain scanner. The transaction completion time is varying with a range from 2.07 seconds to 2.61 seconds, with a standard deviation of 0.09. Average time taken for completion of one transaction is 2.24 seconds. The daily average transaction time is depicted in Figure 7.

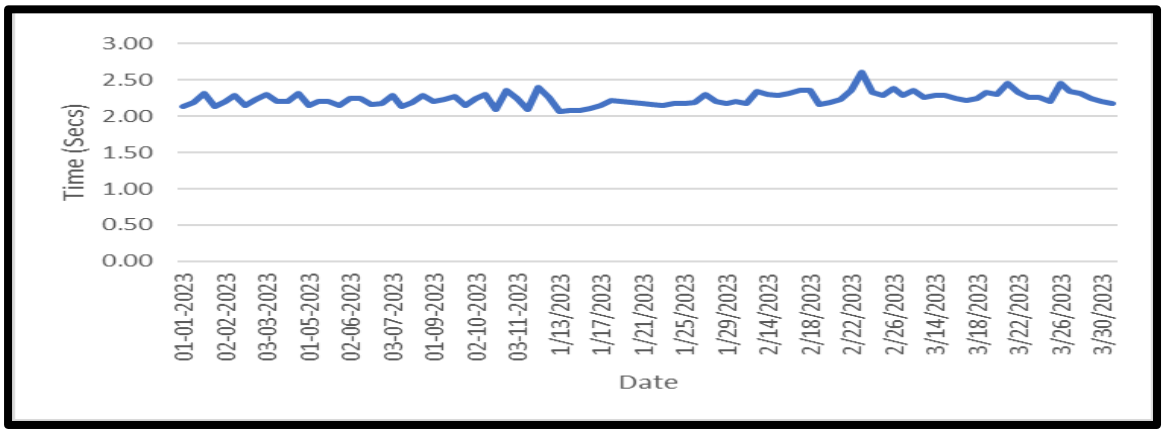

Figure 7. Transaction time in secs on the polygon blockchain

Source: compiled by authors

Using equation (2), the average transaction time is calculated below.

$$\textit{Average Transaction Time} = 4 \times 2.24 = 8.96 \textit{ seconds}$$

As the transaction completion time is hardly few seconds, it is instantaneous and is therefore assessed as positive (+) in comparison to other models.

Transparency. The model involves public blockchain and the transaction fee and the status are available for anyone to access. Therefore, the model can be assessed as Positive (+).

Safety. By bringing together the regulated financial entities and the blockchain together, all the safety of the customer protection extends to the model, while eliminating the settlement risk. Therefore, compared to other models, the assessment is Positive (+).

Accessibility. Since the access is through the financial institutions, the same norms such as those related to having a transaction account would apply. Therefore, accessibility is on the lower side compared to the bitcoin but is at par with the traditional models. Therefore, the assessment is Reasonable (0).

Prefunding. Requirement of pre-funding does not arise as the transactions are settled on real-time basis. As such the model involves peer-to-pool model where in liquidity is pooled by the participants and end-users in return for share in transaction fees. As a result, the balance sheets of the participating Financial Institutions are not negatively affected. The assessment is therefore Positive (+).

Scalability. The scalability of the model depends on the scalability of the blockchain acting as the backend. In the case of polygon, it is 7200 transactions per second. For

comparison, VISA card network processes around 1700 transactions per second. (Boissay et al., 2022). The assessment can therefore be Positive (+).

Volatility. The transaction flow does not involve utilizing any crypto currency as a bridge currency and hence the volatility risk is mitigated. As a result, the assessment is Positive (+).

Compliance. Unlike in other crypto based projects, where there is no single centralized body who is responsible transactions, in the proposed model the participating financial institutions which initiate the transaction or mint the fiat tokens on blockchain can comply with regulations. As such, financial intermediaries who submit the transactions comply to the extant regulations such as those related to KYC/AML. Therefore, the assessment is Positive (+).

The overall assessment is summarized in the Table 3 The model sets out to achieve its objective of drastically reducing the transaction cost and significantly increasing the transaction speed without compromising on regulatory compliance.

Table 3

Evaluation of the Alternate Model

	Banks	MTOs	FinTech	Bitcoin	Other Crypto based	Proposed Model
Transaction Fee	-	-	-	+	+	+
Transaction Time	-	**0**	**0**	+	+	+
Transparency	-	-	-	+	+	+
Safety	**0**	**0**	**0**	-	-	+
Accessibility	**0**	**0**	**0**	+	+	**0**
Pre-Funding	-	-	-	**0**	**0**	+
Scalability	+	+	+	-	+	+
Volatility	+	+	+	-	-	+
Compliance	+	+	+	-	-	+

Sources: Compiled by authors

For instance, to remit $200, transaction fees are highest for banks at $20, while that of the proposed model is just $0.6, which is a 96% reduction. At the same, it could take a few days for the transaction to complete if it is sent through a bank, while on the proposed model it would hardly take few seconds. Figure 8 compares the transaction fee and transaction time across the models. It can be noted here that, using Ripple network is most efficient in terms of cost and time, but these benefits get offset by the safety, liquidity issues in various

jurisdictions, price volatility and compliance related risks. The proposed model addresses all these risks of the crypto based models while retaining the benefits of the blockchain.

Figure 8. Transaction Cost and Time to send $200 - Comparison

Source: compiled by authors

On the other hand, the proposed model preserves the benefits of the traditional models such as compliance compatibility, absence of volatility and improved transparency. Additionally, it addresses the settlement and liquidity risks and enhances the safety aspects. This model combines the best of traditional payment models and blockchain based payment models by bringing together regulated entities and the public blockchain without relying on any cryptocurrency as a bridge currency.

Risks and Challenges. Some of the challenges and risks that could be foreseen include:

- **Governance.** Since the blockchain is the open network, not owned by any single entity, who should do the act of coordination to bring together the participating banks becomes an important question to address. In case of traditional model, for example banks, SWIFT is one among the organizations which strives to enhance adoption to its network. Should it be a role of any new start up or a private entity to deploy the smart contracts for a fee and strive to bring the banks as participants or should a big bank deploy the contracts and influence other banks to use the same smart contract? At the same time, how the rules of the operations are decided or modified? Should it be that any modifications should be possible only after voting on blockchain of all the participants, if so, what should be weightage of each vote? These are some of the important questions to be studies upon in terms of both cost benefit analysis and practicability aspects.

- **Security.** Though public blockchains such as bitcoin and Ethereum are inherently secure and have never been subject to compromise till date, however, there is no assurance that it would be the same in future especially with threat vectors such as 51% attacks. (Makarov et al., 2022). Additionally, there could be issues related to smart contract defects which could result in loss of funds. To manage this risk, the participants need to carry out the Smart Contract audits. (Adrian et al., 2022)
- **Regulatory clarity**. The proposed model is compliant friendly as it is driven by regulated financial entities with blockchain as a backend and relying on fiat tokens for payments as there are already certain regulations on e-money issued by the financial institutions. In general, the regulations are technology neutral (Coelho et al., 2021). However, considering that blockchain introduces a completely new architecture without any centralized entities, lack on regulatory clarity on the broader public blockchain ecosystem could be a concern and could impact the future compliance costs. Regulatory clarity through legislations such as MICA in case of European Union helps address this risk.
- **Banks and financial institutions failures / default risk.** The minting of tokens involves banks acting as custodian to fiat currency and issuing tokens in return on the blockchain. In other words, banks collect fiat currency and issues tokens in return. This introduces Bank failure risk and is increasing relevant under the current banking-sector turmoil. (FSB Chair's letter to G20…, 2023). One way to manage this risk is to replace fiat currency with Central Bank Digital Currencies (CBDCs) for collateral purposes to mint tokens on blockchain. CBDCs are the digital cash issued by the Central banks and are liabilities of central banks unlike fiat currency where the liability rests with the banks. Questions such as who should issue the CBDC backed tokens, startups or Fintech companies or regulated financial entities? What should be the regulations around it? Etc. needs further research.

4.Conclusion

In conclusion, this thesis has proposed a novel blockchain-based conceptual model for cross-border payments. In this thesis, comprehensive study of existing literature was carried out to identify the problems in cross-border payments and to derive a framework that was used for comparative analysis of various cross border payment models. Additionally, the existing literature was used to describe various cross border payment models and also to understand the current status of research in blockchain technology and its application to various domains, especially payments. For traditional models, banks transfer, transfer through MTOs and through FinTechs were considered. For blockchain based transfers, Bitcoin network and Ripple was considered. Data collected through secondary and exploratory data gathering technique was used to carry out a comparative analysis of various cross border payment models. Integrity of the data collected was ensured through relying on neutral sources without bias. The findings therein were thoroughly discussed. One of the important findings is that blockchain models fare considerably well in those characteristics where the traditional models fare poorly and vice versa. Accordingly, a new model of cross border payments that combines the best of traditional and blockchain based models was proposed and illustrated through its flow of funds and architecture diagrams.

The proposed model suggests that regulated financial entities can connect to a scalable, secure and proven public blockchain, while utilizing the liquidity from the peer-to-pool liquidity pools to facilitate cross border payments. This way the model benefits from the low cost, high speed, mitigated settlement risk and transparency aspects of blockchain, while retaining the benefits of traditional models such as safety and regulatory compliance. In sum, the proposed model relied on smart contracts and automated market makers (AMM) and was found to be more effective than other compared models of cross border payments. Risk analysis was also carried out to highlight various risks including those related to regulatory and legal risks, governance risks, security and Banks failure risk. It is essential to address these risks to ensure success of the proposed model.

This article has contributed to the existing literature on cross border payments by proposing a new model which leverages latest developments in blockchain technology, while suggesting the risks and possible risk mitigation measures. Further research could focus on testing the proposed model and risk management of the proposed risks. For instance, future research could focus on various models of governance. Additional research can also be carried to assess and propose suitable regulatory framework for successful implementation of

the model. Further research work can also be carried out on the financial viability of the AMM and the peer-to-pool model where in the liquidity can be supplied by any individual or institution with idle cash, in return for fees. It can also promote wider adoption of blockchain and the model can be used as a reference by the startups developing cross border solutions.

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Resümee

Pealkiri – Piiriüleste maksete muutmine plokiahela tehnoloogia võimendamise abil
Saripalli Sri Harsha Vardhan, Deepak Raman Naidu

See artikkel on aidanud kaasa olemasolevale kirjandusele piiriüleste maksete kohta, pakkudes välja uue mudeli, mis kasutab plokiahela tehnoloogia uusimaid arenguid, soovitades samas riske ja võimalikke riskide vähendamise meetmeid. Näiteks võiks uurimistöö keskenduda erinevatele valitsemismudelitele. Edasised uuringud võiksid keskenduda pakutud mudeli testimisele ja kavandatavate riskide riskijuhtimisele. Mudeli edukaks rakendamiseks sobiva reguleeriva raamistiku hindamiseks ja välja pakkumiseks võib läbi viia ka täiendavaid uuringuid. Täiendavat uurimistööd saab läbi viia ka AMM-i rahalise elujõulisuse ja peer-to-pool mudeli kohta, kus likviidsust saab tasu eest varustada iga eraisik või asutus, kellel ei ole sularaha. Samuti võib see edendada plokiahela laiemat kasutuselevõttu, kuna mudelit saavad piiriüleseid lahendusi arendavad idufirmad kasutada võrdlusalusena.

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