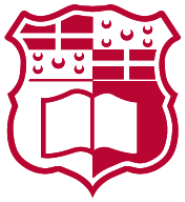

L-Università ta' Malta
Centre for Distributed
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The Future of Global Remittance Payments

On identifying cost drivers and the role of blockchain technology

by

Andre Skauradssun

A dissertation submitted in partial fulfilment of the requirements of the Master of Science in Blockchain and Distributed Ledger Technologies (Business and Finance Stream)

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DECLARATIONS BY POSTGRADUATE STUDENTS

Student's Code: 2201566

Student's Name & Surname: Andre Skauradssun

Course: Master of Science in Blockchain and Distributed Ledger Technologies

Title of Dissertation: "The future of global remittance payments: On identifying cost drivers and the role of blockchain technology"

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Abstract

The estimated number of international migrants has steadily increased over the past decades and so have cross-border payments. Remittances often constitute a lifeline on the receiving end, even more so in low and middle-income countries (LMICs). Despite their importance, transaction costs of sending small-value payments of around $200 remain high. The United Nations has put the reduction of remittance costs on its agenda for 2030 and researchers seem to have placed their focus on remittance flows and their implications again. While most studies analyse the total flow of funds sent between countries, this study investigates the most important cost drivers of current payment services by implementing a Kruskal-Wallis test and a multiple linear regression model. The results suggest that higher remittance flows and higher percentages of mobile subscriptions are negatively related to transaction costs. On the other hand, higher percentages of people receiving remittances to their bank accounts are positively related to transaction costs. Regional differences are also significant and digital solutions generally outperform traditional channels, such as retail banks. The emergence of blockchain-based payment services has widened the gap as they enable low-cost cross-border payments, often within seconds. Therefore, this dissertation also presents case studies of two specific blockchain networks, the Lightning Network and Stellar, that offer payment infrastructures that other FSPs can connect to or build upon. As these new challengers outperform incumbents in terms of transaction speed and cost while partnering with them to benefit from their extensive distribution networks, they are positioned to capture a significant share of the remittance market and shape the direction the market is heading towards. As even established players are leveraging blockchain technologies to offer more competitive rates, they are set to play an integral part in the future of remittance payments.

Keywords: Remittances, Blockchain, Bitcoin, Cross-border payments

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Abbreviations

- Low and middle-income country (LMIC)
- United States dollars (USD)
- Gross national income (GNI)
- Financial service provider (FSP)
- Know-your-customer (KYC)
- Anti-money-laundering (AML)
- Application-Programming-Interface (API)
- International Monetary Fund (IMF)
- Gross domestic product (GDP)
- Money transfer operator (MTO)
- Smart Remitter Target (SmaRT)
- Foreign exchange rate (FX)
- Automated teller machine (ATM)
- Global Knowledge Partnership on Migration and Development (KNOMAD)
- Society for Worldwide Interbank Financial Telecommunications (Swift)

1. Introduction

In 2022, remittance flows to low and middle-income countries (LMICs) increased by 8 per cent over the previous year to reach $647 billion worldwide (Ratha et al., 2023). Especially in LMICs, access to financial services often is scarce which exacerbates inequalities and hampers the already limited upward social mobility (Corak, 2013). Those who do not have access to reasonable education, and do not possess assets such as real estate, or any assets at all, often depend on low-value remittance payments from family members working abroad in countries with better macroeconomic conditions. Typically consisting of regular transactions below $200, remittances to LMICs often constitute a significant share of receiving countries' gross national income (GNI) and offer lifelines to the financially disadvantaged. Above all, due to their relatively stable nature compared to fluctuating foreign aid and investment flows, they provide support in times of economic hardship as can be seen by the rise in remittances during the Covid-19 pandemic (Kpodar et al., 2021).

Despite their importance, global average transaction costs for remittances of $200 stood at 6.3 per cent of the transaction value in the first quarter of 2023, with significant increases for low-value transactions, certain geographical locations, and payment types (World Bank, 2023a). Currently, traditional financial service providers (FSPs) generally offer to exchange currencies within a few business days and at unfavourable rates for users, punishing users from smaller and politically unstable countries with even higher spreads due to low liquidity and higher exchange-rate fluctuations. Therefore, when formulating its sustainable development goals, the United Nations in collaboration with the G20 countries, included a target regarding remittances for 2030. Target 10.c states that, by 2030, remittances shall cost on average no more than three per cent of the transaction value and that remittance corridors with transaction costs higher than five per cent shall be eliminated entirely (United Nations, 2023).

In the past years, new innovative ways of sending money globally, especially using blockchain technology, have sparked renewed interest among entrepreneurs, regulators, and users to steer towards that direction. The emergence of blockchain-based applications has provided users with a low-cost, secure, and

efficient way to conduct financial transactions using cryptocurrencies such as Bitcoin or dollar-backed stablecoins. The Lightning Network is one example of a payment protocol leveraging Bitcoin's blockchain to facilitate near-instant peer-to-peer transactions, denominated in bitcoins, with transaction costs typically below $0.01 (Glassnode, 2023a). Another one is Stellar, which offers international payments using stablecoins at a similar cost, without the need to own a bank account. However, blockchain-based systems presumably still represent a minor share of the overall market and are not reflected in official statistics.

Given the current remittance sector’s size and its oligopolistic structure of a few dominating FSPs, it raises the question of whether there are inefficiencies, especially in the low-value segment of remittances, that can be mitigated by incorporating blockchain-based technologies for the users’ benefit. Literature on the drivers of remittance flows is vast, however, there is a gap when it comes to analysing drivers of remittance costs. As remittances often represent an important source of income, especially for LMICs, a cost reduction could have a notable positive effect on a country’s well-being.

Transaction costs for commercial remittances or foreign aid tend to be small as a percentage of the funds sent as international FSPs compete for large-value transactions. Remittances of around $200, which are typical amounts sent by migrants working abroad, can be as high as 15 or 20 per cent in less favourable country corridors. Therefore, it is useful to differentiate between small-value and large-value remittances. The focus of this study will be on low-value remittances, defined as a $200 payment, in accordance with the World Bank’s approach.

Our research aims to shed light on two issues. Given the generally high transaction costs associated with remittances, the first part of the analysis will identify the cost drivers of remittances. We will do so first, by analysing remittance-related data using a Kruskal-Wallis test and second, through the use of a multiple linear regression model.

The second issue revolves around the integration of blockchain-based applications into cross-border payment systems. Blockchain-based services can be part of the

solution to lower transaction costs, however, they face certain hurdles. Especially in LMICs, day-to-day transactions are mainly conducted using cash rather than digital payment methods, let alone cryptocurrencies. Therefore, the ‘last mile delivery’, converting cryptocurrencies into locally accepted fiat currency, plays an important role. To be legally accepted and widely used, those services also need to comply with current regulations, such as know-your-customer (KYC), anti-money-laundering (AML) and anti-terror financing laws. As some new players have entered the remittances market recently that provide those services, the second analysis will focus on two blockchain networks that specialise in fast and cheap cross-border payments. More specifically, we present two case studies that examine whether the Lightning Network and Stellar provide new bases for financial services that outperform current dominant players in the remittance industry when it comes to transaction speed and cost.

By doing that, we hope to contribute towards advancing the general idea of using blockchain technologies for remittance payments. This will be of interest to current and future research as potential cost savings and increased financial participation can, from an individual’s perspective, improve living conditions, reduce dependencies on other parties, and possibly even allow saving and participating in small-scale and self-financed business activities. From a macroeconomic perspective, it can reduce the need for welfare benefits, increase employment opportunities which creates more demand for domestic goods, and allow savings leading to a more investor-friendly business climate, ultimately positively impacting economic development.

Our target group is three-fold. Mainly, we want to address regulators and policymakers. We want to point out the use case of efficient remittance payments and the benefits of increased financial participation. Given that regulatory uncertainty and compliance concerns with respect to crypto assets are currently significant hurdles to the widespread use of blockchain-based applications, we hope to stimulate a discussion between stakeholders leading to sensible regulations and political support. Given more regulatory certainty, we also want to target entrepreneurs and investors. We want to put the spotlight on this seemingly overlooked, but large market segment to encourage working on building new

services and funding current ones to increase the competitiveness and performance of remittance solutions. Progress in the underlying architecture has also made it easier to be compliant with local laws and regulations. The goal should be to provide an excellent customer experience while minimising complexity. The last group are the remittance senders themselves. We want to encourage users to try out this new technology enabling them to have more control over their finances and save vital resources in terms of transaction costs, time spent waiting for funds to arrive, and time spent to collect them. We share the United Nations' vision of bringing down remittance costs to below three per cent and hope to be contributing towards that goal with our research.

This study is structured as follows. Section two provides an overview of the literature on remittances and blockchain-based services that facilitate cross-border payments. Section three outlines the methodology employed to identify drivers of remittance transaction costs. In section four, the results are presented, both of the Kruskal-Wallis test and of the regression specifying the key determinants of remittance transaction costs, as well as of the case studies. Section five concludes and puts forward a number of policy recommendations.

2. Literature Review

2.1. Measuring Remittances

The International Monetary Fund (IMF) regularly gathers data on remittances as part of its effort to maintain a database about countries' balance of payment statistics. The World Bank builds upon this data and gathers more with the help of FXC intelligence, a US research company. The World Bank also aggregates data on personal remittances as one of their world development indicators. Data is collected by manual outreach of researchers posing as remittance senders and by collecting data from application programming interfaces (APIs) and websites of different FSPs. Data collection needs to fulfil certain requirements such as the inclusion of transfer fees, exchange-rate margins, and payment instruments. For more information on the World Bank's methodology of data collection, see World Bank (2016). The result is a

quarterly updated database on global remittance prices covering 367 country corridors, along with a published report (World Bank, 2023a).

Generally, remittances can be characterised as non-commercial payments of international migrants to family members and friends in their home countries. However, estimates by the IMF include payments that might not fall under the common informal definition of remittances as their statistical definition is broader. More specifically, personal remittances comprise the sum of employee compensation and personal transfers. In this case, the compensation of employees is the income earned by border, seasonal, and other short-term workers who work in an economy where they do not reside, as well as residents working for non-resident businesses. There are three primary elements to this compensation: wages and salaries paid in cash, wages and salaries provided in kind, and contributions made by employers to social programs. The recorded compensation of employees is a gross figure and encompasses amounts that the employee might pay for taxes or other purposes in the economy where the work takes place (World Bank, n.d.).

Personal transfers, introduced in the sixth edition of the IMF's Balance of Payments Manual, also encompass a more comprehensive view of worker remittances (IMF, 2009). These transfers consist of all current exchanges, either in cash or in kind, between individuals who are residents and those who are non-residents. The nature of the sender's income, whether it's derived from labour, entrepreneurship, property income, social benefits, or other types of transfers, does not play a role. Furthermore, the personal relationship between the households involved in the transfer or absence thereof is not determined.

Due to the use of unofficial channels for global remittances, the exact size of flows is difficult to measure. The total volume of remittance payments including unofficial channels that are not reflected in the official numbers is estimated to be at least 50 per cent larger than recorded flows (Ratha, 2017). Remittances using cryptocurrencies are currently also not captured. The most recent statistics point to global formal remittance flows in the order of $647 billion in 2022 (Ratha et al., 2023). Overall, they represent a major source of financial flows to developing countries, next to foreign aid payments and foreign direct investment, and often

constitute a large share of the destination country's GNI (Barajas et al., 2009). Additionally, remittances differ from alternative capital inflows due to their relatively stable nature (Meyer & Shera, 2017) and sometimes exhibit anti-cyclical attributes as migrant workers want to help their relatives even more in situations of economic hardship or political uncertainty (Yang, 2011; Ratha, 2013). However, there is also evidence that remittances are pro-cyclical in certain countries and that the direction of cyclicality can be subject to change (Sayan, 2006; Makhlouf & Kasmaoui, 2020). Since the state of LMICs is also highly relevant for developed countries, as economic and political stability affect migration and the necessity for foreign aid payments, remittances and their various aspects have been extensively studied.

2.2. Remittances and Economic Growth

To assess whether it is worthwhile for policymakers to attract remittances in the first place, one important aspect is their effect on economic growth. Numerous studies have been conducted and opinions diverge. The related literature can be split into three categories. Studies that find a positive relationship between remittances and economic growth, those that find the opposite, and those that fail to find any relationship at all.

A meta-analysis by Cazachevicia, Havraneka, and Horvath (2020) finds that around 40 per cent of the 95 studies considered found a positive relationship, another 40 per cent could not establish any relationship, and 20 per cent discovered a negative relationship. Their work suggests a publication bias towards studies that found evidence of a positive relationship. Furthermore, attempting to correct this bias, using modern analysis tools, results in a median effect above but close to zero. However, they acknowledge that the median results cover up significant regional differences. Remittance seem to have a growth-enhancing effect in Asia, while the opposite seems to be true for African countries.

Meyer & Shera's (2017) analysis of six Eastern European high remittances receiving countries found a significant positive impact of remittances on economic growth, with an increasing effect at higher levels of remittances relative to gross domestic product (GDP). Adams (2011) and Acosta et al. (2006) attributed remittances' positive impact on economic growth to their implications for domestic saving rates, increased

investments in human and productive capital, and to a lesser extent increased consumption. However, especially in rural areas, an increased consumption level might have a multiplier effect, as additional income is likely spent on domestically produced goods and therefore stimulates the local economy (Ratha, 2003).

Remittances also likely increase financial development through multiple channels. Barajas et al. (2009) claim that remittance payments increase the total amount of funds flowing through the financial system which leads to economies of scale in financial intermediation and provides bigger political leverage for the population to introduce beneficial policy reforms. Giuliano and Ruiz-Arranz (2009) analysed data from over 100 developing countries between 1975 and 2002. They found that remittances also contribute to reducing inefficiencies in financial markets, improving credit constraints for the lower-income population and the allocation of capital for investments. Additionally, they also established a link between the absence of remittances and adverse effects on exchange rates, pressuring monetary and fiscal policymakers. However, remittances seem to be able to stimulate economic growth more in less financially developed countries.

Some studies also found a negative effect of remittances on economic growth, which was largely caused by two circumstances: when remittance payments are largely spent on consumption and when they lead to an appreciation of the real exchange rate.

Using remittances for consumption, especially of foreign goods and services, leads to below-optimal saving rates which, in turn, hinder the availability and distribution of capital for investments. In the long term, this undermines productivity growth and therefore economic growth as well (Lipton, 2012; Chami, Fullenkamp and Jahjah, 2005). Increased capital inflows, such as remittances, generally tend to exert upward pressure on a country's real exchange rate, diverting resources away from the tradable sector (Amuedo-Dorantes & Pozo, 2004; Ball, Lopez and Reyes, 2013). As export costs rise, the country in question might lose its competitiveness, decreasing the demand abroad for exports, therefore leading to higher unemployment, which adversely affects economic growth. In economic literature, this

phenomenon is often referred to as the “Dutch Disease” (Lartey, Mandelman and Acosta, 2009 & 2012).

Clemens and McKenzie (2018) stand in between these two factions as they deny any major effects of remittances on economic growth. They attribute the increase in remittances to changes in measurement and argue that rising emigration is the largest driver of remittances which has an opportunity cost to economic productivity in the source country. However, they claim that remittances do have positive first-order effects on poverty alleviation and global GDP.
It is not only important to analyse remittances’ effects on the economy but also to investigate their volume and characteristics, the most important determinants of transaction costs and transaction times.

2.3. Remittance Flows and Elasticities

Ahmed and Martinez-Zarzoso (2014) investigated remittance flows from 23 countries into Pakistan during the period 2001-2011. Their data suggests that a population’s migrant stock in the source country and financial and political conditions have a significant effect on remittances. In contrast to literature up to that point, they excluded geographic proximity as a predictor in favour of actual transaction costs that started to become more readily available at the time thanks to the data collection efforts of the IMF and World Bank. Economic conditions such as the unemployment rate seem to be less relevant predictors of remittances in their case.

Freund and Spatafora (2007) confirm this hypothesis as they explored determinants of remittances and associated transaction costs and found a cost-reducing effect for the number of migrants in a given country due to economies of scale. Higher transfer costs, usually associated with less financially developed regions, as well as excessive exchange-rate fluctuations or restrictions, tended to increase transaction costs. In that case, their survey data points towards increased use of informal remittance channels or potentially a decrease in overall remittances.

A few years later, Ahmed et al. (2021) confirmed the scale effect discovered by Freund and Spatafora (2007) and found that a one per cent cost decrease for a $200

payment is associated with a 1.6 per cent increase in overall remittance. They drew that conclusion after analysing transaction costs for 30 sending and 75 receiving countries over a six-year period from 2011 to 2017. It is important to note that there might be some endogeneity concerns for remittance flows and costs as costs also have affect remittance flows (Aggarwal, Demirgüç-Kunt & Martínez Pería, 2011). Kpodar et al. (2021) analysed monthly data on remittances for a sample of 52 countries during 2020 to provide an early assessment of remittance flows during the COVID-19 pandemic. Their analysis provides evidence that remittances increased together with infection rates in receiving countries, emphasising their role as important stabilisers in times of need. Furthermore, stricter lockdown measures that restricted movement dampened remittances and a shift occurred from informal to formal remittance flows, likely due to travel restrictions. The size of fiscal stimulus in sending countries seems to be positively associated with remittance flows as the fiscal response led to more disposable income or a smaller decrease in available funds.

A recent IMF study adds an important insight into the current understanding of how remittances and transaction costs interact by investigating their elasticity with respect to each other in a high-frequency setting. Analysing 71 countries between 2011 and 2020 and accounting for different country characteristics, their findings suggest that cost reductions have a temporary positive effect on remittances for about 3 months and dissipate afterwards (Kpodar & Imam, 2022). Based on their estimates, lowering transaction costs to the United Nation’s proposed three per cent level could produce an additional $32 billion in remittances, higher than direct cost savings and therefore implying an elasticity greater than one. Higher competition in the remittance market, a deeper financial sector and sufficient correspondent banking opportunities are associated with lower elasticities. Factors influencing available information such as enhanced transparency, higher financial literacy and a better technological infrastructure also coincide with lower transaction cost elasticities.

2.4. Remittance Cost Drivers

Remittance costs are influenced by several factors, often interlinked. Beck and Peria (2011) identify four variables: the prevalence of cash-based transactions that require

first and last-mile delivery, the status quo of cross-border payments involving intermediaries and often insufficient financial infrastructure, costs related to regulatory adherence and compliance, and the absence of competition due to exclusive arrangements between incumbents. Opening up cash pickup locations, involving multiple intermediaries, and placing heavy compliance burdens on banks all increase remittance costs. According to a 2022 survey of 500 players working in the financial industry by Thomson Reuters Regulatory Intelligence, increasingly tight budgets and shortages of skilled professionals combined with increasing compliance demand pose an ever-growing mismatch for FSPs (Hammond & Cowan, 2022). Since the 2008 financial crisis, many banks closed their correspondent banking relationships with money-transfer operators (MTOs), a common practice now known as ‘de-risking’. As FSPs generally need to obtain licenses and register with relevant domestic authorities, and requirements vary across the board, many have decided to withdraw from certain country corridors altogether. Ratha (2005) establishes a positive correlation between high bank concentrations and high remittance fees. A lack of competition and potentially exclusive arrangements between MTOs generally happen in lower-volume remittance channels that often hit the poorest countries.

Carare et al. (2022) focussed their research on remittances to Central America, Panama and the Dominican Republic, contrasting digital with non-digital methods of remittance payments. They confirm past evidence that suggests that more competition as well as financial and digital development are associated with lower transaction costs. More specifically, they used debit and credit card ownership as well as bank branch penetration rates as indicators and surveyed relevant authorities in those countries. Regulators claimed to focus on advancing digital payment methods and integrating them into domestic payment systems but expressed concerns regarding losing monetary sovereignty.

2.5. The World Bank’s Quarterly Report on Remittances

Section 2.5 is based on data from issue 45 of ‘Remittance Prices Worldwide’, a World Bank quarterly report last published in March 2023.

2.5.1. Transaction Costs per Operator

According to the latest World Bank report, the global average cost of remittance payments was 6.3 per cent of the transaction volume in the first quarter of 2023. This includes capturing the services of banks, MTOs such as Western Union, MoneyGram and fintech companies, mobile operators, and post offices. Banks remain the most expensive option with an average cost of 12.1 per cent. Compared to the first quarter of 2022, all cost categories witnessed an increase. Transaction costs related to using banks increased by 1.2 percentage points whereas MTOs only increased by 0.1 percentage points. Looking at the MTO category in more detail, the World Bank differentiates between two groups, regular MTOs and digital-only MTOs. Digital-only MTOs have consistently offered lower transaction costs, although cost differences have decreased over the past years. In 2011, the average cost of sending $200 was ten per cent for regular MTOs compared to roughly six per cent for their digital counterparts, while the latest data suggest a smaller difference, 6.4 per cent for regular MTOs and 3.9 per cent for digital ones. However, the average reduction in transaction costs over the last twelve years using MTOs cannot be seen in all other categories as the average cost using banks never dropped below ten per cent and has been on an upward trend since 2019. Mobile operators' average remittance costs have roughly stayed between 3-4.5 per cent since 2016, recently above four per cent and remittances sent using post offices have fluctuated between four per cent in 2013 to over ten per cent in the second quarter of 2022.

Looking at the World Bank’s two additional indicators offers more insight with respect to remittance volumes and the technological knowledge of remittance parties. The global weighted average cost incorporates the volume of remittance flows of each corridor and adjusts them accordingly. The weighted average has been consistently lower by about two percentage points compared to the absolute global average, standing at 4.8 per cent in the first quarter of 2023. The second indicator is the ‘Smart Remitter Target’ (SmaRT) which tries to capture the cost advantage that a technologically savvy and well-informed user could have in each corridor. More specifically, the SmaRT metric is the average of the three cheapest remittance quotes for a payment of $200 for each corridor, expressed as a percentage of the total remittance amount as the other two indicators. Additionally, more criteria need

to be met to qualify for the SmaRT index, including a transaction speed of less than five days and sufficient accessibility. Accessibility is determined by the geographic coverage of services that require physical interactions and by any technological hurdles, such as owning a certain device, having a bank account, or having Internet access. The SmaRT indicator has outperformed both indicators since 2018, declining in cost until a low of slightly over three per cent in the third quarter of 2022. In 2023Q1, it stands at 3.5 per cent which is close to the United Nations' goal of three per cent. Furthermore, almost three-quarters of all corridors captured by the World Bank report (73%) have SmaRT corridor averages below five per cent, the United Nations' targeted maximum threshold for all corridors until 2030. However, the ones that are currently not captured due to data collection limitations or suspected inaccuracies are likely to exhibit costs above five per cent, as they normally include conflict regions or countries with extremely low financial development.

2.5.2. Transaction Costs per Region

Regional differences are significant as well. Remittance receivers in South Asia faced an average transaction cost of 4.6 per cent, whereas Sub-Saharan Africa remained the most expensive region to send remittances to with 8.4 per cent of transaction costs. In between, there are East Asia and the Pacific region at 5.7 per cent, Latin America and the Caribbean at 5.8 per cent, the Middle East and North Africa at 6.1 per cent, and Europe and Central Asia at 6.6 per cent. Due to the ongoing war in Ukraine and related data concerns, data from Russia was excluded.

Looking at data tracking the cost of sending remittances from G8 countries, which include some of the most important remittance origins in terms of volume, reveals an average cost of six per cent which constitutes a 0.1 percentage-point increase compared to the last quarter of 2022. France, Canada, Germany, Italy, and the US saw increases in remittance costs, while Japan and the United Kingdom registered slight decreases. Extending the scope to emitting G20 countries shows South Africa with an average cost of 13.4 per cent for sending remittances to other countries, followed by Brazil at 8.1 per cent. South Korea (3.3%) and Saudia Arabia (4.5%) make up the top two in terms of transaction costs, with all other countries ranging between 5-7 per cent.

Evaluating the cost of sending money to the G20 countries reveals a similar picture. Overall, receiving markets' costs stood at 5.5 per cent in the first quarter of 2023 with an overall decreasing trend which is in line with the global average. Remittance senders who want to send their funds to South Africa, China, and Turkey paid the highest prices, over six per cent, while Mexico and India were the cheapest destinations with costs of 4.7 per cent. This is especially relevant when looking at remittance volumes in 2022 as those two countries received the most remittances overall, $61 billion and $111 billion, respectively (Ratha et al., 2023).

2.5.3. Transaction Costs per Fee Category

A breakdown of global average costs of sending $200 into foreign exchange-rate (FX) margins and fees reveals, that FX margins make up the smaller part of the two in all regions. FX margins and fees are highest in Sub-Saharan Africa at 3.6 per cent and six per cent, respectively, for cash payments. The best rates for cash remittances are found in South Asia with 3.1 per cent in fees and 1.8 per cent in FX margins. In all regions, digital payments outperform cash ones in terms of transaction costs. Senders can reduce their overall cost by using digital methods the most in Sub-Saharan Africa from a combined level of 9.6 per cent down to 5.5 per cent.

2.5.4. Prospects Index

Since the first quarter of 2023, the report also provides a separate category that monitors new emerging services that do not yet fulfil the requirements to be included in the main index. The so-called Prospects Index currently includes 55 new services from over 25 countries, of which the majority are partnerships of smaller projects with established players including commercial banks and major MTOs such as MoneyGram. Most prospects focus on Sub-Saharan Africa (26) and East Asia and Pacific (18) as receiving regions. There is no data available regarding the specific projects involved. Interestingly, the Prospects Index overall exhibits slightly higher transaction costs than the global average. Additional information is provided regarding the cost split of remittance payments of $200. Looking at cash-based remittances, services in the index charge 4.8 per cent to fund a transaction and 10.8

per cent to disburse the funds, while banks typically charge 11.6 per cent to fund and 5.6 per cent to disburse the same amount.

2.6. Remittances and Transaction Speed

While the literature exploring remittance transaction volumes and their effects is vast, studies analysing transaction times are relatively rare. This might be due to lower data availability. Users generally have different options available to them which differ in transaction speed and therefore also in transaction cost. Evidence from Bangladesh suggests that some transactions were settled on the same day through informal and non-registered monetary instruments called “hundi”, while others using bank transfers took up to 25 days to be settled (Van Doorn & Date, 2002). More recent data by the IMF suggests, that in most cases, the fund transfer does not happen in real-time and usually takes one to five business days as transactions are periodically settled through financial institutions (Ratha, 2017). Frictions include incompatible data formats, complex processing and compliance checks, general working hours, high funding costs, and weak competition. In certain regions such as Latin America, those frictions are amplified by a decrease in correspondent banking coverage (Marcelino et al., 2023). The average settlement time still highly depends on different factors such as the timing of the transfer as settlement generally does not happen on weekends and holidays, the sending and receiving location, and the method used for payment (Lowry, 2021).

2.7. Blockchain-Based Remittance Solutions

Currently, there is a gap in the literature concerning commercial applications of blockchain-based remittance services. While technical literature on how blockchains and their infrastructure work is available, also for adjacent blockchains such as the Lightning Network, the same cannot be said about its applications, with a few exceptions (Ibaba et al., 2021). Marcelino et al. (2023) state that “cryptoization”, a term derived from dollarisation, is mainly driven by excessive inflation and policy credibility concerns. Other common reasons behind the adoption of blockchain-based payment services are reduced transaction costs by lowering switching costs and facilitating currency convertibility, as well as increased interoperability by integrating smart contracts to disrupt financial intermediation

processes. The lack of comparative frameworks and case studies can be explained by the recent emergence of user-facing companies that try to make blockchain payments more accessible to less technologically savvy users by handling technical operations, establishing partnerships with traditional banks, and providing intuitive user interfaces. Some startups are focussing on leveraging blockchain technology for international payments, such as Ripple, Stellar, Circle with its US Dollar-backed stablecoin, and companies building on top of Bitcoin's Lightning Network. For my analysis, I will focus on the Lightning Network and Stellar. As Ripple and Circle mostly cater for institutional clients and banks with high-volume transactions, they fall out of the scope of typical remittance payments.

2.8. The Bitcoin Network

The Bitcoin network is a decentralised network of interconnected nodes that, independently from each other, maintain a data ledger of peer-to-peer transactions. Data is collected and stored in blocks and, after network participants validate proposed transactions contained in a new block, the block is added to the chain of previously verified blocks (Nakamoto, 2008). Important features are that transactions are permissionless and individuals' locations do not matter, exchange rates do not play a role as transactions are settled in the native currency called bitcoin, new blocks are added to the chain every ten minutes on average, and transaction costs are relatively low compared to non-blockchain international transactions. Block sizes are limited to one megabyte which limits the transaction throughput and had to be addressed due to the increasing adoption of Bitcoin transactions (Ibaba et al., 2021). However, depending on network usage, transaction costs can rise to double-digit numbers in dollar value, which makes the Bitcoin blockchain suboptimal for low-value remittances. The most important upgrade in recent years has been the 'Taproot Upgrade', a so-called soft fork, which is compatible with previous versions of Bitcoin software. It aimed at improving multiple factors; scalability, privacy, network efficiency, and smart contract compatibility being the most important ones. For a more technical elaboration, see Casa et al. (2021) and Chan, Chin and Goh (2021). Despite those improvements and cost advantages compared to traditional FSPs, the Bitcoin network still does not fulfil the requirements for extremely low-cost international payments, which is why development on its second layer, the Lightning Network, is continuing to increase.

2.9. The Lightning Network

To address Bitcoin's scalability issue, the Lightning Network was designed in 2016 and technically implemented in January 2018, leveraging the Bitcoin network's security while functioning as an off-chain second layer to its blockchain (Khan & State, 2020). The Lightning Network allows users to open bi-directional peer-to-peer payment channels that adjust user balances according to their transactions. Not settling all transactions on the main blockchain but settling in batches once one of the users wants to close a payment channel, enables micropayments and increases the number of transactions per second significantly. Therefore, near-instant global transactions with negligible fees enable capturing the beneficial effects of more efficient remittance payments suggested by past research (Poon & Dryja, 2016). Arcane Research (2022) even reports a median fee of less than 50 satoshis, equivalent to roughly $0.01, which is confirmed by current data from Glassnode (2023a).

Dasaklis and Malamas (2023) explain how transactions on the Lightning Network are initiated and how channels are maintained, both on a conceptual and technical level. Guasoni, Huberman and Shikhelman (2023) add to the literature by mathematically identifying optimal conditions for two parties to establish a channel, optimal collateral-to-savings ratios, and by isolating and calculating channel cost drivers. Furthermore, Dasaklis and Malamas (2023) illustrate the Lightning Network's increasing adoption and capacity rates, thanks to new technological abilities but also due to integrations with popular e-commerce platforms like Shopify. Since its launch in 2018, the Lightning Network has grown to a network with about 18,000 operating nodes and nearly 70,000 unique payment channels (Glassnode, 2023b; Glassnode, 2023c). Its capacity, as measured by the amount of bitcoins, stood at an all-time high in April 2023 at around 5,500 bitcoins (Glassnode, 2023d). Despite the overall downward trend in Bitcoin's price since November 2021, interest in the Lightning Network seems to be strong as those bitcoins locked in the network to provide liquidity represent around $147 million at the time of writing.

This growth was in part supported by past upgrades that have addressed vulnerabilities with respect to fraudulent behaviour and other attack vectors. For further reading on topology-based attacks and concerns around centralisation,

synchronisation, and anonymity, see Roher et al. (2019) and Martinazzi and Flori (2020), respectively. The underlying software code is maintained and upgraded by Lightning Labs, an organisation of software developers dedicated to providing an open and secure payment layer on top of the Bitcoin blockchain and offering Lightning-based financial services (Lightning Labs, 2023). The Lightning Network can be seen as a general infrastructure that can be built upon in a permissionless manner.

Recently, some companies have emerged that take over setting up and maintaining payment channels, which requires some technical knowledge, and offer conversions into local currencies, to facilitate more widespread adoption. Most notable is Strike, which serves its users in the US by serving country corridors through local partnerships that provide access to the domestic banking sector. So far, payment channels for El Salvador, Mexico and Guatemala have been established in Latin America, and, through its partnership with Bitnob, also for some African countries such as Kenya, Ghana, and Nigeria (Chirico, 2023b; Venegas, 2023; Lederman, 2022). It has also partnered with Pouch and Getbit to expand its services to the Philippines and Vietnam, respectively (Chirico, 2023a). As all service providers have integrations with local banks, users do not necessarily need to own or send cryptocurrencies as they can choose to send and receive local currency. It also implies that those startups comply with local KYC and AML regulations in their jurisdictions or outsource that responsibility to their partners, often financial intermediaries. Another benefit is that payments do not have to be physically collected, exposing oneself to the risk of being robbed, but can be sent to Lightning mobile wallets, such as Strike Wallet, called Chivo, in El Salvador. In this case, this mobile application is specifically for El Salvadorian nationals and transactions are fully covered by the government. Therefore, the only requirement for sending and receiving payments is a mobile phone and an internet connection. In a blog article for the World Bank, Iavorskyi (2021) describes that any person in the US could either send dollars from their US bank account or go to a Bitcoin ATM and send funds over the Bitcoin network to someone’s Chivo wallet in El Salvador, which would be converted into dollars on arrival. Apart from possible fees for using the Bitcoin ATM, additional costs are negligible and transfers are almost instantaneous. Especially for remittance-depending countries like El Salvador (24% of GDP in 2022) where about

65 per cent of adults do not have bank accounts, the Lightning Network can be an effective tool to reduce remittance costs (World Bank, 2023a; World Bank, 2023b). Moreover, there are alternatives to using the Bitcoin network and its second-layer blockchain for remittances, most notably the Stellar Network.

2.10. The Stellar Network

Stellar was founded in early 2014 by Jed McCaleb and Joyce Kim, as a branch of the Ripple cryptocurrency project, which McCaleb also co-founded. McCaleb envisioned a more open-source and inclusive financial network for cross-border transactions compared to Ripple's focus on large banks and institutional clients (Peterson, 2022). Similar to the Lightning Network, Stellar provides a general infrastructure that can be used by other projects to build their services on. It provides separate modules which are compatible with its core software that allow third-party developers to build user-friendly applications that can meet local compliance standards. Stellar operates on its own blockchain with a custom consensus mechanism that prioritises scalability and fast transaction times. This allows users to make international payments involving currency exchanges within seconds for less than $0.01 (Peterson, 2022). However, it comes at the cost of decentralisation. Refer to Coutinho et al. (2023) and Kim et al. (2019) for a more elaborate analysis of centralisation concerns and network attack vectors. Furthermore, a key part of its technology stack is the distributed orderbook which allows cross-asset transactions (Roy, 2020). For example, a transaction can be initiated in euros and disbursed in Indian rupees, which opens up many use cases, especially in the remittance segment.

Trusted participants in the Stellar Network, so-called anchors, take over the role of depositing money, issuing credits into the network, and honouring withdrawals. Typically, those anchors are banks, payment processors, and other FSPs that also check the adherence to international compliance standards. Many centralised cryptocurrency exchanges also use Stellar, such as Binance, Coinbase, Crypto.com, Kraken and Bybit to name a few (Stellar, 2023). There are multiple options for payment vehicles but recently Stellar has integrated Circle's USD-pegged stablecoin, USDC. This comes with multiple advantages as Circle is backed by trusted entities

such as BlackRock and Fidelity, and USDC is the second-most popular stablecoin with a market capitalisation of $26 billion at the time of writing (CoinGecko, 2023a).

Given the importance of physical cash and local currencies, especially in LMICs, cash-to-cryptocurrency on and off-ramps are essential. USDC on the Stellar Network has the second most on-ramp locations worldwide (81,527), only beaten by Bitcoin (276,829). However, Stellar leads by far in off-ramp locations (322,000), with Bitcoin being a distant second place (98,208) (The Block, 2023). This can mainly be attributed to its anchor network of financial institutions around the world, especially MoneyGram. Stellar has partnered with MoneyGram, a remittance service provider, to improve the real-world utility of its network and reach more users. Using MoneyGram Access, USDC can be sent via blockchain networks and instantly converted into dollars or local currency at MoneyGram locations in over 180 countries (Heynen, 2023). This constitutes a significant improvement over the current situation of poor cash-to-crypto accessibility in LMICs, especially for off-ramps. Stellar addresses this underserved market in LMICs through its strategic partnership with MoneyGram, which in turn can offer its users more competitive rates due to using cost-efficient blockchain technology. Stellar also claims that its service is unique as it does not require users to have a bank account or credit card to use it. Apart from its partnership with exchanges and remittance giant MoneyGram, well-known remittance projects building on Stellar are Anclap, mainly focussing on Argentina and Peru, Biccos and Bitso with a focus on the Mexican market, Perahub and Cebuana for the Philippines, as well as Busha, SureRemit, and ClickPesa for several African countries (Stellar, 2023).

2.11. Contribution to the Literature

This study contributes to current literature on remittances by specifically targeting remittance costs and its drivers. So far, remittance flows have been extensively studied and transaction costs have recently been used to explain variations in remittance volumes. The absence of studies focussing explicitly on transaction cost components and its drivers, constitutes a gap in the literature which we address with this study.

3. Methodology

Our dissertation investigates key drivers of remittance costs and evaluates the potential benefits and drawbacks of integrating blockchain-based services for cross-border payments. Our approach contains both quantitative and qualitative elements. First,
we analyse the dataset underlying the quarterly remittances report to obtain further insights by accounting for two categorical variables that are not covered in the quarterly report, namely the time it takes for recipients to be able to collect the payment and the pickup method they choose. Second, we conduct a multiple linear regression using a modified version of the first dataset to identify variables influencing remittance costs. Both our analyses were implemented using the statistical software program SPSS. Lastly, we present two blockchain-based remittance services in the form of case studies to illustrate their services focussing on improvements across two dimensions: transaction cost and transaction speed.

3.1. Data Collection

The examination of remittance data is subject to challenges regarding its definition, accuracy and accessibility. Consequently, it becomes imperative to adopt a globally recognised definition to facilitate cross-country comparisons. In alignment with this perspective, our study adheres to the World Bank's definition of remittances, a definition that is prevalently cited in the literature and aligns with the reporting standards embraced by numerous nations. As described in section 2.1, remittances are characterized as the aggregate of personal transfers and employee compensations, as documented in the national balance of payments data collected by the IMF.

For our statistical analyses, we primarily rely on data collected by the World Bank and IMF. The source for data on remittance costs is the ‘Remittance Prices Worldwide’ dataset, published by the World Bank. Together with research firm FXCintelligence, World Bank researchers gather data in two ways: by posing as customers interested in remitting money for various country corridors and by extracting data from websites and tools of different remittance service providers. National remittance databases do not always follow a consistent methodology which

is why only some of them are used to complement the dataset. For more information on key mandatory requirements for databases, see (World Bank, 2015).

The resulting database encompasses information on 367 corridors derived from a combination of 48 remitting and 105 recipient nations (World Bank, 2023a). It separates the fee categories associated with transferring equivalent sums of $200 and $500 in local currency denominations, as advertised by various remittance service providers. In our analysis, we focus exclusively on $200 as this amount is more representative of the average remittance (IFAD, 2023). The dataset also incorporates the applicable exchange rate for the transaction, when available. It categorises remittance service providers, for instance, banks or MTOs, the duration required for the funds to be accessible to the beneficiary, the permissible payment instruments for the remitter, and the modality of payment to the recipient. Additionally, it outlines the access points for availing of the remittance service. This data has been systematically recorded on a quarterly basis, commencing from the first quarter of 2011. As an example, one data point could describe a payment in euro of the equivalent of $200 at the time, initiated in Germany on the 17th of February 2022, with destination Ghana. It shows the classification of the receiving country's income level and geographic region - lower-middle income and Sub-Saharan Africa - that MTO Remitly facilitated the payment which was initiated online and funded by credit card and arrived on the same day. The flat fee is €0.99 plus a 4.16 per cent margin for the currency conversion, totalling 4.87 per cent for the transfer. The pickup coverage in the destination region is classified as 'medium' and the money was picked up in cash in local currency at an agent.

To identify more drivers of transaction costs, this data is further supplemented by macroeconomic indicators from the World Bank database. More specifically, we made use of the Financial Access Survey, as well as the World Development Indicators. The chosen indicators can be classified into two main categories: socioeconomic variables describing a country's population size and economic output, and numerous variables assessing the depth and access to financial markets and their services, including proxies for technology adoption. An overview of all variables is provided in the next section.

For the case studies, we relied on different sources of data. Primarily, we scanned publicly available information about the underlying blockchain networks and their payment service applications built on top. This was complemented by using research platform Glassnode which provides blockchain data, so-called on-chain data. Especially for the Lightning Network, Glassnode collects the most indicators useful for our case studies.

3.2. Data and Variables

For our analysis, the primary variable of interest is the remittance cost for sending the equivalent of $200, expressed as a percentage of the transferred sum. As part of our descriptive analysis, we considered data points from the last five available quarters, from 2022Q1 until 2023Q1. After cleaning the data, such as removing observations indicating negative transaction costs, 31,766 observations remained, covering well over 300 country corridors. The World Bank's quarterly report on remittances already provides valuable insights into cost differences between regions, destination income levels, payment vehicles, and cost components. It also covers cost developments over the past decade. However, some important indicators remain uncovered. To shed more light on remittance cost drivers we additionally focussed on analysing the pickup method chosen and transaction speed. The payment can be collected either in cash or sent to a bank account or mobile wallet. The transaction speed is measured through six categories: payments that can be picked up within an hour, on the same day, the day after, two days after, three to five days after, and six days after.

For our regression model, we also considered data points on transaction costs between 2022Q1 and 2023Q1. To get a data point per country, the average cost of incoming remittances from all country corridors was taken. Nevertheless, this constitutes a weighted average as the number of observations per country corridor in the dataset was chosen based on the relative amount of remitted funds between countries. To complement the dataset, we included more variables that were deemed to be potential predictors of remittance costs. As stated earlier, our quantitative predictor variables can be grouped into two categories.

Socioeconomic variables include a country's total population, GDP measures adjusted for different price levels and population sizes (both 2022 data), mobile cellular subscriptions per 100 people, and the percentage of people using the internet (both 2021 data). A population measure was chosen to assess a country's potential pool of remittance receivers, while GDP provides information about the economy's size and health. Additionally, it serves as a numeric expression of the income-level classification by the World Bank. Mobile phone subscriptions and general Internet access serve as a proxy for the ability to access digital services and evaluate the domestic technological infrastructure overall.

Variables accounting for access and depth of financial markets are the percentage of people over the age of 15 who have an account at a financial institution or mobile money service provider, the percentage of people over the age of 15 who used a bank account to receive remittances, an economy's bank concentration as measured by the share of total assets held by the five largest banks, the number of commercial bank branches and ATMs per 100,000 adults, the number of deposit accounts with commercial banks per 1,000 adults, the percentage of people over the age of 15 who have used a mobile phone to send money, and the amount of personal remittances received in current dollars (all of the above using 2022 data, except for account ownership at a financial institution and bank concentration where only 2021 data is available). Having access to financial services offers remittance senders and receivers more possibilities with respect to payment vehicles and types of payment collection. The proportion of assets held by the largest banks serves as an indicator that estimates the competitiveness of the financial sector, as proposed by Ratha (2005). A few dominant players might be able to conserve significant margins, whereas competition generally leads to more attractive rates for users. In line with Freund and Spatafora (2007), the overall amount of remittances sent to a given country indicates the extent to which economies of scale might be achievable. Larger target markets tend to attract more competition which again promotes smaller margins for FSPs and more attractive rates for remittance senders and receivers. In some cases, variables were adjusted to arrive at per capita versions. Table 1 shows the explanatory variables that were chosen for the final model.

Table 1: *Descriptive statistics of the dependent variable and its predictors*

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
ln_cost200	90	1.29	3.05	1.9461	.39846
ln_remi_rec	88	16.45	25.43	21.3311	1.70198
acc_remi	63	.48	53.43	15.0300	10.96406
mob_subs	89	30.48	175.34	101.4567	33.90174
Valid N (listwise)	62				

3.3. Method of Analysis

First, we used several descriptive analysis functions in SPSS that helped to provide an overview of our dataset. After evaluating certain assumptions for parametric tests, we conclude that we cannot fit an ANOVA model to the underlying data. Instead, we used the Kruskal-Willis test to determine whether there are statistically significant differences between categories of transaction speed and pickup method. This non-parametric test does neither assume a normal data distribution nor equal variances and is robust to outliers which are present in our dataset.

Following this preliminary analysis, we continued with a modified dataset, as described in the previous section, to investigate drivers of transaction costs. We used a multiple linear regression model that explains the transaction cost of a $200 remittance based on our chosen independent variables. Our primary objective was to understand the strength and direction of the relationship between each predictor and transaction costs. We quantified the proportion of the variance in transaction costs that our predictor variables can explain to get a deeper understanding of the mechanisms involved and evaluate our model's overall adequacy.

Last, we analysed two blockchain-based solutions in a case study to illustrate the remittance process and categorise it with respect to transaction costs and speed. For that, we chose specific country corridors and supplemented our analysis with relevant national data.

3.4. Linear Regression Model

To build a robust model, we computed new versions of the underlying variables in the dataset. Using the population statistics, we calculated a per-capita measure of remittance flows received as well as GDP to account for population differences. For a linear regression model to be valid, certain assumptions about the data need to be fulfilled. Using scatter plots, we checked whether the relationship between our predictors and the dependent variable is in fact linear. Similarly, we analysed whether the residuals are independent of each other. Another action was to remove influential outliers and compute the logarithmic values of certain variables to achieve a normal error distribution. Using collinearity statistics, we also accounted for multicollinearity issues between predictor variables and adjusted our model accordingly. The final model consists of 90 observations, each representing a specific country receiving remittances. Out of those 90 countries, seven are classified as high income, 29 as upper middle income, 36 as lower middle income, and 18 as low income. African countries represent the largest group with 28 nations located in Sub-Saharan Africa, seven in the Middle East and North Africa, 22 in Latin America and the Caribbean, 16 in Europe and Central Asia, twelve in East Asia Pacific, and five in South Asia.

We specified our model in a step-wise fashion to only include relevant and value-adding predictors. Due to multicollinearity issues between some variables, we included three predictors in our assessment of the $200 payment channels. The final regression model is as follows:

$$ln\_cost200_i = \beta_0 + \beta_1 ln\_remi\_rec_i + \beta_2 acc\_remi_i + \beta_3 mob\_subs_i + \epsilon$$

The dependent variable is the cost of sending the equivalent of $200 to a particular country, expressed as the natural logarithm of the percentage cost. Variable one measures the overall remittances received by that country. The second variable captures the percentage of adults who have received remittances using their bank account, while variable three measures the percentage of mobile phone subscriptions.

4. Analysis and Results

4.1. Key Results

The Kruskal-Wallis test suggests that there are significant cost differences for different transaction speed categories. Looking at the frequency distribution per category, one can see that almost half of all payments were accessible to the receiver within one hour. Transactions that took more than three days to arrive are rare (7%). For all categories, the average cost is, sometimes significantly, higher than the median cost which suggests the presence of some large outliers. Payments that are accessible to the receiver within an hour cost 5.8 per cent, on average, with a median cost of 4.8 per cent. Same-day transaction score slightly better, costing 5.7 per cent, on average, and 4.5 per cent as the median value. Prices increase for next-day payments (6%, 4.5%), payments taking two days to arrive (7.5%, 5.3%), and payments taking up to five days (8.6%, 4.6%). $200 payments that are available to the receiver after six days cost, on average, 7.4 per cent with a median cost of 5 per cent.

Isolating remittances that were carried out through a traditional bank, reveals a median speed of two days. Same-day payments are the second most common transaction speed, followed by transactions that take between three and five days. Same-day payments (10%), and even near-instant payments (7.8%), tend to be cheaper than payments that take multiple days (over 11%). Comparing that to remittances that were sent via MTOs shows that these are significantly faster, overwhelmingly arriving within an hour and with a median cost of 4.8 per cent. Remittances that take more than two days to be available are the exception (5.9%).

Implementing the same test to analyse cost differences between different pickup methods, also reveals a statistically significant result of differing means. Most remittance payments are picked up in the form of cash in local currency (55%), followed by payments to bank accounts (39%) and, to a much lesser extent, mobile wallets (6%). On average, receiving remittances to one’s bank account is most expensive at 6.8 per cent, followed by cash pickups costing around 6.1 per cent. Transactions to mobile wallets on average cost slightly less than 4.6 per cent.

Looking specifically at remittances that were sent via a traditional bank, one can see that the vast majority (78%) were sent to another bank account and only some were picked up in cash (22%). Interbank transfers cost, on average, 12.2 per cent with a median cost of 9.5 per cent. Cash pickups were significantly cheaper, costing, on average, 6.6 per cent. On the other hand, payments via MTOs were mostly picked up as local cash (60%), only a third were sent to bank accounts, and seven per cent to mobile wallets.

Analysing our regression output, the adjusted R-squared for our linear regression using three predictors is 61.4 per cent, implying that the model is able to explain 61.4 per cent of the variation observed in remittance cost. The model coefficients are statistically significant (see Table 2). Evaluating the model coefficients leads to the following conclusions: holding all else equal, a one per cent increase in remittances received is associated with a 0.1 per cent reduction in transaction percentage cost, on average. Looking at the number of adults that have received remittances to their bank account, on average, a one percentage point increase, raises the cost by 1.1 per cent. Lastly, a one percentage point increase in mobile subscriptions per 100 people lowers the cost by 0.4 per cent, on average.

Table 2: *Model coefficients*

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	4.671	.512		9.124	<.001
	ln_remi_rec	-.114	.023	-.497	-4.941	<.001
	acc_remi	.011	.003	.394	3.947	<.001
	mob_subs	-.004	.001	-.370	-3.732	<.001

a. Dependent Variable: ln_cost200

4.2. Discussion of Results

Our first analysis suggests that there are significant differences within pickup methods and transaction times. We can confirm the observation that digital payment methods outperform traditional transfers, such as via banks, in both transaction cost and speed. In line with that, the regression results show a slight decrease in transaction costs the more mobile subscriptions there are in a given country. Our

hypothesis is that extensive mobile phone adoption implies a higher degree of technological advancement and adoption, which increases the likelihood of being able and willing to make use of mobile payments. Both our analyses find that having received remittances through a bank account tends to increase overall transaction costs. However, cash pickups are still the most favoured option which underlines the necessity in many places to have access to physical pickup points. We can therefore conclude that mobile or digital-to-cash off-ramps are key elements of the remittance process.

At first glance, it might seem counterintuitive that same-day payments tend to be cheaper than payments that take longer as there is a benefit to receiving funds earlier. This result can be explained by relating the median transaction cost and time between MTOs and banks. MTOs tend to offer significantly better rates at a median speed of less than one hour, while banks charge more for their services and payments usually become available after two days. Lastly, our results point towards economies of scale in the remittance market as there is a negative association between the overall amount of remittances received and transaction costs.

4.3. Case Studies

Although the introduction of digital payment methods has helped to bring down the cost of remittances over the last decades, cost reductions seem to have slowed down and traditional channels, such as transfers using banks, still exhibit costs well above the average. If policymakers want to come closer to the proposed goal of an average transaction cost of three per cent and the elimination of country corridors that have costs exceeding five per cent, new solutions need to be considered. One of the most promising and underutilised methods of sending money is using blockchain networks. Illicit activities, highly volatile prices, and a lack of regulatory oversight have contributed to the industry’s bad reputation among some quarters, especially regulators. However, critics often paint with a broad brush and therefore leave well-designed and compliant projects in the shadows. Over the past years, more services have emerged that operate in compliance with international standards and offer attractive payment conditions to their users. We want to put two of them in

the spotlight that facilitate cross-border payments using a blockchain network at a cost well below the United Nations' goal.

4.4. Strike on the Lightning Network

Strike offers a global payment solution by transferring bitcoins via the Lightning Network. Users can also convert local currencies into USDT, the most popular stablecoin with a market capitalisation of $83 billion (CoinGecko, 2023b). Recently, its regional coverage has expanded to 65 countries, covering six continents and including small countries such as Zambia and top remittance-receiving countries such as India, Mexico, and the Philippines (Munawa, 2023; Stefan, 2023). Strike's focus lies especially on LMICs and close to three billion users now potentially have access to Strike's mobile application. Arguably its most important feature when it comes to remittance-like payments is its 'Send Globally' service. Currently available in twelve countries, users can deposit and send dollars or bitcoins to another user in a foreign country who can receive the payment online or choose to collect it in local currency. It makes sense to look at a concrete example to explain the underlying payment process. In fact, we will have two different scenarios: one in which a recipient is familiar with the workings of a blockchain and related wallet and one in which a recipient is less tech-savvy and prefers traditional payment services such as bank accounts. Let us assume that we have a Nigerian worker, Adanna, employed in the United States who wants to send money to her mother in Nigeria. First, Adanna needs to download Strike's mobile app and register with her personal information. Her mother in Nigeria can either also create a Strike account or create a Bitcoin or Lightning wallet. After a successful verification, Adanna can fund her account via either an on-chain transaction using bitcoins or via her American bank account. Strike waives its fee for dollar deposits from bank accounts, whereas on-chain transactions incur the regular fee of sending bitcoins, which goes to the network's participants and not to Strike. Funds that arrive as dollars are converted by Strike to USDT. Once Adanna has funded her account, she has two options: send bitcoins or send USDT. If she sends bitcoins, she uses her mother's Strike username or her wallet address and transfers the desired amount. If she prefers payment in USDT, she can select her mother's Strike username as the destination address. In both cases, the funds will arrive almost instantaneously. Also, both payments happen in

the background via the Lightning Network. For payments where bitcoins are sent and received, no conversion needs to take place. For USDT transfers, Strike converts USDT into bitcoins, sends those bitcoins via the Lightning Network to the recipient's address and then converts them back into USDT. Even a hybrid solution is possible, where Adanna uses her USDT balance to initiate the transaction and her mother receives bitcoins into her account or wallet. Strike passes on the routing fee incurred for using the Lightning Network which is typically less than $0.01. In the case of conversions, Strike applies a margin on top of the conversion rate provided by a third party (Strike, 2023). Their margin is not explicitly shown but tends to be close to but below one per cent. The funds would be accessible to Adanna's mother within an hour.

However, not all recipients know how to create wallets or are able to pay using USDT or bitcoins. Therefore, Strike has partnered with local companies that provide crypto-to-fiat off-ramps such as Bitnob. Nigeria is one of the twelve countries in which Strike's "Send Globally" feature is enabled. Assuming that Adanna's mother does not have a Bitcoin wallet and needs local currency for her purchases, she can simply create an account with Bitnob and link her local bank account. In that way, Adanna sends bitcoins or USDT to a Lightning address assigned to Adanna's mother but operated by Bitnob. On arrival, the bitcoins are converted into Nigerian naira and will be visible in her Bitnob account. Either the funds remain there and can be withdrawn to her local bank account at a later stage, or they are directly forwarded and would be accessible via ATMs, for example. Therefore, funds are either available within an hour or after a few business days, depending on the pick-up method and her bank. Assuming a payment equivalent to $200, Bitnob would charge a one per cent fee for withdrawing to a bank or mobile money account (Akpan, 2023). Overall, Adanna's mother would either receive the equivalent of $198 in bitcoins into her Bitcoin wallet or Bitnob account or the equivalent of $196 in case she prefers receiving Nigerian naira. Representing a transaction cost of one and two per cent, respectively, would place this remittance well below the global average of 6.3 per cent, and also within the United Nation's target.
In fact, comparing the payment in naira to the average remittance arriving in Nigeria, which costs 4.9 per cent, it represents a significant cost saving of 2.9 percentage

points. Applying those savings to the total inflow of $19.48 billion into Nigeria, it amounts to $565 million of savings overall (World Bank, 2023a).

Strike's cooperation with Bitnob is only one example. Another one is its cooperation with Pouch which establishes a remittance corridor between the United States and the Philippines. Similar to Bitnob, Pouch applies a one per cent spread on the offered conversion rate and charges the equivalent of $0.26 for a withdrawal to a local bank account. In all cases, Strike and its partners collect personal data of their clients to comply with KYC requirements.

Given that technical development on the Lightning Network continues and investors, such as Stone Ridge Asset Management, launch funding programs for startups that want to build services on the Lightning Network, we are likely going to see more services emerging that increase competition and improve remittance payment processes further (Maldonado, 2022).

4.5. Stellar and MoneyGram Access

Stellar offers a similar cross-border solution, however, their approach differs in important aspects. Stellar has decided to offer services built on its own blockchain which is optimised for fast, low-cost, and energy-efficient global payments. Partner financial institutions, so-called anchors, can connect to its payment rails and leverage Stellar's fast finality of less than six seconds and up to 1,000 transactions per second, processing capabilities similar to Swift (Stellar, 2023a). Stellar offers built-in features to its 64 anchors that allow unified KYC and AML checks (Stellar, 2023b). Compliance duties ultimately are fulfilled by the anchors themselves as clients usually do not actively engage with the Stellar blockchain. Rather, anchors can connect their back-end infrastructure to offer clients better rates and faster cross-border payments. Stellar further differentiates itself by not requiring any pre-funding, which minimises working capital requirements. All supported currencies are paired against Stellar's native token Lumens which reduces liquidity concerns for currencies that represent smaller economies.

One of its biggest advantages is that Stellar enables remittances to recipients who do not even own a bank account. This is possible due to Stellar's integration with its anchors Circle and remittance company MoneyGram International. United States-based Circle issues the second most popular stablecoin, USDC, and enables users to convert their dollars into USDC. Using the representative version of the dollar on-chain allows a fast and cheap transaction to the receiving MoneyGram office. There, USDC is again converted back into fiat currency and can be picked up at one of its locations by the remittance receiver, without the need for having a bank account. Its cash-in and cash-out service called MoneyGram Access is available in 181 countries and funds are usually available within an hour (MoneyGram, 2023). The Stellar network not only offers the most off-ramp locations to convert USDC into fiat currency, it also hosts the most geographically distributed service network. As Bitcoin conversion services, such as Bitcoin ATMs, can be mainly found in North America (95%) and Europe (5%), this constitutes an advantage for remittance recipients in LMICs. Stellar offers around 148,000 USDC off ramps in Asia, 57,000 in North America, 54,000 in Africa, 36,000 in Europe, and 25,000 in South America, which makes it an attractive option for remittance payments (The Block, 2023).

Similar to Strike and Bitnob, there are also FSPs that connect to the Stellar blockchain to focus on serving specific country channels. Biccos, for example, allows its users to send dollars from the United States to Mexico where they arrive as Mexican pesos, if desired. Biccos charges a $2.50 flat commission per transaction but provides no specific details regarding its exchange-rate margin, if any. Assuming a one per cent margin as seems to be common, the cost would slightly surpass the two per cent mark per $200 remittance. Given that funds are transferred within ten seconds and can be withdrawn at more than 10,000 ATMs in Mexico, Biccos offers an attractive service to its clients residing in Mexico and the United States (Biccos, 2023).

Following our previous example of Adanna wanting to send funds to her mother in Nigeria, blockchain company Link would be the equivalent of Strike or Bitnob. For a $200 remittance deposit, Link would charge a one per cent fee plus 650 Nigerian Naira, equivalent to roughly $0.8. Withdrawing this amount to a local bank account would cost 760 naira, roughly $1. Both operations add up to slightly below

$4, representing a two per cent overall fee. This results in similar cost savings such as in the case of Bitnob, which used the Lightning Netowrk, which emphasises its utility for clients compared to traditional payment methods.

Given that Stellar also simplifies the requirements of becoming a Stellar anchor, more FSPs are likely to connect their platforms to the Stellar Network. The increased competition could lead to more favourable rates for remittance senders and receivers and will reveal whether the underlying infrastructure is capable of serving increasing transaction requests without delay.

4.6. Limitations

The limitations of our study can be grouped into three categories: limitations regarding data measurement and collection, limitations with respect to the underlying dynamics of remittances, and those related to the statistical analysis.

As mentioned in the section on data collection, the World Bank maintains a large dataset, however, there is significant uncertainty surrounding these estimates. For more information on methodological challenges, see Ratha et al. (2023). There is still an ongoing debate on how to measure remittances. Using the IMF's measure of compensation of employees might significantly overestimate the amount of remittance flows, as pointed out by Alvarez et al. (2015). If a given country is a hub for international companies that operate in labour-intensive industries, for example, employees would be categorised as non-residents and their salaries as remittances. The second part of the remittance definition, personal transfers, also raises some concerns. Alvarez et al. (2015) further state that, as information on residency or nationality is often unknown, many cross-border payments are included, even funds intended for private investments or real estate purchases, for example. Alongside concerns that officially recognised definitions overestimate remittance flows, there are also some factors that work in the opposite direction, mainly the failure to accurately capture funds sent via informal channels. Smaller amounts sent through MTOs, funds sent via blockchain networks, and funds that relatives transport physically are not accounted for. A World Bank study estimated the amount not captured to be as high as 50 per cent of total remittances (Irving, Mohapatra &

Ratha, 2010). Especially countries in Sub-Saharan Africa often do not distinguish remittances in their data submission to the IMF and intra-continental transfers often fail to be accounted for (Melde & Schicklinski, 2011). An improvement in capturing informal channel flows would greatly improve data accuracy. Likewise, more frequent and more accurate measurements of certain socioeconomic variables would help better understand the relationship between them and remittance flows and costs. It also might uncover hidden drivers we are currently unaware of. In April 2022, the World Bank's KNOMAD founded the International Working Group to Improve Data on Remittance Flows to collect more reliable and representative data, in line with the sustainable development targets of the UN (KNOMAD, 2022).

Apart from agreeing on common standards for measuring remittances, data collection methods are controversial as well. Modern-day means of data collection significantly improved in recent years due to automation, access to new data points, and more affordable data storage. The World Bank's quarterly report offers relatively frequent and extensive insights into developments around remittance costs. However, as not all providers offer to connect to their APIs, manual effort is needed which limits the possible number of data points, especially for less covered regions. Rural areas are less covered in the quarterly report as data for each country corridor is gathered for the main sending location in question to the most populous city of the receiving country, often the capital (World Bank, 2016). Additionally, remittance flows overall are still estimated based on the Balance of Payments database by the IMF which collects data on a yearly basis. This might lead to a smoothing of seasonal trends and outlier events which might cover up market reactions and prevent a more thorough analysis. The use of informal channels when sending remittances also poses a challenge as some experts estimate that potentially over 50 per cent of remittance flows are unaccounted for (Ratha, 2017). Kpodar and Imam (2022) further claim that a lack of transparency around remittance options and their associated fees often causes remitters to choose suboptimal payment and pickup options. However, there is no extensive data available yet that tries to capture the level of transparency in pricing models on a local level. The World Bank is aware of this and has started to include an indicator in its quarterly updated database which assesses whether an FSP has displayed a differentiated view of related fees to

customers before the transaction. However, due to an insufficient number of observations, we decided to not include this measure.
Our collection of quantitative data revealed that data on migration and education was not updated frequently. Data on the stock of migrants in a given country is collected every five years and most recent educational data was from 2020 for most indicators. Domestic or regional conflicts in certain regions, such as in Russia, Ukraine, Afghanistan, and Syria, to name a few, complicate data collection and give rise to concerns about its reliability and accuracy.

Another limiting factor is the dynamic nature of the remittance market which is constantly evolving. Current examples are the COVID-19 pandemic and the Russian invasion of Ukraine and their effects on remittances. Changes in foreign exchange rates also have a sizeable impact on remittances. For example, the appreciation of the dollar in 2022 against many currencies has put Mexico in second place for top receiving countries, pushing China down to third. Literature on the causality is not conclusive but an appreciation of the remitting currency seems to be associated with increased remittance flows (Nguyen et al., 2020; Acosta, Baerg & Mandelman, 2009). For instance, regulatory changes in the near future with respect to value transfers on blockchains or general revisions to international financial regulations present a limitation to our research as the payment services environment can change rapidly. The current scope of our research is limited to blockchain services and does not keep track of new innovations in adjacent technologies. As artificial intelligence is improving many aspects of data processing and communication, it will likely bring down the costs of cross-border transactions as well. Even looking at the Bitcoin blockchain itself, the Taproot upgrade has accelerated the adoption of the Lightning Network and likewise attracted new companies that build their services on top of it. The inception of many new RSPs using or collaborating with blockchain-native companies has grown significantly in recent months which suggests that new studies will soon be required to reflect fresh data and new market entrants.

Our statistical analysis also comes with certain limitations. Given the previously mentioned data scarcity, we were forced to compare variables with data from different time periods, ranging from 2021 until the first quarter of 2023. Overall, this

lowers the accuracy of our results. There is also the possibility of having missed potentially significant predictors that would have offered a more suitable fit for the dataset. Eliminating countries because of unusual observations or missing data might increase our model's fit but might also lead to a loss of potentially valuable information. Countries with extremely high remittance costs or unreliable or missing data are often the ones which depend on remittances the most. Given that there are idiosyncratic factors for all countries, it is important to account for these and provide background information on national remittance solutions and regulations. We tried to address this by including two case studies of specific country corridors but many remain unaccounted for.

5. Concluding Remarks

5.1. Implications and Policy Recommendations

Our analysis has several implications. Regulators and policymakers need to evaluate on a domestic level, where remittance senders and receivers face certain hurdles and how they can be lowered. Digital payments seem to be superior in both cost and speed which implies that digital agendas need to be accelerated and information and communication technology (ICT) infrastructure needs to be improved. People need to have easy access to mobile and online payment methods. Nevertheless, cash pickups remain relevant. If feasible and sensible, governments could support the availability of access points in rural areas, which might not be attractive to FSPs. However, normalising the use of digital payment methods might be even more important. Reducing the need for cash also increases security for remittance receivers as they can avoid being robbed when picking up remittances at well-known access points. As MTOs and banks both offer cross-border payments in compliance with regulations, the question arises where cost differences come from. Concentration in the financial sector might be a contributing factor so that regulators could consider encouraging new participants to enter their market. One of the reasons for using more expensive non-digital methods to send money is likely to be unfamiliarity with digital services. Education aimed at enhancing knowledge with respect to mobile devices and digital services will help to reduce concerns and will offer remittance senders and receivers access to cheaper remittance services. Given

compliance with local laws, promising solutions that offer superior services, such as blockchain-based payment methods, should be discussed and advertised more frequently. Some countries or regions have also piloted regulatory sandbox environments in which those upcoming services can be analysed and supported on the way to offering a sustainable and compliant payment service. One example would be the ‘European Blockchain Regulatory Sandbox’ by the European Commission. Lastly, governments could cooperate with those countries that send most remittances to their country to ensure a smooth payment process starting in the sending country.

Supranational organisations, such as the World Bank and IMF, need to provide support and expertise in how to achieve the goals mentioned above and stimulate cooperation between countries. Improving data collection and measurement is an important part of this endeavour. Moreover, providing additional policy and regulatory guidelines, for instance through the Bank for International Settlements and the Financial Action Task Force, will streamline cross-border payments and related issues such as KYC and AML rules. Entrepreneurs working on launching digital solutions will likely have cost advantages over traditional incumbents. That is why they need to focus on offering intuitive, simple, and secure processes while respecting domestic and international laws. As cash off-ramps remain important, it is necessary to offer conversion into cash or collaborate with partners who can do so. A good example is the collaboration between Stellar and MoneyGram International.

5.2. Directions for Future Research

To better understand the nature and underlying dynamics of cross-border payments, a holistic approach is needed. First, the effects on economic growth and poverty alleviation need to be investigated further to justify why policymakers should focus their attention on the topic. This also includes economic savings due to shorter transaction times. Second, there needs to be more research on how to accurately measure remittance flows, the level of market transparency, and technology literacy rates. This would also mitigate the potential effect that informal remittance channels have. Third, it would be beneficial to relate the findings of this study with others from adjacent areas, such as research analysing the success of educational programs,

especially related to financial decisions. Fourth, tracking the progress towards the United Nation's goals will help instil a sense of urgency and also uncover the effectiveness of certain measures. Evaluating past initiatives would provide valuable insights going forward. Fifth, country or regional studies which account for country-specific conditions will also be useful. Sixth, blockchain-based services need to be monitored more frequently. This study sheds light on two popular solutions. However, there are many more. Blockchain-native companies such as Ripple have focussed on inter-bank communication using their blockchain technology but also have ventured into small-value payments through a partnership with TransferGo (Ripple, 2019). Primarily, Ripple offers banks and other FSPs to connect to their network, RippleNet, to bundle global payments by offering currency-independent transfers through their native token XRP. FSPs can hence avoid cumbersome integrations with every new partner and enjoy significantly lower transaction costs. Therefore, Ripple is competing against established systems such as Swift, which itself has been exploring the integration of blockchain-based services and continues to do so (Swift, 2018; Swift, 2023). Payment company VISA has also shown interest in blockchain-based payment systems. VISA published a research paper outlining the concept of 'Universal Payment Channels", which aims at achieving cross-blockchain interoperability (Christodorescu et al., 2021). If implemented, VISA could not only allow communication and payment flows between central-bank digital currencies and stablecoins but also between different blockchain systems, such as Stellar and the Lightning Network. Seventh, current solutions tend to be relatively centralised, reducing their resilience to certain attack vectors. Building on Coutinho et al. (2023), further possibilities to decentralise and its effect on compliance and security need to be studied. Lastly, blockchain-related regulations have been introduced and more are to be released in the near future. Therefore, it will be essential to study their effects in practice and their implications for FSPs, entrepreneurs and users alike.

5.3. Conclusions

Remittances are likely to remain an important source of income for millions of people living in LMICs. However, high transaction costs are in the way of realising their potential positive effects. Therefore, we quantitatively analysed transaction cost

drivers and presented two case studies on different blockchain-based services. Our analysis showed that costs differ between geographic destinations, payment vehicles, and pickup methods. Transaction costs are highest in Sub-Saharan Africa and lowest in South Asia. Digital services outperform traditional channels, such as retail banks, in both transaction speed and cost. MTOs generally send funds within an hour which are picked up in cash. Sending remittances via retail banks takes two days, on average, and usually, funds arrive at the recipient's bank account. Throughout all regions, using MTOs is cheaper than sending remittances via banks. The size of the remittance markets also influences the transaction cost as larger economies can benefit from economies of scale.

Blockchain-based solutions appear promising, as they combine near-instantaneous transfers at costs well below the current average, as shown in both case studies. Last-mile delivery and the conversion into local cash remain critical points but there are more hybrid services emerging. This study concludes that collaborations between blockchain-based FSPs and traditional incumbents with extensive access networks, such as between Stellar and MoneyGram, provide bases for financial services that outperform current dominant players in the remittance industry, when it comes to transaction speed and cost.

Given that most financial systems are not crypto or blockchain-ready yet, there are some hurdles which need to be overcome. Regulators need to address the legal uncertainty surrounding the issuance and management of digital assets of any kind to pave the way for more entrepreneurs and established players to incorporate this new technology into cross-border payment infrastructure. Additionally, blockchain-based services need to not only be compliant but also offer simple and intuitive user experiences that make it easier to switch from traditional and costly alternatives. Getting users to interact more with their services will also require significant educational efforts to demystify an industry niche which has a reputation of housing shady players in some cases and overly complex processes that require some technical knowledge. However, regulations upcoming in the near future, combined with large target markets, will accelerate integrating blockchain technologies into current payment systems. Offering more competitive rates, these

services will be well-positioned to play an integral part in reaching the United Nation’s goals and shaping the future of remittance payments.

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Appendices

Appendix A: Output of statistical analysis

Table 1: *Descriptive statistics of the dependent variable and its predictors*

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
ln_cost200	90	1.29	3.05	1.9461	.39846
ln_remi_rec	88	16.45	25.43	21.3311	1.70198
acc_remi	63	.48	53.43	15.0300	10.96406
mob_subs	89	30.48	175.34	101.4567	33.90174
Valid N (listwise)	62				

Table 2: *Model coefficients*

Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	4.671	.512		9.124	<.001
	ln_remi_rec	-.114	.023	-.497	-4.941	<.001
	acc_remi	.011	.003	.394	3.947	<.001
	mob_subs	-.004	.001	-.370	-3.732	<.001

a. Dependent Variable: ln_cost200