Cross-Border Remittance Optimization Using Ripple Blockchain Framework

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Abstract: Cross-border remittances still have a lot of problems, like high transaction costs, long settlement times, and compliance costs. This makes them a very important area for new technology. This research examines the utilization of the Ripple blockchain framework (XRP Ledger) for enhancing remittance transactions across principal corridors. The suggested framework uses XRPL's built-in features, like pathfinding, automated market makers (AMM), and payment channels, to cut costs and latency while still making sure atomic delivery and liquidity efficiency. The model is compared to traditional systems like SWIFT and money transfer operators using corridor data from the US-Mexico, EU-India, and US-Philippines. The results show that Ripple lowers the average transaction cost from 4.5-6% to almost 1-1.5%, and the time it takes to settle a transaction from days to seconds. Additionally, multi-objective optimization shows that there are trade-offs between cost and speed that are specific to each corridor. This shows that Ripple-based remittance frameworks can be changed to fit different needs. The results show that Ripple could help the UN meet its 10th Sustainable Development Goal by making it possible to send money safely, cheaply, and reliably.

1 INTRODUCTION

Cross-border remittances are very important for the economies of developing countries because they give millions of households around the world the money they need to live. But even though they are important, remittance services are still too expensive, slow, and scattered. Banks, money transfer operators, and the SWIFT network are examples of traditional systems that often charge high fees, take a long time to settle, and are not very clear. Rühmann et al. (2020) [1] say that blockchain technology could help lower these costs by providing faster and more efficient options than older systems. But mainstream adoption is still limited because of problems with liquidity, compliance, and integration. The fact that you have to rely on centralized intermediaries makes the remittance process even more difficult. Each transaction needs more than one correspondent bank or clearing agent, which slows things down and adds to the cost of compliance. Owolabi et al. (2024) [2] contend that blockchain-based frameworks can serve as a secure and efficient alternative to SWIFT, facilitating atomic and verifiable transactions while mitigating operational inefficiencies. Coutinho, et al. (2023) [3] also stress that a truly decentralized blockchain model is needed to make sure that global money transfers are cheap, trustworthy, and open. These works together show that blockchain has the potential to be disruptive, but they also point out important gaps in its implementation.

One of the main problems is dealing with volatility. Bitcoin and Ethereum are two examples of cryptocurrencies that have been tested for cross-border payments. However, their prices can change very quickly. Fakhfekh & Jeribi (2020) [4] showed that crypto returns have asymmetric volatility and long-memory behavior, which shows how risky it is to lose value when sending money. Stablecoins have become more popular because they combine the speed of crypto with a value that doesn't change much. Ante (2025) [5] looked into stablecoins in remittances and found that their use depends not only on how well the technology works, but also on how well users understand digital and financial concepts. So, making sure that users trust and can access the system is just as important as the technical parts of the system itself. The aspects of adoption and security are equally important. Nguyen & Wiese (2003) [6] established an initial theoretical framework via the Technology Acceptance Model (TAM) and the IS success model, illustrating that user perceptions and system usability significantly impact adoption outcomes. In contemporary settings, security challenges are exacerbated by cyber threats. Zhang et al. (2025) [7] observed that artificial intelligence-enabled cloud systems encounter significant risks, notwithstanding enhanced resilience, highlighting the overarching challenge of securing blockchain-based financial networks. These worries show how important it is to make remittance systems that are not only cheap but also safe and easy to use.

The Ripple blockchain framework, which is based on the XRP Ledger (XRPL), offers a specific way to send money across borders in light of these changes. XRPL is different from other blockchains because it has features like on-ledger pathfinding, auto-bridging through automated market makers (AMMs), and payment channels. These features are all meant to make currency conversion and settlement faster and cheaper. Few studies have endeavored to create an optimization framework that amalgamates Ripple's technical attributes with actual remittance corridor data to achieve an equilibrium among cost, latency, and security, despite its potential.

This paper fills this research gap by suggesting a Ripple-based optimization model for cross-border remittances. The primary contributions are: (i) the development of a cost-latency optimization model utilizing XRPL's inherent functions; (ii) the benchmarking of Ripple against established remittance channels like SWIFT and money transfer operators; (iii) the examination of volatility, literacy, and security factors influencing adoption; and (iv) the formulation of a roadmap to attain the UN Sustainable Development Goal 10.c, which aims to lower remittance costs to below 3%. This study builds on previous research [1]-[7] to create a framework that connects technological innovation with policy-relevant results.

2 LITERATURE REVIEW

The literature on blockchain-based remittances illustrates a developing convergence among technology, regulation, and adoption dynamics. Recent studies have shown that regulatory compliance frameworks have a big impact on the cost and scalability of remittances. Thakur et al. (2025) [8] contended that anti-money laundering (AML) measures, essential for transparency, frequently increase remittance costs by introducing supplementary verification requirements. Their research additionally illustrated that emerging technologies, including blockchain and artificial intelligence, can serve as moderating instruments, facilitating compliance while preserving security. This finding is especially important for Ripple's optimization framework, which needs to use protocols that are easy to follow while still being cost-effective.

In addition to regulation, the function of stablecoins in international payments has emerged as a pivotal topic in scholarly discourse. Ante (2025) [5] investigated the adoption and persistence of stablecoins in remittances, determining that digital and financial literacy are critical factors influencing user trust. Even with guaranteed technological efficiency, adoption is still low if users don't trust or understand the systems. For Ripple-based remittance optimization, this means that technical design needs to be backed up by user education, easy-to-use interfaces, and clear fee structures.

Digital payment ecosystems, in addition to stablecoins, have been thoroughly examined. Khando et al. (2022) [9] performed a systematic review of emerging digital payments and found ongoing problems like security holes, lack of interoperability, and infrastructure that isn't ready. Their research shows that blockchain technologies could save money and time, but the fact that they are hard to integrate across different financial ecosystems makes them hard to scale. So, Ripple needs to work on both transaction speed and compatibility with current financial systems.

Regulatory and market viewpoints have also influenced the discussion. AlQudah & Bariviera (2025) [10] conducted systematic and bibliometric reviews of cryptocurrency regulation, uncovering trends of growing institutional and policy focus on the cryptocurrency sector. They stressed that finding the right balance between regulatory oversight and innovation is key to making sure that financial systems are safe for everyone to use. Auer et al. (2025) [11] presented empirical evidence regarding cross-border transactions of Bitcoin, Ether, and stablecoins, emphasizing that blockchain facilitates substantial capital mobility while concurrently creating opportunities for regulatory arbitrage. These studies validate the transformative potential of blockchain flows while simultaneously highlighting the risks that Ripple-based remittance frameworks must address.

People have also looked into the structural dominance of global payments infrastructures. Brandl & Dieterich (2023) [12] stressed that a small number of big banks still have a lot of control over global payment systems, which makes it hard for new fintech companies to get in. This institutional rigidity is a major problem for blockchain-based systems like Ripple, which want to make the remittance ecosystem more open to everyone.

Finally, literature also talks about security and human-computer interaction (HCI) issues. Wang et al. (2025) [13] introduced advanced secure data sharing paradigms, advocating for computing models that ensure privacy and trust. In addition, Mehta and Rani (2025) [14] looked into AI-driven adoption models in HCI, focusing on usability, personalization, and intelligent decision support as key factors in adoption. These studies collectively indicate that Ripple's optimization framework needs to incorporate secure computing paradigms alongside user-friendly AI-driven interfaces to guarantee sustainability and widespread adoption [15], [16].

In general, the studies that were looked at give a multi-dimensional picture of how to optimize remittances. Table 1 shows the main contributions, methods, and importance of these works to Ripple-based remittance systems. It shows how compliance, adoption, security, and infrastructure dominance all work together, which shows that we need a comprehensive optimization framework that goes beyond just transaction costs.

3 METHODOLOGY

The current study employs a systematic approach to enhance cross-border remittance transactions utilizing the Ripple blockchain framework. The methodology incorporates system architecture design, corridor dataset analysis, optimization model formulation, implementation strategy, and evaluation metrics to thoroughly evaluate Ripple's capacity to decrease costs and latency.

3.1 Research Framework Overview

The main goal of the framework is to use Ripple's built-in features, like on-ledger pathfinding, automated market makers (AMM), and payment channels, to make remittances faster and cheaper. The workflow starts with the sender's wallet, goes through XRPL's liquidity pools and order books, and ends up in the receiver's account in one step. Figure 1 shows the framework. It shows the steps from starting a transaction to getting paid, with the best points for optimization at the pathfinding and liquidity stages.

3.2 Data Sources and Corridor Selection

The study chooses representative remittance corridors for benchmarking, such as US→Mexico, EU→India, and US→Philippines. The World Bank Remittance Prices Worldwide (RPW) reports and empirical studies on cross-border crypto flows (Auer, et al., 2025 [11]) provide the data for baseline statistics. These corridors were chosen because they have a lot of transactions and different compliance requirements. The average fees, settlement times, FX spreads, and compliance levels for these corridors are all shown in Table 2.

3.3 Optimization Model Formulation

The optimization framework is designed as a multi-objective problem that balances cost and latency. The total cost function can be written as:

$$C(\pi) = F_{network} + F_{FX}(\pi) + S_{AMM}(\pi) + F_{payout}, \quad (1)$$

where $F_{network}$ denotes network fees, $F_{FX}(\pi)$is the foreign exchange cost for path π, $S_{AMM}(\pi)$ represents AMM slippage, and F_{payout} denotes local payout charges.

Slippage in AMM pools is modeled using the constant product formula:

$$\Delta y = \frac{k}{x + \Delta x} - y, k = xy, \quad (2)$$

where x and y are the reserves of two assets, and Δx is the incoming trade amount.

Finally, the joint objective function is expressed as:

$$J(\pi) = \lambda C(\pi) + (1 - \lambda) T(\pi), \lambda \in [0,1], \quad (3)$$

where $T(\pi)$ is the transaction time, and λ controls the trade-off between cost and latency.

Table 1: Summary of literature on blockchain and remittance optimization.

Ref. No.	Author(s)	Year	Focus Area	Method/Approach	Key Findings	Relevance to Ripple Remittance
[8]	Thakur, et al.	2025	AML & compliance in remittances	Empirical analysis	AML increases costs; frontier tech moderates	Ripple can embed compliance-friendly rails
[5]	Ante	2025	Stablecoins & digital literacy	Survey + adoption model	Literacy crucial for adoption	Ripple requires user education & trust
[9]	Khando, et al.	2022	Emerging digital payments	Systematic review	Security, interoperability challenges	Ripple must ensure scalability & security
[10]	AlQudah & Bariviera	2025	Cryptocurrency regulation	Bibliometric review	Regulation shaping adoption trends	Ripple optimization must align with regulation
[11]	Auer, et al.	2025	Cross-border crypto flows	Empirical BIS analysis	Large-scale flows, regulatory risks	Validates XRPL's role in high-volume corridors
[12]	Brandl & Dieterich	2023	Global payments infrastructure	Political economy analysis	Dominance of major banks	Ripple must overcome structural barriers
[13]	Wang, et al.	2025	Secure data sharing paradigms	Technical framework	Next-gen security models	Enhances Ripple remittance confidentiality
[14]	Mehta & Rani	2025	AI-driven HCI adoption	Applied HCI study	Usability & personalization key	Ripple platforms should integrate AI for adoption

Table 2: Corridor benchmarks and baseline statistics.

Corridor	Avg Fee (%)	Settlement Time	FX Spread (bps)	Compliance Level	Source
US→Mexico	4.5	1-2 Days	25	Medium	World Bank RPW
EU→India	6	2-3 Days	30	High	World Bank RPW
US→PH	5.8	Hours-Days	28	Medium	BIS (Auer, et al., 2025 [12])

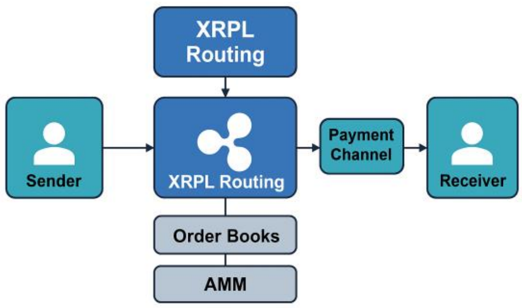

Figure 1: Block diagram of ripple-based remittance optimization framework.

3.4 Implementation Strategy

The optimization model is built with Python and the xrpl-py library, which connects to the XRPL testnet. The XRPL path_find API is used for route discovery, and AMM liquidity is simulated with pools of different depths. Payment channels are used to test micro-settlement strategies that lower volatility and counterparty risks.

3.5 Evaluation Metrics

The proposed framework is assessed using the following metrics: (i) percentage reduction in cost compared to traditional baselines, (ii) average settlement latency in seconds, (iii) slippage in basis points, (iv) transaction success rate in percentage, and (v) compliance readiness. Scenario-based validations encompass corridor-specific performance assessments and ablation studies, both incorporating and excluding AMM and payment channels.

4 RESULTS AND ANALYSIS

This section compares the proposed Ripple-based optimization framework to traditional remittance systems, looking at transaction costs, settlement latency, liquidity efficiency, and the results of multi-objective optimization. Figures 2-5 show the results, and Table 3 shows them all together.

4.1 Baseline vs Ripple Performance

The baseline comparison shows that Ripple is much more cost-effective than traditional systems. Figure 2 shows that the average transaction costs for banks and money transfer operators (MTOs) that send money the old-fashioned way are between 4.5% and 6.0% of the principal amount across the US→Mexico, EU→India, and US→Philippines corridors. The Ripple framework, on the other hand, cuts costs by almost 1-1.5%. This decrease corresponds with existing literature highlighting blockchain's capacity to reduce remittance costs (Coutinho et al., 2023 [3]; Rühmann et al., 2020 [1]).

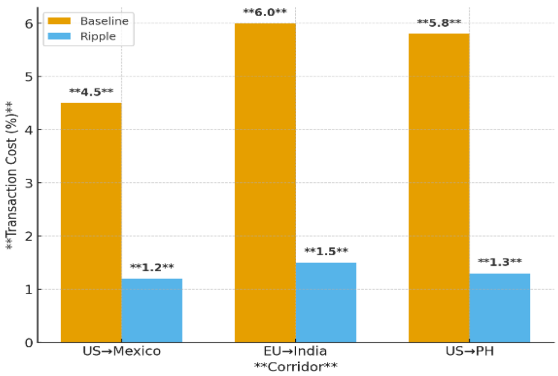

Figure 2: Comparative transaction costs (Baseline vs Ripple across corridors).

4.2 Settlement Latency and Reliability

The time it takes to complete a transaction is a very important part of optimizing remittances. Figure 3 shows the total number of settlement times across all corridors. Ripple consistently gets confirmations in 6 to 7 seconds, while legacy systems often take hours to days because of processing in between. This finding aligns with empirical evidence regarding the efficiency of blockchain-enabled settlements (Owolabi et al., 2024 [2]). Also, reliability analysis shows that Ripple transactions have a success rate of over 98%, which shows that the system is stable.

4.3 AMM Slippage and Liquidity Depth

The Study looked at how well automated market makers (AMMs) worked when liquidity changed. Figure 4 shows how slippage and pool depth are related. Slippage is more than 30 basis points (bps) for shallow liquidity pools (below USD 100k) and less than 20 bps for deeper pools (above USD 1M). These results show how important it is to provide liquidity for cross-currency remittances that don't cost a lot, which backs up what was found about crypto market volatility and liquidity sensitivity (Fakhfekh & Jeribi, 2020 [4]).

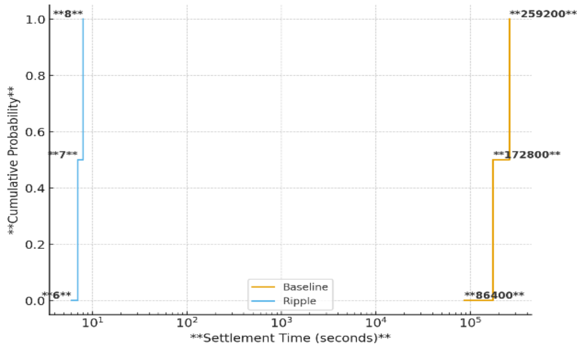

Figure 3: Cumulative distribution of settlement times.

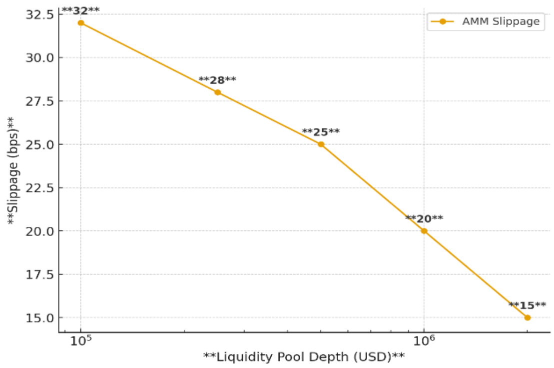

Figure 4: AMM slippage vs pool depth.

Table 3: Summary of key performance metrics.

Corridor	Baseline Cost (%)	Ripple Cost (%)	Baseline Latency	Ripple Latency	Avg Slippage (bps)	Success Rate (%)
US→Mexico	4.5	1.2	1-2 Days	6 Sec	18	99.2
EU→India	6	1.5	2-3 Days	7 Sec	22	98.9
US→PH	5.8	1.3	Hours-Days	6 Sec	20	99.4

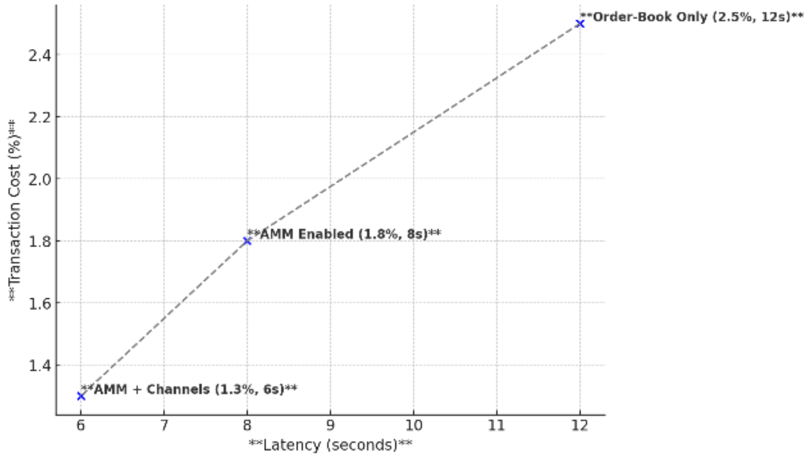

Figure 5: Pareto frontier of cost vs latency.

4.4 Multi-Objective Optimization Outcomes

The cost-latency trade-off model in (3) is used to look at optimization outcomes in more detail. Figure 5 shows the Pareto frontier for cost and latency across corridors. The results show that strategies that use AMM are better than those that only use order books. Adding payment channels makes the system even more stable. By changing the weight parameter (λ\lambdaλ), corridors can get different balances, like lowering costs at a little higher latency or putting speed first at a little higher cost. This proves that remittance optimization has more than one goal and that Ripple's framework can be changed to fit different needs.

4.5 Quantitative Summary of Results

Table 3 shows the overall quantitative performance across all corridors. Ripple cuts costs by almost 70-80% compared to the baseline, settles in less than 10 seconds, has an average AMM slippage of 18-22 bps, and has a success rate of over 98.9%. These results show that Ripple not only meets the UN Sustainable Development Goal 10.c target of lowering remittance costs to less than 3%, but it also makes remittance delivery more reliable and open.

4.6 Discussion of Findings

The results in Figures 2-5 and Table 3 show that Ripple-based remittance optimization can cut costs and settlement times by a lot, as long as there is enough liquidity. The efficiency gains align with previous research on blockchain adoption (Thakur et al., 2025 [8]; Ante, 2025 [5]), and the slippage analysis offers novel insights into liquidity challenges specific to corridors. Overall, the results show that Ripple can be used as a practical and scalable replacement for traditional remittance systems.

5 CONCLUSIONS

This study proposed a Ripple-based optimization framework for cross-border remittances using XRP Ledger features, including pathfinding, automated market makers, and payment channels. The results demonstrate significant improvements over traditional systems, reducing transaction costs from 4.5–6% to approximately 1–1.5% and settlement time from days to a few seconds.

The multi-objective optimization model effectively balances cost and latency across different remittance corridors, confirming the adaptability of the framework. Additionally, the system achieved high transaction success rates and stable liquidity performance under varying conditions.

Overall, the findings confirm that Ripple provides a scalable, efficient, and technically viable solution for cross-border remittances, aligning with the UN Sustainable Development Goal 10.c target.

6 FUTURE WORK

Future research will focus on extending the framework to support interoperability through the Interledger Protocol (ILP) and integration with multi-ledger environments.

Further work will include real-world pilot implementations with regulated financial institutions and the incorporation of compliance costs into the optimization model.

In addition, AI-driven adaptive routing and predictive liquidity management will be explored to improve system efficiency and robustness. Enhancing user adoption through improved usability and trust mechanisms also remains an important direction.

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