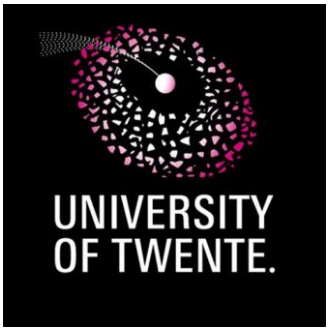
Blockchain and Banking Efficiency: Global Evidence from Ripple Network Adoption

March 14th, 2023

Author: L.V.L. van Breda (s2041545)

1st Supervisor: dr. V.B. Marisetty

2nd Supervisor: dr. X. Huang



ABSTRACT

The adoption of blockchain technology, due to its apparent benefits relating to no reconciliation issues, speed of transaction through smart contracts and immutability of transaction records, is expected to result in overall banking efficiency and profitability. However, there is no empirical evidence to verify these claims. We provide evidence by assessing 101 banks adoption of Ripple technology (for cross border payments) on banking liquidity, operating efficiency and market valuation. Using difference-in-differences approach, we show that, compared to the non-adopted banks, adopted banks did not experience higher liquidity in the post implementation period, nor did adoption result in benefits in operating efficiency or valuation. However, when we focus on early adopters, with longer post-adoption history, we find significant reduction in operating efficiency and liquidity. Taken together, our results indicate that blockchain adoption benefits are negligible in the short run, but significant in the long run.

Key words: Ripple; Blockchain; Banking Efficiency; Cross Border Payments.

1. LIST OF ABBREVIATIONS

IDC	International Data Corporation
CAGR	Compound annual growth rate
OMFIF	Monetary and Financial Institutions Forum
DLT	Distributed ledger technology
ROCE	Return on capital employed
USD	United States Dollar
M USD	Million United States Dollars
T USD	Trillion United States Dollars
M	Mean
SD	Standard Deviation
CPI	Consumer pricing index
GDP	Gross domestic product

2. TABLE OF CONTENTS

1. LIST OF ABBREVIATIONS 3
2. TABLE OF CONTENTS 3
3. INTRODUCTION 4
4. LITERATURE REVIEW 7
5. RESEARCH DESIGN & METHODS 16
6. RESULTS 19
   6.1 Sample Description 19
   6.2 Univariate Analysis: Independent Samples t-Test 23
   6.3 Regressions for the Difference-In-Differences Analysis 26
   6.4 Robustness Check 31
7. CONCLUSION & DISCUSSION 35
8. REFERENCES 39
9. APPENDIX 40
   Appendix A. Literature Review – Ripple Network 40

3. INTRODUCTION

Blockchain is a technology that keeps a record of transactions on a decentralised network shared by its users. This decentralisation removes the need for trust in an intermediary third party and increases trust between interacting agents. Since the ledger is kept by many users who mutually agree on the correct sequence of events, blockchain technology can lead to benefits within the banking sector, namely in terms of risk mitigation, security, transparency, cost efficiency, and processing speed (Navakauskas et al., n.d.; Vovchenko et al., 2017; Wu & Duan, 2019). The increased trust between actors means that banks no longer have to keep their capital locked in nostro accounts with different banks. Consequently, their liquidity can be improved. This study investigates to what extent these benefits of blockchain technology, when implemented by banks, lead to an increase in their banking efficiency.

Blockchain has a large market in banking and the financial services industry, estimated to be 1.455 billion USD in size in 2021 and forecasted to grow to 22.46 billion USD by 2026[1]. Banks show much interest in using blockchain technology to improve the cross-border transaction process. According to the International Data Corporation (IDC), banking is the leading sector in terms of investments in blockchain use cases, accounting for nearly 30% of total global investments in 2021, with cross-border payments being the most common use case, representing 15.9%[2]. Moreover, the volume of global cross-border payments is growing steadily. Between 2018 and 2021 the total flow of cross-border transactions was estimated to have grown from 127.8 trillion USD to $148.3 trillion USD, with a compound annual growth

[1] https://www.cliffordchance.com/content/dam/cliffordchance/PDFDocuments/the-blockchain-revolution-in-banks-and-financial-institutions.pdf (accessed 22/04/2022)

[2] https://www.idc.com/getdoc.jsp?containerId=prUS47617821&utm_medium=rss_feed&utm_source=alert&utm_campaign=rss_syndication (accessed 22/04/2022)

rate (CAGR) of around 5%[3]. The Official Monetary and Financial Institutions Forum (OMFIF) 2022 report that surveyed several global banks found that banks are largely concerned about pain points in cross-border payments, particularly high costs and inefficient processes. Respondents feel that Distributed Ledger Technology (DLT) would provide the tools to surmount these issues. A 2019 Institutional Deposits Corporation study on blockchain spending found that cross-border payments received the highest annual investment at 453 million USD, equivalent to 16% of market share. This makes cross-border transactions an interesting area of research for understanding banking efficiency.

The academic literature dealing with blockchain in the banking sector is still relatively scarce. To the best of our knowledge, there has been no study conducting a thorough, quantitative analysis examining whether the operating efficiency of banks is improved by the implementation of blockchain technology for cross-border transactions. The contribution of this study will lie in filling this gap.

If banks use blockchain technology for cross-border transactions, it is expected that banks can reduce costs by avoiding high foreign transaction fees. Furthermore, it is expected that the high processing speed of recording transactions on a decentralised, identical ledger and the increased trust between actors will result in a reduction in opportunity costs, as the need for keeping capital locked up in nostro accounts is removed. This is expected to result in improved liquidity of banks. Moreover, by using blockchain technology for cross-border transactions, it is expected that banks can mitigate risks by reducing exposure to foreign exchange risks and avoiding foreign exchange spreads. These benefits may then improve overall banking efficiency, which will be reflected in their profitability and valuation.

[3] https://www.ey.com/en_us/banking-capital-markets/how-new-entrants-are-redefining-cross-border-payments (accessed 18/04/2022)

We use the Ripple network for our investigation, since Ripple is a widely used payment network by banks for cross-border transactions, with over 300 banks and financial companies using its services. Ripple has also made the case in a report that its services can help banks cut up to 42% in the costs they incur using legacy systems (*The Cost-Cutting Case for Banks*, 2016). But if that were the case, one would expect many more banks to be using RippleNet. This study examines whether these claims are justified by evidence.

The research question was answered by performing a difference-in-differences analysis on financial variables taken from banks' financial statements of a set of 101 banks between 2008 and 2021 , controlling for the effects of the variables that are known from the existing academic literature to affect bank operating costs and profitability. Regressions were run with a number of measures of cost efficiency ("Fees & Commissions Expense", "Other Operating Expense"), Liquidity ("Cash & Short-Term Deposits Due From Banks" over total assets, capital adequacy, "Interbank Loans & Long-Term Deposits with Other Banks"), foreign exchange risk ("Other Comprehensive Income – Foreign Currency", "Hedging Reserves", "Foreign Currency Translation Adjustment", "Foreign Exchange Effects" (on cashflow statement)), and investments efficiency ("Interest & Dividend Income – Investment Securities"). Regressions were also run with banks' price to book ratios, as a measure of their valuations, and with return on capital employed (ROCE) as a measure of their profitability. Using this methodology, we find that, contrary to the conventional wisdom, Ripple adopted banks saw relatively higher operating costs in the post-adoption period (compared to the control group of banks that did not adopt). Moreover, their liquidity did not improve in the post-adoption period. Banks' foreign exchange risk cannot be said to have decreased after they started using Ripple. Also, banks did not increase their investments efficiency after starting to use Ripple, nor did they see a decrease in their valuation following their implementation of Ripple for cross-border

transactions. However, for early adopting banks, cost efficiency did improve when taking Fees & Commissions Expense as a measure. Consequently, these banks saw their liquidity improve when taking Capital Adequacy as a measure. No different result was found for risk mitigation. Lastly, despite other results for these banks, their investment performance was negatively affected after the adoption of Ripple.

The findings of this study will be useful for researchers and banks who want to know if Ripple specifically – and blockchain technology in general – is a useful tool for the improvement of banking efficiency. Our results suggest that the benefits of blockchain adoption seem to be limited.

The rest of this study is structured as follows: Section 2 will give an overview of the existing literature and build the conceptual framework that will be used to generate the hypotheses. Section 3 will explain the research design and methodology. Section 4 reports results, while section 5 concludes.

4. LITERATURE REVIEW

Technological adoption and innovation are the key drivers of economic growth and firm performance (see Romer, 1990; David, 1990; Aghion and Howitt, 2007). In particular information technology adoption has been a key driver for higher returns (Brynjolfsson, 1993; Brynjolfsson and Hitt, 1998; Bloom et al., 2012). Anderson et al. (2006) and Jun (2008) emphasize that technology innovations particularly are urgent in the financial services sector, especially with the current wave of “fintech” innovation where different technologies can have various effects on organizations. Post global financial crisis and banks failure has spurred more innovations to disrupt the financial intermediation model through Bitcoin invention.

Bitcoin came into being in 2009 after the paper published under the pseudonym of Satoshi Nakamoto (Nakamoto, 2008). Since then, many other cryptocurrencies have emerged. From the technological point of view, something that these cryptocurrencies have in common is their use of the technology of blockchain (sometimes referred to as distributed ledger technology, or DLT), which creates a cryptographically secured sequence of the transactions without the need for a central authority to validate them. The literature has identified a number of advantages that are inherent to blockchain technology.

Navakauskas et al. (2018) and Vovchenko et al. (2017) identified decentralisation as the main benefit of the blockchain, as it removes the need for a trusted intermediary third party in trade. This can lead to a number of advantages. First, Navakauskas et al. (2018) argue that this decentralisation can lead to increased security, as the history of transactions can be held by many users who all agree on the correct sequence of events. This can then mitigate hacking risks and other risks of integrity breach, for example. A similar argument was made by Vovchenko et al. (2017). Secondly, the fact that records are shared by many users gives the blockchain a high degree of transparency. Thirdly, Vovchenko et al. (2017) also identified a reduction in the costs of interaction to companies and banks as an advantage. Chang et al. (2020) also argue that cost reductions and risk mitigation are two of the main drivers affecting banks´ motivation to adopt blockchain.

Among the possible advantages of blockchain technology, there is a subset of advantages that apply to the banking sector. Processing speed is one such advantage, as identified by Navakauskas et al. (2018). Other possible advantages of blockchain technology within the context of banking are the mitigation of risks, such as bill forgery risk and credit risk (Wu & Duan, 2019). Wu & Duan (2019) further examine two applications of blockchain technology

within banking: cross-border transactions and asset securitization. Moreover, Chiu & Koeppl (2019) argue that the main potential benefit of blockchain is high-speed settlement of transactions. Guo & Liang (2016) name increased cost efficiency and settlement speed as potential benefits of blockchain technology in banking, specifically cross-border payments.

Ripple has been talked about by a few authors. Armknecht et al. (2015) analysed the usage of Ripple at the time of its introduction and found then that most of its users held only a small amount of XRP, and most accounts were inactive. However, eventually XRP started rising significantly, at one point even becoming the second most highly valued cryptocurrency, with Bitcoin being the most valued cryptocurrency. In that time, Ripple has partnered with a large number of financial institutions. Therefore, their findings may no longer be completely up to date. Qiu et al. (2019) argued that Ripple's technical advantages (such as real-time delivery, 24/7 services, and low transaction costs) will likely allow it to eventually overtake SWIFT in the cross-border transaction market, even though in the short term SWIFT will likely keep the lead, due to high risk aversion in the industry.

However, to the best of our knowledge, there is no systematic evidence on the impact of blockchain technology and Ripple on banking efficiency. Some authors have identified factors that affect bank profitability and cost efficiency.

HYPOTHESES DEVELOPMENT

Blockchain technology has a number of advantages associated with it, largely deriving from its decentralised nature. This technology provides a means to achieve a decentralized consensus and may enlarge the space of potential contracts with so-called smart contracts, which can be enforced without the need for a third party. This disruptive impact is exacerbated by the fact that traditional banks have specialized in intermediation activities, the need for which may be

reduced by the blockchain technology. Smart contracts can lower contracting and verification costs and reduce informational asymmetries. Of these advantages, a subset is applicable to the banking sector, depending on the use case. Here, the focus lies on cross-border transactions. All in all, the use of blockchain technology can benefit banks in terms of risk mitigation, increased liquidity, and cost efficiency in the context of the use case of cross-border transactions. These benefits should be visible when analysing banks' financial statements. Moreover, if banks are improving their performance in this manner, that should also be indicated in their profitability, of which return on capital employed (ROCE) is a measure, and in their price to book ratio, a measure of their valuation. A representation of the conceptual model used in this paper is shown in Figure 1. This conceptual model is further explained in this section.

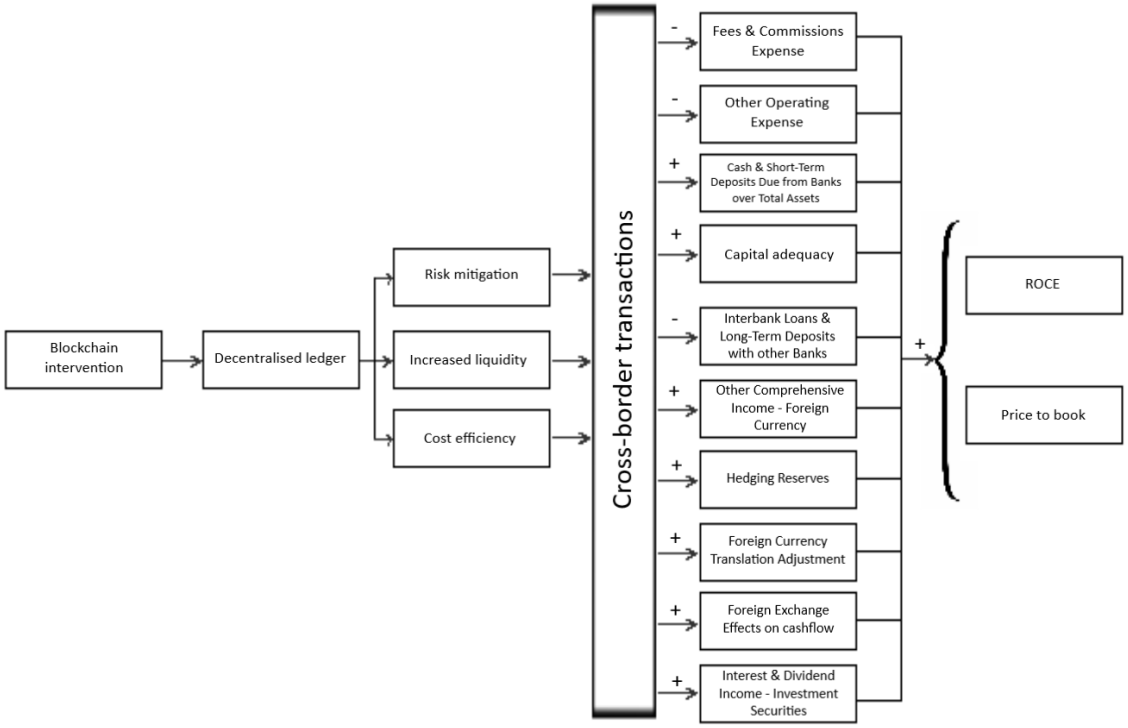


Figure 1. Conceptual model. Banks that implement blockchain technology use a decentralised ledger. This can benefit them in risk mitigation, increased liquidity, and cost efficiency. This should manifest itself on bank's financial statements and financial ratios.

Cross-border transaction occur between individuals or business entities residing in different legal jurisdictions. Transactions of this kind are subject to tax considerations, both of the two individual jurisdictions, and of any tax treaties between the two governments. Furthermore, the process involves a large amount of communications between the payer's and payee's banks in both jurisdictions. Transaction fees and exchange rates then also play a role. The communication is usually done using the SWIFT network.

When a person makes an online purchase from a merchant residing in another country, that person will typically enter his payment information, after which the merchant's bank will communicate with the payer's bank. If the two banks do not have formal agreements with the each other, then the payer's bank will search the SWIFT network for a correspondent bank

that does have such agreements with the payee's bank. The correspondent bank will then function as an intermediary that facilitates the cross-border transaction and will charge a transaction fee. The payer's bank takes the money that is to be transferred and the transaction fee from the payer's account and wires it to the correspondent bank. The correspondent bank transfers the money to the payee's bank. This process usually takes a few days to complete. In order to ensure that these transactions can happen, a bank will keep money in reserve in a vostro account for another bank, who keeps track of those funds using a nostro account.

To illustrate this with an example, if a person in the United States makes a purchase for 100 USD from a merchant in the Netherlands, the merchant's bank will ask the purchaser's bank for the money. But assuming that the two banks have no formal agreements with each other, the Dutch bank will find another bank in the United States that it can trust to facilitate the transaction – the correspondent bank. This bank charges a fee of 3% for this transaction. The purchaser's bank takes the money, from the purchaser's account and sends it, plus the transaction fee to the correspondent bank. The correspondent bank forwards the money to the merchant's bank, but keeps the transaction fee. If the purchaser's bank passed the transaction fee along to the purchaser, it now has 103 USD less on its liabilities, but has also lost money in the conversion from USD to EUR from a foreign exchange spread.

Ripple, with its native token XRP, is one of the largest crypto-related companies. Their stated purpose is to serve as a temporary settlement layer and as a platform for instant trading between different currencies. Currently, Ripple is known to have over 300 financial technology companies, banks, and financial institutions as their customers.[4] This is what makes it interesting in the context of cross-border transactions. Ripple's network, RippleNet, is a digital

[4] https://ripple.com/insights/ripplenet-growth-announcing-more-than-300-customers/ (accessed 30/05/2022)

payment network for financial transactions. Its stated purpose is "[to enable] the world to move value like it moves information today"[5]. Ripple seeks to use the technologies of blockchain and digital assets to dramatically increase the speed and decrease the costs of cross-border transactions with on-demand liquidity. XRP Is used in Ripple's products to facilitate quick conversion between currencies. XRP is currently the sixth most highly valued cryptocurrency and Ripple already has many large financial service providers as partners[6,7].

Ripple has published their own report making the case for how banks can cut costs by using their network (*The Cost-Cutting Case for Banks*, 2016). Instead of keeping many nostro and vostro accounts, banks can hold XRP on their balance sheets and use that as a replacement for the intermediary role of correspondent banks. In this way, much of the friction in the process may be circumvented. Specific categories of costs are indicated in it, which Ripple argues are the sources of banks' cost savings: liquidity costs, treasury operations costs, payment operations costs, Basel III compliance costs, and foreign exchange costs. Liquidity costs are opportunity costs arising from the time that capital is locked in-flight for the time during which a cross-border transaction is being processed and the time necessary to fund the local nostro account. Payment operations costs are the costs originating from the manual interventions for the purpose of exceptions and error handling. Basel III compliance costs are the opportunity costs to the sending bank, originating from their holding of lower-yielding, high quality liquid assets against credit exposure during the "in-flight" period. Foreign exchange costs are the spreads that occur when converting between currencies and costs arising from foreign exchange rate

[5] https://ripple.com/company (accessed 18/04/2022)

[6] https://www.cnbc.com/2017/10/10/ripple-has-over-100-clients-as-mainstream-finance-warms-to-blockchain.html (accessed 15/03/2022)

[7] https://finance.yahoo.com/news/75-banks-now-ripples-blockchain-network-162939601.html?guccounter=1&guce_referrer=aHR0cHM6Ly9jcnlwdG9zbGF0ZS5jb20v&guce_referrer_sig=AQAAAJcHSskHM-Cs0uyZAzuOoi51H9UuuCAPHTEP8UMaf8OTpP-RYFFM1MiFEh-i3H18pCv9Y3tPphcRqpY8FKasZzbVs5zndMqRSMQFlXfpwgz-VqQJQh2CojmXznbZbSZbnpASbMHbPZN2myN0FYvY253XrOVuA-SwT0cFFP20liV_ (accessed 15/03/2022)

fluctuations. Treasury operations costs originate from the capital that banks need to keep in reserve in order to make sure that the transactions that are made via them occur.

Ripple's network, RippleNet, is a platform that connects banks and other financial institutions with each other and allows them to trade with one another on the platform. Each transaction carried out on it is recorded on a decentralised XRP ledger, which is its native token. Unlike a cryptocurrency like Bitcoin, which uses proof-of-work as its validation mechanism, Ripple uses a system with three kinds of nodes: validators, gateways, and regular nodes. Validators are responsible for validating the transactions. Any node can become a validator, but a list of trusted validators is kept by gateway nodes. Gateway nodes are registered financial institutions on RippleNet. Permission is required to become a gateway node. Regular nodes are all the other nodes that fulfil no such role. The validating servers of the ledger can be kept by any validator or gateway node.

In the previously discussed example, if the purchaser's bank used RippleNet, RippleNet would convert the 100 USD to XRP and send it to the receiver. The XRP amount would then be converted into EUR and forwarded to the merchant's bank. This process, known as on-demand liquidity, would only take seconds, so money is not locked in-flight for long periods of time, drastically reducing the risk of conversion rate between currencies (including XRP). Nostro accounts no longer play a role here and by using XRP as an in-between layer, foreign exchange spreads are avoided. Moreover, the transaction fee charged by Ripple is very small compared to the fees charged by correspondent banks[8,9]. This network is also sketched schematically in Appendix A.

[8] https://bitinfocharts.com/comparison/xrp-transactionfees.html#3y (accessed 28/05/2022)

[9] https://ripple.com/xrp/ (accessed 28/05/2022)

Banks make money in facilitating cross-border transactions by charging a transaction fee, which is usually a percentage. At the same time, banks incur costs when paying those fees to other banks. Moreover, banks have to expend resources in order to comply with Basel III regulations. These expenses are used as measures for banks' cost efficiency, as influenced by their use of RippleNet. They are recorded by banks on their income statements, respectively under "Fees & Commissions Expense" and "Other Operating Expense". This leads to the following hypothesis:

H1. Banks' use of blockchain technology for cross-border transactions will have a positive effect on their cost efficiency.

By using RippleNet, which provides banks with on-demand liquidity, it is expected that such expenses can be reduced, and that this will consequently free up cash for banks. Moreover, on-demand liquidity is expected to remove the need for banks to keep nostro accounts with other banks. The following measures of bank liquidity, as influenced by their use of RippleNet, are used: the change in cash should be visible in banks' "Cash & Short-Term Deposits Due from Banks" and "Capital Adequacy", while banks' removed need for keeping nostro accounts should be visible in their "Interbank Loans & Long-Term Deposits With Other Banks". This leads to the following hypothesis:

H2. Banks' use of blockchain technology for cross-border transactions will have a positive effect on their liquidity.

Aside from fees, losses are also incurred in the process of cross-border transactions, namely from the foreign exchange spreads (and other foreign exchange effects). When banks start using Ripple for cross-border transactions, they will no longer incur these costs from spreads.

Instead of using the SWIFT network, RippleNet will use XRP to trade between different currencies, which will take seconds instead of days. This is expected to reduce banks' exposure to foreign exchange risk. These changes may be expected to appear on certain items on banks' income statements ("Other Comprehensive Income – Foreign Currency"), balance sheets ("Hedging Reserves" and "Foreign Currency Translation Adjustment"), and cashflow statements ("Foreign Exchange Effects"). These measures will thus be used as measures to test the following hypothesis:

H3. Banks' use of blockchain technology for cross-border transactions will have a negative effect on their foreign exchange risk.

The additional cash made available to banks can be invested in securities from which banks can generate a return. This can be measured their "Interest & Dividend Income - Investment Securities". Furthermore, if banks are able to use their newly available cash to generate returns from investments, this should be reflected in their profitability and valuations. Therefore, these measures of banks' investments performance will be used to test the following hypothesis:

H4. Banks' use of blockchain technology for cross-border transactions will have a positive effect on their investments performance.

5. RESEARCH DESIGN & METHODS

This study will employ difference-in-differences analysis to answer the research question. First, the Treatment variable, takes value 1 for those banks that have made a public announcement of Ripple adoption or Ripple making a similar announcement, and zero

otherwise. Second, it will contain a PostAdoption dummy, which is equal to one for each bank, starting the first year that they are known to have used Ripple, and zero every year before that year. The interaction between these two variables captures the treatment effect. We use reports from newspapers and announcements from Ripple for getting the exact date of adoption. Next, the right-hand side of the regression equations will contain an interaction variable of the previous two variables. Furthermore, there is literature examining what factors affect bank operating expenses and profitability (Akbas, 2012; Kawshala & Panditharathna, 2017; Petria et al., 2015). These factors will be controlled for. We control for country fixed effects in the model. This gives the following regression equations:

$$y_i = \beta_{i,0} + \beta_{i,1} x_{i,Treatment} + \beta_{i,2} x_{i,PostAdoption} + \beta_{i,3} x_{i,Treatment} x_{i,PostAdoption} + \sum_{j=4}^{N} \beta_{i,j} x_{i,j}$$

The summed variables represent the internal (bank-specific) and external (macroeconomic) factors that affect banks' operating costs and profitability, as well as country dummy variables.

Shown in Table 1 is an overview of the dependent variables with definitions.

Table 1. Variable definitions.

Categories	Variables	Definitions
Cost efficiency	Fees & Commissions Expense	"Fees & Commissions Expense" from banks' income statements under Revenues
	Other Operating Expense	"Other Operating Expense" from banks' income statements under Revenues
Liquidity	Cash Over Total Assets	Ratio of "Cash & Short-Term Deposits Due From Banks" and "Total Assets" from banks' balance sheets under Assets
	Capital Adequacy	Ratio of banks' total capital to total risk-weighted assets
	Interbank Loans & Long-Term Deposits With Other Banks	"Interbank Loans & Long-Term Deposits With Other Banks" from banks' balance sheets under Assets
Risk mitigation	Other Comprehensive Income – Foreign Currency	"Other comprehensive income – foreign currency" from banks' income statements, typically under Other
	Hedging Reserves	"Hedging Reserves" from banks' balance sheets under Shareholder's Equity. Represents accumulated gains/losses from hedges.
	Foreign Currency Translation Adjustment	"Foreign Currency Translation Adjustment" from banks' balance sheets under Shareholder's Equity. Represents translations in banks' equity or liabilities to balance with changes in value of assets caused by foreign exchange rates fluctuations.
	Cashflow Foreign Exchange Effects	"Foreign Exchange Effects" from banks' cashflow statements
Investment performance	Interest & Dividend Income from Securities	"Interest and Dividend Income – Investment Securities" from banks' income statements under Revenues.
	ROCE	Return on capital employed
	PB	Price to book ratio
Bank-specific determinants of bank performance	Liabilities Over Assets	Ratio of "Total Liabilities" and "Total Assets" from banks' balance sheets
	Deposits Over Assets	Ratio of "Deposits - Total" and "Total Assets" from banks' balance sheets
Macroeconomic determinants of bank performance	GDP	Gross domestic product of banks' countries
	CPI Percentage Change	Change of consumer pricing index between years in banks' countries

Additionally, a robustness check was performed for this regression, in order to see whether the results would be different for banks that adopted Ripple relatively early, compared to the results for all the banks that did. It may be the case that any benefits acquired by banks through the use of Ripple take a few years to become apparent. In this new regression, the banks are considered to be in the new treatment group, or the "early adopters" group, only if they started using Ripple in 2017 or before.

6. RESULTS

6.1 Sample Description

To answer the research question, financial statements from between 2008 and 2021 were collected from 101 banks residing in 26 countries from Refinitiv Eikon, including as many banks that are known to have started using Ripple as possible. Some descriptive statistics about these banks are shown in Table 2.

Table 2. Descriptive statistics about the banks.

	Number of banks	Percent	Cumulative Percent	Ripple Introduction Period
Australia	4	4.0	4.0	2016-2019
Brazil	3	3.0	6.9	2017-2020
Canada	6	5.9	12.9	2016
China	7	6.9	19.8	2016
Egypt	1	1.0	20.8	2021
Finland	1	1.0	21.8	2016
France	5	5.0	26.7	2016-2017
Germany	3	3.0	29.7	2014-2016
India	13	12.9	42.6	2017-2018
Italy	2	2.0	44.6	2016
Japan	13	12.9	57.4	2016-2017
Kuwait	2	2.0	59.4	2018-2019
Malaysia	1	1.0	60.4	2018
Netherlands	3	3.0	63.4	2014
Pakistan	1	1.0	64.4	2019
Qatar	1	1.0	65.3	2019
Saudi Arabia	1	1.0	66.3	2018
South Korea	3	3.0	69.3	2017
Spain	2	2.0	71.3	2016-2017
Sweden	1	1.0	72.3	2017
Switzerland	1	1.0	73.3	2016
Thailand	1	1.0	74.3	2016
Turkey	1	1.0	75.2	2017
UAE	3	3.0	78.2	2016-2020
United Kingdom	7	6.9	85.1	2015-2019
United States	15	14.9	100.0	2014-2018
Total	101	100.0	100.0	

For every bank that was used in this analysis, every variable is recorded 14 times (once for each year between 2008 and 2021). Table 3 shows the frequencies of observations in the treatment group and control group.

Table 3. Frequency table of observations in treatment and control group.

	Frequency	Percent	Cumulative Percent
Control group	644	45.5	45.5
Treatment group	770	54.5	100.0
Total	1414	100.0	

Data from the financial statements of these banks were used as test variables for the independent samples t-test and on the left-hand side of the regressions. Table 4 shows some descriptive statistics of both dependent and independent variables. All of the financial data are scaled by millions (except GDP, which is reported in trillions) and recorded in US dollars. Most banks report many of the items of interest on their financial statements, but not all. Therefore, the sample size varies between variables.

Table 4. Descriptive statistics on variables.

		N	Mean	Std. Deviation
Cost efficiency	Fees & Commissions Expense (M USD)	757	6.57	2.15
	Other Operating Expense (M USD)	1031	6.56	2.57
Liquidity	Cash Over Total Assets	1217	0.09	0.10
	Capital Adequacy	1013	15.78	3.47
	Interbank Loans & Long-Term Deposits With Other Banks (M USD)	846	9.43	2.61
Risk mitigation	Other Comprehensive Income – Foreign Currency (M USD)	582	2.95	2.70
	Hedging Reserves (M USD)	554	2.65	3.16
	Foreign Currency Translation Adjustment (M USD)	670	2.21	3.21
	Cashflow Foreign Exchange Effects (M USD)	699	-0.02	0.38
Investment performance	Interest & Dividend Income from Securities (M USD)	1015	7.77	1.94
	ROCE (%)	1158	10.01	15.41
	PB	1073	1.24	0.80
	Treatment	1414	0.54	0.49
	Post Adoption	1414	0.20	0.39
	Treatment*Post Adoption	1414	0.19	0.39
	CPI Percentage Change (%)	1414	2.66	3.08
	Liabilities Over Assets	1221	15.15	13.18
	Deposits Over Assets	1193	0.63	0.19
	GDP (T USD)	1414	16.02	1.94

As most of the dependent variables are on the order of magnitude of at least 1000, while most of the independent variables are on the order of 1-10, the dependent variables are log-transformed (after being translated upward by their minimum value in the case where both positive and negative values are present). Furthermore, while many banks report many of the data on their financial statements, the frequency with which variables appear on banks´ financial statements varies to a substantial degree.

6.2 Univariate Analysis: Independent Samples t-Test

Table 5 shows the independent samples t-test. The appropriate means test results are shown based on the results of Levene's test of equality of variances. We find a significant difference in banks' "Fees & Commissions Expense" between the treatment group (M = 6.57, SD = 2.15); t = 2.03, p = 0.04, and the control group, however, not in their "Other Operating Expense" (M = 6.56, SD = 2.57); t = -1.20, p = 0.22. This suggests that banks that used Ripple between 2008 and 2021 had lower cost efficiency than those that did not. Specifically, they paid more in fees and commissions. This can explain why they would look to blockchain as a potential solution to this.

For liquidity, the independent samples t-test did not show a significant difference in banks' "Cash Over Total Assets" (M = 0.09, SD = 0.10); t = -0.23, p = 0.81. It did show a significant difference in their "Capital Adequacy" (M = 15.78, SD =3.47); t = 5.5, p = 0.00. But no significant difference was found for banks' "Interbank Loans & Long-Term Deposits With Other Banks" (M = 9.43, SD = 2.61); t = 0.22, p = 0.82. This suggests that overall banks that used Ripple between 2008 and 2021 had more capital available to them relative to their risk-weighted credit exposures, compared to banks that did not use Ripple in that period.

Banks' "Other Income – Foreign Currency" did not differ significantly between the treatment and control group (M = 2.95, SD = 2.70); t = 1.80, p = 0.07. "Hedging Reserves" did differ significantly (M = 2.65, SD = 3.16); t = 5.78, p = 0.00. "Foreign Currency Translation Adjustment" (M = 2.21, SD = 3.21) and "Cashflow Foreign Exchange Effects" (M = -0.02, SD = 0.38) did not differ significantly between the treatment and control group; t = 1.71, p = 0.08 and t = 1.54, p = 0.12, respectively. These findings suggest that while "Other Income – Foreign Currency" did not differ significantly between banks who used Ripple between 2008 and 2021

and banks who did not, they had higher cumulative gains from hedges, although there was no such difference in the effects on the balance sheets of banks' foreign subsidiaries from changes in exchange rates. Moreover, foreign exchange effects on banks' cashflows did not differ either.

The independent samples t-test showed no significant difference in banks' "Interest & Dividend Income from Securities" ($M = 7.77$, $SD = 1.94$); $t = -0.68$, $p = 0.49$, nor in their "ROCE" ($M = 10.01$, $SD = 15.41$); $t = 1.32$, $p = 0.18$. However, banks' "PB" did differ significantly ($M = 1.24$, $SD = 0.80$); $t = 6.65$, $p = 0.00$. In other words, even though banks who used Ripple between 2008 and 2021 did not generate significantly more revenues from their investments in the recorded period, nor have higher returns on their employed capital, those banks did have higher valuations in terms of their price to book ratios.

Table 5. Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means		
		F	Sig.	t	Sig. (2-tailed)	Mean Difference
Cost efficiency	Fees & Commissions Expense	3.24	0.07	2.03*	0.04	0.32
	Other Operating Expense	0.39	0.53	-1.20	0.22	-0.19
Liquidity	Cash Over Total Assets	7.47*	0.00	-0.23	0.81	-0.01
	Capital Adequacy	1.94	0.16	5.50*	0.00	1.18
	Interbank Loans & Long-Term Deposits With Other Banks	46.92*	0.00	0.23	0.81	0.04
Risk mitigation	Other Comprehensive Income – Foreign Currency	0.13	0.71	1.80	0.07	0.40
	Hedging Reserves	73.16*	0.00	5.70*	0.000	1.49
	Foreign Currency Translation Adjustment	18.12*	0.00	1.67	0.095	0.42
	Cashflow Foreign Exchange Effects	13.61*	0.00	1.86	0.062	0.05
Investment performance	Interest & Dividend Income from Securities	24.50*	0.00	-0.68	0.492	-0.08
	ROCE	3.38	0.06	1.32	0.185	1.20
	PB	20.77*	0.00	6.599*	0.000	0.31

6.3 Regressions for the Difference-In-Differences Analysis

Regressions were run with every variable from Table 4 as a dependent variable. The first dependent variable is "Fees & Commissions Expense". This item from banks' income statements includes transaction fees paid for cross-border payments. The coefficient for the interaction variable has a positive value of 0.25 that is significant; that is, after banks started using Ripple, their "Fees & Commissions Expense" expense rose significantly. With "Other Operating Expense", the coefficient from the Treatment variable has a positive value of 0.13 that is insignificant, meaning that banks that started using RippleNet have higher "Other Operating Expenses". While the coefficient for the interaction variable is positive, it is not significant. These findings suggest that, contrary to the conventional wisdom, banks' cost efficiency in fact decreased after starting to use blockchain technology.

The next dependent variable is "cash over total assets", which was defined as the ratio of banks' "Cash & Short-Term Deposits Due From Banks" and "Total Assets". Table 6 shows a positive and significant effect from both the Treatment variable (0.12), and positive but insignificant from the interaction variable of Treatment and PostAdoption (0.03); that is – banks with more "Cash & Short-Term Deposits Due From Banks" relative to their total assets are more likely to start using RippleNet, but do not see a subsequent rise in this ratio after starting to use RippleNet. The capital adequacy of banks in the treatment group are not significantly different from those in the control group and did not change significantly after they started using RippleNet. The next dependent variable is "Interbank Loans & Long-term Deposits" with Other Banks. Here there is a positive and significant effect from the Treatment variable with a coefficient of 0.15, but not from the *TreatmentPostAdoption* interaction variable. In other words, banks that started to use RippleNet have more "Loans & Long-Term Deposits with Other Banks" on their balance sheets, but this did not significantly change after

they started using RippleNet. Overall, we find that banks increased their liquidity after starting to use blockchain technology. This indicates that, banks might significantly reduce blocking funds in overseas accounts for facilitating cross-border payments for their clients.

For “Other Comprehensive Income – Foreign Currency”, neither the Treatment nor the interaction variable of the Treatment and PostAdoption variables show significant coefficients. So banks that started using Ripple did not have significantly differing “Other Comprehensive Income – Foreign Currency” on their income statements, nor did this income change significantly after they started using it. When it comes to “Hedging Reserves”, banks in the treatment group have higher “Hedging Reserves” on their balance sheets. The coefficient for the Treatment variable is 0.35. The coefficient for the interaction variable is insignificant; after banks start using RippleNet, their “Hedging Reserves” cannot be said to have changed. An opposite result is found for “Foreign Currency Translation Adjustment”: the Treatment variable sees a negative, significant coefficient of -0.25, whereas the interaction variable of the Treatment and PostAdoption variables sees an insignificant coefficient. Table 6 shows that banks that started using Ripple and banks that have not started using Ripple did not report significantly different foreign exchange effects on their cashflow statements between 2008 and 2021, nor did these numbers change significantly after they started using it. Banks’ cumulative losses from hedging increased after starting to use blockchain technology, while banks’ reserves increased as a result of foreign subsidiaries’ account translations. The overall effect of banks’ use of blockchain technology on their exposure to foreign exchange risk is mixed.

Table 6. Regression results

	Cost efficiency		Liquidity		
	Fees & Commissions Expenses	**Other Expenses**	**Cash & Short term deposits**	**Capital Adequacy**	**Interbank loans and Long term Deposits**
Constant					
Treatment	0.43***	0.13***	0.12***	-0.07	0.15***
	(10.23)	(3.24)	(3.24)	(-1.57)	(4.09)
Post Adoption	-0.19	0.01	0.11	0.26*	-0.00
	(-1.54)	(0.04)	(0.71)	(1.81)	(-0.03)
Treatment*Post	0.25**	0.05	0.03	0.12	-0.01
Adoption	(2.03)	(0.35)	(0.19)	(-0.81)	(-0.10)
CPI	0.05	-0.05	0.07*	0.06	0.03
	(1.39)	(-1.05)	(1.83)	(1.36)	(0.71)
Liabilities/ Assets	-0.04	0.03	-0.20***	-0.50***	0.09**
	(-0.91)	(1.07)	(-7.21)	(-12.82)	(2.49)
Deposits/ Assets	-0.19***	-0.15***	0.12***	-0.04	0.03
	(-5.18)	(-4.14)	(3.65)	(-1.14)	(0.65)
Ln (GDP)	0.47***	0.89***	-0.26**	0.33*	0.21
	(3.08)	(5.51)	(-2.04)	(1.94)	(1.51)
Country Fixed Effects	yes	yes	yes	yes	yes
Adj R-Square	0.63	0.41	0.33	0.47	0.59
N	678	927	1187	895	758

Table 6. Regression results (cont.)

	Risk mitigation				Investment Performance		
	Other Comprehensive Income-Foreign	**Hedging Reserves**	**Foreign Currency Adjustments**	**Foreign Exchange Effects**	**Interest and Dividend Income**	**ROCE**	**Price to Book**
Constant							
Treatment	0.05	0.35***	-0.25***	-0.02	0.31***	0.13***	0.34***
	(0.70)	(5.27)	(-4.79)	(-0.03)	(8.31)	(2.71)	(7.95)
Post Adoption	-0.09	-0.27	0.12	-0.01	0.05	-0.10	-0.16
	(-0.30)	(-1.44)	(0.68)	(-0.03)	(0.34)	(-0.55)	(-1.06)
Treatment*Post Adoption	0.03	0.16	0.18	-0.04	-0.05	0.04	0.06
	(0.11)	(0.85)	(1.05)	(-0.21)	(-0.35)	(0.23)	(0.42)
CPI	-0.03	-0.04	-0.05	-0.02	-0.07	0.11**	-0.02
	(-0.44)	(-0.60)	(-0.97)	(-0.33)	(-1.70)	(2.27)	(-0.52)
Liabilities/ Assets	0.11**	-0.04	0.20***	-0.04	0.19***	-0.05	-0.22***
	(2.39)	(-0.54)	(3.67)	(-0.62)	(7.01)	(1.13)	(-5.41)
Deposits/ Assets	-0.04	0.01	-0.04	0.01	-0.07**	-0.01	-0.07*
	(-0.75)	(0.21)	(-0.88)	(0.15)	(-2.17)	(-0.18)	(-1.76)
Ln (GDP)	-0.03	-0.26	-0.19	-0.05	-0.26**	-0.87***	-0.23
	(-0.37)	(-1.04)	(-0.91)	(-0.21)	(-1.99)	(-4.29)	(-1.27)
Country Fixed Effects	yes	yes	yes	yes	yes	yes	yes
Adj R-Square	0.11	0.20	0.35	-0.03	0.51	0.16	0.35
N	521	484	578	684	896	1028	959

Table 6 shows a positive, significant coefficient of 0.31 for the Treatment variable when "Interest & Dividend Income – Investment Securities" is taken as the dependent variable, so it is significantly higher for banks that started to use RippleNet. But this did not change significantly after they started using it. Banks in the treatment group have a higher ROCE, as the Treatment coefficient is 0.13. But the interaction variable has an insignificant coefficient. In other words, this return did not change significantly for banks after they started using RippleNet. In terms of valuation, banks that started using Ripple are more highly valued compared to their book values. The treatment coefficient is 0.34. But the coefficient from the TreatmentPostAdoption interaction variable is insignificant, indicating that banks' Price to Book ratio did not change significantly after they started using RippleNet. This suggests that banks' investment performance did not benefit from using blockchain technology.

Overall, Ripple's claims that its services can help banks drastically cut costs are not borne out by this analysis. Contrary to the expected reduction in banks' expenses from foreign transaction fees, banks "Fees & Commissions Expense" in fact rose after their implementation of RippleNet. There is also no clear indication that banks saved money in Basel III compliance costs. Moreover, banks did not gain cash or improve their capital adequacy after starting to use RippleNet, suggesting banks did not benefit from Ripple's on-demand liquidity. Banks' exposure to foreign exchange risk does not clearly seem to have increased or decreased as a consequence of adopting blockchain technology. There is also no indication in these results that banks' investments performance improved or worsened. Banks' income from their investments, their returns and their valuations did not change significantly after banks' adoption of blockchain technology.

6.4 Robustness Check

Regressions were also run as a robustness check to see if the results would be different for early adopters. In this regression, instead of the normal treatment variable, an early adopters variable was used. As can be concluded from table 2, banks have adopted Ripple in a number of waves, first predominantly in the United States and Europe, and later in other countries around the world. For that reason, banks were included in the early adopters group if they started using Ripple in 2017 or before. The results of these regressions are shown in table 7.

Fees & Commissions Expenses shows a positive and significant coefficient for the Early Adopter Variable, but a negative and significant coefficient for the interaction variable. This indicates that banks that used Ripple had higher Fees & Commissions Expenses, but these expenses shrank after they started using it. A positive and significant coefficient was found for the Early Adopter Variable with Other Expenses, but no significant coefficient was found for the interaction variable. These results suggest that for banks that started using Ripple in 2017 or before, it may have helped reduce their Fees & Commissions Expenses.

For Cash & Short term deposits, no significant coefficient was found for either the Early Adopters variable, nor for the interaction variable. For capital adequacy, no significant coefficient was found for the Early Adopter variable, but a positive and significant coefficient was found for the interaction variable, indicating that banks that used Ripple saw their capital increase after they started using it. This result notably differs from the regular regressions of table 6, where the effects were insignificant with this variable. For Interbank Loans & Long Term Deposits Due from Other Banks, the coefficient for the Early Adopter variable is positive and significant, but the coefficient for the interaction variable is not significant. These results

suggest that the use of Ripple by early adopting banks had little effect on their liquidity, except by increasing their capital slightly.

When looking at risk mitigation, these regressions gave a positive and significant coefficient for the Early Adopter variable, but a negative and significant coefficient for the interaction variable with the Other Comprehensive Income – Foreign Currency and Hedging Reserves variables, meaning that banks that used Ripple had higher Other Comprehensive Income – Foreign Currency and Hedging Reserves, but these shrank after they started using Ripple. Here there is a notable difference with the regressions presented in table 6, as Other Comprehensive Income – Foreign Currency showed no significant coefficients there, and the interaction variable coefficient was insignificant with Hedging Reserves. The opposite was found with Foreign Currency Translation Adjustments; the Early Adopter coefficient is negative and significant, but the interaction variable coefficient is positive and coefficient. Notably again, the interaction variable coefficient with this dependent variable was insignificant in table 6. No significant coefficient was found with Foreign Exchange Effects on banks' cashflow statements. These results suggest that overall the effects of banks' early adoption of Ripple had a negative effect on their risk mitigation, except when taking Foreign Currency Translation Adjustments as a measure.

Interest & Dividend Income from Investment Securities shows a positive and significant coefficient for the Early Adopter variable, but a negative and significant coefficient for the interaction variable. This coefficient for the interaction variable was insignificant in table 6. ROCE likewise shows a positive and significant coefficient for the Early Adopter variable, but no significant coefficient for the interaction variable. Price to Book shows no significant coefficient for the Early Adopter variable, but shows a negative and significant coefficient for

the interaction variable. Again, the interaction variable coefficient was insignificant in table 6. These results suggest that for banks that were early in starting to use Ripple, investment performance was negatively affected in terms of both their income from investments, and their valuations.

Table 7. Robustness check regression results

	Cost efficiency		**Liquidity**		
	Fees & Commissions Expenses	**Other Expenses**	**Cash & Short term deposits**	**Capital Adequacy**	**Interbank loans and Long term Deposits**
Constant					
Early Adopter	0.426***	0.11***	0.045	-0.07	0.17***
	(10.94)	(2.62)	(1.21)	(-1.52)	(4.57)
Post Adoption	0.17***	0.14**	0.17***	0.04	0.06
	(2.63)	(2.06)	(2.83)	(0.64)	(0.99)
Early Adopter*Post Adoption	-0.14**	-0.09	-0.009	0.12*	-0.09
	(-2.10)	(-1.21)	(-0.146)	(1.72)	(-1.41)
CPI	0.05	-0.05	0.07*	0.06	0.03
	(1.20)	(-1.11)	(1.75)	(1.45)	(0.76)
Liabilities/ Assets	-0.04	0.03	-0.19***	-0.49***	0.08**
	(-1.09)	(0.97)	(-7.15)	(-12.78)	(2.34)
Deposits/ Assets	-0.19***	-0.15***	0.11***	-0.04	0.01
	(-5.05)	(-4.31)	(3.48)	(-1.04)	(0.26)
Ln (GDP)	0.12	0.87***	-0.26**	-0.35**	0.19
	(1.01)	(5.34)	(-2.09)	(-2.07)	(1.36)
Country Fixed Effects	yes	yes	yes	yes	yes
Adj R-Square	0.63	0.40	0.32	0.47	0.59
N	678	927	1187	895	758

Table 7. Robustness check regression results (cont.)

	Risk mitigation				Investment Performance		
	Other Comprehensive Income-Foreign	**Hedging Reserves**	**Foreign Currency Adjustments**	**Foreign Exchange Effects**	**Interest and Dividend Income**	**ROCE**	**Price to Book**
Constant							
Early Adopter	0.14* (1.88)	0.21*** (3.25)	-0.28*** (-5.21)	0.001 (0.009)	0.41*** (10.75)	0.10** (2.06)	0.04 (0.95)
Post Adoption	0.16 (1.31)	0.56*** (3.46)	0.08 (0.84)	-0.02 (-0.14)	0.12** (2.03)	-0.02 (-0.27)	0.27*** (3.91)
Early Adopter*Post Adoption	-0.30** (-2.20)	-0.67*** (-4.02)	0.24** (2.36)	-0.03 (-0.25)	-0.15** (-2.45)	-0.03 (-0.40)	-0.34*** (-4.62)
CPI	-0.04 (-0.55)	-0.05 (-0.78)	-0.05 (-0.89)	-0.02 (-0.32)	-0.07* (-1.70)	0.11** (2.25)	-0.04 (-0.86)
Liabilities/ Assets	0.12** (2.55)	-0.03 (-0.47)	0.22*** (4.01)	-0.04 (-0.59)	1.19*** (7.14)	-0.06 (-1.27)	-0.24*** (-5.76)
Deposits/ Assets	-0.05 (-0.90)	0.01 (0.19)	-0.04 (-0.76)	0.01 (0.16)	-0.09*** (-2.67)	-0.01 (-0.34)	-0.09** (-2.35)
Ln (GDP)	0.05 (0.18)	-0.29 (-1.16)	-0.17 (-0.85)	-0.05 (-0.22)	0.25** (2.02)	-0.88*** (-4.35)	-0.34* (-1.86)
Country Fixed Effects	yes	yes	yes	yes	yes	yes	yes
Adj R-Square	0.12	0.19	0.36	0.03	0.53	0.16	0.32
N	521	484	578	684	896	1028	959

7. CONCLUSION & DISCUSSION

Blockchain is a technology that keeps a record of transactions on a decentralised network shared by its users. This decentralised ledger gives rise to certain benefits to banks who use it for cross-border transactions, namely risk mitigation, improved liquidity, and improved cost efficiency.

Ripple was used as a test case to investigate the research question, "What is the effect of banks' use of blockchain technology for cross-border transactions on their banking efficiency?", using an independent samples t-test and a difference-in-differences analysis using regressions. By using RippleNet for cross-border transactions, banks no longer need to keep nostro accounts with capital denominated in foreign currencies. Instead, they can keep their domestic accounts and use RippleNet to facilitate cross-border transactions. Banks will no longer need to pay foreign transaction fees to correspondent banks, but a smaller transaction fee to Ripple. This was expected to result in a reduction in banks' fees & commissions expense and Basel III compliance costs. Furthermore, it was expected that this would free up cash for the banks, increasing their liquidity. Moreover, the use of RippleNet for cross-border transactions was argued to remove the need for banks to keep nostro accounts with other banks. This would then be apparent in banks' "Interbank Loans & Long-Term Deposits with Other Banks". Regressions were also run to check whether banks that adopted Ripple earlier experienced better results.

After banks started using RippleNet for cross-border transactions, they saw a significant increase in their "Fees & Commissions Expense". "Other Operating Expense" did not change significantly. For early adopters, "Fees & Commissions Expense" shrank slightly, contrary to the pool of banks as a whole. This result is more in line with expectations, and supports the

idea that any benefits acquired from the adoption of Ripple takes a few years to become apparent. The first hypothesis (that bank cost efficiency would be improved) is accepted for early adopting banks.

In line with the lack of cost reduction for the whole pool of banks, there is no significant change in “Cash & Short-Term Deposits Due From Banks” relative to banks’ total assets from the Treatment and PostAdoption interaction variable, indicating that banks who started using Ripple did not see a subsequent rise in this ratio. Nor was such a change found for banks’ capital adequacy, contradicting the expectation that banks increase their available capital by using Ripple. However, capital adequacy was improved for early adopting banks. These banks also managed to save in “Fees & Commissions Expenses”. In line with this, it was expected that these banks would have more capital. The regression with “Interbank Loans & Long-Term Deposits with Other Banks”, while negative, did not see a statistically significant coefficient for the interaction variable either. Therefore, the second hypothesis (that bank liquidity would be improved) is accepted for early adopting banks.

The second immediate effect that is expected is that banks will be less exposed to risk arising from foreign exchange rate fluctuations after beginning to use Ripple, since they now have less capital locked up in foreign currencies. The regression results above suggest that banks’ foreign currency translation adjustment and hedging reserves did not change significantly as a result of using Ripple. Other Comprehensive Income – Foreign Currency and Hedging Reserves were in fact negatively affected by using Ripple for early adopters. But the effect on Foreign Currency Translation Adjustment was better for early adopters. Cashflow from foreign exchange effects was also not significantly affected. Therefore, the hypothesis that foreign exchange risk would be reduced is rejected.

It was also expected that banks will then be able to invest their newly available cash in securities, from which they can generate a return. However, contrary to expectations, although banks that started to use RippleNet have higher interest & dividend income from investment securities, this did not change significantly after they started using Ripple. It did change significantly for early adopters, however. But this change was negative. The last hypothesis (that bank investment efficiency would be improved) is rejected. Moreover, while more highly valued banks are more likely to use Ripple, there is no significant change in their price to book ratio after they start using it. This is also true for banks' ROCE. Price to book was negatively affected for early adopters.

The findings of this study shed light on the value of blockchain technology to banks, specifically in the use case of cross-border transactions. The findings suggest that banks are not likely to improve their liquidity by implementing blockchain technology, at least in the short term. The findings regarding foreign exchange risk also contradict expectations, as do the findings for cost efficiency (again in the short term), at least when considering transaction fees as a measure. Furthermore, the results suggest that banks do not increase their valuation, as contrary to expectations there is no newly available capital. There are also some limitations to this study. It may be argued that the sample could be improved by including data from more banks residing in each country. These would probably all be part of the control group, as all of the banks that are currently known to use RippleNet and of which financial statements are available from Refinitiv Eikon have been included here. The inclusion of more banks could help make the results more generalisable. Furthermore, the measures used in the regressions are influenced by cross-border transactions, but not exclusively. A similar study may be conducted in the future that uses measures more strictly reflective of cross border transaction influences. Future research can look further into the relationships between blockchain advantages in

banking for cross-border payments and investigate why the improved liquidity of banks does not translate to increased profitability. Alternatively, a future study could investigate the advantages of blockchain technology for banking in a different use case, such as asset securitisation.

8. REFERENCES

Akbas, H. E. (2012). *Determinants of Bank Profitability: An Investigation on Turkish Banking Sector*. https://www.acarindex.com/pdfler/acarindex-1401-9308.pdf

Armknecht, F., Karame, G. O., Mandal, A., Youssef, F., & Zenner, E. (2015). *Ripple: Overview and Outlook*.

Chang, V., Baudier, P., Zhang, H., Xu, Q., Zhang, J., & Arami, M. (2020). How Blockchain can impact financial services – The overview, challenges and recommendations from expert interviewees. *Technological Forecasting and Social Change*, *158*, 120166. https://doi.org/10.1016/j.techfore.2020.120166

Chiu, J., & Koeppl, T. v. (2019). Blockchain-Based Settlement for Asset Trading. *The Review of Financial Studies*, *32*(5), 1716–1753. https://doi.org/10.1093/rfs/hhy122

Guo, Y., & Liang, C. (2016). Blockchain application and outlook in the banking industry. In *Financial Innovation* (Vol. 2, Issue 1). SpringerOpen. https://doi.org/10.1186/s40854-016-0034-9

Kawshala, H., & Panditharathna, K. (2017). The Factors Effecting on Bank Profitability. *International Journal of Scientific and Research Publications*, *7*(2), 212. www.ijsrp.org

Nakamoto, S. (2008). *Bitcoin: A Peer-to-Peer Electronic Cash System*. 1–9. https://doi.org/10.2139/ssrn.3440802

Navakauskas, D., Romanovs, A., Plonis, D., Institute of Electrical and Electronics Engineers. Lithuania Section, Institute of Electrical and Electronics Engineers. Latvia Section, Vilniaus Gedimino technikos universitetas, Rīgas Tehniskā universitāte, Institute of Electrical and Electronics Engineers. Lithuania Section. Education Society Chapter, & Institute of Electrical and Electronics Engineers. (n.d.). *2018 IEEE 6th Workshop on Advances in Information, Electronic and Electrical Engineering (AIEEE) : proceedings of the 6th IEEE workshop : November 8-10, 2016, Vilnius, Lithuania*.

Petria, N., Capraru, B., & Ihnatov, I. (2015). Determinants of Banks' Profitability: Evidence from EU 27 Banking Systems. *Procedia Economics and Finance*, *20*(15), 518–524. https://doi.org/10.1016/s2212-5671(15)00104-5

Qiu, T., Zhang, R., & Gao, Y. (2019). Ripple vs. SWIFT: Transforming Cross Border Remittance Using Blockchain Technology. *Procedia Computer Science*, *147*, 428–434. https://doi.org/10.1016/j.procs.2019.01.260

The Cost-Cutting Case for Banks. (2016). http://ripple.com/files/xrp_cost_model_paper.pdf

Vovchenko, N. G., Andreeva, A. v, Orobinskiy, A. S., & Filippov, Y. M. (2017). Competitive Advantages of Financial Transactions on the Basis of the Blockchain Technology in Digital Economy. In *European Research Studies: Vol. XX*.

Wu, B., & Duan, T. (2019). The advantages of blockchain technology in commercial bank operation and management. *ACM International Conference Proceeding Series*, 83–87. https://doi.org/10.1145/3340997.3341009

9. APPENDIX

Appendix A. Literature Review – Ripple Network

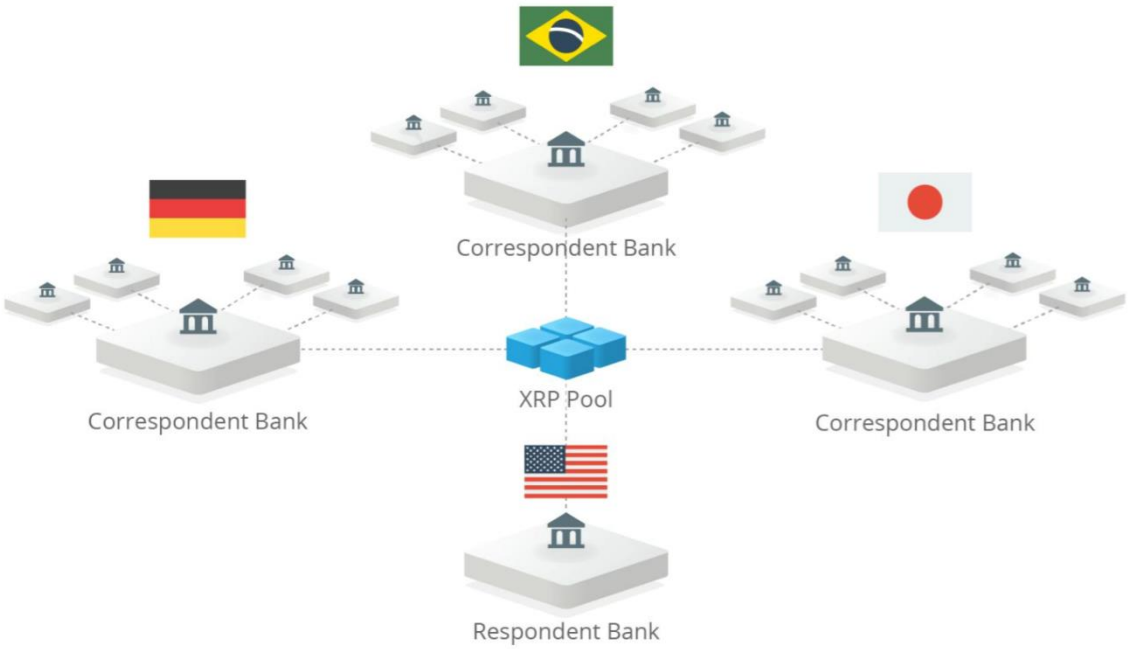


Figure 2. Schematic representation of Ripple network (The Cost-Cutting Case for Banks, 2016).