ABDERRAHMANE MIRA UNIVERSITY OF BEJAIA

جامعة بجاية
Tasdawit n Bgayet
Université de Béjaïa

Faculty of Economic, Commercial and Management Sciences

Department of Accounting and Financial Sciences

A THESIS

Submitted In Partial Fulfilment of The Requirements for The Degree of

Master of Accounting and Financial Sciences

Specialisation: Corporate Finance

FinTech as a Catalyst In The Development of Sustainable Banking, Including Green Lending When financing Pro-Environmental Projects

By: Bokang MOKOCHOA **Supervisor: Dr. Sonia KHERBACHI**

Defended Before The Jury Composed of:

President: Dr. Khoukha AZRI-MEKLAT

Examiner: Dr. Mohand Akli OUGHLISSI

Supervisor: Dr. Sonia KHERBACHI

Date: 29 June 2024 Academic Year: 2023/2024

ABSTRACT

The growing importance of environmental sustainability has led to increased focus on the role of the financial sector, particularly banks, in supporting green projects and promoting eco-friendly practices. In this context, financial technology (fintech) has emerged as a determinant in advancing green finance and promoting sustainable banking initiatives. This thesis seeks to investigate the relationship between fintech and sustainable banking. It focuses on green lending context to determine the impact that fintech has in sustainable banking when financing pro-environmental projects. We formulated a research hypothesis based on a theoretical framework and tested it using panel data from 14 countries, based on a 5-year period from 2018 to 2022. Using regression techniques such as pooled OLS, fixed effects and random effects model, we explored the relationship between these two phenomena where green lending was used to represent sustainable banking. The results show that fintech has a significant impact on the development of sustainable banking.

Acknowledgements

I would like to thank my family and friends for their unwavering support throughout the duration of my master's programme. My gratitude also goes to my supervisors, Dr. Kherbachi and Dr. Benkhider, for their guidance and mentorship.

Table of Contents

List of Tables

List of Abbreviations

AI	Artificial Intelligence
AML	Anti-money Laundering Campaigns
BIS	Bank for International Settlements
CFT	Countering the financing of terrorism
COP	Conference of the Parties
CSR	Corporate Social Responsibility
DLT	Decentralized Ledger Technology
EBRD	European Bank for Reconstruction and Development
EDGAR	Emission Database for Global Atmospheric Research
ESG	Environmental, Social and Governance
EU	European Union
FCA	Financial Conduct Authority
FE	Fixed Effects
Fintech	Financial Technology
FSB	Financial Stability Board

FSI	Financial Services Industry
GFC	Global Financial Crisis
GEFF	Green Economy Financing Facility
GDP	Gross Domestic Product
IaaS	Infrastructure as a Service
IFR	Inflation Rate
IMF	International Monetary Fund
IOSCO	International Organization of Securities Commissions
IPFS	Inter Planetary File System
IoT	Internet of Things
KYC	Know Your Client
ML	Machine Learning
MDBs	Multilateral Development Banks
OLS	Ordinary Least Squares
P2P	Peer-to-peer
PaaS	Platform as a Service
RBA	Robo-Advisors

RE	Random Effects
Regtech	Regulatory Technology
SaaS	Software as a Service
SDGs	Sustainable Development Goals
SEM	Structural Equation Modelling
UN	United Nations
UNFCCC	United Nations Framework Convention on Climate Change
US	United States
VIF	Variance Inflation Factors
WWW	World Wide Web

Chapter 1

Introduction

With the on-going poverty and climate change crises that keep piling up across the globe, sustainability is increasingly becoming an important aspect of society. Following the implementation of the Sustainable Development Goals (SDGs) cosigned by over 190 countries, sustainability has been embedded in every aspect of life and adopted by numerous participants in various industries, including the banking sector (Jan et al., 2022). Having a prosperous economy while maintaining environmental sustainability has become a global goal (Kurbanov et al., 2023). With rising pressure from investors, customers, and other stakeholders, banks have been under immense pressure to design corporate social responsibility structures that pay close attention to their environmental, social, and governance (ESG) activities. SDG13 focuses on climate action and provides guidelines and measures to be taken by the members of society to address climate change issues. With the issuance of green bonds, green loans, sustainability-linked loans, and bonds, the banking sector has been consistently directing their funds towards climate action initiatives (Akomea-Frimpong et al., 2021). This phenomenon is referred to as green banking. The emergence of green banking practices has widened the pool of opportunities for funding eco-friendly projects. Environmentally friendly projects are constantly being financed through green bonds to mitigate the negative impact on the environment while fostering economic development (Jian, 2023). Most banks have begun dedicating a significant chunk of their investment and loan portfolios to financing pro-environmental projects. They create funding opportunities for projects that offer services such as building renewable energy sources like solar panels, clean water treatment, and sustainable infrastructure. They have also been incorporating ESG disclosures in their annual reports to promote transparency on their carbon emissions and

green initiatives. With the help of technology, the global banking sector has recorded a considerable reduction in carbon emissions. The adoption of technology within the financial sector is referred to as financial technology. As a subsector of the financial industry, the banking sector has greatly benefited from technological inceptions in the wake of digitisation. With innovations like mobile banking and internet banking, banks have been able to reach multitudes of customers from anywhere at any time without the need to travel to brick-and-mortar branches. This means that fintech helps banks reach underrepresented communities, thus promoting financial inclusion. Financial inclusion forms part of SDG 8, which advocates for inclusive and sustainable economic growth for all. Innovations like blockchain technologies and DLTs have also allowed banks to store a plethora of information about their customers digitally. The adoption of technology within the banking sector has also led to reduced paper usage, which has a significant impact on carbon emission reductions. Studies exploring the impact of fintech in sustainable banking have been conducted by numerous researchers. The existing literature provides a comprehensive understanding of the relationship between fintech and sustainable banking and how they directly affect each other. The relationship was studied under various scopes such as green finance, green lending, digital transformation, sustainable performance etc. However, the literature is insufficient on the influence of fintech in promoting sustainable banking in the context of funding pro-environmental projects. This study seeks to address this problem using a model conceived from panel data collected from 14 countries over a 5-year period. By running various regression models using techniques such as pooled OLS, fixed effects and random effects model, we can answer the research questions by testing the hypothesis formulated in the literature review section. These questions are as follows:

- Is there an empirical relationship between fintech and sustainable banking? If so, what role does fintech play in the development of sustainable banking when financing pro-environmental projects?

These questions interrogate the influence of fintech in promoting sustainable banking in the context of financing pro-environmental projects where green lending (measured by green bonds) was the source of funding. The results from this study will contribute significantly to the existing literature. It paints a clearer picture of how fintech may be employed by the banking sector to practise sustainability measures such as financing pro-environmental projects using green bonds.

Chapter 2

Literature Review - Fintech and Sustainable Banking

This literature review explores the impact of FinTech adoption on sustainable banking and highlights gaps in existing research. It examines the principles and practices of sustainable banking and how they relate to the adoption of FinTech. Finally, this study investigates how a developed sustainable banking system, through FinTech, can be a significant method for financing pro-environmental projects. By expounding on these topics, this literature review provides a comprehensive overview of the role of FinTech in promoting sustainable banking, developing pro-environmental projects, and identifying areas for future research.

2.1 Fintech overview

Fintech (financial technology) is a contraction of the terms “finance” and “technology” and refers to the integration of technological innovation within the financial service industry. This integration is considered by various experts to be a marriage between the two, with the ability to revolutionise the financial services industry (Hasan et al., 2020).

There exist multiple definitions of fintech by different scholars. Unlike academic scholars, most international bodies refer to fintech as typically new types of business models or start-ups that emerged because of the industry revolution within the last century. The World Economic Forum defined fintech as utilising technology and innovative business models within the finance industry (Ventura et al., 2015). The Financial Stability Board (FSB) described fintech as a “technology-enabled innovation in financial services that could result in new business models, applications, processes, or products with an associated material effect on the provision of financial services” (FSB, 2017). Subsequently, IOSCO (2017) iterated that “The term Financial Technologies or ‘Fintech’ is used to describe a variety of innovative business models and emerging technologies that have the potential to transform the financial services industry”. Fintech is often associated with innovation; therefore, these business models are believed to be benefiting from the new era of digitalisation which has caused significant disruption across the financial services sector through the provision of goods and services (Barroso & Laborda, 2022). These start-ups are complete game changers; through automation and digitalisation, they have reshaped the financial services sector, promoting ease of access to services to their customers (Siddiqui & Rivera, 2022). They provide a range of services, including but not limited to payments, investment management, capital raising, deposits and loans, insurance, leasing credit, risk assessment, securities, and regulatory compliance, to customers anywhere in the world at any given point, hence eliminating geographical and time restrictions. Here is a perusal of the theoretical definitions of FinTech as elaborated by some of the academic scholars; Aik & Zhang (2023) claimed that FinTech "refers to the use of innovative digital technology to deliver financial services". Balaskas et al. (2024) defined it as "an advanced and expanding sector that utilises technological breakthroughs to deliver novel financial services and models. It is the embodiment of the combination of the economic and technological industries".

2.2 FinTech History and Evolution

The emergence of fintech dates as far back as the late 19th century. It has evolved remarkably due to the massive technological advancements within the financial service sector that came with every era of digitalisation. The relationship between finance and technology has always been correlated and causal, hence the intertwinement in the growth and development of the two (Giglio, 2021).

The evolution of fintech is categorised into 3 eras as follows:

2.2.1 Fintech 1.0 (1866-1967): The Analogue Industry

Although the formal history of fintech can be precisely traced back to 1866, there is a belief among researchers that it goes way beyond this age (Burke, 2021). However, because of the lack of documented information and clarity, we can only pinpoint 1866 as the ultimate birth year of fintech. The successful implementation of telegraphy and the construction of the first transatlantic cable line marked a preliminary step towards the globalised financial services industry (Thakor, 2020). 1866-1967 is an era of moving from analogue to digital within the financial services industry. It signifies the strong foundation of financial globalisation, focused on the design and engineering of an infrastructure that facilitates a worldwide interconnection among financial institutions (Karaömer, 2021).

The subsequent step debuts after the end of World War II. This is where major technological innovations within the financial services like the creation of the first portable calculator by Texas Instruments and the issuing of credit cards by various banks and financial institutions surged in the 1950s (Arner et al., 2015).

2.2.2 FinTech 2.0 (1967 – 2008)

This phase starts with an introductory usage of Barclays' ATM, which completely changed the trajectory of the banking system, steering the world towards a better, interconnected and digitised financial sector (Arner et al., 2015). At that juncture, the deployment of digital technology became widespread, platforming the advanced development and provision of products and services by traditional financial institutions (Demirdogen, 2020). In 1970, the financial sector also realised the inception of Fedwire, an advanced electronic payment system. It was followed by the setup of NASDAQ, which was then recognised as the premier digital stock market (Arner et al. 2015). The implementation of cell phones and personal computers in the 1980s was a major turning event in the fintech space, allowing global communication among traders (Bhasin, 2018). The downfall of Long-Term Capital management resulting from the 1997-1998 Russian and Asian financial crises also contributed significantly towards the development of fintech during this era (Bhasin, 2018). Wells Fargo took things further with its implementation of the World Wide Web (WWW), the first online banking service for its customers (Setiawan et al., 2020).

2.2.3 FinTech 3.0 and 3.5 (2008-present)

The 2008 global financial crisis created an enormous shift that introduced us to modern-day fintech (Alam et al., 2021). Different factors fuelled the overall growth of this era. Many employees across different industries, including finance professionals, were also negatively impacted by this ordeal, leading to many losing their jobs (Zhang, 2023). This led to an upsurge in public's mistrust in large traditional banks (Hurley et al., 2014). When the global financial crisis ended, a tight regulatory framework was designed to govern traditional banks (Arner et al., 2016), which presented new opportunities like innovative start-ups and business models. During this time, the unemployed finance professionals resorted to applying their skill sets elsewhere given that they could not get any jobs. This was a major turning point in the Fintech 3.0 era, triggering the realisation that even non-financial organisations are not only capable but also legally permitted to provide financial services and products that were at the time only curated by traditional financial institutions (Treu, 2022). Peer-to-peer lending and crowdfunding methods of finance also came into play, making possible the financing of newly founded non-financial startups and business models. The industry, on the other hand, was also trying hard to reduce operational expenses through the adoption of technology and in the process innovations like artificial intelligence (AI), Big Data, distributed computing, machine learning, cryptocurrency, and mobile Internet access were conceived (Arner et al., 2015, Ratecka, 2020). The debut of Bitcoin in 2009 as the first cryptocurrency and the creation of Peer-to-Peer payment systems in 2011 are also identifiable as major turning events in the history of Fintech**.** Bloomberg and PayPal founded in the 1980s and late 1990s are perfect examples of fintech start-ups that have long existed but only became popular after the 2008 financial crisis (Arner et al., 2017).

The 3.5 era debuted in 2014, when China and India experienced inconsistent growth in fintech adoption (Pushpa et al., 2023). Multiple determinants catalysed the growth of fintech in developing economies like Africa and Asia. A significant portion of fintech development in these regions is attributable to the lack of quality banking infrastructure, the overwhelming number of unbanked populations in this area, and rapid digital technology penetration (A. J. Alexander et al., 2017). During this era, there were disruptive innovative solutions such as financial software for Indian IT companies (Asia), M-Pesa in Kenya (Africa), Payment banks in India (Asia), and Alipay in China (Asia) (Cai, 2018).

2.3 Regtech

Like any other industry, the FSI needs a solid and stringent framework that ensures standard reporting and compliance with the preset pieces of legislation to curb financial miscreances. This regulatory framework referred to as financial regulation is imperative for the functionality and stability of the financial system (Chao et al., 2022). In the context of fintech, the scholarship of regulatory technology has been of great substance since these two phenomena have evolved parallel to each other (Jadhav, 2024). An interesting debate was evoked by Arner et al., (2016) about the definition of regtech and its relationship with fintech. This was in response to the

FCA's claim that "RegTech is a subset of FinTech that focuses on technologies that may facilitate the delivery of regulatory requirements more efficiently and effectively than existing capabilities." In their argument, Arner et al., (2016) iterated that; regtech cannot be viewed as a subdivision of fintech as this is an "overly narrow perspective". They further argued that regtech cannot be reduced to being a mere "efficiency tool" but instead should be regarded as a full circle moment in the history of regulation within the financial services sector.

Despite the difference in their theoretical explanations of what regtech is and how it relates to fintech, one can infer that they agree on one thing: regtech is an integral part of the FSI just as fintech, and both are complementarily effective in advancing the FSI by reducing the rate of non-legal activities and remedying the GFC that the FSI may face. Fintech 2.0 (1960s-2008) marks an era in history where the world realised a tremendous influx of financial institutions and markets that emerged in the FSI. The operational complexities and product development intricacies that accompanied this growth compelled these institutions and markets to adopt technological measures to enhance their risk management, financial engineering, and legal compliance (Arner, 2015). From this adoption, they cultivated benefits such as operational efficiency, enhanced corporate investment efficiency, an increase in corporate innovation output, improved customer experience, reduced costs and corporate financing constraints (Khan et al., 2023). They also enjoyed improved risk controls which facilitated advanced mitigation of risks such as credit risk, interest rate risk, compliance risk, liquidity risk, reputational risk, strategic risk and operational risk (Deng & Jia, 2021). This however led to the FSI over-relying on the use of fintech which resulted in a GFC, subsequently revealing the insufficiency and loopholes in the Basel II Capital Accord that had an overconfidence in these systems (Arner et al., 2017). Following the 2008 GFC, financial policymakers strive to attain these objectives: financial stability and a prosperous economy, protecting the customers, financial inclusion, and combating financial crime and money laundering

(Arner et al., 2017). Through AI (Artificial Intelligence) and ML (Machine Learning), regulators launched automated anti-money laundering campaigns (AML), fraud detection, countering the financing of terrorism (CFT) detection and KYC regulations all of which played a pivotal role in assisting financial institutions with their risk-taking strategies and increased profitability (Financial Stability Board, 2017). Despite all the fruitful advantages that fintech rocked the FSI with, it is also linked to serious risks that have necessitated the attention of regulators and policymakers. As the fintech scope advances worldwide, there is a significant amount of concern among the fintech stakeholders (companies, customers, regulators, investors, and competitors) regarding the security and privacy of personal data (Okazaki et al., 2020) and financial data. The expansion of fintech adoption increased the amount of personal data and financial transactions being processed daily by these fintech companies (Fáykiss et al., 2018). This triggered an escalation of potential threats such as data breaches and cyberattacks. Malicious hacking, phishing attacks, identity theft, and data monetization (which typically refers to the exploitation of data by firms for their benefit - such as marketing and competition purposes) have been on the rise since the inception of fintech (Kamuangu, 2024; Quach et al., 2022). This is due to insufficient regulations and consumers' ignorance about data privacy protection laws. Consistent education about data privacy laws to consumers, a draw up of new stricter data protection laws, encryption and access controls, and the adoption of cloud computing technologies by regulators are viable recourse to these issues (Mougayar, 2016).

Moving forward, the FCA implemented regulatory sandboxes as an initiative to nurture innovation within the financial services sector in the UK (Sajtos & Tőrös, 2018). The regulatory sandboxes are a monitored test ground for industry players to test their new products and services for a certain duration, at a lower cost while simultaneously allowing consumers to easily access them. The sandboxes were implemented to achieve these three goals; monitored product testing, reduced marketing expenses, and nurtured innovation. Access to these sandboxes is highly competitive and participating firms are selected on a merit basis. To ensure consumer protection while promoting innovation, the FCA suggested the regulators put the following rules in place; the first one is consumer consent which states that the product and service testing may only be carried out on and by consumers who have granted an informed consent. Secondly, they recommended a case-by-case discretionary model, which allows the FCA the autonomy to decide appropriate consumer protection acts and compensation when testing a specific good or service. The third emphasises the equality between the consumers participating inside and outside the sandbox of innovative testing - they have equal rights and should enjoy the same privileges such as access to the UK Financial Ombudsman Service. Lastly, compensation, it is incumbent on participatory firms to portray capability and readiness to cover any losses and expenses incurred by the consumers.

The above approaches and recommendations are a testament to the effective contribution the FCA has made towards the development of regtech.

2.4 FinTech Innovation

Besides combating the GFC, the occurrence of Fintech has been instrumental in shaping the current FSI and redefining the business structure across different sub-sectors such as commercial banking, investment banking, insurance, asset management etc. It is made possible by a combination of innovations like blockchain and IoT, cloud computing, artificial intelligence (AI), machine learning (ML), gamification, cybersecurity, data analytics, robo-advising and peer-to-peer lending that keep evolving and getting more sophisticated by the day to cater to the needs of both consumers and business managers.

2.4.1 Blockchain

Blockchain, also termed digital ledger transactions (DLT), is a decentralised financial system comprising a plethora of networked computers. It encompasses a recurrently growing list of records called blocks, orderly sorted and linked with one another through cryptography. Cryptography is defined by scholars as using a computer code to facilitate secure communication between different parties (Saraireh, 2013). In essence, it is a system that constitutes the storage of a well of data in which users cannot alter one another's information due to end-to-end encryption encapsulated in this system therefore making it easy for the involved parties to safely perform financial transactions. Not only does it promote transparency of data, but the DLT ledger relies on peer-to-peer encryption to eliminate the need for authentication by third parties, thus improving the security of the banking and financial system and limiting chances of hacking which is a serious threat to the banks and fintech companies (Soltani et al., 2022). Smart contracts are the epitome of how a successful blockchain adoption within an enterprise can help economise and reduce expenses (Hałaburda et al., 2019). They are self-monitored computerised contracts that function and ensure adherence to the set of rules and legal obligations without the intermediation of a notary. A perfect example of how blockchain promotes cost efficiency in a firm is derived from an exploratory and descriptive case study conducted by Mercuri et al. (2021) on an Italian start-up called Develeum. It is a start-up that focuses on tracking and analysing a food supply chain using a decentralised system made out from Ethereum blockchain, AI and IPFS. In this study, their findings revealed that blockchain technology is a potential cornerstone for the implementation of social economic systems and sustainable business models. On top of that, the study underpinned the reduction of transactional costs and improvement in transparency due to the incorporation of smart contracts used to trace the entirety of the production process. They anonymously notarise contracts between the business and consumers. Given the reduction of costs, improved traceability, and how it strengthens consumer consent through smart contracts, blockchain has proven to be an effective contributor towards sustainable business growth within an enterprise. Specifically in sustainable business models where these attributes are the drivers of development towards sustainable growth which is in alignment with the sustainable development goals. Despite the valuable input of this study in the contemporary fintech, blockchain and sustainability literature, this is a single case study, with a limited scope only focusing on the application of blockchain technology by Devoleum in the agri-food sector. This means that the findings and conclusions from this study may not be indicative of what plays out in other sectors.

2.4.2 IoT

The Internet of Things is an interconnection of multiple hardware devices embedded with attributes such as sensors, actuators, Bluetooth and other technologies. These devices are virtually operated and transfer data among themselves without human intervention in real-time. IoT goes way beyond just normal computers, notebooks, smartphones, tablets etc. It entails an array of items such as smart watches, smart fridges, irons etc, all the devices with an embedded sensor and technology that allows them to be connected with other devices across the network and perform pre-determined tasks. These devices rake in a vast amount of data that is usually stored, managed and analysed by data experts in computers to ameliorate their efficiency which is fundamental towards business operations (Rajadnye, 2018). The integration of IoT is prominent in the manufacturing process and saw its growth with the advancing 4th industry revolution also known as Industry 4.0 (Soori et al., 2023). In this case, it is referred to as the Industrial Internet of Things (IIoT). This integration automates the production process which means high productivity and reduced labour costs.

2.4.3 Cloud computing

An internet-based technology that facilitates data storage, rendering users access to a wide variety of digital services over the internet without human interaction. Users can read-only, write, edit, share and delete digital items at any time from anywhere depending on their access rights. These services (data storage) are offered by multiple firms at fixed prices and packages for individuals and customised ones for enterprises to meet the needs of the employees and business managers. The services are categorised as Infrastructure as a Service (IaaS), Platform as a Service (PaaS), and Software as a Service (SaaS). IaaS is where users can access services such as storage, servers (virtual machines) and networking. PaaS offers tools, both hardware and software necessary for application development. SaaS is a type of cloud computing model where users can access software over the internet without installing them. They can launch these services through internet browsers, virtual machines and mobile apps without installing them on their local machines i.e. physical devices. By incorporating cloud computing in their operations, specifically in integral areas such as accounting departments, businesses get to enjoy high employee productivity and increased business performance (Musyaffi et al., 2023). They also get to experience efficient and secure data management systems that can be accessed anywhere at any time at affordable costs (Ogiela et al., 2020).

2.4.5 Artificial Intelligence (AI) and Machine Learning (ML)

Another technological innovation that has been dominating the FSI is a combination of Artificial Intelligence (AI) and Machine learning (ML). These two are the main fintech innovations that have caused a disruption across the FSI which has led to many corporations retrenching their employees to replace them with AI and Machine Learning. This has led to these corporations realising a significant cut down in labour costs (Xie, 2019). AI is defined as a computer science branch that specialises in automating and digitising natural human intelligence and experience. Natural intelligence and people's experiences in distinguished backgrounds are the main foundation of AI. The experts in this field use computer code to design highly sophisticated systems aligning themselves with the natural intelligence and human experience which allows these to diligently carry out complex tasks at a greater volume and rapidness that is almost impossible for human beings to exhibit.

Machine learning (ML) is a form of artificial intelligence in which computer systems carefully study the data they are provided with and make human-like decisions without the need for explicit programming. ML uses statistical models and algorithms to execute predictions and make decisions based on the provided data. There are four major categories of ML: supervised learning, unsupervised learning, semi-supervised learning, and reinforcement learning. In supervised learning, the algorithms are utilised to train models to perform accurate predictions and recognise correct data patterns. Unsupervised learning is a category of ML in which the algorithms are trained using unlabelled datasets; they are free to make discoveries on data structures. Unlike supervised learning, there are no programmed accurate answers and there is no human intervention or guidance. Semi-supervised learning is a mixture of supervised and unsupervised learning whereby the algorithm relies on both labelled and unlabelled datasets to perform predictions. Reinforcement learning is a type of machine learning where the algorithm deploys its agents (software and hardware), to inspect and interact with an environment using a reward or penalty-based feedback technique. The agent will be awarded a positive (reward) or negative (penalty) answer in accordance with its behaviour; positive for good and negative for bad.

These models are predominantly trained and deployed to function in the realm of financial risk management within the FSI. The ML models are trained to detect the systematic financial risks which have been delineated as an imminent threat to the stability of the financial sector after the 2008 GFC (Alessi & Savona, 2021). Depending on the context and business goals, the managers will use different types of ML to perform financial risk prediction. In collaboration with other forms of fintech like big data shared across a large body of networked computers (IoT), the mission becomes a success. The econometrics and finance discipline within the FSI holds a wealth of informational research on the application of ML models within the FSI. This is where the earliest adoption of Bayesian Statistics was first recorded in the early 1960s. Kou et al. (2019) claim that not only was Bayesian used in systematic risk detection, but it was also used in the auditing discipline to complement the auditor's opinion derived from their contextual assessment. Besides the Bayesian Method, several forms of machine learning such as Logistic Regression, Clustering Based Methods, Decision Tree, Genetic Algorithm, have been deployed by multiple parties within the FSI to assist them in fraud detection. Ali et al. (2022) conducted a Systematic Literature Review investigating the use of ML in financial fraud detection from 2010 to 2021 and their findings revealed that starting from 2013 there was a swift increase in the number of published articles related to this topic. The study also further indicated that the year 2016 saw the highest number of output articles in this area which portrays a growing interest in the implications of ML in helping combat and perhaps surmount financial fraud. Financial fraud comes in many forms such as credit card fraud, financial statement fraud, insurance fraud, financial cyber-fraud etc.

Despite the growing list of various positive implications of the widespread adoption of fintech innovations such as AI and ML, it does not come without its negatives. The greatest concern about AI is the cybersecurity threats it imposes on the FSI. Financial AI algorithms may be used as an accessory to transfer wealth to foreign powers to the detriment of the national economy and financial system (Buckley et al., 2019; Zetzsche et al., 2020).

2.4.6 Big Data Analytics

Another fintech innovation that has been growing steadily and making a ginormous impact within the FSI is big data analytics. Different scholars believe that big data finance is at the forefront of revolutionising the finance system and is transforming the business models in financial companies (Sun et al., 2019). Data Analytics is the process of collecting and examining raw data extracted from different sources to realise different financial market trends, understand customer behaviour and draw conclusions from them. It is performed by specialised experts within an enterprise, usually data scientists or data analysts using data visualisation tools with the main objective of aiding the firm make informed business decisions. The adoption of big data within the FSI is crucial in the production process within an enterprise giving birth to what researchers call "Intelligent Manufacturing" (Wang et al., 2022). Working together with ML models, artificial intelligence and IoT, the big data is usually collected from the sensors and transferred into data management systems from which the data experts will perform their due tasks. Big data is also being deployed by enterprises to assist in designing new products by leveraging the analysis deduced from consumers who are representative of the market demand sentiment (Qi et al., 2016). Due to the high predictive accuracy of statistical algorithms used by big data analytic tools, they are now being introduced into other compartments of the financial system. Groundbreaking research by Han and Li (2018) proposed an unconventional way of using section volatility to predict volatility in performing High-Frequency Trading. The big data analytics process entails the collection and storage of large volumes of data. Companies dealing with this data are subject to compliance laws protecting the rights of consumers and all parties involved. However, some companies decide to manipulate the collected data to push their motives and use the collected data for completely unrelated reasons for which it was collected, therefore disregarding data security and privacy regulations (Lin, 2019). This may stem from greed, driven by yearning for more returns, wanting to gain a competitive edge, and evading the incurrence of certain fees and expenses (Baker et al., 2010). This may have negative implications on the labour market which may prompt many different policies to resolve this.

2.4.7 Peer-to-peer lending (P2P)

Peer-to-peer (P2P) lending is a fintech platform where individuals (people and businesses) can lend and borrow money from one another without the intervention of a third party, usually banks or traditional financial institutions. Users across the internet can apply for unsecured loans from one another through websites or mobile applications and receive funds instantaneously without the need for complicated paperwork hence sparing them the trouble of tedious processes they would usually be required to undergo when using a bank or traditional financial institution. P2P lending from the corporate finance point of view is a form of business or project debt financing (specifically crowdfunding) in which different people contribute small amounts of money to reach a set target with the hope of gaining financial returns from their investment (Pierrakis, 2019). P2P platforms have been praised for their great contribution towards promoting financial inclusion in underrepresented communities. There are less strict credit score requirements than in conventional banks (Ho et al., 2022) and SMEs can borrow money at slightly lower interest rates than in traditional banks (Z. Liu et al., 2020). Because of the nature of P2P, the bidding system gives a chance to investors to diversify their portfolios and have access to palatable interest rates by lending their money to different borrowers across different platforms (Luo et al., 2011). The returns from these investments are substantially higher than what would usually be yielded had they been invested in traditional bank deposits. Different scholars have emphasised the great potential that the P2P platforms hold in restructuring the current organisations and institutions however this is in great contrast to the beliefs of Milne and Parboteeah (2016) who claim that although P2P platforms have greatly benefited consumers, their impact is significantly minute when compared to the traditional bank loans, even in the US and UK – countries where the adoption of these platforms has developed expeditiously.

2.4.8 Robo-advising

A form of fintech where computer systems utilise specialised AI and ML algorithms to offer virtual and automated investment advice and portfolio management services. These systems collect information about users through questionnaires posted on different websites to learn more about the investors before offering investment advice or performing investment decisions on their behalf. The aim of collecting the data is to determine the investors' financial goals, affordability and risk tolerance (Muganda & Kasamani, 2023). The collected data will then be assessed by the AI and ML-based systems to curate appropriate investment advice to the individual. These systems are internet-based websites, so they are available 24/7 and accessible from anywhere. Robo advice means there is no need for a human interceptor therefore they're less costly compared to human investment advisors (Salo-Lahti, 2022). The robo-advisors are consistently updating the investor's portfolio in alignment with the economic and political climate, investor's risk tolerance, market trends, investor behaviour preferences and other evolving factors that may affect investment decisions (Liang, 2023). A comparative study conducted by Liu et al. (2023) between RBA users and non-users determined that during the market downturn caused by the COVID-19 financial crisis, the RBAs experienced significantly minor losses in comparison with non-RBA users. This underpins the effectiveness of adopting algorithmic investment advisors during the financial crisis.

We should however be sceptical about relying on this when providing evidence of RBA's effectiveness during financial crises and market downturns as the conclusions were only deduced from a single study and the FSI is constantly and rapidly evolving so this study may prove to be void in years to come.

2.4.9 Gamification

Gamification is the use of video game effects in non-game environments to transform traditional tasks into enjoyable activities to encourage customer participation and improve engagement (Tobón et al., 2020). A marketing-centred definition of gamification by Hofacker et al., (2016) describes gamification as "use of game design elements to enhance non-game goods and services by increasing customer value and encouraging value-creating behaviours such as increased consumption, greater loyalty, engagement or product advocacy." Business firms and organisations make use of game design effects like rewards for attaining defined milestones, leaderboards to create a competitive spirit among employees, badges to honour and recognise highly productive employees, and integration of interactive games within the system to intentionally grab the employees' attention and unequivocally keep them engaged (Yathiraju & Dash, 2023). Gamification may also be used in marketing to collect data about customers to make varied observations that may eventually be used in targeted marketing campaigns.

2.5 Sustainable banking

Sustainability is becoming an increasingly significant topic as a remedy to global environmental and social challenges such as global warming, climate change, energy crises, poverty alleviation and development inequality faced by contemporary society (Desalegn & Tangl, 2022). Sustainable development goals are a collective effort initiated by global leaders to resolve current man-made problems focusing on three main dimensions; social, economic and environmental. To commit decisively towards combating climate change, 196 countries across the globe, came together to sign an international treaty on climate change called "The Paris Agreement" in which they committed to taking a social and economic action towards ameliorating the environmental state of the planet (UNFCCC, 2024). Since then, different corporations including banks have become wary of their carbon emissions and implemented strategic measures to facilitate its reduction. The banks leveraged their financial muscle, social impact and other economic activities in taking the necessary steps and committing to attaining the Paris Agreement objectives (Kocornik-Mina et al., 2021). They address the rising climate change risks while concurrently striving to maintain a satisfactory financial performance (Fabris, 2020). In December 2023, at the COP28 meeting held in Dubai, the European Bank for Reconstruction and Development (EBRD) in collaboration with the EU pledged a cumulative amount of € 220 million towards green investments and strategic climate action activities in Eastern and Southern EU including Türkiye (EBRD & EU, 2023). This is not their first nor their only initiative in utilising green investments towards the attainment of sustainable development goals since the two have also partnered with banks and financial institutions in Morocco during the COVID-19 crisis, to extend a helping hand to private sector companies in the form of grants. An amount worth € 253 million was contributed through EBRD's Green Economy Financing Facility (GEFF) towards this cause to assist in restoring the country's economy during that devastating time while equally promoting the low carbon future (EBRDGEFF, n.d.). In developing countries, multilateral development banks (MDBs) have created various initiatives to promote long term sustainability efforts like financing power systems, transportation and urban development (Gugliotta, 2021). Besides aligning their financial flows with the Paris Agreement objectives, the MDBs have also designed an approach called “six building blocks” in alignment with the same cause to get to the desired destination: low carbon emission (Anja et al., 2022). The six building blocks are “alignment with mitigation goals; adaptation and climate-resilient operations; accelerated contribution to the transition through climate finance; engagement and policy development; reporting; and alignment of internal activities.” (Anja et al., 2022). Citi Bank pledged $250 billion to finance and advocate for a sustainable economy as part of the “2025 Sustainable Progress Strategy " (Light & Skinner, 2021). Banks have also begun incorporating ESG reporting metrics in annual reports to promote transparency and accountability of their SDGs achievement efforts.

The effects of adopting sustainable banking practices in the banking sector has been under scrutiny by researchers. Different studies were conducted bearing varying results; some positive while others indicated that these practices may negatively affect the financial performance of banks. Research by Buallay (2019) on 235 European banks showed that by deciding to incorporate ESG disclosures in their reporting, the performance of these banks improved which speaks to the overall financial health of these institutions. The previous literature further indicates that banks gain a competitive edge by adopting sustainable banking and green lending practices due to the reputation and stakeholders’ loyalty that’s associated with good CSR performance, and this subsequently leads to improved financial performance (Jain & Sharma, 2023). This emanates from the fact that investors, customers, and other stakeholders have begun being more demanding and inquisitive of banks and other financial institutions to gravitate more towards business activities that are regarded as being environmentally friendly and sustainable (Mir & Bhat, 2022). A combination of the shareholder and stakeholder theory in the context of corporate social responsibility (CSR) emphasises the importance of prioritising the maximisation of the shareholder’s wealth while simultaneously upholding ethical standings (Inyang et al., 2023; Rahman & Pandey, 2020; Zhu, 2021). As there are always opposing sides to every solution, the banks’ incorporation of green banking practices was determined to negatively impact their operations by increasing the expenses while gaining no financial returns on CSR investments therefore putting them at a great disadvantage in comparison with their competitors (Oyewumi et al., 2018). A study conducted by Salim et al. (2023) on 473 commercial banks from 74 countries spanning over 9 years (from 2007 to 2016) indicated that there is a negative relationship between Corporate Environmental Performance and Non-performing Loans (a proxy for banks' stability) whereby the country's environmental and social score was not taken into account. Salim et al. (2023) claim that these results were consistent with previous findings which indicated that the financial performance of banks that are socially and environmentally friendly is less impressive when compared to that of their counterparts that do not adopt sustainable banking practices. The very same study yielded slightly differing results when using Corporate Social Performance as a proxy for banks' stability in which there was no significant relationship between the two which means incorporating sustainable banking practices does not affect the banks financial performance. Although the study contributes a significant value to contemporary literature, it was conducted using data last updated a couple of years ago and the banking industry has evolved tremendously ever since, especially considering the occurrence of COVID-19 financial crisis which was an imminent threat to banks' stability. The study's contradictory results do not provide any solution but instead adds further confusion about the complex sustainability and banks' stability nexus.

Because of the banking industry's ability to optimise financial resources, it plays an integral role as an intermediary towards achieving the SDGs (Alexander, 2014; Aracil et al., 2021; Beck et al., 2010; Yip and Bocken, 2018). Sustainable banking practices such as offering green finance products like green bonds and green loans by traditional banks are a true testament of banks' commitment to adhering to ESG principles. Research has shown that the incorporation of fintech within the banking sector has been a platform for banks to practise sustainable banking (M. S.

Rahman et al., 2024). For example, emerging technologies like internet banking and many other solutions brought forward by the 4th Industrial revolution are at the forefront of revolutionising and digitising the banking sector.

The following section explores how these fintech innovations have interacted with sustainable banking and green lending and their influence in advancing sustainable banking development.

2.6 FinTech overview and impact on sustainable banking (including green lending)

As the adoption of fintech increases parallel to its advancements, so does the researchers' interest in understanding its ramifications across varied sectors. The adoption of fintech in the banking sector, particularly the inspection of its impact in driving the success of sustainable banking adoption has been taken on by a few scholars. An SEM study by Zheng and Siddik (2022) revealed that a combination of fintech adoption, green finance and green innovation by the banking industry was a perfect vehicle in steering the industry towards environmental sustainability. Green finance is an industry wide strategic measure agreed upon by the financial players to mitigate climate change risks and promote sustainability (Serdarušić et al., 2024). Green bonds, carbon emissions trading, and green credit are three investment fund strategies under green finance, gaining prominence in financing environmentally friendly projects within the private sector (Muganyi et al. 2021; Udeagha & Muchapondwa, 2023). With the emergence of digital transformation came a highly anticipated disruption by fintech within the banking sector (Barroso & Laborda, 2022) although scholars like Valavan (2023) and Oshodin et al. (2017) claim that thoroughly detailed empirical research depicting whether FinTech is a disruptor or collaborator is undergoing and forthcoming. To push forward the United Nations' Sustainable Development climate change agenda, the banking industry has come up with its own policies, strategies, and environmentally friendly innovative products to accelerate the reduction of paper usage and subsequent low carbon emissions (Alexander et al., 2018). An example of this is an invention like the internet banking or e-banking, where users can perform financial transactions, access their bank balances, pay bills, apply for loans, apply for overdrafts and perform many other bank related activities at the blink of an eye without the need to travel to a branch. This does not only promote financial inclusion, but further reduces the need for paper usage in these bank branches. Another instance is that of mobile money, although not part of the conventional banking sector, it gives an opportunity to disadvantaged communities in sub-Saharan Africa to gain access to basic financial services and banking products using their mobile phones at reasonable costs without the need for an official bank account (Kulu et al., 2022). By incorporating advanced technology in their business operations, banks have established and maintained close relations with their customers (Achimba et al., 2014) and other stakeholders which has not only reduced information asymmetry but led to improved operations efficiency and financial performance (Broby, 2021). A good overall performance by banks leads to a thriving banking industry which is imperative for financial sector stability. Transparency and data protection have improved tremendously as the adoption of Fintech upsurges. Owing to KYC laws, most banks are inclined to keep identifying records of their clients; and the adoption of a modernised blockchain based KYC system (e-KYC) has led to a significant reduction in the chances of money laundering and embezzlement of funds while simultaneously facilitating easy and secure management of privacy data since all client files are held electronically (Hannan et al., 2023). Nevertheless, data privacy and security issues have been the concern of consumers (Aldboush & Ferdous, 2023). In 2023, the IBM Security report 'Cost of a Data Breach Report 2023' revealed that an unprecedented amount of USD 4.45 million was spent on data breaches, which is 2.3% higher than the data breach cost recorded in 2022, and 15% higher than in 2020 (IBM, 2023).FinTech serves as a foundation for the creation of new business models, products, and organisations. The existing and previous literature demonstrates that FinTech, through previously mentioned innovations such as DLT, IoT, big data, and financing models such as SPFMS, has played a pivotal role in promoting financial access to start-up owners of environmentally friendly projects (Kedir & Kouame, 2022). A study conducted by Pawłowska et al. (2022) on the "Impact of Fintech on Sustainable Development" established that fintech can substantially influence the growth of green finance and mitigate the ongoing climate and environmental issues that the world is currently facing with the issuance of financial instruments such as green bonds. In their investigation, Pawłowska et al. (2022) concluded that "The next step in research will be to calculate the econometric model. However, estimating the quantitative impact of FinTech on sustainable growth, due to the complexity of the problem, will require the development of a more detailed methodology and the use of a sample of comparability of data, which at this stage seems very difficult."

Research on sustainable banking and fintech has mostly been restricted to the exploration of each of these subjects independently; rarely have there been studies investigating the relationship between the two. There is limited independent research delving into sustainable banking as an integral part of emerging sustainable and green finance, analysing the role it plays in funding environmentally friendly projects, hence the need for this study: To investigate, draw direct linkages, and solidify a rapport between FinTech and sustainable banking, including green lending. To indulge deeper into the topic at hand by further addressing the question, "Is there an empirical relationship between fintech and sustainable banking? What role does fintech play in the development of sustainable banking when financing pro-environmental projects?"

The adoption of fintech did not only elevate the banking sector but extended to other sub industries such as financial services, and insurance sectors (Sreenu & Mishra, 2023). To facilitate an informative exploration of the relationship in detail and induce necessary inferences, the following hypothesis was developed:

H0: Fintech has no significant impact on the development of sustainable banking when financing pro-environmental projects.

H1: Fintech positively influences the development of sustainable banking when financing pro-environmental projects.

Chapter 3

Research Methodology

This chapter highlights the strategic research approach employed by the author to address the research questions posed in this study.

3.1 Research Approach

An integral part of any scientific research is the selection of an appropriate methodology and data. The type of data and methodology used varies from study to study depending on the questions and objectives of the researcher. There are two types of research methods to choose from: qualitative and quantitative. In the qualitative research method, the researcher seeks to address the research questions by analysing non-numerical data to have a clear perspective on the different dynamics and relationships between the objects of the study. In this method, data may be collected using different techniques such as interviews, focus groups, and observations. Quantitative research is an objective research approach that uses numerical data and quantifiable variable measurements of a specific sample representing the entire population. In this method, inferences and conclusions are made by performing statistical data analysis using different techniques and software. In this study, we used a quantitative research method because we will analyse the secondary panel data.

3.2 Data Collection

This study investigates the role of fintech in advancing the development of sustainable banking practices, specifically in countries that have consistently portrayed commitment towards attaining the Paris Agreement. These countries have developed various green finance initiatives such as encouraging and supporting banks and financial institutions to practise sustainable banking and offer green finance products such as green bonds and green loans. They have also developed multiple funding vehicles to make it easier for entrepreneurs and investors to access funding for their pro-environmental projects. Due to availability, the data were collected based on a 5-year period (2018-2022) from a total of 14 countries namely; Argentina, Australia, France, Germany, Indonesia, Italy, Mexico, Netherlands, South Africa, Spain, Sweden, Switzerland, Türkiye and the United States of America. A total of 70 observations was obtained (n=70).

3.3 Variables

A combination of different macroeconomic variables was collected from various renowned sources, as shown in Table 1.

3.3.1 Dependent Variable

3.3.1.1 Green Lending

Green lending was used as a proxy variable for sustainable banking practises of each country. This was measured by the sum of green bonds issued by banks and financial institutions in each of these countries.

3.3.2 Independent Variables

Independent variables were also chosen carefully in alignment with the objectives of the study to investigate their relationship with sustainable banking.

3.3.2.1 Fintech

Fintech was chosen as one of the independent variables because evaluating its impact on the development of sustainable banking practises is the main purpose of this study. As discussed in the literature review section, different scholars have already delved deeply into the relationship between fintech and sustainable banking. Previous studies conducted by researchers such as Kanga et al. (2021) have used different proxy variables for fintech, such as ATM usage, number of digitally active accounts, and mobile phone transactions. For this study, we chose to use the total value of cashless payments, domestic card and e-money payments with cards and e-money issued inside the country, by card with a credit function, e-money payments reported annually by each country to the International Bank of Settlements. The amounts were recorded in millions of local currencies, and we converted them into dollars using the XE Currency Converter to have them in the same currency to simplify the research process.

3.3.2.2 GDP Growth Per Capita

Annual GDP growth per capita was used to measure each country's economic reaction to sustainable banking and green finance practises over the years.

3.3.2.3 Inflation Rate

The inflation rate was also used to evaluate the influence of changes in the inflation rate on sustainable banking.

3.3.2.4 Carbon Emissions Per Capita

Carbon Emissions were used as a variable to measure each country's commitment to sustainability. Multiple studies have shown that the more committed a country is to sustainability, the less Carbon emissions it will have and the more green bonds it will issue. In a study evaluating the relationship between carbon emissions and green bonds (whose returns were directed towards financing green projects), Flammer (2023) reported that "the issuance of $1,000 of green bonds per capita is associated with a subsequent decrease in state-level emissions by 0.9–1.4 per cent."

Table 1: Summary of variables used

Variable	**Unit of Measure**	**Source**
Fintech (FNT)	Million Dollars	Bank for International Settlements (BIS)
1. Green Lending	Billion Dollars	International Monetary Fund (IMF)

(GLN)		
2. Carbon Emissions Per Capita (CO2EPC)	Tonnes per capita per year	Emission Database for Global Atmospheric Research (EDGAR)
3. GDP growth per capita (GDP)	Annual % change GDP per capita	World Bank
4. Inflation Rate (IFR)	Annual % change in inflation rate	World Bank

Source: Designed by the author

3.3.3 Model Conception

To address the research questions and evaluate the relationship between fintech and sustainable banking, an econometric model was developed using secondary panel data collected from different sources. The equation of the model is developed as follows:

$$GLN_{it} = \beta_0 + \beta_1 FNT_{it} + \beta_2 GDP_{it} + \beta_3 IFR_{it} + \beta_4 CO2EPC_{it} + \varepsilon_{it}$$

Where:

β_0 is the constant term.

$\beta_1, \beta_2, \beta_3, \beta_4$ are the coefficients for the independent and control variables.

ε (epsilon) is the error term. It represents the difference between the observed values of the dependent variable and the values predicted by the regression model.

i denotes different countries (cross-sectional dimension).

t denotes different time periods (time-series dimension).

The hypothesis of this model, developed in the literature review section of this study, was tested by running a multiple regression analysis using three different techniques: Pooled Ordinary Least

Square (OLS) regression, fixed effects (FE), and random effects (RE) models. These techniques offer different advantages, and each of them helped us build a solid perspective on the relationship between fintech and sustainable banking. In the pooled OLS regression model, a pool of all 70 observations was generated to estimate a single regression unit. The model assumes that all coefficients are the same for all countries. In the FE model, there is an assumption of correlation between the unobserved and observed variables, whereas in the RE model, the unobserved variables are not related to the observed variables. Both the FE and RE models account for the observed heterogeneity.

Before continuing with the OLS regression, a probability Test was run to check if the Pooled OLS regression was applicable to the dataset or not. The Durbin-Wu Hausman specification test (Hausman test) was run to help select a better model between FE and RE based on their compatibility with data. A unit root test was also incorporated in this study to test the stationary of the series on the variables used. A robustness test was run to verify the validity and reliability of the obtained results. The model was tested using Rstudio (R version 4.4.0).

In the next chapter, we will go over the analysis and discussion of the findings from the model estimations.

Chapter 4

Results and Discussion

This chapter analyses and discusses the findings from the model estimations and tests.

Descriptive statistics

Table 2: Summary of descriptive statistics

Variable	N	Mean	Standard Deviation	Minimum	Median	Maximum
GLN	70	12.8477	17.8884	0.0000	4.5187	83.8401
FNT	70	513591.4261	1248169.4701	1.8101	137222.9800	5492440.0000
CO2PC	70	6.6820	3.9493	2.1830	5.1622	16.7120
GDP	70	1.0110	4.3572	-11.6001	1.5260	10.4293
IFR	70	8.1049	15.2193	-0.7258	2.8200	72.4307

Source: Arthur's calculations

4.1 Elaboration of descriptive statistics

4.1.1 Green Lending (GLN)

The above descriptive statistics show that an average of $12.85 billion was issued in Green Bonds per country annually. The minimum value of 0.00 is an indicator that some countries did not record an issuance of green bonds in certain years. The highest recorded value of green bonds issued in a single country was a whopping $83.84 billion. Half of the green bonds issued in each country were under $4.52 billion. The corresponding standard deviation of $17.89 billion indicates a significant disparity in the issue of green bonds among these countries.

4.1.2 Fintech (FNT)

The average value of fintech transactions recorded per country was $513,591.43 million. The lowest amount of fintech transactions ever reported by a country to BIS between 2018 and 2022 was $1.81 million, while the highest was close to $5.5 trillion. The results also show that half of the transactions fell below $137,222.98 million. The standard deviation of $1.248 trillion portrays an overwhelming difference in the value of fintech transactions across the countries.

4.1.3 Carbon Emissions Per Capita (CO2EPC)

With regards to carbon emissions, an annual average of 6.6820 tonnes per capita was recorded per country. The minimum was 2.1830 tonnes per capita while the maximum was 16.7120 tonnes per capita. Half of the carbon gas emissions per country were below 5.1622 million tonnes per capita. The standard deviation value of 3.9493 tonnes per capita indicates the varying levels of emissions by different countries.

4.2 Model Diagnostics

A couple of preliminary tests were run to check if there were any issues with the model before engaging in further analysis. The Levin-Lin-Chu Unit-Root Test was conducted to check for the stationarity of the model. A p-value of 0.000657 is significant at the 5% level and the null hypothesis is rejected, which means that the model does not contain any unit root. Therefore, we conclude that there is stationarity throughout the entire data series. The presence of heteroscedasticity was tested using the Breusch-Pagan test. A p-value of 0.8487, which is greater than the 5% significance level, was found. In this instance, we fail to reject the null hypothesis, which states that there is constant variance in the model, indicating that the model is homoscedastic.

4.3 Correlation Analysis

Pearson correlation matrix was run to explore the relationship between variables to comprehend the impact and influence they may have on one another.

Table 3: Pearson Correlation Matrix

Variables	**FNT**	**GLN**	**CO2EPC**	**GDP**	**IFR**
FNT	1.00***				
GLN	0.34**	1.00***			
CO2EPC	0.58***	0.23*	1.00***		
GDP	0.04	0.11	0.03	1.00***	
IFR	-0.12	-0.22	-0.18	0.09	1.00***

P-values: ***denotes significance at 1%, **denotes significance at 5% and *denotes significance at 10%

The relationship between fintech and sustainable banking (represented by green lending) is the main focus of this study. The p-value of 0.34 is greater than the 5% significance level, which implies that the correlation is not statistically significant. These findings do not present enough evidence to reject the null hypothesis, which states that fintech has no significant impact on the development of sustainable banking when financing pro-environmental projects. Looking at the graphical representation of this relationship in Appendix 1, the horizontal linear scatter plot further indicates that the correlation between fintech and sustainable banking is not statistically significant. The correlation between various independent variables was also analysed to check if there are any possible multicollinearity issues in the model. Multicollinearity refers to a situation in which there is a high correlation between two or more explanatory variables in a regression model. The high correlation between the independent variables reduces their statistical significance, leading to bias in model regression. In this study, the highest correlation is between fintech and CO2 emissions per capita at 0.58 which does not call for any concern. The variance inflation factors (VIF) test was used to confirm the absence of multicollinearity. In the VIF test, any value below 5 is acceptable, whereas any value above 5 indicates that there is a problem of multicollinearity. The results summarised in table 4 confirmed the absence of the multicollinearity problem therefore no corrective measures are necessary.

Table 4: Summary of the multicollinearity test using VIF

Variable	**VIF**
FNT	1.5155
C02EPC	1.5469
GDP	1.011
IFR	1.0451

Source: Arthur's statistical tests

4.4 Regression Analysis

4.4.1 Pooled OLS

Before getting into the pooled OLS regression, the poolability test was ran to determine if the pooled OLS method is applicable to the dataset. The poolability test is about the following hypothesis:

H0: Pooled OLS is stable

H1: Pooled OLS is unstable

The p-value of 0.36 is greater than 5%, therefore we fail to reject the null hypothesis. This means that the dataset we are working with is poolable. The evidence of this test can be found in Appendix 2.

The next step is to run the pooled OLS regression model. A summary of the results is presented in table 6. The full detailed results are captured in appendix 3.

Table 5: Results from Pooled OLS Regression

Variable	**Coefficient**	**Probability**
Constant	11.6499	0.0132**
FNT	0.0000	0.0296**
CO2EPC	0.0387	0.9518
GDP	0.4686	0.3208
IFR	-0.2248	0.1040
R-Squared		**0.1631**
Adjusted R-Squared		**0.1116**
F-Statistic		**3.1675**
p-value		**0.0193**

P-values: *** denotes 0.01, **0.05 and *0.1 significance levels

The results from the pooled OLS regression model show that the p-value of Fintech is 0.0296, which is less than the 5% significance level. In this instance, we reject the null hypothesis (H0), which states that fintech has no possible impact on the development of sustainable banking when financing pro-environmental projects. The estimated coefficient for FNT is 0.0000, which means that for every one-unit increase in FNT, GLN is predicted to increase by 0.0000 units, holding all other variables constant.

Carbon emissions per capita have no significant impact on sustainable banking with 0.95181 p-value ($p > 0.05$). GDP has a p-value of 0.3208 ($p>0.05$), which means it has no significant effect on sustainable banking development. With a p-value of 0.10399 ($p>0.05$), the inflation rate also seems to have no particular influence on sustainable banking development. The p-value of 0.019 ($p<0.05$) associated with the F-statistic indicates that the overall model is significant and therefore reliable.

The analysis of the results obtained from the fixed-effects and random-effects regression models is discussed below.

4.4.2 Fixed and Random effects

To increase the reliability of the model and help gain a better understanding from different angles of statistics, additional techniques such as FE and RE were used to estimate the model. The comparative results are listed in table 7. The full results can be found in appendices 4 and 5.

Table 6: Results of FE and RE model regression

Variable	**Fixed Effects**		**Random Effects**	
	Coefficient	**Probability**	**Coefficient**	**Probability**
Constant			18.9278	0.0315**
FNT	0.0000	0.0909*	0.0000	0.0159**
CO2EPC	-8.5512	0.0119**	-1.6509	0.1801

GDP	0.6516	0.0470**	0.5237	0.10504
IFR	-0.0056	0.9751	-0.0558	0.7324
R-Squared	0.2574		0.1137	
Adjusted R-Squared	0.0146		0.0592	
F-Statistic	4.5055			
Chisq			8.3393	
p-value	**0.0034**		**0.0799**	

P-values: *** denotes 0.01, **0.05 and *0.1 significant levels

The results show that Fintech has a significant impact on sustainable banking with a p-value of 0.0909 ($p<0.10$) in FE and 0.0159 ($p<0.05$) in RE regression technique. In this case, we reject the null hypothesis and conclude that fintech may be a factor in the development of sustainable banking when financing pro-environmental projects. These results are in line with the outcomes of the Pooled OLS technique where we had the statistical evidence to reject the null hypothesis too. The rest of the results are consistent with those that were found in the pooled OLS. It was determined that GDP growth per capita, carbon emissions per capita and inflation rate do not have any significant influence on the development of sustainable banking. An interesting observation was made regarding the p-values associated with the F-statistic. Under the FE regression model, the p-value was found to be 0.0034 ($p<0.05$). This suggests that the overall model is effective to work with. However, the RE regression model rendered different results; with 0.0799 p-value, showing that the model is significant to work with at 10% significance level.

4.4.3 The Durbin-Wu-Hausman test

Selecting an ideal technique to work with between FE and RE is an important step in panel data analysis. The Hausman test proposes the null hypothesis, which states that the RE model is consistent, and an alternative hypothesis, which states that the FE model is consistent. The p-value obtained from the test is equal to 0.0141 ($p<0.05$). We reject the null hypothesis and assume that FE is the most preferable technique to work with because of its consistency with the model.

4.6 Discussion

The objective of this study was to explore the relationship between fintech and sustainable banking in the context of green lending where green bonds are used to finance pro-environmental projects. Green lending is an important component of sustainable banking, and it forms part of funding initiatives by banks and other financial institutions that seek to finance eco-friendly projects (Mirza et al., 2023). In our model, green bonds issued by banks and financial institutions in various countries were used as a proxy variable for green lending. The results obtained from all three regression models consistently showed that the effect of Fintech on Sustainable banking is statistically significant, however in practical terms this effect is negligible due to the estimated coefficient of Fintech being 0.0000. This means that when analysing the statistical significance, we can infer that fintech may have a possible impact on advancing sustainable banking development when financing pro-environmental projects. However, the effect size of this relationship is so minute that it does not likely hold any practical importance or relevance in real-world applications. These results prompt us to conclude that although banks have consistently demonstrated their commitment towards environmental sustainability through various financial and non-financial initiatives, their priorities lie with generating attractive returns to keep the shareholders satisfied while also meeting the needs of their clients. In this instance, it is not farfetched to assume that banks may prioritise leveraging fintech to attain their financial objectives than advancing the state of sustainable banking practices.

The findings from descriptive statistics also create a reason to infer that as the value of fintech transactions increases across these countries, so does the amount of green bonds offered by banks and financial institutions to promote funding for environmentally friendly projects. These findings align with the results of an empirical study on cities in China conducted by Huang et al. (2024), who also documented a positive relationship between fintech development and bond issuance. A significant disparity in the value of fintech transactions reported by each country to the BIS was also noted. This could be influenced by varying levels of mobile banking penetration and adoption of digital payments such as cashless transactions and e-payments, across these countries. Some countries are far more advanced than others in terms of the digitisation of the banking and financial services sector (Pakhnenko et al., 2021). Varying levels of carbon emissions per capita by different countries were also observed in this study. This indicates a noticeable gap in environmental sustainability commitment between these countries. Multiple factors such as economic activity, political structures, and environmental policies may be a prominent cause. Some countries have committed to attaining sustainability by reducing industrial carbon emissions to develop a more sustainable economy (Mehmood et al., 2024). Carbon emissions per capita, alongside two macroeconomic variables used in this study, (GDP per capita and inflation rate), showed no significant relationship with green lending under Pooled OLS and RE. Contradictory observation is made regarding these relationships under the FE model except for the inflation rate that consistently seems to have no significant relationship with green lending.

In recent years, banks have shown great commitment to environmental sustainability and implemented different strategies to address the ongoing climate change problems. They have created various funding opportunities for green and environmentally friendly projects. They issue affordable green sustainability-linked bonds and loans to fund projects addressing issues such as high carbon emissions, water treatment and building sustainable infrastructures.

From these results, we can draw a linkage between fintech and sustainable banking and comprehend the role that fintech plays in sustainable banking development.

Chapter 5

Conclusion

The results obtained from this study have shown that there is indeed an empirical, positive relationship between fintech and sustainable banking. The study was carried out under the green lending context, where green bonds are used as a financing tool for eco-friendly projects. The null hypothesis from our study is not rejected; hence, we conclude that fintech has an empirical relationship with sustainable banking and acts as a catalyst in its development when financing pro-environmental projects. Although the relationship between fintech and sustainable banking was found to be statistically significant which caused us to reject the null hypothesis. It is imperative to note that in this study the influence of fintech in advancing sustainable banking may not be practically important due the effect size of fintech being extremely small therefore negligible. This suggests that the relationship between fintech and sustainable banking exists as established in our analysis of statistical significance, but the estimated coefficient of fintech is too small to cause any impactful influence. The research questions were addressed by running the panel data collected from 14 countries in Pooled OLS, FE, and RE regression models. These results may be considered by policymakers, investors, banks, and governments to comprehend the effectiveness of fintech in developing sustainable banking.

Limitations of the study

Although this study adds a significant contribution to the existing literature exploring the interplay between fintech and sustainable banking. It relied on green bonds to represent sustainable banking practices in various countries. The values recorded in the dataset may be inconsistent because there is currently a lack of international standards guiding banks and financial institutions on reporting green bond issuances. This means that the results from the regression model may not be as efficient.

References

Achimba, C., Ongonga, J. O., Nyarondia, S. M., Amos, A. a. L., & Okwara, M. O. (2014). Innovation in banking industry: Achieving customer satisfaction. *Open Journal of Business and Management*, *02*(04), 261–274. https://doi.org/10.4236/ojbm.2014.24031

Aik, N. C., & Zhang, Q. (2023). Use of theil for a specific duality economy: Assessing the impact of digital inclusive finance on urban-rural income gap in Chongqing. *FinTech*, *2*(4), 668–679. https://doi.org/10.3390/fintech2040037

Akomea-Frimpong, I., Adeabah, D., Ofosu, D., & Tenakwah, E. J. (2021). A review of studies on green finance of banks, research gaps and future directions. *Journal of Sustainable Finance & Investment*, *12*(4), 1241–1264. https://doi.org/10.1080/20430795.2020.1870202

Alam, M. M., Awawdeh, A. E., & Muhamad, A. I. (2021). Using e-wallet for business process development: challenges and prospects in Malaysia. *Business Process Management Journal*, *27*(4), 1142–1162. https://doi.org/10.1108/bpmj-11-2020-0528

Aldboush, H. H., & Ferdous, M. (2023). Building Trust in Fintech: An analysis of ethical and privacy considerations in the intersection of big data, AI, and customer trust. *International Journal of Financial Studies*, *11*(3), 90. https://doi.org/10.3390/ijfs11030090

Alessi, L., & Savona, R. (2021). Machine learning for financial stability. In *Springer eBooks* (pp. 65–87). https://doi.org/10.1007/978-3-030-66891-4_4

Alexander, K., 2014. Stability and Sustainability in Banking Reform: are Environmental Risks Missing in Basel III? CISI & UNEPFI, Cambridge & Geneva.

Alexander, A. J., Shi, L., & Solomon, B. B. (2017). How Fintech is Reaching the Poor in Africa and Asia: A Start-Up Perspective. In *International Finance Corporation, Washington, DC eBooks*. https://doi.org/10.1596/30360

Alexander, S., Fisher, P., & Van Den Boezem, F. B. (2018). Banking regulation and sustainability.

Social Science Research Network.https://doi.org/10.2139/ssrn.3299351

Ali, A., Razak, S. A., Othman, S. H., Eisa, T. a. E., Al-Dhaqm, A., Nasser, M., Elhassan, T., Elshafie, H., & Saif, A. (2022). Financial Fraud Detection Based on Machine Learning: A Systematic Literature review. *Applied Sciences*, *12*(19), 9637. https://doi.org/10.3390/app12199637

Anja, C. G., Aki, K., & Lauren, S. (2022). *Aligning finance flows with the Paris Agreement: The role of multilateral development banks*. Edward Elgar Publishing. https://www.elgaronline.com/edcollchap/book/9781784715656/book-part-9781784715656-22.xml

Aracil, E., Sánchez, J. J. N., & Forcadell, F. J. (2021). Sustainable banking: A literature review and integrative framework. *Finance Research Letters*, *42*, 101932. https://doi.org/10.1016/j.frl.2021.101932

Arner, D. W., Barberis, J. N., & Buckley, R. P. (2015). The evolution of fintech: A new post-crisis paradigm? *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.2676553

Arner, D. W., Barberis, J., & Buckley, R. P. (2016). 150 years of Fintech: An evolutionary analysis. *JASSA: The Journal of the Securities Institute of Australia*, *3*, 22–29. https://search.informit.org/doi/10.3316/ielapa.419780653701585

Arner, D. W., Barberis, J., & Buckley, R. P. FinTech, RegTech and the Reconceptualization of Financial Regulation'(2017). *Northwestern Journal of International Law and Business*, *37*, 371. http://hub.hku.hk/bitstream/10722/235796/1/content.pdf

Arner, D. W., Barberis, J., & Buckley, R. P. (2017). FinTech and RegTech in a nutshell, and the future in a sandbox. *Social Science Research Network*. https://doi.org/10.2139/ssrn.3088303

Baker, S., Waterman, S., & Ivanov, G. (2010). *In the Crossfire: Critical Infrastructure in the Age* *of Cyber War: A Global Report on the Threat Facing Key Industries*. McAfee. https://books.google.dz/books?id=vh77swEACAAJ

Balaskas, S., Koutroumani, M., Komis, K., & Rigou, M. (2024). FinTech services adoption in Greece: The roles of trust, government support, and technology acceptance factors. *FinTech*, *3*(1), 83–101. https://doi.org/10.3390/fintech3010006

Barroso, M., & Laborda, J. (2022). Digital transformation and the emergence of the Fintech sector: Systematic literature review. *Digital Business*, *2*(2), 100028. https://doi.org/10.1016/j.digbus.2022.100028

Beck, T., Kunt, A. D., & Levine, R. (2010). Financial Institutions and Markets across Countries and over Time: The Updated Financial Development and Structure Database. *the World Bank Economic Review*, *24*(1), 77–92. https://doi.org/10.1093/wber/lhp016

Bhasin, B. (2018). Evolution of technology in financial markets. *International Journal of Information Research and Review*, *5*(8), 5663-5666.

Board, F. F. S. (2017). *Artificial intelligence and machine learning in financial services: Market developments and financial stability implications*. Financial Stability Board.

Buallay, A. (2019). Is sustainability reporting (ESG) associated with performance? Evidence from the European banking sector. *Management of Environmental Quality*, *30*(1), 98–115. https://doi.org/10.1108/meq-12-2017-0149

Buckley, R. P., Arner, D. W., Zetzsche, D. A., & Selga, E. (2019). The dark side of digital financial transformation: the new risks of FinTech and the rise of TechRisk. *Social Science Research Network*. https://doi.org/10.2139/ssrn.3478640

Burke, J. J., & Burke, J. J. (2021). FinTech. *Financial Services in the Twenty-First Century: The Present System and Future Developments in Fintech and Financial Innovation*, 107–130. https://doi.org/10.1007/9

Broby, D. (2021). Financial technology and the future of banking. *Financial Innovation, 7*(1). https://doi.org/10.1186/s40854-021-00264-y

Cai, C. W. (2018). Disruption of financial intermediation by FinTech: A review on crowdfunding and blockchain. *Accounting & Finance, 58*(4), 965–992. https://doi.org/10.1111/acfi.12405

Chao, X., Ran, Q., Chen, J., Li, T., Qian, Q., & Ergu, D. (2022). Regulatory technology (Reg-Tech) in financial stability supervision: Taxonomy, key methods, applications and future directions. *International Review of Financial Analysis (Online)/International Review of Financial Analysis*, *80*, 102023. https://doi.org/10.1016/j.irfa.2022.102023

Commission, I. O. of S. (2017). IOSCO Research report on financial technologies (Fintech). *Retrieved October*, *31*, 2022.

Demirdogen, Y. (2020). Finteklerin gelişimini etkileyen faktörler. Isparta Uygulamalı Sosyal Bilimler ve Güzel Sanatlar Dergisi, 2(Özel Sayı), 43-55.

Deng, X., & Jia, Z. (2021). Discussion on the influence of fin-tech on financial risk management. *International Journal of Frontiers in Sociology*, *3*(11). https://doi.org/10.25236/ijfs.2021.031101

Desalegn, G., & Tangl, A. (2022). Enhancing Green Finance for Inclusive Green Growth: A Systematic Approach. *Sustainability*, *14*(12), 7416. https://doi.org/10.3390/su14127416

EU and European Bank for Reconstruction and Development commit to accelerate green investments in partner countries. (2023, December 2). European Neighbourhood Policy and Enlargement Negotiations (DG NEAR). https://neighbourhood-enlargement.ec.europa.eu/news/eu-and-european-bank-reconstruction-and-development-commit-accelerate-green-investments-partner-2023-12-02_en

EBRD, EU and partners support green investments in Morocco – SME Green Value Chain. (n.d.).

https://ebrdgeff.com/morocco/ebrd-eu-and-partners-support-green-investments-in-morocco-2/

Fabris, N. (2020). Financial stability and climate change. *Journal of Central Banking Theory and Practice*, *9*(3), 27–43. https://doi.org/10.2478/jcbtp-2020-0034

Flammer, C. (2023). Green bonds and carbon emissions. *Oxford Review of Economic Policy*, *39*(4), 752–764. https://doi.org/10.1093/oxrep/grad040

Fáykiss, P., Papp, D., Sajtos, P., & Tőrös, Á. (2018). Regulatory Tools to Encourage FinTech Innovations: The innovation hub and regulatory sandbox in international practice. *Hitelintézeti Szemle*, *2017*(2), 43–67. https://doi.org/10.25201/fer.17.2.4367

Financial Stability Board (FSB) (2017): Financial stability implications from FinTech, June

Giglio, F. (2021). Fintech: A literature review. *European Research Studies Journal*, *24*(2B), 600-627.

Gugliotta, O. R. (2021). The Paris Agreement 5 years later: The challenges of climate finance and multilateral development banks. *Białostockie Studia Prawnicze*, *26*(5), 23–40. https://doi.org/10.15290/bsp.2021.26.05.02

Hałaburda, H., Levina, N., & Min, S. (2019). Understanding smart contracts as a new option in transaction cost economics. *Social Science Research Network*. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3506223

Han, H., & Li, M. (2018). Big data Analytics for high frequency trading volatility estimation. In *Springer proceedings in business and economics* (pp. 351–359). https://doi.org/10.1007/978-3-319-72745-5_39

Hannan, M. A., Shahriar, M. A., Ferdous, S., Chowdhury, M. J. M., & Rahman, M. S. (2023). A systematic literature review of blockchain-based e-KYC systems. *Computing*, *105*(10), 2089–2118. https://doi.org/10.1007/s00607-023-01176-8

Hasan, R., Hassan, M. K., & Aliyu, S. (2020). Fintech and islamic finance: Literature review and research agenda. *International Journal of Islamic Economics and Finance (IJIEF)*, *3*(1). https://doi.org/10.18196/ijief.2122

Ho, A. Y., Lin, W., & Yu, H. (2022). Does the P2P Credit Spread Predict Economic Activity? Evidence from LendingClub. In *Advances in Pacific Basin business, economics and finance* (pp. 59–90). https://doi.org/10.1108/s2514-465020220000010003

Hofacker, C. F., De Ruyter, K., Lurie, N. H., Manchanda, P., & Donaldson, J. (2016). Gamification and mobile marketing effectiveness. *Journal of Interactive Marketing*, *34*, 25–36. https://doi.org/10.1016/j.intmar.2016.03.001

Huang, J., Liu, R., Wang, W., Wang, Z., Wang, C., & Jin, Y. (2024). Unleashing Fintech's potential: A catalyst for green bonds issuance. *Journal of International Financial Markets, Institutions & Money*, *93*, 102009. https://doi.org/10.1016/j.intfin.2024.102009

Hurley, R. F., Xue, G., & Waqar, A. (2014). Understanding the loss of trust in large banks. *International Journal of Bank Marketing*, *32*(5), 348–366. https://doi.org/10.1108/ijbm-01-2014-0003

IBM. (2023). Cost of a Data Breach Report 2023 (p. 5). *IMB Security*. https://www.ibm.com/downloads/cas/E3G5JMBP

Inyang, W. S., Joel, E. E., Okoi, I. O., Orok, A. B., Ubi, I. U., & Mbu-Ogar, G. B. (2023). Corporate social responsibility and shareholders' wealth of industrial goods producing companies listed on the Exchange Group PLC of Nigeria. *International Journal of Professional Business Review*, *8*(6), e02476. https://doi.org/10.26668/businessreview/2023.v8i6.2476

Jadhav, J. (2024). An Empirical Study on Regulatory Technology (REGTech). *Social Science Research Network*. https://doi.org/10.2139/ssrn.4483816

Jan, A. A., Lai, F., Asif, M., Akhtar, S., & Ullah, S. (2022). Embedding sustainability into bank strategy: implications for sustainable development goals reporting. *International Journal of Sustainable Development and World Ecology/the International Journal of Sustainable Development and World Ecology*, *30*(3), 229–243. https://doi.org/10.1080/13504509.2022.2134230

Jian, Y. (2023). Green bonds and green environment: exploring innovative financing mechanisms for environmental project sustainability. *Environmental Science and Pollution Research International*, *30*(58), 122293–122303. https://doi.org/10.1007/s11356-023-30580-y

Jain, P., & Sharma, B. K. (2023). Impact of green banking practices on sustainable environmental performance and profitability of private sector banks. *International Journal of Social Ecology and Sustainable Development*, *14*(1), 1–19. https://doi.org/10.4018/ijsesd.330135

Kamuangu, P. (2024). A review on cybersecurity in fintech: Threats, solutions, and future trends. *Journal of Economics, Finance and Accounting Studies*, *6*(1), 47–53. https://doi.org/10.32996/jefas.2024.6.1.5

Kanga, D., Oughton, C., Harris, L., & Murinde, V. (2021). The diffusion of fintech, financial inclusion and income per capita. *European Journal of Finance*, *28*(1), 108–136. https://doi.org/10.1080/1351847x.2021.1945646

Karaömer, Y. (2021). An overview of financial technology sector in Turkey. *Journal of Politics*, *4*(2), 12.

Khan, H. H., Khan, S., & Ghafoor, A. (2023). Fintech adoption, the regulatory environment and bank stability: An empirical investigation from GCC economies. *Borsa Istanbul Review*, *23*(6), 1263–1281. https://doi.org/10.1016/j.bir.2023.10.010

Kocornik-Mina, A., Bastida-Vialcanet, R., & Huerta, M. E. (2021). Social Impact of Value-Based Banking: best practises and a continuity framework. *Sustainability*, *13*(14), 7681. https://doi.org/10.3390/su13147681

Kou, G., Chao, X., Alsaadi, F. E., & Herrera-Viedma, E. (2019). MACHINE LEARNING METHODS FOR SYSTEMIC RISK ANALYSIS IN FINANCIAL SECTORS. *Technological and Economic Development of Economy*, *25*(5), 716–742. https://doi.org/10.3846/tede.2019.8740

Kulu, E., Opoku, A., Gbolonyo, E., & Kodwo, M. a. T. (2022). Mobile money transactions and banking sector performance in Ghana. *Heliyon*, *8*(10), e10761. https://doi.org/10.1016/j.heliyon.2022.e10761

Kurbanov, S., Meshchangina, E., & Stefanova, N. (2023). Environmental economics and sustainable development. *E3S Web of Conferences*, *451*, 01010. https://doi.org/10.1051/e3sconf/202345101010

Liang, S. (2023). The Future of Finance: Fintech and Digital transformation. *Highlights in Business, Economics and Management*, *15*, 20–26. https://doi.org/10.54097/hbem.v15i.9222

Light, S. E., & Skinner, C. P. (2021). BANKS AND CLIMATE GOVERNANCE. *Columbia Law Review*, *121*(6), 1895–1956. https://www.jstor.org/stable/27075597

Lin, T. C. (2019). Artificial intelligence, finance, and the law. *Fordham L. Rev.*, *88*, 531.

Liu, C., Yang, M., & Wen, M. (2023). Judge me on my losers: Do robo-advisors outperform human investors during the COVID-19 financial market crash? *Production and Operations Management*, *32*(10), 3174–3192. https://doi.org/10.1111/poms.14029

Liu, Z., Shang, J., Wu, S. Y., & Chen, P. Y. (2020). Social collateral, soft information and online peer-to-peer lending: A theoretical model. *European Journal of Operational Research*, *281*(2), 428–438. https://doi.org/10.1016/j.ejor.2019.08.038

Luo, C., Xiong, H., Zhou, W., Guo, Y., & Deng, G. (2011). Enhancing investment decisions in P2P lending: An investor composition perspective. *Proceedings of the 17th ACM SIGKDD*

International Conference on Knowledge Discovery and Data Mining, 292–300.

Mehmood, S., Zaman, K., Khan, S., Ali, Z., & Khan, H. U. R. (2024). The role of green industrial transformation in mitigating carbon emissions: Exploring the channels of technological innovation and environmental regulation. *Energy and Built Environment*, *5*(3), 464–479. https://doi.org/10.1016/j.enbenv.2023.03.001

Mercuri, F., Della Corte, G., & Ricci, F. (2021). Blockchain Technology and Sustainable Business Models: A case study of Devoleum. *Sustainability (Basel)*, *13*(10), 5619. https://doi.org/10.3390/su13105619

Milne, A., & Parboteeah, P. (2016). The business models and Economics of Peer-to-Peer lending. *Social Science Research Network*. https://doi.org/10.2139/ssrn.2763682

Mir, A. A., & Bhat, A. A. (2022). Green banking and sustainability – a review. *Arab Gulf Journal of Scientific Research*, *40*(3), 247–263. https://doi.org/10.1108/agjsr-04-2022-0017

Mirza, N., Afzal, A., Umar, M., & Skare, M. (2023). The impact of green lending on banking performance: Evidence from SME credit portfolios in the BRIC. *Economic Analysis and Policy*, *77*, 843–850. https://doi.org/10.1016/j.eap.2022.12.024

Mougayar, W. (2016). *The business blockchain: promise, practice, and application of the next Internet technology*. John Wiley & Sons.

Muganda, B. W., & Kasamani, B. S. (2023, June). Parallel programming for portfolio optimization: A robo-advisor prototype using genetic algorithms with recurrent neural networks. In 2023 *International Conference on Intelligent Computing, Communication, Networking and Services (ICCNS)* (pp. 167-176). IEEE. https://ieeexplore.ieee.org/document/10193396

Muganyi, T., Yan, L., & Sun, H. (2021). Green finance, fintech and environmental protection: Evidence from China. *Environmental Science & Ecotechnology*, *7*, 100107.

https://doi.org/10.1016/j.ese.2021.100107

Müller, B., & Ram Bhandary, R. (2022). Aligning finance flows with the Paris Agreement: the role of multilateral development banks. *Edward Elgar Publishing eBooks* (pp. 256–292). https://doi.org/10.4337/9781784715656.00022

Musyaffi, A. M., Oli, M. C., & Afriadi, B. (2023). Drivers of student technology readiness in using cloud accounting to improve student performance. *International Journal of Information and Education Technology*, *13*(8), 1169–1176. https://doi.org/10.18178/ijiet.2023.13.8.1918

Ogiela, L., Ogiela, M. R., & Ko, H. (2020). Intelligent data management and security in cloud computing. *Sensors*, *20*(12), 3458. https://doi.org/10.3390/s20123458

Okazaki, S., Eisend, M., Plangger, K., De Ruyter, K., & Grewal, D. (2020). Understanding the Strategic Consequences of customer Privacy Concerns: A Meta-Analytic Review. *Journal of Retailing*, *96*(4), 458–473. https://doi.org/10.1016/j.jretai.2020.05.007

Oshodin, Osemwonyemwen; Molla, Alemayehu; Karanasios, Stan; and Ong, Chin Eang, "Is FinTech a Disruption or a New Eco-system? An Exploratory Investigation of Banks' Response to Fintech in Australia" (2017). *ACIS 2017 Proceedings*. 95 https://aisel.aisnet.org/acis2017/95

Pakhnenko, O., Rubanov, P., Hacar, D., Yatsenko, V., & Vida, I. (2021). Digitalization of financial services in European countries: Evaluation and comparative analysis. *Journal of International Studies*, *14*(2), 267–282. https://doi.org/10.14254/2071-8330.2021/14-2/17

Pawłowska, M., Staniszewska, A., & Grzelak, M. (2022). Impact of FinTech on sustainable development. *Nauki O Finansach*, *27*(2), 49–66. https://doi.org/10.15611/fins.2022.2.05

Pierrakis, Y. (2019). Peer-to-peer lending to businesses: Investors' characteristics, investment criteria and motivation. *International Journal of Entrepreneurship and Innovation*, *20*(4), 239–251. https://doi.org/10.1177/1465750319842528

Pushpa, A., Jaheer Mukthar, K. P., Ramya, U., Asis, E. H. R., & Martinez, W. R. D. (2023). Adoption of Fintech: A Paradigm Shift Among Millennials as a Next Normal Behaviour. *Fintech and Cryptocurrency*, 59–89. https://doi.org/10.1002/9781119905028.ch4

Qi, J., Zhang, Z., Jeon, S., & Zhou, Y. (2016). Mining customer requirements from online reviews: A product improvement perspective. *Information & Management*, *53*(8), 951–963. https://doi.org/10.1016/j.im.2016.06.002

Quach, S., Thaichon, P., Martin, K. D., Weaven, S., & Palmatier, R. W. (2022). Digital technologies: Tensions in privacy and data. *Journal of the Academy of Marketing Science*, *50*(6), 1299–1323. https://doi.org/10.1007/s11747-022-00845-y

Rahman, F., & Pandey, P. (2020). The Impression of Corporate Social Responsibility (CSR) on Corporate Financial Performance (Cfp) & the Concept and Role of Agency Theory. *Social Science Research Network*. https://doi.org/10.2139/ssrn.3644483

Rahman, M. S., Moral, I. H., Kaium, M. A., Sarker, G. A., Zahan, I., Hossain, G. M. S., & Khan, M. a. M. (2024). FinTech in sustainable banking: An integrated systematic literature review and future research agenda with a TCCM framework. *Green Finance*, *6*(1), 92–116. https://doi.org/10.3934/gf.2024005

Rajadnye, A. (2018). Data management framework for internet of things. *Social Science Research Network*. https://doi.org/10.2139/ssrn.3315541

Salim, K., Disli, M., Ng, A., Dewandaru, G., & Nkoba, M. A. (2023). The impact of sustainable banking practices on bank stability. *Renewable & Sustainable Energy Reviews*, *178*, 113249. https://doi.org/10.1016/j.rser.2023.113249

Salo-Lahti, Marika (2022). Good or Bad Robots? Responsible Robo- Advising. *European Business Law Review* 33(5), 239-254.

https://kluwerlawonline.com/journalarticle/European+Business+Law+Review/33.4/EULR2022030

Saraireh, S. (2013). A secure data communication system using cryptography and steganography. *International Journal of Computer Networks & Communications (IJCNC) Vol*, *5*. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3668796

Serdarušić, H., Pancić, M., & Zavišić, Ž. (2024). Green Finance and Fintech Adoption Services among Croatian Online Users: How Digital Transformation and Digital Awareness Increase Banking Sustainability. *Economies*, *12*(3), 54. https://doi.org/10.3390/economies12030054

Setiawan, K., & Maulisa, N. (2020, March). The evolution of fintech: a regulatory approach perspective. In *3rd International Conference on Law and Governance (ICLAVE 2019)* (pp. 218-225). Atlantis Press.

Siddiqui, Z., & Rivera, C. A. (2022). FinTech and FinTech ecosystem: A review of literature. *Risk Governance and Control: Financial Markets and Institutions*, *12*(1), 63–73. https://doi.org/10.22495/rgcv12i1p5

Sreenu, N., & Mishra, S. (2023). Impact of green finance and fintech on sustainable economic growth: Empirical evidence from India. *Heliyon*, *9*(5), e16301. https://doi.org/10.1016/j.heliyon.2023.e16301

Soltani, R., Zaman, M., Joshi, R., & Sampalli, S. (2022). Distributed Ledger Technologies and their Applications: a review. *Applied Sciences*, *12*(15), 7898. https://doi.org/10.3390/app12157898

Soori, M., Arezoo, B., & Dastres, R. (2023). Internet of things for smart factories in industry 4.0, a review. *Internet of Things and Cyber-physical Systems*, *3,* 192–204. https://doi.org/10.1016/j.iotcps.2023.04.006

Sun, Y., Shi, Y., & Zhang, Z. (2019). Finance Big Data: management, analysis, and applications. *International Journal of Electronic Commerce*, *23*(1), 9–11. https://doi.org/10.1080/10864415.2018.1512270

Thakor, A. V. (2020). Fintech and banking: What do we know? *Journal of Financial Intermediation*, *41*, 100833. https://doi.org/10.1016/j.jfi.2019.100833

Tobón, S., Ruiz-Alba, J., & García-Madariaga, J. (2020). Gamification and online consumer decisions: Is the game over? *Decision Support Systems*, *128*, 113167. https://doi.org/10.1016/j.dss.2019.113167

Treu, J. (2022). The Fintech Sensation–What is it about. *Journal of International Business and Management*, *5*(1), 1-19.

Udeagha, M. C., & Muchapondwa, E. (2023b). Green finance, fintech, and environmental sustainability: fresh policy insights from the BRICS nations. *International Journal of Sustainable Development and World Ecology/the International Journal of Sustainable Development and World Ecology*, *30*(6), 633–649. https://doi.org/10.1080/13504509.2023.2183526

UNFCCC. (2024). The Paris Agreement. Available at https://unfccc.int/process-and-meetings/the-paris-agreement

Valavan, T. (2023). FinTech is enabler or disruptive to the Banking Industry: An analytical study. *World Journal of Advanced Research and Reviews*, *17*(1), 067–072. https://doi.org/10.30574/wjarr.2023.17.1.1472

Ventura, A., Koenitzer, M., Stein, P., Tufano, P., & Drummer, D. (2015). The Future of FinTech: A paradigm shift in small business finance. *Recuperado de http://www3. weforum. org/docs/IP/2015/FS/GAC15_The_Future_of_FinTech_Paradigm_S hift_Small_Business_Finance_report_2015. pdf.*

Wang, J., Xu, C., Zhang, J., & Zhong, R. Y. (2022). Big data analytics for intelligent manufacturing systems: A review. *Journal of Manufacturing Systems*, *62*, 738–752. https://doi.org/10.1016/j.jmsy.2021.03.005

Xie, M. (2019). Development of artificial intelligence and effects on financial system. *Journal of Physics: Conference Series*, *1187*(3), 032084. https://doi.org/10.1088/1742-6596/1187/3/032084

Yathiraju, N., & Dash, B. (2023). Gamification Of E-Wallets With The Use Of Defi Technology- A Revisit To Digitization In Fintech. *International Journal of Engineering, Science*, *3*(1).

Yip, A. W., & Bocken, N. (2018). Sustainable business model archetypes for the banking industry. *Journal of Cleaner Production*, *174*, 150–169. https://doi.org/10.1016/j.jclepro.2017.10.190

Zetzsche, D. A., Tang, B., Buckley, R. P., & Arner, D. W. (2020). Artificial intelligence in finance: Putting the humans in the loop. *Social Science Research Network*. https://papers.ssrn.com/sol3/Delivery.cfm/SSRN_ID3560701_code1617212.pdf?abstractid=3531711&mirid=1

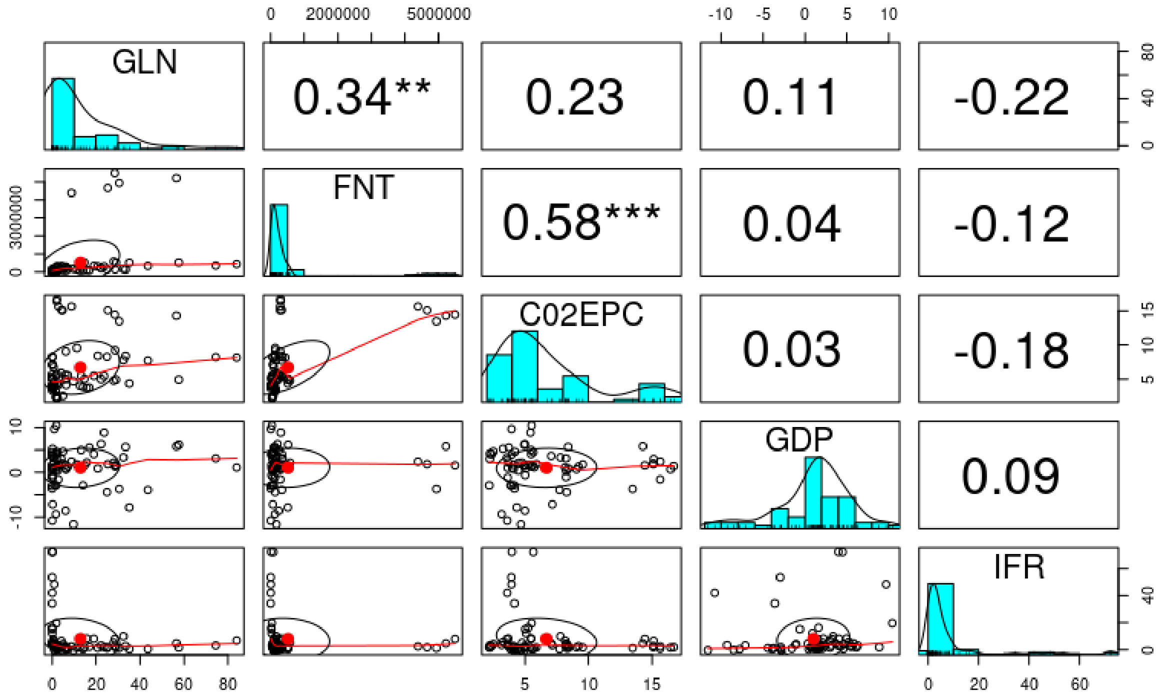
Zhang, R. (2023). 2008 Financial Crisis: Cause & Regulatory Response. *Highlights in Business, Economics and Management*, *13*, 252–257. https://doi.org/10.54097/hbem.v13i.8828

Zheng, G., & Siddik, A. B. (2022). The effect of Fintech adoption on green finance and environmental performance of banking institutions during the COVID-19 pandemic: the role of green innovation. *Environmental Science and Pollution Research International*, *30*(10), 25959–25971. https://doi.org/10.1007/s11356-022-23956-z

Zhu, B. (2021). The self-centered philanthropist: family involvement and corporate social responsibility in private enterprises. *the Journal of Chinese Sociology*, *8*(1). https://doi.org/10.1186/s40711-021-00157-8

APPENDICES

Appendix 1: Scatter Plot showing correlation between variables



Appendix 2: Results from the Pooliability test

```
F = 1.2135, df1 = 39, df2 = 14, p-value = 0.3601
alternative hypothesis: unstability
```

Appendix 3: Results from Pooled OLS Regression

```
Pooling Model

Call:
plm(formula = GLN ~ FNT + C02EPC + GDP + IFR, data = pdata, model = "pooling")

Balanced Panel: n = 14, T = 5, N = 70

Residuals:
    Min.  1st Qu.   Median  3rd Qu.     Max.
-23.4652 -10.4422  -6.3677   3.1752  70.9941

Coefficients:
                 Estimate    Std. Error t-value Pr(>|t|)
(Intercept) 11.6498562219  4.5730250784  2.5475  0.01322 *
FNT          0.0000044530  0.0000020015  2.2249  0.02957 *
C02EPC       0.0387292243  0.6383757450  0.0607  0.95181
GDP          0.4686233728  0.4684075860  1.0005  0.32080
IFR         -0.2247703073  0.1363124938 -1.6489  0.10399
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Total Sum of Squares:    22081
Residual Sum of Squares: 18479
R-Squared:      0.16313
Adj. R-Squared: 0.11163
F-statistic: 3.16753 on 4 and 65 DF, p-value: 0.019314
```

Appendix 4: Results from fixed effects regressions results

```
Oneway (individual) effect Within Model

Call:
plm(formula = GLN ~ FNT + C02EPC + GDP + IFR, data = pdata, model = "within")

Balanced Panel: n = 14, T = 5, N = 70

Residuals:
      Min.    1st Qu.     Median    3rd Qu.       Max.
-31.765200  -3.061501   0.011829   3.454047  34.581553

Coefficients:
          Estimate   Std. Error t-value Pr(>|t|)
FNT     0.000021763  0.000012635  1.7225  0.09093 .
C02EPC -8.551214952  3.278897732 -2.6080  0.01186 *
GDP     0.651591269  0.320256248  2.0346  0.04701 *
IFR     0.005604836  0.178895487  0.0313  0.97513
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Total Sum of Squares:    7568.5
Residual Sum of Squares: 5620.5
R-Squared:      0.25738
Adj. R-Squared: 0.014598
F-statistic: 4.50554 on 4 and 52 DF, p-value: 0.0033573
```

Appendix 5: Results from Random Effects regression

```
Call:
plm(formula = GLN ~ FNT + C02EPC + GDP + IFR, data = pdata, model = "random")

Balanced Panel: n = 14, T = 5, N = 70

Effects:
                 var std.dev share
idiosyncratic 108.09   10.40 0.331
individual    218.06   14.77 0.669
theta: 0.6997

Residuals:
    Min.  1st Qu.   Median  3rd Qu.     Max.
-26.6705  -5.1897  -1.8824   2.1956  48.0630

Coefficients:
                 Estimate    Std. Error z-value Pr(>|z|)
(Intercept) 18.9278108817  8.8026263634  2.1502  0.03154 *
FNT          0.0000095035  0.0000039423  2.4107  0.01592 *
C02EPC      -1.6509116681  1.2314941644 -1.3406  0.18006
GDP          0.5236670675  0.3230732186  1.6209  0.10504
IFR         -0.0558658546  0.1633899977 -0.3419  0.73241
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Total Sum of Squares:    8877.4
Residual Sum of Squares: 7868
R-Squared:      0.11371
Adj. R-Squared: 0.059168
Chisq: 8.33932 on 4 DF, p-value: 0.07991
```

Appendix 6: Results from the Durbin-wu-hausman test

```
        Hausman Test

data:  GLN ~ FNT + C02EPC + GDP + IFR
chisq = 12.491, df = 4, p-value = 0.01405
alternative hypothesis: one model is inconsistent
```

Appendix 7: Results from Levin-Lin-Chu Unit-Root Test

```
        Levin-Lin-Chu Unit-Root Test (ex. var.: Individual Intercepts)

data:  Fintechsb1
z = -3.2129, p-value = 0.000657
alternative hypothesis: stationarity
```

Appendix 8: Results from the Breusch-Pagan test

```
        studentized Breusch-Pagan test

data:  model1
BP = 1.3742, df = 4, p-value = 0.8487
```

Appendix 9: Inverse Correlation Matrix – VIF Test