Essays on Fintech Adoption, Cashless Payments, and Cashless Sales: Evidence from Saudi Arabia

Khaled Abdulrahman Saleh Alatram

Thesis Submitted to the University of Nottingham

for the Degree of Doctor of Philosophy

Acknowledgements

I would like to express my deepest gratitude to my supervisors, Dr. Ahmed Barakat and Prof. Meryem Duygun, for their support, insightful guidance, invaluable advice, and patience throughout this journey.

My sincere appreciation also extends to Prof. Khaled Hussainey, Dr. Erdinc Akyildirim, Dr. Aristeidis Dadoukis, and Dr. Maurizio Fiaschetti for their constructive feedback and suggestions. I am also grateful to Prof. Jane Frecknall-Hughes, and all stakeholders at the University of Nottingham.

A heartfelt thank you to my beloved parents, whose wisdom, love, and guidance have always been my compass. Your unwavering belief in me has given me the strength to reach this point. My heartfelt thanks also go to my brothers and sisters for their constant encouragement and support.

To my dear wife, your constant support, encouragement, and patience have been my foundation throughout this journey. I couldn't have achieved this without your understanding and love. I am also grateful to my dedicated and kind parents-in-law.

To my children, your joy and laughter have been my motivation and light, reminding me of the importance of perseverance and hope. Thank you for your patience and love, which have fuelled me during the toughest moments.

I would also like to extend my thanks to my relatives, friends, and colleagues for their constant encouragement and support.

Last but certainly not least, I gratefully acknowledge the financial support provided by Majmaah University, which made this research possible.

Abstract

Financial technology (Fintech) is reshaping global financial systems, offering opportunities for financial inclusion, economic growth, and cost reduction. Saudi Arabia presents a unique context for studying Fintech adoption due to its state-led financial transformation under Vision 2030. This thesis adopts an inductive (theory-building) approach to investigate the determinants of Fintech adoption, digital payment behaviours, and cashless transactions through three interconnected essays. The first essay examines the determinants of individual Fintech adoption, focusing on socio-demographic and financial factors. Using a survey of 1,666 respondents, the study finds that gender, age, employment status, and financial literacy significantly influence adoption. Younger, more educated individuals exhibit higher adoption rates, while financial well-being and inclusion emerge as key enablers of digital financial participation. The findings highlight the need for targeted financial literacy programs and consumer protection mechanisms. The second essay analyses digital payment behaviours using a dataset of 716 million transactions over 36 months. It differentiates between payment channels, including Chip-and-PIN, contactless, digital wallet, and E-commerce, revealing variations across demographic groups. Results show that females and expatriates conduct lower-value transactions, while unemployed individuals and younger users engage in higher-value digital payments. These findings challenge conventional assumptions and underscore the influence of demographic and socio-economic characteristics on financial behaviours. The third essay investigates macroeconomic and structural determinants of cashless sales and cash withdrawals using 30.42 billion cashless transactions and 28.30 billion cash withdrawals over 25 years. The study assesses the impact of the COVID-19 pandemic, geopolitical risks, temperature variations, and cultural events such as Ramadan. It finds that the pandemic negatively impacted cashless sales in Saudi Arabia, contrasting with global trends. Geopolitical risks had limited sectoral or urban impacts, while infrastructure, particularly international airports and seaports, significantly enhanced urban cashless transactions. This thesis advances understanding of Fintech adoption and cashless financial behaviours in Saudi Arabia, contributing to Financial Inclusion Theory, Behavioural Finance, and the Technology Acceptance Model (TAM). It provides transaction-level insights and informs regulatory strategies to promote financial inclusion, offering valuable lessons for policymakers and financial institutions in emerging economies.

Contents

List of Tables

List of Figures

Chapter 1

Introduction

1 Introduction

Financial technology (Fintech) has emerged as a transformative force in the global financial landscape, but nowhere is this more visible than in Saudi Arabia, a nation undergoing rapid transformation driven by its ambitious Vision 2030 initiative. While Fintech is recognised globally as a tool to enhance financial inclusion, cost reduction, and economic growth (Alhassan et al., 2021; Chen et al., 2020; Demir et al., 2022), Saudi Arabia presents a unique case study. The country's efforts to diversify its economy, reduce dependence on oil, and modernise its financial sector through Vision 2030 place it at the forefront of a Fintech revolution in the Middle East and North Africa (MENA). Unlike other emerging markets, Saudi Arabia's transition to a digital financial system is driven not only by economic imperatives but also by deep-rooted social, cultural, and political reforms, making its Fintech journey distinct (FSDP, 2022; SAMA, 2019).

The motivation for this research is both theoretical and practical, driven by the evolving role of Fintech in Saudi Arabia's financial and economic transformation. My interest in Fintech adoption and financial behaviour stems from a broader engagement with the intersection of finance, technology, and economic development. Observing the rapid changes in Saudi Arabia's financial ecosystem under Vision 2030 has further reinforced the significance of this research. Unlike other emerging economies where Fintech growth is primarily market-driven, Saudi Arabia's digital financial transformation is guided by a structured government strategy. This unique policy-driven model raises important questions about how state intervention, regulatory frameworks, and socio-cultural reforms shape the adoption of financial technologies, particularly in a high-income economy with developing and emerging market characteristics (FSDP, 2022).

This study adopts an inductive (theory-building) approach by investigating the determinants of Fintech adoption, digital payments, and cashless transactions in a rapidly evolving regulatory environment. Prior research on Fintech adoption has largely concentrated on macroeconomic, technological, and regulatory determinants (Kara et al., 2021; Danisman & Tarazi, 2020; Bhagat & Roderick, 2020; Yang & Zhang, 2022), while fewer studies provide a granular, individual-level analysis of socio-demographic and financial factors shaping adoption decisions in Saudi Arabia (Demir et al., 2022; Dogan et al., 2021). This research fills this gap by analysing Fintech adoption at three levels: individual Fintech adoption patterns (Chapter 2), digital payment behaviours and

transaction values (Chapter 3), and macroeconomic influences on cashless transactions (Chapter 4).

Saudi Arabia's institutional and demographic characteristics make it an ideal case for studying Fintech adoption. As a high-income country with emerging market traits, Saudi Arabia presents an atypical Fintech landscape, blending state-led financial transformation, regulatory modernization, and socio-cultural shifts (FSDP, 2022; SAMA, 2019). While other emerging economies have witnessed Fintech growth as a market-driven process, Saudi Arabia's development is distinct in its top-down policy approach. The country's young, technology-savvy population and high proportion of expatriates also create a unique environment where digital finance adoption patterns differ from those observed in other regions (FSDP, 2022; SAMA, 2019; stc pay, 2021). This distinction is crucial, as most studies on emerging markets examine Fintech adoption in the context of financial liberalization and technological innovation, whereas Saudi Arabia's Fintech evolution is fundamentally tied to economic and social reforms under Vision 2030.

Vision 2030 plays a pivotal role in shaping the adoption of Fintech in Saudi Arabia by establishing a structured regulatory framework, advancing digital infrastructure, and promoting financial inclusion. The Financial Sector Development Program (FSDP), introduced under Vision 2030, has been instrumental in modernizing the financial sector by encouraging digital payments, supporting Fintech startups, and increasing competition in the banking industry (FSDP, 2022). A key objective of the FSDP is to transition towards a cashless economy, leading to widespread adoption of mobile payments, blockchain applications, and AI-driven financial services. Additionally, Vision 2030 has prioritized investments in financial and technological infrastructure, enabling broader access to Fintech solutions (SAMA, 2019). Through the introduction of digital banking regulations and the licensing of financial technology firms such as stc pay, the Saudi government has actively supported the expansion of secure and regulated digital financial services (stc pay, 2021). These regulatory initiatives have increased trust in Fintech platforms while fostering a more inclusive financial ecosystem.

Economic diversification is another major driver of Fintech adoption. By reducing dependence on oil revenues, Vision 2030 has recognized Fintech as a strategic sector for economic growth, promoting entrepreneurship, foreign investment, and digital finance innovation (FSDP, 2022).

Unlike many emerging markets where Fintech evolves in response to market demand, Saudi Arabia's model demonstrates how state-led policies can accelerate Fintech adoption while maintaining financial stability. Furthermore, Vision 2030 has influenced consumer behaviour and institutional adoption of Fintech. Government-backed campaigns promoting cashless transactions, financial literacy programs, and mobile banking expansion have encouraged both individuals and businesses to embrace digital payments as the new norm. These insights extend beyond Saudi Arabia, providing valuable lessons for other developing economies that seek to balance regulatory intervention with financial modernization.

The historical development of Fintech can be divided into three distinct eras. The first, from 1866 to the 1960s, began with the establishment of the transatlantic cable, laying the groundwork for the convergence of finance and technology. The second era, from the 1960s to 2008, witnessed the creation of the 'Society for Worldwide Interbank Financial Telecommunication' (SWIFT), initially for cashless wholesale payments (large-value transactions between financial institutions like commercial and investment banks) and later expanding to cashless retail payments (smaller, more frequent transactions such as transfers, remittances, direct debits, and card payments). This period was also marked by innovations like debit and credit cards, ATMs, POS terminals, E-commerce, and online banking. The third and current era, from 2008 onwards, has seen Fintech evolve into a mature ecosystem offering services such as digital wallets, crypto-assets, and robo-advisors (Arner et al., 2016; Bech & Hancock, 2020; BIS, 2020; FSB, 2017; Goldstein et al., 2019; Kahn & Roberds, 2009; Lubis et al., 2019; Scott & Zachariadis, 2012).

Understanding this evolution is essential for appreciating Fintech's role in promoting financial inclusion and growth, particularly in developing and emerging economies like Saudi Arabia. Additionally, global studies have shown that the adoption of digital financial services is not uniform, with emerging markets often lagging behind in infrastructure and financial literacy, presenting both challenges and opportunities for rapid growth (Sahay et al., 2020).

This thesis is structured around three interconnected essays, each addressing a specific dimension of Fintech adoption and cashless transactions in Saudi Arabia. Chapter 2 examines the socio-demographic and financial determinants of individual Fintech adoption. Chapter 3 analyses digital payment behaviours, focusing on transaction values across different payment methods. Chapter 4

investigates the macroeconomic and structural factors influencing cashless transactions, considering external shocks such as COVID-19, geopolitical risks, and infrastructure development. By addressing these areas, this study contributes to both theoretical discourse and policy development, offering empirical insights that inform financial institutions, regulators, and policymakers on enhancing financial inclusion and digital financial services in Saudi Arabia.

Chapter 2 identifies several key gaps in the existing literature. The existing literature on FinTech adoption has primarily focused on macroeconomic, technological, and regulatory determinants, emphasizing infrastructure development, regulatory challenges, and digital transformation policies (Kara et al., 2021; Danisman & Tarazi, 2020; Alhassan et al., 2021; Bhagat & Roderick, 2020; Yang & Zhang, 2022). However, few studies provide a granular analysis of individual adoption patterns, particularly within the Saudi Arabian context. While prior research has extensively examined macro-level factors influencing FinTech adoption, little attention has been given to the interplay of individual-level socio-demographic and financial factors in shaping adoption decisions. This study addresses this gap by investigating how demographic characteristics—including gender, domiciliation, employment status, age, and education level—along with financial variables such as financial inclusion, financial literacy, financial well-being, financial service costs, and consumer protection, influence FinTech adoption in Saudi Arabia (Chen et al., 2020; Demir et al., 2022; Dogan et al., 2021).

The primary aim of Chapter 2 is to provide a comprehensive understanding of individual-level FinTech adoption by exploring how financial behaviours and socio-demographic factors influence digital financial participation. Unlike previous research that predominantly examines regulatory and macroeconomic determinants, this study adopts a micro-level approach to assess the financial and social characteristics that drive adoption patterns. Given Saudi Arabia's youthful population, high proportion of expatriates, and rapid digital transformation under Vision 2030, understanding these individual determinants is crucial for designing policies that promote inclusive financial participation (Demir et al., 2022; Panos & Wilson, 2020).

The findings of Chapter 2 reveal that socio-demographic and financial factors significantly shape FinTech adoption in Saudi Arabia. Gender, age, and employment status play a crucial role, with women and unemployed individuals being less likely to engage with FinTech services (Chen et

al., 2023; Kara et al., 2021). Conversely, younger and more educated individuals exhibit higher adoption rates, highlighting the importance of digital literacy and financial knowledge (Danisman & Tarazi, 2020; Alhassan et al., 2021). From a financial perspective, financial inclusion, financial literacy, and financial well-being emerge as strong enablers of adoption, reinforcing the necessity of accessible and cost-effective financial services (Demir et al., 2022; Panos & Wilson, 2020). Meanwhile, consumer protection concerns appear to have a limited direct influence on adoption decisions, as convenience and accessibility often outweigh regulatory considerations (Rösner et al., 2020; Fu & Mishra, 2022).

This Chapter 2 contributes to the existing literature in several ways. First, it extends prior studies by providing empirical insights into how socio-demographic and financial factors drive FinTech adoption, moving beyond the traditional macroeconomic focus (Chen et al., 2023; Kara et al., 2021). Second, it underscores the role of financial inclusion, financial literacy, and financial well-being as key drivers of digital financial participation, reinforcing the significance of individual financial behaviours (Meoli et al., 2022; Prete, 2022). Third, it advances discussions on digital financial inclusion by evaluating the impact of cost-related factors and consumer protection mechanisms on adoption decisions (Allen et al., 2022; Rösner et al., 2020; Fu & Mishra, 2022). These contributions offer valuable implications for policymakers, financial institutions, and regulators, providing evidence-based recommendations to enhance financial inclusion and support the expansion of digital financial services in Saudi Arabia (Sha'ban et al., 2020; Dogan et al., 2021).

While Chapter 2 focuses on the factors influencing FinTech adoption at the individual level, adoption alone does not fully capture financial behaviour. A deeper understanding of how individuals actually engage with digital financial services is needed. Chapter 3 builds on this perspective by shifting from adoption trends to examining transaction-level digital payment behaviours.

Chapter 3 identifies several key gaps in the existing literature. While prior research has examined digital payment adoption, it primarily focuses on factors influencing adoption rates rather than actual transaction behaviours (See-To & Ngai, 2019; Choudrie et al., 2018; Thaker et al., 2022). This limits the understanding of how digital payments are used in practice, particularly in terms of

transaction values across different payment methods. Existing studies often assume uniform engagement once digital payment methods are adopted, failing to account for variations in spending behaviour based on demographic and socio-economic characteristics (Cruijsen & Knoben, 2021). Another limitation is the narrow scope of payment methods analysed in previous studies, as most research generalizes digital payment adoption rather than differentiating between distinct payment channels such as Chip-and-PIN, Contactless, Digital Wallet, and E-commerce payments (Bounie & Camara, 2020). This generalization prevents a nuanced understanding of which demographic groups engage more actively with certain payment types and why transaction values differ across these methods. Furthermore, many studies rely on survey-based methodologies, which, while useful for capturing attitudes and perceptions, lack transaction-level empirical evidence (Chen et al., 2019). This methodological gap restricts the ability to assess actual financial engagement. In the context of Saudi Arabia, little empirical work has examined digital payment transaction values, despite the country's unique financial and regulatory landscape and its Vision 2030-driven financial inclusion initiatives.

In response to these gaps, Chapter 3 analyse how demographic factors—gender, domiciliation (citizens vs. foreigners), employment status, and age—affect digital payment transaction values. Unlike prior research, which predominantly focuses on technology acceptance and adoption trends (See-To & Ngai, 2019; Choudrie et al., 2018), this study investigates actual transaction behaviours across multiple payment methods. It differentiates between Chip-and-PIN, Contactless, Digital Wallet, and E-commerce transactions to provide a more granular understanding of financial engagement (Bounie & Camara, 2020). By utilizing transaction-level data rather than self-reported surveys, the study identifies patterns in digital payment behaviours and develops theoretical insights into how demographic and institutional factors shape cashless financial participation in Saudi Arabia (Cruijsen & Knoben, 2021). Additionally, the study incorporates control variables such as the COVID-19 stringency index, GPR index, temperature, Ramadan, inflation, and the stock market index to account for exogenous influences, ensuring a comprehensive analysis of the drivers behind financial inclusion (Chen et al., 2019; Thaker et al., 2022).

The findings of Chapter 3 reveal significant differences in transaction values across demographic groups. Females conduct lower-value transactions than Males in Chip-and-PIN and Contactless payments, supporting the Pain of Paying Theory (See-To & Ngai, 2019), which suggests that

Females experience greater financial caution when using payment methods perceived as less secure. However, no significant gender differences are observed in Digital Wallet and E-commerce transactions, challenging prior research that suggested Females favour Digital Wallets due to security concerns (Choudrie et al., 2018; Thaker et al., 2022). Foreigners conduct lower-value transactions than Citizens across Chip-and-PIN, Contactless, and Digital Wallet payments, with the largest differences observed in Contactless and Digital Wallet transactions. While previous studies have attributed expatriate financial behaviour to regulatory constraints (Kumar et al., 2021), this study suggests that cultural adaptation and social influence play a more significant role (Cruijsen & Knoben, 2021).

Interestingly, no significant differences are observed in E-commerce payments between Foreigners and Citizens, indicating that online purchases serve as a universal payment channel. Additionally, unemployed individuals conduct lower-value transactions in Chip-and-PIN payments, reflecting financial uncertainty (Bounie & Camara, 2020), yet they engage in relatively higher-value transactions through Digital Wallets and E-commerce payments, suggesting that these payment methods provide a more accessible financial alternative, supporting the findings of Chen et al. (2019). Older individuals (45-55+) prefer Chip-and-PIN payments for higher-value transactions, whereas younger individuals (15-24) exhibit higher transaction values in Contactless, Digital Wallet, and E-commerce payments, aligning with Convenience Theory (Brown et al., 2022; Li et al., 2023), which suggests that younger individuals prioritize speed and ease of use.

Chapter 3 makes several important contributions to the Fintech and financial inclusion literature. It extends Financial Inclusion Theory (Demir et al., 2022) by demonstrating that transaction values vary based on demographic factors, rather than assuming uniform engagement once digital payment methods are adopted. It advances Behavioural Finance Theories by linking the Pain of Paying Theory to gender differences in Contactless payments (See-To & Ngai, 2019) and Social Influence Theory to expatriate spending behaviours (Cruijsen & Knoben, 2021). Additionally, it builds upon the work of Manshad & Brannon (2021) in Behavioural Finance by further examining the role of demographic characteristics in shaping digital payment behaviours. Furthermore, by analysing transaction-level data instead of self-reported adoption surveys, the study provides a more objective measure of financial engagement. It also enhances the understanding of digital payments within Saudi Arabia's institutional context, particularly in relation to Vision 2030's

financial inclusion agenda (Thaker et al., 2022). By shifting the focus from adoption rates to actual transaction behaviours, the study challenges previous assumptions and contributes to the broader academic discourse on digital financial participation in emerging economies. These findings offer practical implications for policymakers and financial institutions, highlighting demographic disparities in transaction behaviours that could inform targeted financial literacy programs and regulatory adjustments aimed at fostering greater financial inclusion (Kumar et al., 2021).

Although Chapter 3 provides insight into how different demographic groups engage with digital payments, individual behaviours are influenced by broader macroeconomic and structural factors. To fully understand cashless financial participation, it is essential to examine how external shocks—such as the COVID-19 pandemic, geopolitical risks, and infrastructure development—shape financial transactions at a larger scale. Chapter 4 addresses these issues by investigating macro-level determinants of cashless sales and cash withdrawals across different economic and institutional settings.

Chapter 4 identifies several key gaps in the existing literature. The global transition toward cashless economies has been extensively studied in high-income countries, yet gaps remain in understanding how external shocks and structural factors influence financial behaviours in emerging economies like Saudi Arabia. While prior research has examined individual determinants of cashless transactions, there is a lack of comprehensive studies assessing the combined effects of multiple exogenous factors. These include the COVID-19 pandemic (Suder et al., 2024; Jonker et al., 2022), geopolitical risks (Arena & Julio, 2023; Liu & Zhang, 2024), temperature variations (Liang et al., 2024; Martínez-de-Albéniz & Belkaid, 2021; Bertrand & Parnaudeau, 2019; Keleş et al., 2018), and cultural influences such as Ramadan (Campante & Yanagizawa-Drott, 2015; Maung et al., 2020). While these factors have been examined independently, their simultaneous impact within the Saudi Arabian institutional and economic context remains underexplored. Furthermore, the role of infrastructure—including international airports, railway stations, sea ports, and distance from the capital city—in shaping urban cashless sales has not been adequately analyzed, despite evidence that improved connectivity fosters urban economic activity and financial inclusion (Wang et al., 2020; Sheard, 2019; Banerjee et al., 2020; Uchida et al., 2024).

Chapter 4 investigate the determinants of cashless sales and cash withdrawals at the country, sectoral, and urban levels in Saudi Arabia. It examines how exogenous factors—such as pandemics, geopolitical instability, climate variability, and religious observances—shape financial behaviours at POS terminals and ATMs. Additionally, it evaluates the role of infrastructural development in influencing urban cashless sales, offering novel insights into the spatial and economic dimensions of financial transactions.

The findings of Chapter 4 reveal several key patterns in cashless transaction behaviours. The COVID-19 pandemic had a statistically significant negative impact on cashless sales at the country, sectoral, and urban levels, diverging from global trends where digital payment adoption accelerated (Jonker et al., 2022; Kotkowski & Polasik, 2021). Unlike studies that document increased digital transactions, this analysis assesses payment behaviour before, during, and after the pandemic, showing that Saudi Arabia experienced a decline, potentially due to sectoral shutdowns and economic uncertainty affecting consumer confidence (Altig et al., 2020). Geopolitical risks influenced cashless sales and cash withdrawals at the country level, but their effect on sectoral and urban cashless transactions was statistically insignificant (Liu & Zhang, 2024; Arena & Julio, 2023), suggesting that macroeconomic uncertainty affects financial markets more directly than payment behaviours in Saudi Arabia, likely due to government intervention and financial stability measures. Temperature variations exhibited a nonlinear effect, with moderate increases stimulating cashless sales and withdrawals across all levels, while extreme temperatures led to reduced transaction volumes (Bertrand & Parnaudeau, 2019; Keleş et al., 2018; Liang et al., 2024). This pattern aligns with findings that extreme heat affects consumer mobility and retail activity, ultimately influencing cashless transaction volumes. Ramadan significantly impacted cash withdrawals and urban cashless sales, yet had no effect on cashless transactions at the country or sectoral levels when infrastructure-related factors were considered (Campante & Yanagizawa-Drott, 2015; Maung et al., 2020), indicating that while digital payments are increasing, cash remains essential for specific religious and cultural practices.

Infrastructure emerged as a significant determinant of urban cashless sales. Cities with international airports, railway stations, and sea ports exhibited higher cashless transaction volumes, reinforcing the relationship between transport connectivity and financial modernization (Wang et al., 2020; Sheard, 2019; Banerjee et al., 2020; Uchida et al., 2024). Conversely, greater

distance from the capital city was associated with lower cashless adoption, reflecting persistent financial inclusion disparities (Jedwab & Storeygard, 2022).

The Chapter 4 makes several theoretical and empirical contributions. It refines the theory of economic uncertainty by demonstrating that uncertainty does not uniformly drive digital payment adoption but is mediated by institutional settings and financial responses (Altig et al., 2020). Furthermore, it advances the theory of payment choice by highlighting that sectoral and geographic variations significantly shape financial behaviours (Jonker et al., 2022). The findings also reinforce the importance of infrastructure in financial modernization, demonstrating that transport connectivity plays a crucial role in urban cashless transactions (Wang et al., 2020; Sheard, 2019; Banerjee et al., 2020). Methodologically, the study employs Autoregressive Distributed Lag (ARDL) modelling, following established approaches (Mohamed & Saâdaoui, 2023; Kahouli, 2017; Shahzad et al., 2021; Damane, 2022; Swamy, 2022), to examine relationships between financial behaviours and macroeconomic factors, including inflation rate, stock market return, interest rate, GDP growth rate, and unemployment rate. Additionally, panel data analysis is used to investigate sectoral and urban effects.

By addressing these research gaps, this study contributes to a broader academic discourse on Fintech adoption, financial inclusion, and cashless transactions in emerging economies. It also offers valuable insights for other state-led financial modernization initiatives, demonstrating how strategic policies, demographic shifts, and technological advancements intersect to shape the future of digital finance. These findings reinforce Saudi Arabia's position as a leading model for Fintech-driven economic transformation, providing lessons that could inform financial policy frameworks in other developing economies.

The remaining chapters of the thesis are organised as follows: Chapter 2 discusses the Determinants of Individual Fintech Adoption, Chapter 3 examines the Determinants of Cashless Payments for Individuals, and Chapter 4 explores the Determinants of Cashless Sales at Country, Sectoral, and Urban Levels. The final chapter presents the conclusions of the thesis.

Chapter 2

Determinants of Individual Fintech Adoption

2 Determinants of Individual Fintech Adoption

Abstract

The rise of financial technology (Fintech) is transforming the global financial landscape, with significant implications for financial inclusion, particularly in emerging markets like Saudi Arabia. This study examines the key demographic, socio-economic, and financial factors driving individual Fintech adoption in Saudi Arabia, within the framework of the country's Vision 2030 initiative. Using data collected during the COVID-19 pandemic from an online survey of 1,666 respondents, the research analyses the influence of variables such as age, gender, domiciliation status, employment status, and education level, alongside financial inclusion, financial literacy, and financial well-being. The study employs a logit regression model, supplemented by robustness checks using Linear Probability Models (LPM) and Probit models, and controls for multicollinearity, heteroscedasticity, and model fit. The findings reveal that younger individuals, particularly those aged 25–44, are more likely to adopt Fintech services due to higher digital literacy and familiarity with technology, while individuals aged 45 and above are less likely to engage with these services. Females are also less likely to adopt Fintech services, indicating gender-based barriers to financial inclusion that need to be addressed. Furthermore, non-citizens (foreigners) are more likely to adopt Fintech services, especially when financial inclusion factors are considered. Unemployed individuals are less likely to engage with Fintech services, highlighting the role of financial stability in adoption. Lastly, education level is a significant driver, with higher education levels positively associated with Fintech engagement due to the greater financial literacy and technological skills of educated individuals. This research contributes to the growing body of literature on Fintech adoption in emerging markets, offering insights for policymakers and financial institutions aiming to bridge the digital divide. The findings provide actionable recommendations to reduce barriers to Fintech adoption, particularly for women, non-citizens, the unemployed, and older individuals, fostering broader financial inclusion in the digital age.

2.1 Introduction

In recent years, financial technology (FinTech) has transformed the global financial landscape, redefining how individuals and businesses access financial services. The rapid advancement of digital financial technologies has disrupted traditional banking models by introducing innovative financial products such as mobile payments, peer-to-peer lending, and digital wallets (Demir et al., 2022; Panos & Wilson, 2020). This shift has been particularly impactful in emerging economies, where FinTech enhances financial inclusion by addressing barriers such as high transaction costs, limited access to banking services, and information asymmetries (Chen et al., 2020; Demir et al., 2022; Dogan et al., 2021).

Despite the growing body of literature on FinTech adoption, few studies provide a granular analysis of individual adoption patterns, particularly in the context of Saudi Arabia's rapidly evolving financial landscape. Prior research has predominantly focused on macroeconomic, technological, and regulatory determinants (Kara et al., 2021; Danisman & Tarazi, 2020; Alhassan et al., 2021), emphasizing infrastructure development, regulatory challenges, and digital transformation policies (Bhagat & Roderick, 2020; Yang & Zhang, 2022). However, little attention has been given to the interplay of individual-level socio-demographic and financial factors in shaping FinTech adoption decisions. This study fills that gap by examining how demographic factors (gender, domiciliation, employment status, age, and education level) and financial variables (financial inclusion, financial literacy, financial well-being, financial service costs, and consumer protection) influence adoption behaviour in Saudi Arabia.

Unlike prior studies that emphasize macroeconomic and regulatory determinants, this study takes a micro-level approach, investigating individual financial behaviours and their impact on FinTech adoption. By focusing on individual adoption patterns, this research provides new insights into how financial literacy, financial well-being, and cost-related factors influence digital financial participation. Given Saudi Arabia's youthful population, high proportion of expatriates, and rapid digital transformation, understanding these individual factors is essential for developing targeted policies that promote inclusive financial participation under Vision 2030.

This study follows an inductive, theory-building approach, identifying emerging patterns in FinTech adoption rather than testing a predefined theoretical model. While Financial Inclusion Theory (Demir et al., 2022) serves as an analytical lens, the study also integrates risk perceptions, technological accessibility, and regulatory conditions as additional factors influencing digital financial engagement. By contextualizing FinTech adoption within Saudi Arabia's socio-economic and institutional setting, this research ensures that its findings contribute to the broader discourse on digital financial inclusion.

This research makes several contributions. First, it provides empirical insights into how socio-demographic and financial factors influence FinTech adoption, extending previous literature that has primarily focused on macro-level determinants (Chen et al., 2023; Kara et al., 2021). Second, it highlights the role of financial inclusion, financial literacy, and financial well-being as key drivers of digital financial participation, reinforcing the significance of individual financial behaviours in shaping adoption patterns (Meoli et al., 2022; Prete, 2022). Third, it advances discussions on digital financial inclusion by examining how cost-related factors and consumer protection mechanisms affect adoption decisions (Allen et al., 2022; Rösner et al., 2020; Fu & Mishra, 2022). These findings offer practical implications for policymakers, financial institutions, and regulators, providing evidence-based recommendations to support the expansion of digital financial services and enhance financial inclusion in Saudi Arabia (Sha'ban et al., 2020; Dogan et al., 2021).

The findings highlight several socio-demographic and financial determinants of FinTech adoption in Saudi Arabia. Gender, age, and employment status play a significant role, with women and unemployed individuals being less likely to engage with FinTech (Chen et al., 2023; Kara et al., 2021). Conversely, younger and more educated individuals demonstrate higher adoption rates, emphasizing the role of digital literacy and financial knowledge (Danisman & Tarazi, 2020; Alhassan et al., 2021). From a financial perspective, financial inclusion, financial literacy, and financial well-being emerge as strong enablers of adoption, reinforcing the importance of accessible and cost-effective financial services (Demir et al., 2022; Panos & Wilson, 2020). Meanwhile, consumer protection concerns appear to have a limited direct influence on adoption decisions, as convenience and accessibility often outweigh regulatory considerations (Rösner et al., 2020; Fu & Mishra, 2022).

To ensure robust and reliable findings, this study employs a logit regression model to analyse the determinants of FinTech adoption, complemented by robustness checks using Linear Probability Models (LPM) and Probit models. These methods are chosen for their suitability in analysing binary adoption decisions. Diagnostic tests, including multicollinearity, heteroscedasticity, and goodness-of-fit checks, are conducted to validate the results and confirm their reliability.

The remainder of this chapter is structured as follows. Section 2.2 provides a review of the literature and hypotheses development. Section 2.3 outlines the research methodology, statistical analysis, and empirical models. Section 2.4 presents the results and discussion, along with diagnostic tests and robustness checks. Finally, the chapter concludes with Section 2.5, which summarizes key findings and highlights limitations.

2.2 Conceptual Framework and Hypotheses Development

This section presents the conceptual framework that underpins the study of individual Fintech adoption, integrating Financial Inclusion Theory as a guiding perspective. Fintech plays a crucial role in expanding financial access by addressing market imperfections such as information asymmetries, transaction costs, and financial exclusion (Demir et al., 2022). This framework examines how demographic, socio-economic, and financial factors influence Fintech adoption, highlighting their interconnected role in shaping financial behaviour.

The analysis focuses on key influencing factors, including gender, domiciliation, employment status, age group, and education level, which collectively shape an individual's likelihood of adopting Fintech services. Additionally, financial-related factors such as financial inclusion, financial literacy, financial well-being, consumer protection, and financial service cost play a crucial role in determining adoption patterns. These factors interact with market structures, technological developments, and regulatory conditions, influencing how individuals engage with digital financial services.

By drawing on empirical research, this section systematically analyses the determinants of Fintech adoption and formulates hypotheses that reflect both theoretical insights and real-world dynamics. While Financial Inclusion Theory provides a foundational explanation, the framework also considers risk perceptions, technological accessibility, and regulatory environments as contributing factors. The inclusion of Saudi Arabia's institutional setting ensures that the analysis is contextually relevant, aligning with the country's financial landscape and ongoing digital transformation initiatives under Vision 2030.

2.2.1 Demographic and Socio-Economic Factors Influencing Fintech Adoption

2.2.1.1 Gender

The role of gender in Fintech adoption is complex and varies across different contexts. While some studies suggest gender-neutral access to financial services, others highlight persistent disparities in digital financial inclusion. Allen et al. (2016) found no significant gender association with bank account ownership on a global scale, suggesting that access to traditional financial services may

be relatively balanced between men and women. However, more recent research highlights a substantial gender gap in Fintech adoption.

Chen et al. (2023) examined Fintech usage across 28 countries and found that men were significantly more likely to engage with Fintech services than women. Similarly, Kara et al. (2021) observed that women in emerging economies face higher rejection rates and exclusion from formal credit markets, which may further discourage Fintech adoption. These findings suggest that while Fintech has the potential to enhance financial inclusion, it may inadvertently reinforce existing inequalities, particularly in societies where women already experience financial exclusion.

Conceptually, gender disparities in Fintech adoption can be attributed to differences in financial accessibility, technology exposure, and economic participation. Women in many regions face greater challenges in accessing credit, lower digital literacy rates, and socio-cultural barriers that limit their engagement with digital financial services. These structural barriers may further contribute to differences in Fintech adoption, particularly in economies where traditional financial exclusion persists.

H1: Males are more likely to adopt Fintech services compared to females, particularly in contexts where financial exclusion and technological barriers are more pronounced.

2.2.1.2 Domiciliation

The influence of domiciliation status on Fintech adoption is particularly relevant for immigrants and refugees, who often face significant barriers to accessing traditional financial services. While Fintech has the potential to enhance financial inclusion, the extent to which it mitigates these challenges remains subject to various structural and institutional factors.

Bhagat and Roderick (2020) highlighted that Fintech serves as a primary means of accessing credit for refugees in Kenya, demonstrating its role in financial inclusion for displaced populations. However, Kara et al. (2021) found that immigrants in emerging economies are more likely to be excluded from formal credit markets due to regulatory and institutional constraints. Similarly, Dobbie et al. (2021) reported significant biases against immigrant applicants in the UK, further reinforcing concerns regarding access to digital financial services. These findings suggest that

while Fintech can bridge financial access gaps, it does not eliminate the structural barriers faced by non-citizens in many economies.

Conceptually, the disparities in Fintech adoption based on domiciliation status can be attributed to differences in access to formal financial systems, documentation requirements, and trust in financial institutions. Immigrants and refugees often encounter challenges related to financial identity verification, regulatory restrictions, and lower levels of financial inclusion in their host countries. These factors may limit their engagement with Fintech services, particularly in environments where digital financial systems are closely linked to national identification frameworks.

Based on this evidence, the following hypothesis is proposed:

H2: Immigrants and refugees face greater barriers to Fintech adoption than citizens, influenced by factors such as access to formal financial systems, documentation requirements, and trust in financial institutions.

2.2.1.3 Employment Status

Employment status plays a crucial role in financial inclusion and Fintech adoption, as individuals with stable income sources are more likely to engage with digital financial services. While employment generally facilitates access to financial tools, variations exist based on economic conditions, financial literacy, and market structure.

Sha'ban et al. (2020) demonstrated a positive correlation between employment and financial inclusion across 95 countries, indicating that employed individuals are more likely to utilize financial services. Conversely, Danisman and Tarazi (2020) observed that unemployed individuals in the EU exhibited lower levels of bank account ownership and digital payments, reinforcing the association between employment stability and financial engagement. In the context of Fintech, Chen et al. (2020) found that participants in China's online financing market typically had moderate incomes and limited work experience, suggesting that access to Fintech services may depend not only on employment status but also on income levels and economic participation.

These findings suggest that employment provides financial stability, enhances financial literacy, and increases demand for digital financial tools, all of which contribute to higher Fintech adoption.

Conceptually, the relationship between employment status and Fintech adoption can be attributed to differences in financial stability, income regularity, and perceived financial needs. Employed individuals are more likely to have formal financial histories, which facilitates easier access to digital financial services. By contrast, unemployed individuals often face challenges related to creditworthiness, financial literacy, and reduced engagement with formal financial institutions, limiting their Fintech adoption.

Based on this evidence, the following hypothesis is proposed:

H3: Employed individuals are more likely to adopt Fintech services than unemployed individuals, driven by their greater financial stability, regular income, and need for diverse financial tools.

2.2.1.4 Age Group

Age is a critical determinant of Fintech adoption, influencing how individuals interact with financial technologies. Younger individuals tend to be more receptive to digital financial solutions, while older populations often face adoption barriers due to lower digital literacy and resistance to technological change.

Danisman and Tarazi (2020) found that younger individuals (15–24 years) exhibited lower rates of bank account ownership and digital payments in the EU, suggesting that while they are digitally engaged, they may have lower financial inclusion in traditional banking. In contrast, Chen et al. (2020) observed that participants in China's online financing market were predominantly young, indicating a strong preference for Fintech among younger demographics. Conversely, older individuals often encounter barriers in accessing Fintech services, as seen in the UK, where Dobbie et al. (2021) reported significant biases against older applicants from high-cost lenders, limiting their ability to engage with digital financial platforms. These findings highlight how age-related differences in digital literacy, technological exposure, and financial behaviours shape Fintech adoption patterns.

Conceptually, the relationship between age and Fintech adoption can be attributed to variations in digital literacy, technological familiarity, and risk perception. Younger individuals typically have greater exposure to digital environments and are more adaptable to financial innovations, increasing their likelihood of using Fintech services. By contrast, older individuals may exhibit lower adoption rates due to unfamiliarity with digital financial tools, concerns over security risks, and preferences for traditional banking channels.

Based on this evidence, the following hypothesis is proposed:

H4: Younger individuals (ages 15–24) are more likely to adopt Fintech services compared to older individuals, due to higher digital literacy and greater familiarity with technology-driven financial solutions.

2.2.1.5 Education Level

Education is a key factor in Fintech adoption, as individuals with higher education levels generally demonstrate greater financial inclusion and technological engagement. Higher education enhances financial literacy, improves digital skills, and fosters confidence in using digital financial services, making educated individuals more likely to adopt Fintech solutions.

Danisman and Tarazi (2020) found that individuals with lower education levels were less likely to own bank accounts or use digital payments in the EU, suggesting that limited financial literacy may contribute to lower engagement with financial services. Similarly, Alhassan et al. (2021) demonstrated that higher education levels are linked to increased financial inclusion in MENA and OIC countries, reinforcing the idea that education promotes financial engagement. However, Caglayan et al. (2020) reported that higher education levels could sometimes discourage individuals from seeking high-cost loans on peer-to-peer platforms in China, illustrating how financial knowledge can lead to more cautious financial behaviour. These findings highlight the dual role of education in Fintech adoption—while it generally enhances engagement with financial services, it may also lead to selective participation in certain financial products.

Conceptually, the relationship between education and Fintech adoption can be explained by differences in financial literacy, technological proficiency, and risk awareness. Individuals with

higher education levels typically have a stronger understanding of financial products and digital platforms, making them more comfortable adopting Fintech services. Conversely, those with lower education levels may lack the necessary skills to navigate digital financial systems or may distrust technology-driven financial solutions, limiting their adoption of Fintech services.

Based on these insights, the following hypothesis is proposed:

H5: Higher education levels are positively correlated with Fintech adoption, as more educated individuals are likely to possess the financial literacy and technological skills necessary to engage with digital financial services.

2.2.2 Financial-Related Factors Influencing Fintech Adoption

2.2.2.1 Financial Inclusion

The relationship between financial inclusion and Fintech adoption is well-documented, with extensive research highlighting the role of digital financial services in expanding access to financial resources. Fintech has the potential to bridge financial gaps by providing alternative financial solutions to underserved populations, reducing barriers traditionally associated with banking, and enhancing financial participation.

Sha'ban et al. (2020) found a significant positive correlation between financial inclusion and internet usage across 95 countries, suggesting that digital connectivity plays a crucial role in improving access to financial services. Similarly, Demir et al. (2022) emphasized that Fintech contributes to reducing income inequality through increased financial inclusion, particularly in higher-income countries where digital financial services complement traditional banking. Additionally, Yang and Zhang (2022) demonstrated that higher Fintech adoption led to increased household consumption and reduced consumption inequality in China, reinforcing the argument that digital financial solutions improve economic participation. These findings collectively suggest that Fintech adoption is a key driver of financial inclusion by expanding access to financial services beyond traditional banking networks.

Conceptually, the link between Fintech adoption and financial inclusion can be explained through digital accessibility, reduced transaction costs, and alternative credit mechanisms. Fintech platforms enable individuals, particularly those in underserved regions, to engage with financial services that would otherwise be unavailable due to geographical, regulatory, or institutional constraints. By lowering entry barriers, streamlining financial transactions, and offering digital lending solutions, Fintech enhances financial inclusion and broadens economic opportunities for excluded populations.

Based on these findings, the following hypothesis is proposed:

H6: Fintech adoption significantly enhances financial inclusion, particularly among underserved populations, by providing easier access to financial services and reducing barriers traditionally associated with banking.

2.2.2.2 Financial Literacy

Financial literacy plays a crucial role in shaping individuals' engagement with Fintech services, as it enhances their ability to navigate digital financial products and make informed financial decisions. Higher financial literacy levels are generally associated with greater confidence in adopting and utilizing digital financial tools, reducing the perceived risks associated with Fintech services.

Meoli et al. (2022) found that higher financial literacy levels improved the survival profiles of security-based crowdfunding platforms, indicating that financially literate individuals are better equipped to assess risks and benefits in Fintech markets. Similarly, Prete (2022) demonstrated that both digital technology proficiency and financial literacy are significant predictors of digital payment usage across 25 OECD countries, reinforcing the argument that financial knowledge facilitates digital financial engagement. These findings highlight how financial literacy not only influences the adoption of Fintech services but also contributes to their effective and sustained use.

Conceptually, the relationship between financial literacy and Fintech adoption can be explained by differences in financial decision-making capabilities, risk assessment, and digital proficiency. Financially literate individuals are more likely to understand complex financial products, evaluate

potential risks, and leverage Fintech solutions effectively. By contrast, lower levels of financial literacy may contribute to scepticism, reluctance, or mismanagement of digital financial tools, limiting Fintech adoption.

Based on this evidence, the following hypothesis is proposed:

H7: Higher levels of financial literacy are positively associated with increased Fintech adoption, as financially literate individuals are better equipped to understand and utilize complex digital financial products.

2.2.2.3 Financial Well-Being

Financial well-being, as an individual's ability to effectively manage financial resources and maintain financial security, is closely linked to Fintech adoption. Fintech provides users with tools for budgeting, saving, and credit access, which can enhance financial well-being by improving financial decision-making and stability. However, the impact of Fintech adoption on financial well-being may vary depending on how these services are used.

Panos and Wilson (2020) emphasized the importance of financial knowledge acquired during early life in shaping financial well-being in adulthood and highlighted how Fintech could positively influence individuals' financial outcomes and overall quality of life. Their findings suggest that digital financial tools can empower individuals by increasing financial literacy and providing access to diverse financial resources. However, Schomburgk and Hoffmann (2023) observed that the use of certain Fintech services, such as buy-now-pay-later (BNPL) schemes, is associated with lower subjective evaluations of financial well-being, underscoring the risks of over-reliance on digital credit. These findings highlight that while Fintech can enhance financial well-being through improved financial management and access to credit, it may also contribute to financial stress if not used responsibly.

Conceptually, the relationship between Fintech adoption and financial well-being can be explained by differences in financial resource management, access to credit, and financial literacy. Individuals who effectively utilize Fintech services can experience improved financial planning, better credit accessibility, and increased financial security. However, those who engage with high-

risk Fintech products without adequate financial knowledge may face greater financial instability, leading to reduced financial well-being.

Based on these considerations, the following hypothesis is proposed:

H8: Fintech adoption is positively associated with improved financial well-being, as it provides individuals with tools and services that enhance financial management and access to credit.

2.2.2.4 Consumer Protection

Consumer protection is a critical factor in fostering trust and encouraging the adoption of Fintech services. Effective consumer protection mechanisms enhance user confidence by ensuring transparency, security, and regulatory compliance, which are essential for increasing trust in digital financial services.

Rösner et al. (2020) demonstrated that standardized consumer protection measures within the EU positively impact consumer trust and their willingness to make online purchases, suggesting that well-regulated digital financial environments encourage greater consumer participation. Similarly, Fu and Mishra (2022) highlighted the importance of robust consumer protection frameworks in the rapidly evolving Fintech space, emphasizing the need for ongoing efforts to safeguard consumers from fraud, data misuse, and financial risks. These findings suggest that clear and enforceable consumer protection regulations are fundamental to strengthening consumer trust, thereby increasing Fintech adoption.

Conceptually, the relationship between consumer protection and Fintech adoption can be explained by differences in perceived trust, risk mitigation, and regulatory transparency. Consumers are more likely to engage with Fintech services when they believe that their financial transactions are secure and their rights are protected. Conversely, concerns about weak regulatory oversight, fraud risks, or data security breaches may deter individuals from adopting digital financial services.

Based on these findings, the following hypothesis is proposed:

H9: Perceived strong consumer protection mechanisms increase the likelihood of Fintech adoption, as trust in the safety and reliability of digital financial services encourages greater usage.

2.2.2.5 Financial Service Cost

The cost of financial services is a significant factor influencing Fintech adoption, as affordability directly affects individuals' willingness to engage with digital financial solutions. Fintech has been recognized for reducing transaction costs, making financial services more accessible to historically excluded populations and economically constrained users.

Chen et al. (2020) argued that the rapid diffusion of digital technologies has created opportunities to deliver financial services at lower costs, benefiting marginalized groups such as women who face financial access barriers. Similarly, Allen et al. (2022) highlighted that Fintech solutions have successfully mitigated the high transaction costs prevalent in traditional financial systems, making financial transactions more affordable and efficient. These findings suggest that the affordability of Fintech services enhances financial inclusion by providing cost-effective alternatives to conventional banking systems, particularly for price-sensitive and underserved populations.

Conceptually, the relationship between financial service costs and Fintech adoption can be explained by differences in price sensitivity, accessibility, and financial inclusion. Consumers seeking affordable financial solutions are more likely to adopt Fintech services when they perceive lower fees, reduced transaction costs, and cost-effective digital payment options. Conversely, if Fintech services impose hidden fees, high-interest rates, or unpredictable pricing structures, adoption may be hindered, particularly among low-income users.

Based on this evidence, the following hypothesis is proposed:

H10: Lower perceived costs of Fintech services compared to traditional financial services positively influence Fintech adoption, particularly among price-sensitive and underserved populations.

2.3 Research Methodology

2.3.1 Data Description and Statistics

This study examines the determinants of individual Fintech adoption by analysing data collected through an online survey during the COVID-19 pandemic lockdown. The survey was available in both Arabic and English and was designed to capture a comprehensive range of demographic, socio-economic, and financial information from respondents. The online format allowed for rapid data collection, aligning with the methodological approach recommended during pandemic conditions, as noted by Danisman and Tarazi (2020).

A pilot study was conducted before the main survey to test the clarity of the questionnaire and identify any potential errors. Given the constraints of the COVID-19 pandemic, a remote approach was adopted to ensure continuity and broad participation despite physical restrictions. Initially, a virtual focus group was conducted, followed by expert interviews to gain insights into the Fintech environment in Saudi Arabia and indirectly inform the development of the survey. These interviews involved representatives from international organizations, regulatory managers overseeing Fintech, key Fintech stakeholders in Saudi Arabia, Fintech company owners, C-level executives of Fintech firms, and Fintech researchers. Their perspectives provided a deeper understanding of Fintech adoption trends, regulatory challenges, and consumer behaviour, which helped refine the survey structure and ensure its relevance. Following these discussions, the pilot survey was distributed online to over 400 participants to assess the clarity, accessibility, and effectiveness of the questionnaire.

Based on the pilot study findings, numerical questions in the financial literacy section were removed to ensure that responses did not require numeracy skills or the use of a calculator. This adjustment enhanced accessibility and ease of participation, particularly given the stress and cognitive burden imposed by the pandemic and the diverse age range of respondents (15 years and older). Simplifying the questionnaire ensured that all participants, regardless of their mathematical proficiency, could engage with the survey without difficulty, thereby improving response accuracy and reliability.

Additionally, the survey was initially distributed in Arabic, with an English-language version later added to accommodate a broader audience. Some binary questions were modified to Likert scale formats to allow for more nuanced responses, and additional clarifications were incorporated to improve response accuracy. These refinements ensured that the final survey was clear, comprehensible, and well-suited for remote administration during pandemic conditions.

The survey was distributed across various social media platforms, including WhatsApp, Twitter, Instagram, and Facebook, from April to May 2021. These platforms were selected for their widespread use in Saudi Arabia, ensuring broad reach across diverse demographic groups. This decision was supported by Sha'ban et al. (2020), who highlighted the significant correlation between digital platform usage and financial inclusion.

To ensure data quality and reliability, specific criteria were applied during the data cleaning process. Participants who completed the survey in less than five minutes were excluded from the analysis, resulting in a final sample size of 1,666 respondents. This threshold was established based on the estimated time required to read and thoughtfully respond to all survey items. Excluding rapid responses helps mitigate potential biases associated with inattentive or rushed answers, which could compromise the validity of the findings (DeSimone et al., 2015; Meade & Craig, 2012). Ensuring data reliability in survey-based research requires addressing issues such as measurement errors, response biases, and sample selectivity bias, which can distort empirical findings (Gujarati & Porter, 2009; Morgenstern, 1963). In this regard, widely recognized best practices in survey research advocate for the use of response validation techniques and exclusion criteria to enhance data integrity.

Given that this survey was conducted online during the COVID-19 pandemic, response bias was a potential concern, as participation patterns may have varied across demographic groups. Prior research highlights the risks of relying on potentially biased samples in economic studies (Gujarati & Porter, 2009; Morgenstern, 1963), particularly in online settings where selection effects may arise. To mitigate these concerns, measures such as broad participant recruitment, response validation techniques, and data screening criteria were implemented to improve the reliability of the findings (DeSimone et al., 2015; Meade & Craig, 2012).

The study adhered strictly to ethical guidelines, with approval obtained from the university's ethics board. Data security was maintained by storing all data within the university's secure system, in compliance with GDPR privacy policies, ensuring respondents' privacy and data protection. Participation in the survey was entirely voluntary, with no compensation or incentives offered, thereby reducing the risk of biased responses. Respondents' identities were anonymized to protect their privacy, with only demographic, socio-economic, and financial information being analysed.

The survey questions were inspired by and developed based on key insights from publications by the World Bank (WB), International Monetary Fund (IMF), Organisation for Economic Co-operation and Development (OECD), International Network on Financial Education (INFE), G20, and the Global Partnership for Financial Inclusion (GPFI). Additionally, they were developed using established literature, prior empirical studies, and theoretical insights from financial behaviour research.

The survey questions were designed through a structured process: key themes from international reports and academic studies were identified, validated questions were adapted where applicable, and new items were developed to reflect the Saudi Fintech landscape. Expert input was incorporated to refine clarity, and a pilot study was conducted to test the questionnaire for accuracy before final implementation.

Each variable was carefully selected to ensure that the survey comprehensively captures the determinants of individual Fintech adoption. The survey structure follows validated methodologies from previous studies, ensuring methodological rigor and comparability with existing research.

To ensure linguistic accuracy and conceptual equivalence, the survey was initially developed in English and translated into Arabic by the researcher. To further enhance translation validity, an independent bilingual reviewer provided additional feedback to refine the Arabic version. This process aimed to maintain the clarity, cultural appropriateness, and consistency of the questionnaire across both language versions, ensuring that the meaning of survey items remained unchanged for all respondents.

The primary dependent variable in this study is Fintech adoption, capturing whether respondents have an account with a Fintech provider. This variable is crucial for understanding the extent of

Fintech penetration among different population segments and is measured as a binary variable, where a value of 1 indicates that the respondent has an account with a Fintech provider, and a value of 0 indicates that they do not. This operationalization of Fintech adoption is supported by Chen et al. (2023), who emphasized the importance of such binary measures in capturing the digital divide in financial services.

Several demographic variables were included to explore their influence on Fintech adoption. Gender is measured as a binary variable, with 1 representing female respondents and 0 representing male respondents. This variable allows for the exploration of potential gender disparities in Fintech adoption, a significant issue highlighted by Kara et al. (2021) in their study of gender-based financial exclusion.

Domiciliation status indicates whether the respondent is a citizen or a foreigner, measured as a binary variable where 1 represents non-citizens (foreigners) and 0 represents citizens. The expatriate population plays a significant role in the economy, as noted by Bhagat and Roderick (2020), making this variable particularly relevant in the context of Saudi Arabia.

Regarding socio-economic variables, employment status is also a binary variable, with 1 indicating unemployment and 0 indicating employment (including retirees and business owners). This variable provides insight into how employment status might influence access to and use of Fintech services, consistent with the findings of Sha'ban et al. (2020).

Age group is categorized into five ordinal groups: 15-24 years, 25-34 years, 35-44 years, 45-54 years, and 55 years and above, reflecting different life stages and their associated financial behaviours, as supported by findings from Danisman and Tarazi (2020).

Education level is measured on a categorical scale, with values ranging from 1 (primary and secondary education) to 4 (postgraduate degree), allowing for the examination of how educational attainment impacts Fintech adoption, as discussed by Alhassan et al. (2021).

In addition, several financial variables were included in the analysis. Financial inclusion is measured by summing the presence of various financial inclusion indicators, including bank accounts, credit cards, bank loans, savings accounts, and investment accounts. A higher sum

indicates a higher level of financial inclusion, which is critical for understanding how Fintech services complement or substitute traditional financial services. This method concept is in line with recent studies by Dogan et al. (2021) and Koomson and Danquah (2021).

Financial literacy is assessed through a categorical variable that measures respondents' knowledge of three fundamental financial concepts: inflation, risk-return, and diversification. This variable ranges from 0 (no knowledge) to 3 (knowledge of all three concepts), providing a nuanced view of respondents' financial acumen, aligned with the work of Meoli et al. (2022) on financial literacy and digital financial services.

Financial well-being is measured on a binary scale, where 1 indicates that the respondent sets and actively strives for long-term financial goals, and 0 indicates that they do not. This variable is essential for linking financial behaviours with long-term financial security and planning. Philippas and Avdoulas (2020) used a similar measure to assess financial well-being, and Collins and Urban (2020) propose that financial well-being is a valuable construct that should be incorporated into new surveys to enhance comprehension of the determinants of individual Fintech adoption.

Consumer protection is measured based on respondents' perceptions of consumer protection within the financial sector, categorized into four levels from 0 (lack of protection) to 3 (high level of perceived protection). This variable reflects the respondents' confidence in the safety and fairness of financial services, which is likely to influence their willingness to adopt Fintech, as emphasized by Rösner et al. (2020).

Finally, the financial service cost variable assesses respondents' perceptions of the cost of financial services, measured as a binary variable where 1 indicates that the respondent perceives the cost to be high, and 0 indicates otherwise. Understanding perceptions of cost is crucial for identifying barriers to Fintech adoption, particularly among price-sensitive populations, as discussed by Allen et al. (2022).

The variables included in this study were carefully selected based on their relevance to the research questions and their representation in the literature. This approach ensures that the survey is grounded in empirical evidence, methodologically sound, and capable of capturing the multidimensional aspects of Fintech adoption. The inclusion of validated measures and theoretical

considerations strengthens the reliability and validity of the survey instrument, enhancing the study's contribution to the literature on digital financial behaviour.

The detailed definitions and descriptions of these variables are provided in Table 1, ensuring clarity and consistency in the analysis. The comprehensive nature of the data allows for a robust exploration of the factors influencing Fintech adoption in Saudi Arabia, contributing to the broader understanding of financial inclusion in emerging markets.

Table 1: Definitions and Descriptions of Individual Fintech Adoption

	Definitions and Descriptions
Fintech Adoption	This variable captures whether respondents have an account with a financial technology (Fintech) provider. It is measured as a binary variable, taking a value of 1 if the respondent has an account with a Fintech provider, and 0 if the respondent does not
Female	This variable represents the gender of the respondents. It is measured as a binary variable, taking a value of 1 if the respondent is female, and 0 if the respondent is male
Foreigner	This variable indicates whether the respondent is a citizen or not. It is measured as a binary variable, taking a value of 1 if the respondent is not a citizen (i.e., a foreigner or resident), and 0 if the respondent is a citizen
Unemployed	This variable indicates the employment status of the respondent. It is measured as a binary variable, taking a value of 1 if the respondent is unemployed, retired, and does not own a business, while a value of 0 indicates that the respondent is either employed, retired, or a business owner
Age Group	This variable categorizes respondents into 5 age groups. 15-24 years, 25-34 years, 35-44 years, 45-54 years, and 55+ years
Education Level	This variable indicates the highest level of education attained by the respondent. It is measured on a categorical scale, where higher values indicate higher levels of education: 1 for primary and secondary education, 2 for a diploma, 3 for an undergraduate degree, and 4 for a postgraduate degree
Financial Inclusion	Financial Inclusion represents the level of financial inclusion of respondents. It is calculated by summing the presence of various financial inclusion indicators, including bank accounts, credit cards, bank loans, savings accounts, and investment accounts. A higher value indicates a higher level of financial inclusion
Financial Literacy	This variable measures the level of financial knowledge possessed by the respondent. It is categorized into discrete values ranging from 0 to 3, where 0 indicates no knowledge of inflation, risk-return, and diversification; 1 indicates knowledge of one concept; 2 indicates knowledge of two concepts; and 3 indicates knowledge of all three concepts
Financial Well-Being	This variable measures the extent to which the respondent sets long-term financial goals and makes efforts to achieve them. It is measured on a binary scale, with a value of 1 indicating that the respondent sets long-term financial goals and actively strives to achieve them, and 0 indicating otherwise
Consumer Protection	This variable measures the perceived level of consumer protection experienced by the respondent within the financial sector. It is measured on a categorical scale with values ranging from 0 to 3: 0 indicates a lack of perceived protection, 1 indicates a low level, 2 indicates a moderate level, and 3 indicates a high level of perceived protection
Financial Service Cost	This variable measures the respondent's perception of the cost of financial services. It is measured as a binary variable, with a value of 1 indicating that the respondent perceives the cost of financial services to be high, and 0 indicating otherwise

Table 2 presents a summary of the descriptive statistics for each variable in the study. The sample consists of 1,666 respondents, with a nearly equal distribution between Fintech adopters (49.04%) and non-adopters (50.96%).

Regarding gender, 40.04% of respondents were female, while 59.96% were male. In terms of domiciliation status, 9.06% were non-citizens who spoke Arabic or English, whereas 90.94% were citizens. For employment status, 24.97% of respondents were unemployed, while 75.03% were employed, retired, or business owners.

Age distribution showed that the largest group of respondents fell within the 35–44-year age range (30.43%), followed by those aged 25–34 years (28.27%). Respondents aged 15–24 years comprised 18.43%, while 16.39% were between 45 and 54 years old, and 6.48% were 55 years and older.

In terms of education level, 22.51% had completed primary or secondary education, 13.33% held a diploma, 50.18% had an undergraduate degree, and 13.99% held a postgraduate degree.

Financial inclusion levels also showed diversity, with 5.34% of respondents being unbanked. Additionally, 22.15% had at least one financial service, 21.01% had two, 28.75% had three, 16.03% had four, and 6.72% had all five financial services included in the index.

Financial literacy was assessed across three key concepts inflation, risk-return, and diversification with 10.74% of respondents answering all questions incorrectly. In contrast, 31.69% had knowledge of one concept, 54.26% were knowledgeable in two concepts, and 3.30% demonstrated knowledge of all three.

In terms of financial well-being, 60.20% of respondents reported setting and striving for long-term financial goals, while 39.80% did not. The perception of consumer protection varied among respondents, with 35.71% feeling a lack of protection, 25.99% perceiving a low level, 22.57% perceiving a moderate level, and 15.73% perceiving a high level of consumer protection. Lastly, 42.74% of respondents perceived the cost of financial services as high, while 57.26% did not.

Table 2: Descriptive Statistics of Individual Fintech Adoption

	Mean	S.D	C.V	Min	Max	Frequency	Percentage
Fintech Adoption	0.490	0.500	1.020	0	1	1,666	100.00
Yes						817	49.04
No						849	50.96
Female	0.400	0.490	1.225	0	1		
Yes						667	40.04
No						999	59.96
Non-Citizen Speaks Arabic or English	0.091	0.287	3.154	0	1		
Yes						151	9.06
No						1,515	90.94
Unemployed	0.250	0.433	1.732	0	1		
Yes						416	24.97
No						1,250	75.03
Age Group	2.642	1.147	0.434	1	5		
15 – 24 years						307	18.43
25 – 34 years						471	28.27
35 – 44 years						507	30.43
45 – 54 years						273	16.39
55 years and above						108	6.48
Education level	2.556	0.989	0.387	1	4		
Primary/Secondary School						375	22.51
Diploma						222	13.33
Undergraduate						836	50.18
Postgraduate						233	13.99
Financial Inclusion Index	2.481	1.318	0.531	0	5		
Unbanked						89	5.34
Have at least one financial service						369	22.15
Have two financial services						350	21.01
Have three financial services						479	28.75
Have four financial services						267	16.03
Have five financial services						112	6.72
Financial Literacy	1.501	0.729	0.486	0	3		
Incorrect answers						179	10.74
One correct answer						528	31.69
Two correct answers						904	54.26
Three correct answers						55	3.30
Financial Well-Being	0.602	0.490	0.814	0	1		
Yes						1,003	60.20
No						663	39.80
Consumer Protection	1.183	1.086	0.918	0	3		
Lack of consumer protection						595	35.71
Low level of perceived consumer protection						433	25.99
Moderate level of perceived consumer protection						376	22.57
High level of perceived consumer protection						262	15.73
Financial Service Cost - High	0.427	0.495	1.159	0	1		
Yes						712	42.74
No						954	57.26

2.3.2 Empirical Model

Model 1

$$P(Fintech_i = 1) = \Lambda(\beta_o + \beta_1 Female_i + \beta_2 Foreign_i + \beta_3 Unemployed_i + \beta_4\ Age\ Group_i + \beta_5 Education_i)$$

Model 2

$$P(Fintech_i = 1) = \Lambda(\beta_o + \beta_1 Female_i + \beta_2 Foreign_i + \beta_3 Unemployed_i + \beta_4\ Age\ Group_i + \beta_5 Education_i + \beta_6 Financial\ Inclusion_i + \beta_7\ Fiancial\ Literacy_i + \beta_8 Financial\ Wellbeing_i + \beta_9 Consumer\ Protection_i + \beta_{10} Financial\ Cost_i)$$

Where $\Lambda(x) = \frac{\exp(x)}{1+\exp(x)}$ is the logistic function, and i represents for individual

2.3.3 Correlation and Relationship Analysis

Table 3 presents the Pearson correlation coefficients between the dependent variable, Fintech Adoption, and various explanatory variables.

The Female variable is negatively and significantly correlated with Fintech Adoption ($r = -0.16$, $p < 0.01$), indicating that females are less likely to adopt Fintech services. The Foreigner variable shows a weak positive but non-significant correlation with Fintech Adoption ($r = 0.025$), suggesting that foreign status does not have a meaningful impact on Fintech adoption in this sample. The Unemployed variable is negatively correlated with Fintech Adoption ($r = -0.21$, $p < 0.01$), indicating that unemployed individuals are less likely to adopt Fintech services.

The Age Group variable exhibits a weak but positive correlation with Fintech Adoption ($r = 0.04$, $p < 0.1$), suggesting that older individuals may have a slightly higher likelihood of adopting Fintech services.

In contrast, Education Level is positively and significantly correlated with Fintech Adoption ($r = 0.18$, $p < 0.01$), implying that higher education levels increase the probability of adopting Fintech services.

Financial inclusion exhibits the strongest positive correlation with Fintech adoption ($r = 0.31$, $p < 0.01$), indicating that individuals who are more financially included are more likely to adopt Fintech services. Financial literacy also shows a positive correlation with Fintech adoption ($r = 0.18$, $p < 0.01$), as does financial well-being ($r = 0.13$, $p < 0.01$), both suggesting that higher financial literacy and well-being are associated with a greater likelihood of adopting Fintech services.

Consumer protection does not show a significant correlation with Fintech adoption ($r = 0.00$), indicating that perceptions of consumer protection do not directly influence Fintech adoption in this sample. Finally, the perceived cost of financial services is positively correlated with Fintech adoption ($r = 0.11$, $p < 0.01$), suggesting that those who perceive higher costs are slightly more likely to adopt Fintech services.

Overall, the correlation matrix highlights several significant relationships, particularly the strong positive associations of Financial Inclusion, Education Level, and Financial Literacy with Fintech adoption, while also noting the negative relationships with variables such as female and unemployment.

Table 3: Correlation Matrix of Individual Fintech Adoption

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
(1) Fintech Adoption	1										
(2) Female	-0.16***	1									
(3) Foreigner	0.03	-0.01	1								
(4) Unemployed	-0.21***	-0.30***	0.30	1							
(5) Age Group	0.04*	-0.22***	-0.09***	-0.47***	1						
(6) Education Level	0.18***	-0.05**	-0.10***	-0.29***	0.25***	1					
(7) Financial Inclusion	0.31***	-0.21***	-0.27***	-0.53***	0.37***	0.36***	1				
(8) Financial Literacy	0.18***	-0.28***	-0.07***	-0.14***	0.09***	0.20***	0.19***	1			
(9) Financial Well-Being	0.13***	-0.10***	0.06**	-0.07***	0.04	0.13***	0.12***	0.11***	1		
(10) Consumer Protection	0.003	0.29***	0.12***	0.004	-0.12***	-0.04**	-0.03	-0.04	-0.002	1	
(11) Financial Cost	0.11***	-0.26***	-0.09***	-0.11***	0.14***	0.03	0.10***	0.16***	0.06***	-0.32***	1

**** p<0.01, ** p<0.05, * p<0.1*

2.4 Empirical Results

2.4.1 Results and Discussion

The empirical analysis examines the key determinants of individual Fintech adoption using two logit models, as shown in Table 4. Both models consider various demographic, socio-economic, and financial factors, providing insights into the drivers of Fintech adoption among individuals. The results are interpreted in relation to the hypotheses formulated in Section 2.2.

Table 4: Regression Results of Individual Fintech Adoption

	Model 1 Logit	Model 2 Logit
Female	-0.547***	-0.349***
	(0.112)	(0.128)
Foreigner	0.224	0.766***
	(0.180)	(0.205)
Unemployed	-0.712***	-0.185
	(0.149)	(0.164)
Age Group (25-34) years	0.365**	0.216
	(0.182)	(0.190)
Age Group (35-44) years	0.255	-0.051
	(0.187)	(0.195)
Age Group (45-54) years	-0.269	-0.552**
	(0.209)	(0.218)
Age Group (55+) years	-0.604**	-0.860***
	(0.259)	(0.273)
Education Level	0.275***	0.143**
	(0.059)	(0.062)
Financial Inclusion		0.471***
		(0.054)
Financial Literacy		0.282***
		(0.081)
Financial Well-being		0.258**
		(0.111)
Consumer Protection		0.087
		(0.054)
Financial Cost		0.343***
		(0.119)
Constant	-0.476**	-2.186***
	(0.203)	(0.279)
Correctly classified	62.42%	66.39%

Obs. 1,666
Male, Citizen, Employed and Age Group (15-24), are the reference categories for Gender, Domiciliation, Employment Status and Age Group, respectively
*Significant: *<0.1, **<0.05, ***<0.01*
Unstandardised coefficients
Robust standard errors in parentheses

2.4.1.1 Gender

The regression results show a significant and negative association between being female and Fintech adoption in both Model 1 and Model 2, indicating that women are less likely to adopt Fintech services compared to men. This aligns with the hypothesis that men are more likely to engage with Fintech, especially in environments where women face financial exclusion or technological barriers (Chen et al., 2023; Kara et al., 2021).

These findings confirm the gender gap in digital financial inclusion. Chen et al. (2023) found similar trends across 28 countries, and Kara et al. (2021) highlighted that women in emerging markets often face rejection and exclusion from formal credit markets, contributing to lower engagement with digital financial services. Unlike traditional banking, which has fewer gender disparities, Fintech presents distinct challenges for women, including lower digital literacy and socio-cultural constraints.

From a theoretical perspective, these results align with Financial Inclusion Theory, which argues that Fintech reduces financial exclusion by addressing barriers such as high transaction costs and limited access to services (Demir et al., 2022). However, socio-economic disparities persist, with women facing unique challenges in adopting Fintech, reflecting pre-existing financial inequalities.

In Saudi Arabia, these results are significant within the context of Vision 2030, which aims to promote financial inclusion and digital transformation. Despite regulatory efforts, women still face barriers such as lower employment rates and cultural influences on financial behaviour. To address these disparities, targeted policies, including financial literacy programs, improved digital access, and alternative credit models, are needed.

This study provides novel insights into how gender disparities in Fintech adoption are shaped by both global trends and Saudi-specific institutional factors. While Chen et al. (2023) and Kara et al. (2021) highlight the gender gap in Fintech, this study underscores the role of national policies and cultural norms in shaping these behaviours. Unlike traditional banking, Fintech presents evolving challenges for women, as it intersects with broader socio-economic and cultural barriers.

In summary, while Fintech has the potential to enhance financial inclusion, gendered barriers remain, particularly in contexts with deep socio-economic disparities. These findings emphasize the need for inclusive policies that bridge the gender gap in Fintech adoption (Chen et al., 2023; Kara et al., 2021).

2.4.1.2 Domiciliation Status

The regression results show a significant positive association between being a foreigner (immigrant or refugee) and Fintech adoption in Model 2, indicating that immigrants are more likely to adopt Fintech compared to citizens. This challenges the hypothesis that immigrants face greater barriers to Fintech adoption, as they may turn to Fintech as an alternative to traditional financial services, which are often inaccessible due to documentation requirements. The effect in Model 1, however, is not significant, suggesting that other factors in Model 2 clarify the relationship.

These results align with Bhagat and Roderick (2020), who highlighted Fintech's role in providing financial access to marginalized groups like refugees, and Kara et al. (2021), who noted that immigrants in emerging economies face exclusion from formal credit markets. The positive relationship in Model 2 suggests that Fintech helps overcome barriers to financial inclusion for non-citizens. This is consistent with Dobbie et al. (2021), who documented biases against immigrant applicants in the UK’s formal financial sector, implying Fintech could serve as an alternative means of accessing financial services.

From a theoretical perspective, these findings align with Financial Inclusion Theory, which argues that Fintech can reduce financial exclusion by addressing barriers like high transaction costs and limited access to services (Demir et al., 2022). The results support the idea that Fintech provides an alternative pathway for financial inclusion, particularly for immigrants and refugees.

In Saudi Arabia, these results are significant within the context of Vision 2030, which seeks to enhance financial inclusion. Despite efforts to expand digital financial services, immigrants and refugees face challenges in accessing traditional financial services, suggesting that Fintech adoption could play a crucial role in promoting financial inclusion for non-citizens.

This study provides novel insights into how domiciliation status influences Fintech adoption, particularly in Saudi Arabia. While global studies have documented challenges faced by immigrants in accessing formal financial services, this study highlights how Fintech can bridge these gaps, helping non-citizens overcome unique barriers (Bhagat & Roderick, 2020; Dobbie et al., 2021; Kara et al., 2021).

In summary, the study challenges the assumption that immigrants face greater barriers to Fintech adoption and suggests that Fintech may offer an alternative path to financial inclusion. The findings underscore the importance of creating policies that enhance access to Fintech services for non-citizens, ensuring inclusivity in digital financial services (Bhagat & Roderick, 2020; Dobbie et al., 2021).

2.4.1.3 Employment Status

The regression results show a significant negative relationship between being unemployed and Fintech adoption in Model 1, indicating that unemployed individuals are less likely to adopt Fintech compared to employed individuals. However, in Model 2, this relationship becomes insignificant, suggesting that other factors, like financial literacy or inclusion, moderate the effect.

This finding aligns with the hypothesis that employed individuals are more likely to adopt Fintech due to their financial stability and regular income, as shown by Sha'ban et al. (2020). Similarly, Danisman and Tarazi (2020) observed that unemployed individuals in the EU were less likely to engage with digital payments, and Chen et al. (2020) found that those with moderate incomes in China were less likely to adopt Fintech, reinforcing the importance of financial stability.

From a theoretical perspective, these results support Financial Inclusion Theory, which suggests that employment enhances access to financial services by providing income stability and financial credibility (Demir et al., 2022). Unemployed individuals may face challenges like lower creditworthiness and limited engagement with financial systems, hindering their Fintech adoption.

In Saudi Arabia, these results suggest that employment status influences Fintech adoption, particularly as the country works toward digital financial inclusion under Vision 2030.

Unemployed individuals may need additional support, such as financial literacy programs, to improve access to digital services.

These findings contribute novel insights by emphasizing the role of employment status in shaping Fintech adoption patterns, particularly for unemployed populations in emerging economies like Saudi Arabia. Sha'ban et al. (2020) and Danisman & Tarazi (2020) highlight how financial stability is key to engagement with financial services, and this study extends their work by focusing on how income regularity specifically affects Fintech adoption in Saudi Arabia, a context underrepresented in the literature.

In summary, while employed individuals are more likely to adopt Fintech, the findings suggest that unemployment limits engagement, underscoring the need for policies that address barriers for unemployed individuals and ensure equitable access to digital financial services (Sha'ban et al., 2020; Danisman & Tarazi, 2020).

2.4.1.4 Age Group

The regression results show that younger individuals, especially those in the 15–24 years reference category, are more likely to adopt Fintech services. This aligns with Danisman and Tarazi (2020) and Chen et al. (2020), who found that younger populations in the EU and China are more open to digital financial services due to higher digital literacy and technological comfort.

The 25–34 years group also shows a positive relationship with Fintech adoption in Model 1, but the effect diminishes in Model 2, suggesting that other factors may moderate this relationship. Older age groups (45–54 years and 55+ years) are significantly less likely to adopt Fintech, supporting findings by Dobbie et al. (2021), who noted barriers for older individuals, such as biases and lower digital literacy.

The results align with Financial Inclusion Theory, which suggests that younger individuals are more adaptable to technology and can benefit more from Fintech, which reduces traditional financial barriers (Demir et al., 2022). However, older individuals face challenges like lower digital literacy, limiting their engagement with Fintech.

In Saudi Arabia, these results are particularly relevant in light of Vision 2030, which aims to enhance financial inclusion. While younger populations are more receptive to Fintech, older age groups may require targeted interventions to improve digital literacy.

This study contributes novel insights by highlighting the unique challenges older populations face in adopting Fintech, extending the literature by emphasizing the need for inclusive policies targeting all age groups (Danisman & Tarazi, 2020; Chen et al., 2020).

In summary, younger individuals are more likely to adopt Fintech due to their digital literacy, while older populations face greater barriers. These findings stress the need for policies that address the digital literacy gap to ensure equitable access to Fintech services (Danisman & Tarazi, 2020; Chen et al., 2020).

2.4.1.5 Education Level

The regression results show a significant positive relationship between education level and Fintech adoption in both models. In Model 1, the coefficient for education is highly significant, suggesting that individuals with higher education levels are more likely to adopt Fintech services. This remains significant in Model 2, though slightly reduced, indicating that education remains a key determinant even when controlling for other factors.

These results support the hypothesis that higher education is positively correlated with Fintech adoption, as more educated individuals possess the financial literacy and technological skills needed to engage with digital services (Alhassan et al., 2021; Danisman & Tarazi, 2020). Alhassan et al. (2021) found that higher education is linked to increased financial inclusion, aligning with the positive relationship observed in this study.

From a theoretical perspective, these findings align with Financial Inclusion Theory, which suggests that education enhances financial literacy, improving engagement with Fintech services (Demir et al., 2022). Educated individuals are better equipped to navigate digital tools and understand the risks and benefits of Fintech platforms.

Interestingly, while Caglayan et al. (2020) found that higher education levels in China could discourage seeking high-cost loans, this study shows a clear positive relationship between education and Fintech adoption, highlighting a novel insight: higher education encourages Fintech adoption by enhancing financial literacy and confidence (Alhassan et al., 2021).

This study offers novel insights by emphasizing the role of education in Fintech adoption, particularly in Saudi Arabia's context under Vision 2030. The findings suggest that improving education and financial literacy can significantly boost Fintech engagement, filling a gap in research specific to Saudi Arabia and emerging economies (Danisman & Tarazi, 2020).

In summary, the results confirm that individuals with higher education levels are more likely to adopt Fintech due to greater financial literacy and digital competency. These findings highlight the importance of policies to enhance financial literacy and support broader financial inclusion (Alhassan et al., 2021; Danisman & Tarazi, 2020).

2.4.1.6 Financial Inclusion

The regression results show a significant positive relationship between financial inclusion and Fintech adoption in Model 2, indicating that individuals with higher financial inclusion are more likely to adopt Fintech services. This supports the hypothesis that Fintech adoption enhances financial inclusion by providing easier access to financial services and reducing traditional banking barriers.

These results align with Sha'ban et al. (2020), who found a positive correlation between financial inclusion and internet usage, suggesting that access to digital tools is key to both financial inclusion and Fintech adoption. Similarly, Demir et al. (2022) showed that Fintech reduces income inequality by improving financial inclusion, particularly for underserved populations. Yang and Zhang (2022) also found that increased Fintech adoption in China led to reduced consumption inequality, further highlighting the broader economic benefits.

From a theoretical perspective, these findings support Financial Inclusion Theory, which posits that Fintech can reduce barriers like transaction costs and limited credit access, allowing underserved populations to engage with financial services (Demir et al., 2022).

In the context of Saudi Arabia, these results are relevant under Vision 2030, which seeks to promote financial inclusion and reduce reliance on traditional banking. The findings suggest that Fintech adoption can play a key role in advancing financial inclusion, especially for marginalized groups.

This study offers novel insights into how Fintech adoption can enhance financial inclusion, particularly in the context of Saudi Arabia's Vision 2030. Unlike previous studies, such as Demir et al. (2022) and Yang and Zhang (2022), which focused on broader global contexts, this study emphasizes the role of Fintech in improving access to financial services in emerging economies like Saudi Arabia. The findings show that Fintech not only broadens financial inclusion but also reduces income inequality by providing economic opportunities to underserved populations.

In summary, the study confirms that Fintech adoption significantly enhances financial inclusion, particularly among underserved populations, contributing to the literature by showing how Fintech can reduce financial barriers and promote economic equity (Demir et al., 2022; Yang & Zhang, 2022).

2.4.1.7 Financial Literacy

The regression results show a significant positive relationship between financial literacy and Fintech adoption in Model 2, indicating that individuals with higher levels of financial literacy are more likely to adopt Fintech services. This finding supports the hypothesis that financially literate individuals are better equipped to understand and utilize complex digital financial products, making them more inclined to engage with Fintech platforms.

These results align with Meoli et al. (2022), who demonstrated that higher levels of financial literacy improved engagement with financial services, particularly in crowdfunding platforms. Similarly, Prete (2022) emphasized that both digital technology proficiency and financial literacy are significant predictors of digital payment usage across 25 OECD countries, further reinforcing the role of financial literacy in Fintech adoption.

From a theoretical perspective, these findings align with Financial Inclusion Theory, which posits that financial literacy enhances engagement with financial services by improving individuals'

understanding of financial products and reducing barriers to digital financial services (Demir et al., 2022).

In the context of Saudi Arabia, these results are particularly relevant under Vision 2030, which aims to promote financial inclusion and reduce reliance on traditional banking. The findings suggest that improving financial literacy could significantly enhance Fintech adoption, especially among populations who may face challenges in engaging with digital financial platforms.

This study contributes novel insights by highlighting the critical role of financial literacy in Fintech adoption. While previous studies, such as Meoli et al. (2022) and Prete (2022), have underscored the importance of financial literacy in digital financial engagement, this study extends the literature by focusing on the specific relationship between financial literacy and Fintech adoption in the context of Saudi Arabia's Vision 2030. The findings suggest that improving financial literacy can play a pivotal role in advancing digital financial inclusion.

In summary, the results strongly support the hypothesis (H7) that financial literacy is positively associated with Fintech adoption, particularly among individuals with greater financial knowledge. These findings underscore the importance of enhancing financial literacy to facilitate broader Fintech engagement and financial inclusion (Meoli et al., 2022; Prete, 2022).

2.4.1.8 Financial Well-Being

The regression results show a significant positive relationship between financial well-being and Fintech adoption in Model 2, suggesting that individuals with higher financial well-being are more likely to adopt Fintech services. This finding supports the hypothesis that Fintech adoption is positively associated with improved financial well-being, as it provides individuals with tools for better financial management and access to credit.

These results align with Panos and Wilson (2020), who emphasized that early financial knowledge and Fintech services can improve individuals' financial outcomes and quality of life. Prete (2022) also highlighted that financial literacy and digital technology proficiency are significant predictors of Fintech usage across 25 OECD countries, reinforcing the role of financial literacy in promoting Fintech adoption.

However, Schomburgk and Hoffmann (2023) presented a contrasting perspective, noting that services like buy-now-pay-later (BNPL) schemes may negatively impact financial well-being if not managed responsibly. This highlights that not all Fintech services contribute positively to financial well-being, and their effects can vary depending on usage patterns.

From a theoretical perspective, these findings align with Financial Inclusion Theory, which suggests that access to digital financial services through Fintech can improve financial well-being by enabling better financial management, enhanced access to credit, and more informed decision-making (Demir et al., 2022). This theory supports the idea that while Fintech generally facilitates financial management and access to credit, users must approach these services with financial literacy and responsibility to avoid negative outcomes, such as increased debt or financial instability (Panos & Wilson, 2020).

In the context of Saudi Arabia, these results are particularly relevant as the country continues to promote financial inclusion under Vision 2030. While Fintech has the potential to enhance financial well-being, especially for underserved populations, efforts to improve financial literacy and ensure responsible usage are essential to maximizing the benefits of digital financial tools.

This study contributes novel insights by highlighting the complex relationship between Fintech adoption and financial well-being, particularly the importance of responsible usage. While Panos and Wilson (2020) and Schomburgk and Hoffmann (2023) discuss how Fintech can both enhance and harm financial well-being, this study emphasizes the need for financial literacy to ensure that users gain the benefits of Fintech without falling into financial stress.

In summary, the results support the hypothesis (H8) that Fintech adoption is positively associated with improved financial well-being, though responsible usage is essential. These findings contribute to the literature by demonstrating that while Fintech can enhance financial management and access to credit, its impact on financial well-being is contingent upon how services are used and the financial knowledge of the individuals adopting them (Panos & Wilson, 2020; Schomburgk & Hoffmann, 2023).

2.4.1.9 Consumer Protection

The regression results show a positive but statistically insignificant relationship between consumer protection and Fintech adoption in Model 2, suggesting that perceived consumer protection mechanisms do not play a decisive role in influencing Fintech adoption. This finding contrasts with the hypothesis that strong consumer protection frameworks enhance Fintech adoption by fostering trust in digital services.

Despite the lack of significance in this study, existing literature underscores the importance of consumer protection in promoting trust in Fintech. Rösner et al. (2020) demonstrated that standardized consumer protection measures in the EU positively impact consumer trust, encouraging engagement with Fintech services. Similarly, Fu and Mishra (2022) highlighted the importance of robust consumer protection frameworks to safeguard consumers from risks, contributing to higher adoption rates. However, the insignificant findings in this study suggest that perceived consumer protection may not be a primary concern for individuals adopting Fintech services or that existing protections are not well-communicated.

From a theoretical perspective, these results align with the notion that consumer protection mechanisms can foster trust in regulated environments, as suggested by Rösner et al. (2020). In less regulated or emerging markets like Saudi Arabia, individuals may place more emphasis on convenience or ease of use rather than on consumer protection.

In the context of Saudi Arabia, these findings are particularly relevant as the country continues to expand its digital financial ecosystem under Vision 2030. While consumer protection is important, the results suggest that consumers may not yet fully perceive or prioritize these protections when adopting Fintech services. Enhancing consumer awareness of these protections could be key to improving trust and boosting Fintech adoption.

This study offers novel insights into the complex relationship between consumer protection and Fintech adoption. While previous studies, such as Rösner et al. (2020) and Fu and Mishra (2022), emphasize the role of consumer protection in building trust, this study highlights that in emerging markets like Saudi Arabia, convenience and ease of use may be more influential than perceived consumer protection in driving Fintech adoption.

In summary, while the regression results do not show a significant relationship between consumer protection and Fintech adoption in this study, the literature suggests that strong consumer protection frameworks remain crucial in fostering trust and potentially influencing adoption, particularly in regulated markets (Rösner et al., 2020; Fu & Mishra, 2022).

2.4.1.10 Financial Service Cost

The regression results show a significant positive relationship between financial service cost and Fintech adoption in Model 2, indicating that individuals who perceive lower costs in Fintech services are more likely to adopt these platforms. This finding supports the hypothesis that reduced costs of Fintech services compared to traditional financial services positively influence adoption, especially among price-sensitive and underserved populations.

These results align with Chen et al. (2020), who demonstrated that the diffusion of digital technologies has enabled financial services to be delivered at lower costs, making them more accessible to marginalized groups. Similarly, Allen et al. (2022) highlighted that Fintech has been successful in reducing the high transaction costs associated with traditional financial systems, which supports the notion that affordability plays a key role in encouraging Fintech adoption.

From a theoretical perspective, these findings align with Financial Inclusion Theory, which posits that reducing financial service costs enhances access to financial products, particularly for low-income and marginalized groups (Demir et al., 2022). By offering lower-cost alternatives to traditional banking, Fintech helps bridge the gap between underserved populations and financial services, facilitating broader economic participation.

In the context of Saudi Arabia, these results are particularly relevant under Vision 2030, which aims to promote financial inclusion and digital transformation. The findings suggest that making Fintech services more affordable could help increase adoption, particularly among individuals who face barriers to traditional banking due to high costs.

This study contributes novel insights by demonstrating that the cost-reducing advantages of Fintech play a critical role in promoting financial inclusion. While previous studies, such as Chen et al. (2020) and Allen et al. (2022), have emphasized the impact of lower costs in Fintech, this

study further shows how affordability can encourage adoption, particularly in emerging economies like Saudi Arabia, where traditional banking costs may be prohibitive.

In summary, the results support the hypothesis (H10) that lower perceived costs of Fintech services positively influence adoption, particularly among individuals for whom traditional financial services may be prohibitively expensive. These findings contribute to the literature by demonstrating that Fintech's cost-reducing advantages are key to promoting financial inclusion, particularly among price-sensitive and underserved populations (Chen et al., 2020; Allen et al., 2022).

2.4.2 Diagnostic Tests

To ensure the robustness of the regression models, various diagnostic tests were conducted. These tests address potential issues such as multicollinearity, model misspecification, and the fit of the model. Multicollinearity can lead to inflated standard errors and unreliable coefficient estimates. The Variance Inflation Factor (VIF) values for all variables in the model were well below the commonly accepted threshold of 5, indicating no severe multicollinearity (Table 5). The VIF values ranged from 1.05 to 2.87, suggesting that the explanatory variables do not exhibit multicollinearity that would distort the regression results.

Table 5: Multicollinearity Test of Individual Fintech Adoption

	VIF
Financial Well-being	1.05
Foreigner	1.14
Financial Literacy	1.16
Financial Cost	1.18
Consumer Protection	1.22
Education Level	1.33
Female	1.35
Age Group (55+) years	1.58
Financial Inclusion	1.71
Unemployed	1.81
Age Group (45-54) years	2.26
Age Group (25-34) years	2.54
Age Group (35-44) years	2.87

The Ramsey RESET test was conducted to check for model misspecification, specifically whether any omitted variables or incorrect functional forms could be present. The test yielded a p-value of 0.9281, indicating no evidence of omitted variables and suggesting that the model is correctly

specified. Additionally, the Pearson chi-squared goodness-of-fit test was performed to evaluate the fit of the logistic regression model. A p-value of 0.1026 was observed (Table 6), indicating that the model may have a marginal fit issue. However, given the complexity of real-world data and the focus on predictive accuracy, this was not deemed a significant concern for the validity of the findings (Table 6).

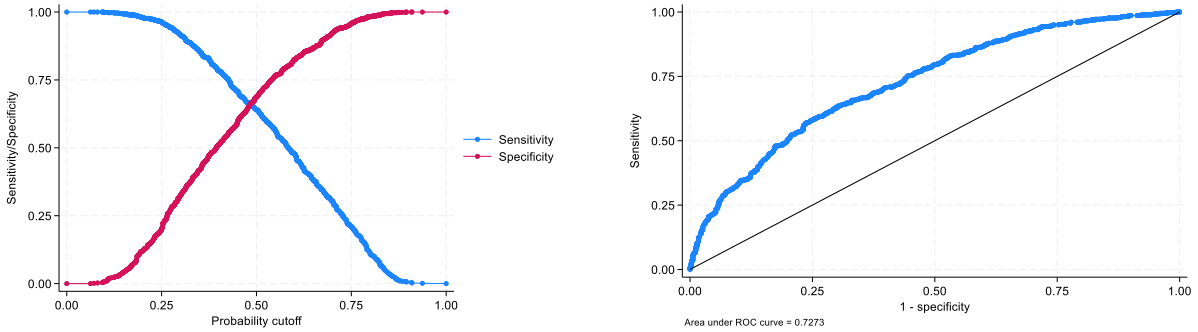
Table 6: Ramsey RESET and Fit Tests of Individual Fintech Adoption

	Value
F (3, 1649)	0.15
Prob > F	0.9281
Number of Observations	1,666
Number of Covariate Patterns	1,236
Pearson $chi^2(1222)$	1285.02
Prob > chi^2	0.1026

The models were estimated both with and without robust standard errors to check for heteroscedasticity. The results showed minimal differences in the statistical significance of the estimates, confirming that heteroscedasticity was not a major issue in this analysis. As none of the variables in the model are continuous, the issue of outliers does not arise. The categorical nature of the variables mitigates concerns about extreme values distorting the results.

To further evaluate the performance of the logistic regression model, several tests were performed to check for bias in the predictions. The model's classification performance was assessed through sensitivity (true positive rate) and specificity (true negative rate) analysis. The sensitivity and specificity were plotted against different probability cutoffs (Figure 1). This graph provides insight into the optimal threshold for classifying Fintech adoption. The intersection point where sensitivity and specificity are balanced can guide the selection of a cutoff for maximizing prediction accuracy. The Receiver Operating Characteristic (ROC) curve provides a visual assessment of the model's discriminatory ability. The area under the ROC curve (AUC) was found to be 0.7273, indicating that the model has a moderate-to-good ability to distinguish between adopters and non-adopters of Fintech. An AUC value above 0.7 is typically considered acceptable in logistic regression, showing that the model performs reasonably well in predicting the outcome.

Figure 1: Sensitivity, Specificity, and ROC Curve of Individual Fintech Adoption



2.4.3 Robustness Checks

To ensure the robustness of the results for individual Fintech adoption, additional models were estimated using the Linear Probability Model (LPM) and the Probit model. These checks were aimed at determining whether the relationships between demographic, socio-economic, and financial factors remained consistent across different model specifications. This process ensures that the findings are not driven by the choice of the Logit model alone (Table 7).

The results indicate that Female remains negatively associated with Fintech adoption across all models, reaffirming that women are less likely to adopt Fintech services. Conversely, Foreigner becomes significantly positive in Model 2, suggesting that non-citizens exhibit a higher likelihood of Fintech adoption when additional controls are introduced.

Regarding Age Group, individuals aged 25–34 years show a positive relationship with Fintech adoption in Model 1; however, this effect becomes insignificant in Model 2. In contrast, the 45–54 years and 55+ years groups consistently exhibit a significant negative relationship across all models, reinforcing lower adoption rates among older individuals.

The findings for Education Level, Financial Inclusion, Financial Literacy, Financial Well-being, and Financial Cost remain positive and significant in both the LPM and Probit models, underscoring their robust influence on Fintech adoption.

Overall, the robustness checks confirm the validity of the main regression findings, demonstrating consistency across different model specifications.

Table 7: Robustness Checks for Models of Individual Fintech Adoption

	Model 3 LPM	Model 4 LPM	Model 5 Probit	Model 6 Probit
Female	-0.127***	-0.076***	-0.337***	-0.215***
	(0.026)	(0.027)	(0.069)	(0.077)
Foreigner	0.051	0.163***	0.135	0.469***
	(0.041)	(0.042)	(0.111)	(0.123)
Unemployed	-0.164***	-0.041	-0.443***	-0.120
	(0.034)	(0.035)	(0.091)	(0.100)
Age Group (25-34) years	0.083**	0.047	0.221**	0.125
	(0.041)	(0.040)	(0.111)	(0.115)
Age Group (35-44) years	0.059	-0.009	0.154	-0.035
	(0.042)	(0.041)	(0.114)	(0.118)
Age Group (45-54) years	-0.066	-0.120***	-0.171	-0.341***
	(0.047)	(0.046)	(0.127)	(0.131)
Age Group (55+) years	-0.144**	-0.185***	-0.383**	-0.534***
	(0.058)	(0.057)	(0.159)	(0.165)
Education Level	0.063***	0.029**	0.169***	0.086**
	(0.013)	(0.014)	(0.036)	(0.038)
Financial Inclusion		0.102***		0.288***
		(0.011)		(0.033)
Financial Literacy		0.062***		0.171***
		(0.017)		(0.048)
Financial Well-being		0.055**		0.158**
		(0.024)		(0.067)
Consumer Protection		0.017		0.052
		(0.011)		(0.033)
Financial Cost		0.072***		0.210***
		(0.025)		(0.072)
Constant	0.395***	0.032	-0.285**	-1.326***
	(0.046)	(0.056)	(0.123)	(0.166)
R-squared	0.091	0.157		

Obs. 1,666

Male, Citizen, Employed and Age Group (15-24), are the reference categories for Gender, Domiciliation, Employment Status and Age Group, respectively

*Significant: *<0.1, **<0.05, ***<0.01*

Unstandardised coefficients

Robust standard errors in parentheses

2.5 Conclusion and Limitations

2.5.1 Conclusion

This study has examined the key demographic, socio-economic, and financial factors influencing individual FinTech adoption in Saudi Arabia, using data collected during the COVID-19 pandemic. The findings confirm that gender, domiciliation status, employment status, age, and education level, alongside financial inclusion, financial literacy, financial well-being, financial service costs, and consumer protection, play a significant role in adoption patterns.

The results show that women are significantly less likely to adopt FinTech, emphasizing persistent gender disparities in digital financial services. These findings reinforce prior research highlighting the barriers women face in financial inclusion and the need for targeted policies to enhance digital financial participation (Chen et al., 2023; Kara et al., 2021). Additionally, non-citizens (foreigners) exhibit higher FinTech adoption rates, particularly when financial factors are considered. This aligns with findings by Bhagat and Roderick (2020), who demonstrated that FinTech provides vital financial access for marginalized groups such as immigrants and refugees, who often face exclusion from formal banking systems. Similarly, Kara et al. (2021) highlighted that immigrants in emerging markets depend more on alternative financial solutions due to restricted access to credit.

Employment status also influences FinTech adoption, with unemployed individuals being less likely to engage with digital financial services, reinforcing the role of financial stability in FinTech usage (Sha'ban et al., 2020; Danisman & Tarazi, 2020). The findings confirm that younger individuals (25–44 years) are more likely to adopt FinTech, reflecting their higher digital literacy and technological familiarity, while those aged 45 and above are less inclined to engage with digital financial services (Danisman & Tarazi, 2020; Chen et al., 2020). Education level also plays a significant role in FinTech adoption. Higher education levels are positively correlated with FinTech engagement, supporting findings by Alhassan et al. (2021), who showed that higher education enhances financial inclusion. Educated individuals tend to possess greater financial literacy and technological skills, which facilitate FinTech adoption (Danisman & Tarazi, 2020).

From a financial perspective, financial inclusion, financial literacy, and financial well-being are strong predictors of FinTech adoption (Demir et al., 2022; Panos & Wilson, 2020). These results underscore the need to enhance financial education and expand access to financial services to bridge the digital divide. The study also highlights that lower financial service costs significantly drive adoption, reinforcing the affordability advantage of FinTech over traditional banking (Chen et al., 2020; Allen et al., 2022). Interestingly, while consumer protection is widely recognized as important, its perceived role in influencing FinTech adoption appears limited in this study (Rösner et al., 2020; Fu & Mishra, 2022). In emerging markets like Saudi Arabia, convenience and accessibility seem to outweigh regulatory concerns. This suggests that while strong consumer protection frameworks remain essential, raising consumer awareness of these protections could enhance trust in digital finance. Furthermore, while FinTech has the potential to improve financial well-being, ensuring responsible usage is crucial to avoiding financial distress (Panos & Wilson, 2020; Schomburgk & Hoffmann, 2023).

This study extends existing research by providing empirical evidence on the determinants of FinTech adoption in Saudi Arabia. While previous studies (Chen et al., 2023; Kara et al., 2021; Danisman & Tarazi, 2020) have explored demographic influences, this research integrates socio-economic and financial dimensions, offering a comprehensive analysis of adoption patterns. The findings confirm that younger, financially stable, and literate individuals are more inclined to engage with FinTech, while women, older adults, and the unemployed face greater adoption barriers, reinforcing the need for targeted financial inclusion initiatives.

From a theoretical perspective, these findings support Financial Inclusion Theory, demonstrating that FinTech reduces barriers to financial access, particularly for underserved populations (Demir et al., 2022; Sha'ban et al., 2020). However, the study also highlights limitations in the theory, showing that access alone is insufficient without financial literacy and trust-enhancing mechanisms. While affordability remains a strong driver (Chen et al., 2020; Allen et al., 2022), consumer protection measures appear to have a limited direct impact, suggesting that convenience and accessibility outweigh regulatory concerns in emerging markets (Rösner et al., 2020; Fu & Mishra, 2022).

From a policy standpoint, these findings highlight the importance of financial literacy initiatives to equip individuals with the skills needed to use FinTech effectively (Meoli et al., 2022; Prete, 2022), cost transparency and affordability measures to ensure that Fintech remains a viable alternative for price-sensitive users, and targeted regulatory interventions to strengthen consumer trust and security, encouraging broader adoption under Vision 2030. As Saudi Arabia continues its digital financial transformation, ensuring that underserved populations—particularly women, older adults, and low-income individuals—have access to Fintech will be crucial for achieving sustainable financial inclusion.

In summary, while Fintech holds significant potential to enhance financial inclusion, addressing gender disparities, financial literacy gaps, and affordability concerns is essential to ensuring equitable access. This study extends the literature by demonstrating how socio-economic and structural factors interact to shape Fintech adoption in emerging markets, offering valuable insights for policymakers, regulators, and industry stakeholders (Demir et al., 2022; Sha'ban et al., 2020; Yang & Zhang, 2022). Ultimately, this study not only reinforces existing theories of financial inclusion but also provides a distinctive perspective on Fintech adoption in Saudi Arabia. By highlighting the interplay between affordability, financial literacy, and demographic disparities, these findings provide a foundation for future research and policymaking. Strengthening financial inclusion through Fintech will require a balanced approach that prioritizes both accessibility and financial responsibility, ensuring that digital finance serves as a catalyst for economic empowerment rather than deepening existing inequalities.

2.5.2 Limitations

While this study provides valuable insights into the determinants of Fintech adoption in Saudi Arabia, several limitations must be acknowledged. Firstly, the data was collected during the COVID-19 pandemic, a period of significant financial and technological disruption that may have influenced respondents' adoption behaviours. As a result, the findings may not fully capture Fintech adoption patterns under more stable economic conditions. Future research should consider longitudinal studies that track post-pandemic consumer behaviours to assess the long-term impact of demographic and financial factors on Fintech adoption (Jonker et al., 2022; Bounie & Camara, 2020).

Secondly, the dataset is drawn from a single-country context (Saudi Arabia), which may limit the generalizability of the findings to other regions. Saudi Arabia's financial and technological landscape is shaped by Vision 2030-driven reforms, regulatory developments, and socio-cultural factors, which may not be directly applicable to other emerging markets. Future research could undertake comparative analyses across Middle Eastern or emerging economies to assess whether the same adoption drivers hold in different regulatory, economic, and cultural environments (Kara et al., 2021; Bhagat & Roderick, 2020).

Lastly, while the study examines a broad range of demographic and financial factors, some potential determinants were not included, such as marital status, digital infrastructure, social and cultural attitudes, and the inclusion of additional languages in the survey beyond Arabic and English (e.g., Indian, Pakistani, Filipino, Indonesian, and Bengali speakers). These factors could influence access to and engagement with Fintech services, particularly among expatriate populations and digitally marginalized communities. Future research should incorporate these variables to provide a more holistic understanding of Fintech adoption dynamics (Meoli et al., 2022).

Despite these limitations, this study lays a strong foundation for further research into Fintech adoption in emerging markets. By identifying key demographic and financial drivers, it provides critical insights that can inform policy interventions, regulatory strategies, and digital inclusion efforts aimed at fostering broader financial participation through Fintech innovations.

Appendix

The survey, provided in both Arabic and English

1. Gender ☐ Male ☐ Female 2. Age ☐ 15-24 years ☐ 25-34 years ☐ 35-44 years ☐ 45-54 years ☐ 55-above years 3. Nationality Are you Saudi? ☐ Yes ☐ No 4. Education level ☐ Secondary School ☐ Diploma ☐ Undergraduate ☐ Postgraduate 5. Do you work? ☐ No ☐ Yes (if Yes, please answer below) 6. Level Job ☐ Junior ☐ Senior ☐ Executive ☐ Other 7. Do you have your own business? ☐ Yes ☐ No 8. What is the level of the business? ☐ Micro Small ☐ Small ☐ Medium ☐ Large 9. Do you have a bank account? ☐ Yes (Financially Included) ☐ No (Financially Excluded – Unbanked) (if No, please tick the responses that best apply from the list below) I do not have a bank account due to (select all that apply): ☐ Poor consumer protection for financial services ☐ Lack of confidence in my level of financial expertise ☐ The high cost of financial services, such as opening a bank account	1. الجنس ☐ ذكر ☐ أنثى 2. العمر ☐ 15-24 سنة ☐ 25-34 سنة ☐ 35-44 سنة ☐ 45-54 سنة ☐ 55 سنة فأكثر 3. الجنسية هل أنت سعودي؟ ☐ نعم ☐ لا 4. مستوى التعليم ☐ ثانوية عامة ☐ دبلوم ☐ جامعي ☐ دراسات عليا 5. هل تعمل؟ ☐ لا ☐ نعم (إذا كانت الإجابة بنعم، يرجى الإجابة أدناه) 6. المستوى الوظيفي ☐ مبتدئ ☐ كبير ☐ تنفيذي ☐ آخر 7. هل لديك عملك الخاص؟ ☐ نعم ☐ لا 8. ما هو مستوى العمل؟ ☐ متناهية الصغر صغيرة ☐ صغيرة ☐ متوسطة ☐ كبيرة 9. هل لديك حساب مصرفي؟ ☐ نعم (مشمول ماليًا) ☐ لا (مستبعد ماليًا - غير متعامل مع البنوك) (إذا كانت الإجابة لا، يرجى تحديد الإجابات التي تنطبق بشكل أفضل من القائمة أدناه) ليس لدي حساب مصرفي بسبب (حدد كل ما ينطبق): ☐ ضعف حماية المستهلك للخدمات المالية ☐ عدم الثقة في مستوى خبرتي المالية ☐ التكلفة العالية للخدمات المالية، مثل فتح حساب مصرفي ☐ الجودة المنخفضة للخدمات المالية المقدمة ☐ عدم وجود أموال كافية لجعلها تستحق العناء

☐ The low quality of financial services offered	☐ عدم الحاجة إلى حساب مصرفي
☐ Not having enough money to make it worthwhile	☐ أحد أفراد الأسرة لديه حساب مصرفي بالفعل، لذلك لا أحتاج إلى واحد
☐ The lack of need for a bank account	☐ المؤسسات المالية بعيدة جدًا
☐ A family member already having a bank account, so I do not need one	☐ عدم وجود الوثائق اللازمة
☐ Financial institutions being too far away	☐ عدم الثقة في المؤسسات المالية
☐ Lacking the necessary documentation	☐ عدم السماح بفتح حساب مصرفي
☐ Not trusting financial institutions	10. هل لديك بطاقة مصرفية (بطاقة خصم)؟
☐ Not being allowed to open a bank account	☐ نعم
10. Do you have a bank card (Debit Card)?	☐ لا
☐ Yes	11. هل لديك بطاقة ائتمان؟
☐ No	☐ نعم
11. Do you have credit card?	☐ لا
☐ Yes	12. هل لديك قرض بنكي؟
☐ No	☐ نعم
12. Do you have a bank loan?	☐ لا
☐ Yes	13. هل لديك حساب توفير؟
☐ No	☐ نعم
13. Do you have a saving account?	☐ لا
☐ Yes	14. هل لديك حساب استثماري؟
☐ No	☐ نعم
14. Do you have an investment account?	☐ لا
☐ Yes	15. هل لديك بوليصة تأمين؟
☐ No	☐ نعم
15. Do you have an insurance policy?	☐ لا
☐ Yes	16. هل لديك حساب لدى مزود تكنولوجيا مالية مثل STCPay أو غيره؟
☐ No	☐ نعم
16. Do you have an account with a financial technology provider such as STCPay or others?	☐ لا
☐ Yes	17. من المرجح أن يكون الاستثمار ذو العائد المرتفع محفوفًا بالمخاطر، (إذا عرض عليك شخص ما فرصة جني الكثير من المال، فمن المحتمل أيضًا أن تكون هناك فرصة لخسارة الكثير من المال).
☐ No	☐ صحيح
17. An investment with a high return is likely to be high risk, (if someone offers you the chance to make a lot of money it is likely that there is also a chance that you will lose a lot of money).	☐ خطأ
☐ True	☐ لا أعرف
☐ False	18. انخفاض التضخم يعني أن تكلفة المعيشة تتزايد بسرعة.
☐ I do not know	☐ صحيح
18. Low inflation means that the cost of living is increasing rapidly.	☐ خطأ
☐ True	☐ لا أعلم
☐ False	19. من الممكن عادةً تقليل مخاطر الاستثمار في سوق الأوراق المالية من خلال شراء مجموعة واسعة من الأسهم والسندات (من غير المرجح أن تخسر كل أموالك إذا قمت بتوفيرها في أكثر من مكان).
☐ I do not know	☐ صحيح
19. It is usually possible to reduce the risk of investing in the stock market by buying a wide	☐ خطأ

range of stocks and shares, (it is less likely that you will lose all of your money if you save it in more than one place).
☐ True
☐ False
☐ I do not know
20. I tend to live for today and let tomorrow take care of itself, and money is there to be spent
☐ Strongly Agree
☐ Agree
☐ Neutral
☐ Disagree
☐ Strongly Disagree
21. I find it more satisfying to spend money than to save it for the long term
☐ Strongly Agree
☐ Agree
☐ Neutral
☐ Disagree
☐ Strongly Disagree
22. Before I buy something, I carefully consider whether I can afford it
☐ Yes
☐ No
☐ I hadn't considered it before
23. I set long term financial goals and strive to achieve them
☐ Yes
☐ No
☐ I hadn't considered it before
24. The last time my income did not cover my living costs I:
☐ Borrowed from family or friends
☐ Borrowed from employer/salary advance
☐ Pawned something that I own
☐ Used credit card for a cash advance
☐ Took out a personal loan from a financial service provider (including bank, credit union or microfinance)
☐ Took out a loan from an informal provider/moneylender
☐ Paid my bills late; missed payments
☐ This has never happened to me
25. Which of the following statements best describes how you made your choice of financial products?

☐ لا أعرف
20. أميل إلى العيش من أجل اليوم وأترك الغد يعتني بنفسه، والمال موجود لإنفاقه
☐ أوافق بشدة
☐ أوافق
☐ محايد
☐ لا أوافق
☐ لا أوافق بشدة
21. أجد إنفاق المال أكثر إرضاءً من ادخاره على المدى الطويل
☐ أوافق بشدة
☐ أوافق
☐ محايد
☐ لا أوافق
☐ لا أوافق بشدة
22. قبل أن أشتري شيئًا، أفكر بعناية فيما إذا كان بإمكاني تحمله
☐ نعم
☐ لا
☐ لم أفكر في ذلك من قبل
23. أضع أهدافًا مالية طويلة الأجل وأسعى جاهدًا لتحقيقها
☐ نعم
☐ لا
☐ لم أفكر في ذلك من قبل
24. آخر مرة لم يغطي فيها دخلي تكاليف معيشتي أنا:
☐ اقترضت من العائلة أو الأصدقاء
☐ اقترضت من صاحب العمل/سلفة راتب
☐ رهنت شيئًا أمتلكه
☐ استخدمت بطاقة ائتمان للحصول على سلفة نقدية
☐ أخذت قرضًا شخصيًا من مزود خدمة مالية (بما في ذلك البنك أو اتحاد الائتمان أو التمويل الأصغر)
☐ أخذت قرضًا من مزود غير رسمي/مقرض أموال
☐ دفعت فواتيري متأخرًا؛ فاتتني المدفوعات
☐ لم يحدث لي هذا من قبل
25. أي من العبارات التالية تصف بشكل أفضل كيف اخترت المنتجات المالية؟
☐ لقد فكرت في عدة خيارات من شركات مختلفة قبل اتخاذ قراري
☐ لقد فكرت في الخيارات المختلفة من شركة واحدة
☐ لم أفكر في أي خيارات أخرى على الإطلاق
☐ لقد بحثت ولكن لم تكن هناك خيارات أخرى للنظر فيها
26. معاملة المستهلكين الماليين منصفة أو عادلة والوصول إلى الشكاوى والانتصاف الكافي كافٍ في المملكة العربية السعودية:
☐ أوافق بشدة
☐ أوافق
☐ محايد
☐ لا أوافق

☐ I considered several options from different companies before making my decision ☐ I considered the various options from one company ☐ I did not consider any other options at all ☐ I looked around but there were no other options to consider 26. The treatment of financial consumers is equitable or fair and the access to adequate complaints and redress is sufficient in Saudi Arabia: ☐ Strongly Agree ☐ Agree ☐ Neutral ☐ Disagree ☐ Strongly Disagree 27. The consumer protection mechanisms of financial providers against fraud and data misuse in Saudi Arabia are sufficient: ☐ Strongly Agree ☐ Agree ☐ Neutral ☐ Disagree ☐ Strongly Disagree 28. Financial services providers and authorised agents do not work in the best interest of their customers because of the low level of competition and financial foreign direct investment in Saudi Arabia: ☐ Strongly Agree ☐ Agree ☐ Neutral ☐ Disagree ☐ Strongly Disagree 29. The fees and /or profits of financial products and services (remittance, credit, saving, investment, and insurance) are too expensive in Saudi Arabia ☐ Strongly Agree ☐ Agree ☐ Neutral ☐ Disagree ☐ Strongly Disagree 30. In general, the quality of financial products and services in Saudi Arabia is weak ☐ Strongly Agree ☐ Agree	☐ لا أوافق بشدة 27. آليات حماية المستهلك لمقدمي الخدمات المالية ضد الاحتيال وإساءة استخدام البيانات في المملكة العربية السعودية كافية: ☐ أوافق بشدة ☐ أوافق ☐ محايد ☐ لا أوافق ☐ لا أوافق بشدة 28. لا يعمل مقدمو الخدمات المالية والوكلاء المعتمدون لصالح عملائهم بسبب انخفاض مستوى المنافسة والاستثمار الأجنبي المباشر المالي في المملكة العربية السعودية: ☐ أوافق بشدة ☐ أوافق ☐ محايد ☐ غير موافق ☐ غير موافق بشدة 29. الرسوم و/أو الأرباح للمنتجات والخدمات المالية (التحويلات، والائتمان، والادخار، والاستثمار، والتأمين) باهظة الثمن في المملكة العربية السعودية ☐ موافق بشدة ☐ موافق ☐ محايد ☐ غير موافق ☐ غير موافق بشدة 30. بشكل عام، جودة المنتجات والخدمات المالية في المملكة العربية السعودية ضعيفة ☐ موافق بشدة ☐ موافق ☐ محايد ☐ غير موافق ☐ غير موافق بشدة 31. لا أستطيع التقدم بطلب للحصول على قرض بنكي بسبب الضمانات المطلوبة. ☐ نعم ☐ لا ☐ لا أعرف 32. شركات التأمين أقل احتمالاً للموافقة على طلبات التأمين الطبي من كبار السن (60 عامًا وما فوق) ☐ نعم ☐ لا ☐ لا أعرف 33. لا تمنح البنوك قروضًا للعملاء والتي سيتم استخدامها في استثمارات عالية المخاطر ☐ نعم ☐ لا ☐ لا أعرف

☐ Neutral ☐ Disagree ☐ Strongly Disagree 31. I am not able to apply for a bank loan because of the collateral needed. ☐ Yes ☐ No ☐ I do not know 32. Insurance companies are less likely to approve medical insurance applications from elderly people (60 and above) ☐ Yes ☐ No ☐ I do not know 33. Banks do not grant loans to clients which will be used for high-risk investments ☐ Yes ☐ No ☐ I do not know 34. People with health insurance are more likely to have risky lifestyles ☐ Yes ☐ No ☐ I do not know 35. Fintech providers, such as STC Pay, Apple Pay, HALA etc. have enabled the financially excluded (female, adults 15-24 years, immigrants' employees, SME) to open a bank account and use financial services in Saudi Arabia. ☐ Yes ☐ No ☐ I do not know 36. Fintech companies have lower cost and higher quality of financial services than traditional financial institutions (remittance, credit, saving, investment, and insurance) in Saudi Arabia ☐ Yes ☐ No ☐ I do not know 37. The services of Fintech companies are simpler, easier, and faster than the traditional financial institutions ☐ Yes ☐ No ☐ I do not know	34. الأشخاص الذين لديهم تأمين صحي هم أكثر عرضة لأنماط حياة محفوفة بالمخاطر ☐ نعم ☐ لا ☐ لا أعرف 35. مكنت شركات التكنولوجيا المالية، مثل STC Pay وApple Pay وHALA وما إلى ذلك، المستبعدين ماليًا (الإناث والبالغين من سن 15 إلى 24 عامًا وموظفي المهاجرين والشركات الصغيرة والمتوسطة) من فتح حساب مصرفي واستخدام الخدمات المالية في المملكة العربية السعودية. ☐ نعم ☐ لا ☐ لا أعرف 36. تتمتع شركات التكنولوجيا المالية بتكلفة أقل وجودة أعلى للخدمات المالية مقارنة بالمؤسسات المالية التقليدية (التحويلات، والائتمان، والادخار، والاستثمار، والتأمين) في المملكة العربية السعودية ☐ نعم ☐ لا ☐ لا أعرف 37. خدمات شركات التكنولوجيا المالية أبسط وأسهل وأسرع من المؤسسات المالية التقليدية ☐ نعم ☐ لا ☐ لا أعرف

Chapter 3

Determinants of Cashless Payments for Individuals

3 Determinants of Cashless Payments for Individuals

Abstract

This study examines how demographic factors—gender, domiciliation, employment status, and age—influence digital payment transaction values in Saudi Arabia's rapidly evolving cashless economy. While previous research primarily focuses on Fintech adoption rates, relatively little is known about actual spending behaviours across different payment methods. Using a proprietary dataset of 716 million transactions spanning 36 months (April 1, 2019 – March 31, 2022) from a major Saudi commercial bank, this study adopts an inductive (theory-building) approach to analyse transaction values across Chip-and-PIN, contactless, digital wallet, and E-commerce payments. The findings reveal significant demographic disparities in digital transaction values. Females conduct lower-value transactions than Males in Chip-and-PIN and contactless payments only, supporting the concept that spending caution varies by gender. Foreigners conduct lower-value transactions than Citizens, particularly in Chip-and-PIN, contactless and digital wallet payments, highlighting the role of cultural adaptation and social influence in expatriate spending behaviours. Unemployed individuals engage in lower-value transactions in Chip-and-PIN payments, except in digital wallet and E-commerce payments, where they exhibit relatively higher spending, reinforcing the financial accessibility benefits of digital payments. Older individuals (45-55+) conduct higher-value transactions in Chip-and-PIN payments, while younger individuals (15-24) prefer contactless, digital wallet, and E-commerce transactions, emphasizing the impact of convenience and technological familiarity. Control variables, including the COVID-19 stringency index, geopolitical risk, temperature, Ramadan, inflation, and stock market index, are incorporated to account for exogenous influences, ensuring a robust analytical framework. This study contributes to the financial inclusion and Fintech adoption literature by providing empirical evidence of transaction-level variations across demographic groups. It also offers novel insights into Saudi Arabia's Vision 2030-driven financial transformation, emphasizing the need for targeted financial literacy programs and policy interventions to address demographic disparities in digital financial engagement.

3.1 Introduction

The rise of financial technology (Fintech) has fundamentally reshaped global payment systems, accelerating the shift toward cashless transactions (Bounie & Camara, 2020). This transformation is particularly significant in emerging economies, where digital payment adoption plays a crucial role in expanding financial inclusion and reducing reliance on cash transactions (Demir et al., 2022). In Saudi Arabia, the adoption of digital payment methods has been a key priority under Vision 2030, which aims to increase financial accessibility, modernize banking infrastructure, and foster a cashless economy. Despite this momentum, there remains a critical gap in understanding how different demographic groups engage with digital payment systems beyond adoption rates.

While previous studies (See-To & Ngai, 2019; Choudrie et al., 2018; Thaker et al., 2022) have examined the adoption of digital payments, they primarily focus on factors influencing adoption rates rather than actual transaction behaviours. This focus limits the current understanding of how digital payments are used in practice, particularly in terms of transaction values across different payment methods. Existing research often assumes that once digital payment methods are adopted, all users engage with them equally. However, this assumption fails to account for variations in spending behaviour based on demographic and socio-economic characteristics (Cruijsen & Knoben, 2021). Another limitation is the narrow scope of payment methods analysed in previous studies. Most research generalizes digital payment adoption rather than differentiating between distinct payment channels, such as Chip-and-PIN, Contactless, Digital Wallet, and E-commerce payments. This generalization prevents a nuanced understanding of which demographic groups engage more actively with certain payment types and why transaction values differ across these methods (Bounie & Camara, 2020).

Additionally, some previous studies primarily use survey-based methodologies, which, while useful for capturing perceptions and attitudes, lack transaction-level empirical evidence (Chen et al., 2019). This methodological gap restricts the ability to capture actual financial engagement and spending behaviours. While financial inclusion remains a global research priority, little empirical work has examined digital payment transaction values in Saudi Arabia. Given the country's unique financial and regulatory landscape, there is a need to analyse how Vision 2030-driven financial inclusion initiatives influence digital transaction behaviours (Thaker et al., 2022).

In response to these gaps, this study adopts an inductive (theory-building) approach to examine how demographic factors—gender, domiciliation (citizens vs. foreigners), employment status, and age—affect digital payment transaction values. Unlike prior research, which primarily focuses on technology acceptance and adoption trends, this study investigates actual transaction behaviours across multiple payment methods. The study differentiates between Chip-and-PIN, Contactless, Digital Wallet, and E-commerce transactions to provide a more granular understanding of financial engagement. By utilizing transaction-level data rather than self-reported surveys, this study identifies patterns in digital payment behaviours and develops theoretical insights into how demographic and institutional factors shape cashless financial participation in Saudi Arabia.

Control factors such as the COVID-19 stringency index, GPR index, temperature, Ramadan, inflation, and the stock market index are included to account for exogenous influences. This robust analytical framework ensures a nuanced understanding of the drivers behind financial inclusion in a cashless society.

Using a proprietary dataset of 716 million transactions spanning a 36-month period (April 1, 2019 – March 31, 2022) from one of the 10 listed commercial banks in Saudi Arabia, the study analyzes digital payment transaction values across demographic groups. The findings reveal significant differences in transaction values based on demographic characteristics. Females conduct lower-value transactions than Males in Chip-and-PIN and Contactless payments, reinforcing the Pain of Paying Theory (See-To & Ngai, 2019), which suggests that Females experience greater financial caution when using payment methods perceived as less secure. However, in Digital Wallet and E-commerce transactions, no significant gender differences are observed, indicating that secure authentication measures mitigate gender-based disparities in these payment methods. This finding challenges prior research (Choudrie et al., 2018; Thaker et al., 2022), which suggested that Females favour Digital Wallets due to security concerns.

Foreigners conduct lower-value transactions than Citizens across Chip-and-PIN, Contactless, and Digital Wallet payments. The largest difference is observed in Contactless and Digital Wallet transactions, where Foreigners exhibit a more cautious approach to spending. While prior studies attribute expatriate financial behaviour to regulatory constraints (Kumar et al., 2021), this study suggests that cultural adaptation and social influence (Cruijsen & Knoben, 2021) play a more

significant role. However, in E-commerce payments, transaction values between Foreigners and Citizens do not differ significantly, indicating that online purchases serve as a universal payment channel for both groups.

Unemployed individuals conduct lower-value transactions in Chip-and-PIN payments, reflecting their lower disposable income and financial uncertainty (Bounie & Camara, 2020). However, when using Digital Wallets and E-commerce payments, Unemployed individuals engage in relatively higher-value transactions compared to their Chip-and-PIN spending. This suggests that Digital Wallets and E-commerce payments provide a more accessible financial alternative, supporting Chen et al. (2019), who highlight that digital payments help consumers navigate financial constraints.

Older individuals (45-55+) conduct higher-value transactions in Chip-and-PIN payments, indicating a preference for traditional, secure payment methods. However, in Contactless, Digital Wallet, and E-commerce payments, transaction values decrease as age increases, with the largest values observed among younger individuals (15-24 years old). This finding aligns with Convenience Theory (Brown et al., 2022; Li et al., 2023), which suggests that younger individuals prioritize speed and ease of use when selecting payment methods, leading to higher spending in digital payment channels.

This study makes several important contributions to the Fintech and financial inclusion literature. It extends Financial Inclusion Theory (Demir et al., 2022) by demonstrating that transaction values vary based on demographic factors, rather than assuming uniform engagement once adoption occurs. It advances Behavioural Finance Theories (See-To & Ngai, 2019; Manshad & Brannon, 2021) by linking the Pain of Paying Theory to gender differences in Contactless payments and Social Influence Theory to expatriate spending behaviours. The study also provides a novel empirical perspective by analysing transaction-level data instead of self-reported adoption surveys, offering a more objective measure of financial engagement. Furthermore, it enhances the understanding of digital payments in the Saudi institutional context, particularly within Vision 2030's financial inclusion agenda.

By shifting the focus from adoption rates to actual transaction behaviours, this study provides new empirical insights that challenge previous assumptions and contribute to the broader academic discourse on digital financial participation in emerging economies. The findings also propose practical implications for policymakers and financial institutions by identifying demographic disparities in transaction behaviours, which can inform targeted financial literacy programs and regulatory adjustments aimed at fostering greater financial inclusion (Kumar et al., 2021).

The remainder of this paper is organised as follows, Section 2 a review of the literature and hypotheses development. Section 3 details the research methodology, including data description, empirical models, and correlation analysis. Section 4 presents the empirical results, followed by diagnostic tests and robustness checks. The final section offers conclusions and discusses the study's limitations.

3.2 Conceptual Framework and Hypotheses Development

This section presents the conceptual framework for understanding transaction values as a key measure of financial inclusion in a cashless society. This study is grounded in Financial Inclusion Theory, which highlights how digital payment adoption enhances financial accessibility, particularly for underbanked populations. Financial Inclusion Theory posits that financial technologies reduce market frictions, such as information asymmetries, transaction costs, and barriers to formal financial services (Demir et al., 2022). By leveraging digital payment systems, individuals previously excluded from traditional banking systems can participate more effectively in the economy. This theoretical foundation helps explain the observed variation in transaction values across demographic and socio-economic groups in a digital payment ecosystem.

Building on this foundation, the study incorporates the Technology Adoption Model (TAM) to explain how perceived ease of use and perceived usefulness influence digital payment adoption (Bounie & Camara, 2020). Additionally, Behavioural Finance Theories, including the 'pain of paying' (Manshad & Brannon, 2021; See-To & Ngai, 2019), suggest that digital payment methods influence consumer spending behaviour by reducing transaction friction, while 'social influence and psychological comfort' (Cruijsen & Knoben, 2021) shape adoption decisions. Rather than testing pre-established hypotheses, this study identifies patterns in financial behaviour, aligning with an inductive (theory-building) approach.

By drawing on empirical research, this section systematically analyses the determinants of Fintech adoption and formulates hypotheses that reflect both theoretical insights and real-world dynamics. The inclusion of Saudi Arabia’s institutional setting ensures that the analysis is contextually relevant, aligning with the country’s financial landscape and ongoing digital transformation initiatives under Vision 2030.

3.2.1 Gender

Empirical research has consistently highlighted gender-based differences in digital payment adoption. Choudrie et al. (2018) find that women tend to be more cautious in adopting new financial technologies due to concerns about security and trust, making them more likely to prefer digital-wallet payments. Similarly, Thaker et al. (2022) emphasize that trust and habit are

significant determinants of e-wallet adoption, particularly among individuals who prioritize financial security. In contrast, See-To and Ngai (2019) suggest that men are more inclined to use payment methods that offer immediacy and efficiency, such as Chip-and-PIN transactions, due to lower sensitivity to the "pain of paying" effect.

The psychological and behavioural factors underlying these gender differences can be explained through established theoretical frameworks. The "pain of paying" theory (See-To & Ngai, 2019) suggests that digital payment methods reduce the psychological discomfort associated with spending. Since women may prioritize financial security and control over spending, they are more likely to adopt digital wallets, which offer additional security features. Meanwhile, men, who exhibit lower sensitivity to the psychological discomfort of spending, may continue using Chip-and-PIN transactions, favouring speed and convenience. Additionally, trust theories (Choudrie et al., 2018; Thaker et al., 2022) indicate that women are more likely to use payment methods that provide a sense of safety, reinforcing their preference for digital wallets.

The Saudi institutional and cultural context further shapes gender differences in digital payment adoption. While Vision 2030 promotes women's financial inclusion, historical banking access disparities still influence their payment behaviours. Women in Saudi Arabia tend to prefer digital wallets due to their enhanced security and ease of use, aligning with previous findings on gendered adoption patterns. In contrast, men, who may have had greater historical access to financial services, might continue relying on conventional payment methods such as Chip-and-PIN.

H1: Females are more likely to adopt Digital Wallet and E-commerce payments, whereas males are more likely to use Contactless and Chip-and-PIN transactions.

3.2.2 Domiciliation

Empirical research suggests that domiciliation status—whether an individual is a local citizen or a foreign resident—plays a significant role in digital payment adoption. Choudrie et al. (2018) highlight that foreign residents often face barriers in accessing traditional banking services due to regulatory and institutional constraints, making them more inclined to adopt alternative digital payment solutions. Similarly, Kumar et al. (2021) emphasize that cultural differences influence the adoption of mobile and digital payment technologies, with expatriates often seeking payment

methods that facilitate ease of use across different financial systems. Cruijsen and Knoben (2021) further demonstrate that social influences play a key role in shaping payment preferences, with foreign residents being more likely to adopt digital payment methods that align with their home-country norms and peer influences. Additionally, See-To and Ngai (2019) discuss the role of psychological comfort in payment method selection, suggesting that foreigners may gravitate toward digital wallets and E-commerce payments due to their perceived security and ease of use in managing cross-border transactions.

From a theoretical perspective, the digital divide theory (Choudrie et al., 2018) explains why access to financial services differs between citizens and foreign residents, often leading non-citizens to rely more heavily on digital financial solutions. Additionally, cultural adaptation theories (Kumar et al., 2021) suggest that individuals from different backgrounds adopt payment technologies based on familiarity and convenience. Social influence theories (Cruijsen & Knoben, 2021) further support this argument, as expatriates tend to adopt digital financial services based on peer adoption and shared experiences in new financial environments. Finally, psychological comfort theories (See-To & Ngai, 2019) highlight that foreign residents may prefer digital-wallet and E-commerce payments due to their flexibility and security, which reduces the perceived risks of handling physical cash or using unfamiliar banking infrastructure.

In Saudi Arabia, the large expatriate population plays a significant role in the financial ecosystem. Given the reliance on international remittances and cross-border transactions, foreign residents may find digital wallets and E-commerce payments more convenient for financial management and day-to-day transactions. Moreover, banking access for expatriates has historically been more restrictive than for citizens, further motivating their adoption of alternative digital payment methods. Meanwhile, citizens, who may have greater access to established financial institutions, might continue using other digital payment methods such as Contactless and Chip-and-PIN. Given these considerations, the following hypothesis is proposed:

H2: Foreigners are more likely to adopt Digital Wallet and E-commerce payments, while citizens are more likely to use Contactless and Chip-and-PIN transactions.

3.2.3 Employment-Status

Empirical research highlights that employment status significantly influences the adoption of digital payment methods. Bounie and Camara (2020) find that financial stability and disposable income levels impact payment preferences, with employed individuals more likely to adopt convenient, fast payment solutions such as contactless payments. Similarly, Brown et al. (2022) emphasize that convenience is a key determinant in payment adoption, particularly among individuals with regular financial transactions. Choudrie et al. (2018) discuss the digital divide, highlighting that individuals with lower financial stability, including the unemployed, may be slower to adopt new payment technologies due to barriers such as access to banking services, digital literacy, and trust. Additionally, Thaker et al. (2022) identify trust and habit as significant factors shaping digital payment adoption, which may explain why unemployed individuals, facing financial uncertainty, are less inclined to shift from traditional payment methods to newer digital alternatives. Lastly, Chen et al. (2019) further highlight the inconvenience of handling cash, particularly coins, leading consumers to switch to card payments for low-value transactions. This insight is crucial for understanding how transaction values may differ based on the perceived convenience of different payment methods across demographic groups.

From a theoretical perspective, the convenience and technological adoption theories (Bounie & Camara, 2020; Brown et al., 2022) suggest that individuals with stable incomes are more likely to use digital payments that offer speed and ease of use, such as contactless payments. The digital divide theory (Choudrie et al., 2018) further explains that disparities in technology adoption arise from differences in financial access and literacy, affecting how employed and unemployed individuals engage with digital payment systems. Meanwhile, trust and habit theories (Thaker et al., 2022) indicate that unemployed individuals may be more hesitant to adopt new financial technologies due to perceived risks and established reliance on traditional payment methods.

In Saudi Arabia, financial inclusion policies and Vision 2030 initiatives are driving digital payment adoption across all employment segments. However, employed individuals, particularly those in urban areas and professional sectors, are more likely to adopt contactless payments due to their financial stability and frequent daily transactions. In contrast, unemployed individuals may continue using more familiar payment methods such as Chip-and-PIN or cash, given financial

constraints and limited access to digital banking tools. Given these considerations, the following hypothesis is proposed:

H3: Unemployed individuals are more likely to use Chip-and-PIN and E-commerce payments, while employed individuals are more likely to adopt Contactless and Digital Wallet payments.

3.2.4 Age Group

Empirical research highlights that age is a key determinant in digital payment adoption, with younger individuals more likely to embrace newer payment technologies. Jonker et al. (2022) demonstrate that external events, such as the COVID-19 pandemic, have accelerated the shift toward contactless payments, particularly among younger consumers who are more adaptable to technological change. Similarly, Brown et al. (2022) emphasize that convenience is a primary driver of payment adoption, with younger individuals preferring contactless and digital wallet payments for their speed and ease of use. See-To and Ngai (2019) explore the psychological aspects of digital payments, showing that younger individuals experience lower "pain of paying", making them more inclined to adopt digital transactions. Additionally, Li et al. (2023) find that electronic payments increase discretionary spending, particularly among younger and urban consumers, reinforcing the preference for digital wallets and contactless transactions.

From a theoretical perspective, the convenience theory (Brown et al., 2022) suggests that younger individuals prioritize fast and seamless transactions, making contactless and digital wallet payments more attractive. Psychological comfort theories (See-To & Ngai, 2019) further explain that younger consumers perceive digital payments as effortless, reducing psychological friction in spending. Meanwhile, the impact of external events (Jonker et al., 2022) highlights how younger demographics are more responsive to technological shifts, particularly following major events such as the COVID-19 pandemic. Li et al. (2023) extend this by demonstrating that digital payments contribute to higher discretionary spending, a behaviour more prevalent among younger age groups.

In Saudi Arabia, younger individuals are leading the shift toward digital finance, driven by Vision 2030 initiatives, widespread smartphone penetration, and the expansion of Fintech services. The reference group (15-24 years) is expected to show the highest adoption of contactless and digital

wallet payments. As individuals age, their likelihood of adopting these technologies may decline, with older groups (45-54 years, 55+ years) continuing to prefer Chip-and-PIN and E-commerce payments, which provide familiarity and perceived security. Given these considerations, the following hypothesis is proposed:

H4: Compared to younger individuals (15-24 years), older individuals (25-34, 35-44, 45-54, 55+) are more likely to use Chip-and-PIN and E-commerce payments, while younger individuals are more likely to adopt contactless and digital wallet payments.

3.3 Research Methodology

3.3.1 Data Description and Statistics

This research explores transaction values as a key indicator of financial inclusion in a cashless society. By examining transaction values across various payment types Chip-and-PIN payments, contactless payments, digital-wallet payments, and E-commerce payments the study evaluates the effectiveness of financial inclusion efforts within the formal financial system.

The data spans from 1 April 2019 to 31 March 2022, comprising 1,096 observations, and was secured from one of the 10 listed commercial banks in the country. The bank payment cards used in the study operate via the local payment provider, 'mada', as well as international payment providers, either Visa or Mastercard. All transaction data is aggregated daily and includes payments made both inside and outside the country, providing a view of payment behaviours.

Demographic factors such as gender, domiciliation (foreigner and citizen), employment status (unemployed and employed), and age group (15-24 years, 25-34 years, 35-44 years, 45-54 years, and 55+ years) are considered to analyse how digital payment adoption varies among different segments of the population. By monitoring digital payment adoption across these demographics, the study aims to identify strategies for bridging the digital divide and enhancing financial inclusion.

In addition to transaction data, the study incorporates exogenous factors that may influence financial behaviours, such as the COVID-19 stringency index, which measures the impact of government responses to the pandemic on daily life, and the GPR index, which tracks the economic effects of adverse geopolitical events.

Environmental, social, and economic indicators, including daily temperature data from NOAA and NCEI, Ramadan (captured as a dummy variable), the Inflation Rate provided by GASTAT, and the Stock Market Index sourced from Tadawul and Investing.com, are also included to provide a well-rounded analysis of financial behaviours and inclusion in the context of a cashless society. The definitions and descriptions of the variables used in this study are provided in Table 8.

Table 8: Definitions and Descriptions of Cashless Payments for Individuals

	Definition and Description	Source
Chip-and-PIN Payments	The use of a physical bank payment card that requires the cardholder to authorize transactions by inserting the card into a physical Point of Sale (POS) terminal and entering their Personal Identification Number (PIN) for retail location purchases	Listed Commercial Bank (LCB)
Contactless Payments	The use of a physical bank payment card embedded with a microchip, allowing for retail purchases by remotely communicating within approximately 3 cm of a POS terminal via Near-Field Communication (NFC) technology. This method eliminates the need to insert the card into the POS terminal. For small-value transactions, a PIN or re-inserting the card is typically not required	LCB
Digital-Wallet Payments	Payments made using a mobile phone or other device equipped with the functions of a bank card account, belonging to digital banking services. This software-based system securely stores bank payment card information, allowing users to make transactions using their devices. Digital wallets can be used for retail location purchases by remotely communicating within approximately 3 cm of a POS terminal via NFC technology, or for transactions through an internet gateway payment system (virtual POS), without the need to physically present a bank card	LCB
E-commerce Payments	The use of a physical bank payment card where the cardholder authorizes transactions by entering their personal information (i.e., name, card number, expiry date, and Card Code Verification (CCV)) via a virtual POS payment system. These payments are made online for the purchase of goods or services	LCB
Age Group	15-24 years, 25-34 years, 35-44 years, 45-54 years, and 55+ years	LCB
Gender	Female and Male	LCB
Domiciliation	Foreigner and Citizen	LCB
Employment Status	Unemployed and Employed	LCB
COVID-19 Stringency Index	The COVID-19 Stringency Index is a daily composite measure that tracks the stringency of government responses to the pandemic based on nine key metrics: school closures, workplace closures, cancellation of public events, restrictions on public gatherings, closures of public transport, stay-at-home requirements, public information campaigns, restrictions on internal movements, and international travel controls. The index for any given day is calculated as the mean score of these nine metrics, with each metric ranging from 0 to 100. A higher score indicates a stricter response, with 100 representing the most stringent possible response	Our World In Data (University of Oxford)
Geopolitical Risk (GPR) Index	Developed by Dario Caldara and Matteo Iacoviello, this monthly measure is based on a tally of newspaper articles covering geopolitical tensions. The index captures the evolution and economic effects of adverse geopolitical events, categorized into eight areas: war threats, peace threats, military build-ups, nuclear threats, terror threats, beginning of war, escalation of war, and terror acts. The GPR Index is derived from automated text-search results within the electronic archives of 10 newspapers, dating back to 1985, by counting the number of articles related to these geopolitical events each month, expressed as a share of the total number of news articles. This monthly data was then converted and distributed on a daily basis for more granular analysis	EPU
Temperature (Celsius)	The average daily temperature data is sourced from the National Oceanic and Atmospheric Administration (NOAA) and the	NOAA and NCEI

	National Centers for Environmental Information (NCEI). This data is reported in Celsius and is collected from 29 weather stations across the country, providing a measure of daily temperature variations	
Ramadan	Ramadan is a lunar month that lasts either 29 or 30 days, unlike the fixed lengths of calendar months in the Gregorian system. Because of its lunar basis, Ramadan shifts across different months of the Gregorian calendar each year. To reflect the influence of Ramadan within calendar-based financial data, a dummy variable is created where days falling within Ramadan are assigned a value of 1, and all other days are assigned a value of 0. This allows the lunar cycle of Ramadan to be represented in analyses that use the Gregorian calendar	Researcher calculations, by using Umm Al-Qura Islamic Calendar
Inflation Rate	The inflation rate is provided by the General Authority for Statistics in Saudi Arabia (GASTAT) on a monthly basis. GASTAT defines the inflation rate as the average rate of change in the Consumer Price Index (CPI) compared to the same month in the previous year. To align with daily financial data, this monthly inflation rate data was converted and distributed on a daily basis	GASTAT
Stock Market Index	The stock market data is sourced from Tadawul and Investing.com, based on the daily closing price index. On days when the stock market is closed, such as weekends, religious holidays, and national days, the last available closing price from the most recent trading day is retained and used until the market reopens	Tadawul and Investing.com

The descriptive statistics in Tables 9, 10, and 11 provide a detailed analysis of cashless payment behaviours across different demographic groups and control variables. Tables 9 and 10 present statistics for various payment types and demographic segments, including gender, domiciliation, employment status (with t-tests), and age groups (with ANOVA tests) highlighting significant differences in transaction values. Table 11 summarizes key statistics for control variables such as the COVID-19 index, GPR index, and other relevant factors, which are important for understanding the broader context of cashless payment during the study period.

Table 9 presents the descriptive statistics for cashless payments across different demographic groups, including gender, domiciliation, and employment status. The table is divided into five panels (A-E), each representing a different payment type: overall cashless payments, Chip-In payments, contactless payments, digital wallets, and E-commerce payments.

Table 9 also includes the results of t-tests, which assess the statistical significance of differences in payment behaviours between groups (e.g., male vs. female). The t-statistics and associated p-values indicate statistically significant differences in payment behaviours across all demographic comparisons, with p-values of 0.0000 in all cases. This suggests that these differences are unlikely to be due to chance or random variation.

For example, Panel A shows that males have significantly higher overall cashless payment values (mean: USD 167.88 thousand) compared to females (mean: USD 75.86 thousand), with a t-statistic of -72.45. Similarly, Panel B indicates that citizens have higher Chip-and-PIN payment values compared to foreigners, with a mean difference of USD 87.30 thousand, as shown by the t-statistic of -72.10.

Table 10 shows the descriptive statistics for cashless payments across different age groups, with payment values expressed in USD thousands. The table is divided into five panels (A-E), each representing a different payment type: overall cashless payments, Chip-In payments, contactless payments, digital-wallet payments, and E-commerce payments.

Table 10 also includes the results of an ANOVA test, which evaluates the statistical significance of differences in payment behaviours across age groups. The F-statistic and associated p-values (Prob > F) indicate that the differences across age groups for all payment types are statistically significant ($p < 0.001$). This finding suggests that age groups have distinct preferences or patterns in the use of different cashless payment methods, with these differences unlikely to be due to chance or random variation.

For example, Panel C shows that the 25-34 age group has the highest mean value for contactless payments (USD 515.27 thousand), indicating a greater tendency to use contactless payments compared to other age groups. Similarly, Panel D shows that digital wallet payments are most popular among the 25-34 age group, with a mean value of USD 355.58 thousand.

Table 11 provides descriptive statistics for the control variables used in the study, including the COVID-19 index, GPR index, temperature, Ramadan, inflation, and the stock index. For instance, the COVID-19 stringency index has a mean value of 45.15, with a maximum of 94.44, indicating that government responses to the pandemic varied significantly over time. The GPR index, with a mean of 0.23, reflects generally low but occasionally heightened geopolitical tensions during the study period. Temperature data, measured in degrees Celsius, ranges from a minimum of 11.29 to a maximum of 35.68, showing the variability in daily temperatures across the country.

Table 9: Descriptive Statistics by Gender, Domiciliation, Employment Status, and t-Test of Cashless Payments

	N	Min	p1	Mean	Std. Err.	p50	SD	p99	Max	t-statistic	Pr(T < t)
Panel A: Overall Cashless Payments by USD Thousand											
Gender											
Female	87,680	0.00	0.00	75.86	0.55	11.52	162.18	823.92	1,715.00		
Male	87,680	0.00	0.09	167.88	1.15	38.29	339.33	1,774.59	3,126.48		
Total	175,360	0.00	0.01	121.87	0.64	22.21	269.89	1,421.51	3,126.48		
diff				-92.02	1.27					-72.45	0.0000
Domiciliation											
Foreigner	87,680	0.00	0.00	35.71	0.34	4.95	101.37	597.42	1,330.80		
Citizen	87,680	0.02	1.00	208.03	1.17	72.08	347.21	1,774.59	3,126.48		
Total	175,360	0.00	0.01	121.87	0.64	22.21	269.89	1,421.51	3,126.48		
diff				-172.32	1.22					-140.00	0.0000
Employment Status											
Unemployed	87,680	0.00	0.01	95.52	0.70	16.71	208.74	1,119.40	1,965.99		
Employed	87,680	0.00	0.01	148.22	1.07	30.16	317.36	1,772.01	3,126.48		
Total	175,360	0.00	0.01	121.87	0.64	22.21	269.89	1,421.51	3,126.48		
diff				-52.70	1.28					-41.08	0.0000
Panel B: Chip-In Payments by USD Thousand											
Gender											
Female	21,920	0.00	0.01	42.80	0.61	8.71	89.92	476.61	940.30		
Male	21,920	0.00	0.19	87.97	1.11	31.29	163.83	901.09	1,653.74		
Total	43,840	0.00	0.04	65.38	0.64	18.71	134.06	713.46	1,653.74		
diff				-45.17	1.26					-35.78	0.0000
Domiciliation											
Foreigner	21,920	0.00	0.01	21.73	0.35	3.14	51.19	273.96	572.74		
Citizen	21,920	0.08	0.96	109.03	1.16	44.16	171.80	902.96	1,653.74		
Total	43,840	0.00	0.04	65.38	0.64	18.71	134.06	713.46	1,653.74		
diff				-87.30	1.21					-72.10	0.0000
Employment Status											
Unemployed	21,920	0.00	0.10	48.24	0.66	14.22	97.01	542.37	940.30		
Employed	21,920	0.00	0.01	82.52	1.09	24.60	161.08	901.09	1,653.74		
Total	43,840	0.00	0.04	65.38	0.64	18.71	134.06	713.46	1,653.74		
diff				-34.28	1.27					-26.99	0.0000
Panel C: Contactless Payments by USD Thousand											
Gender											

Female	21,920	0.01	0.30	148.64	1.49	43.61	221.06	985.31	1,533.47		
Male	21,920	0.11	1.42	356.90	3.34	152.62	495.02	2,196.77	3,126.48		
Total	43,840	0.01	0.53	252.77	1.90	80.52	397.23	1,945.84	3,126.48		
diff				-208.26	3.66					-56.87	0.0000
Domiciliation											
Foreigner	21,920	0.01	0.29	81.50	1.16	18.22	171.96	841.59	1,330.80		
Citizen	21,920	1.66	7.65	424.04	3.22	249.84	476.82	2,196.77	3,126.48		
Total	43,840	0.01	0.53	252.77	1.90	80.52	397.23	1,945.84	3,126.48		
diff				-342.54	3.42					-100.00	0.0000
Employment Status											
Unemployed	21,920	0.10	0.94	191.57	1.93	62.68	286.31	1,311.10	1,879.95		
Employed	21,920	0.01	0.31	313.97	3.21	110.00	475.53	2,196.77	3,126.48		
Total	43,840	0.01	0.53	252.77	1.90	80.52	397.23	1,945.84	3,126.48		
diff				-122.40	3.75					-32.65	0.0000
Panel D: Digital Wallet Payments by USD Thousand											
Gender											
Female	21,920	0.00	0.00	93.31	1.30	11.31	192.77	918.28	1,715.00		
Male	21,920	0.00	0.06	183.91	2.41	35.25	357.12	1,724.49	3,062.97		
Total	43,840	0.00	0.00	138.61	1.39	21.99	290.51	1,445.50	3,062.97		
diff				-90.60	2.74					-33.05	0.0000
Domiciliation											
Foreigner	21,920	0.00	0.00	27.35	0.49	3.65	73.24	411.34	811.21		
Citizen	21,920	0.02	1.29	249.87	2.52	87.20	372.39	1,724.49	3,062.97		
Total	43,840	0.00	0.00	138.61	1.39	21.99	290.51	1,445.50	3,062.97		
diff				-222.53	2.56					-86.81	0.0000
Employment Status											
Unemployed	21,920	0.00	0.00	115.58	1.71	15.03	253.58	1,239.65	1,965.99		
Employed	21,920	0.00	0.00	161.64	2.17	29.47	321.62	1,689.76	3,062.97		
Total	43,840	0.00	0.00	138.61	1.39	21.99	290.51	1,445.50	3,062.97		
diff				-46.05	2.77					-16.65	0.0000
Panel E: E-commerce Payments by USD Thousand											
Gender											
Female	21,920	0.00	0.01	18.69	0.23	4.55	33.81	150.61	565.65		
Male	21,920	0.00	0.02	42.76	0.38	14.76	56.08	224.13	623.52		
Total	43,840	0.00	0.01	30.73	0.23	8.07	47.85	203.56	623.52		
diff				-24.07	0.44					-54.42	0.0000

Domiciliation											
Foreigner	21,920	0.00	0.00	12.27	0.17	2.58	25.27	114.23	238.99		
Citizen	21,920	0.04	0.66	49.19	0.39	25.24	57.09	227.59	623.52		
Total	43,840	0.00	0.01	30.73	0.23	8.07	47.85	203.56	623.52		
diff				-36.91	0.42					-87.55	0.0000
Employment Status											
Unemployed	21,920	0.00	0.01	26.69	0.30	6.97	44.87	188.54	565.65		
Employed	21,920	0.00	0.01	34.77	0.34	9.61	50.33	213.73	623.52		
Total	43,840	0.00	0.01	30.73	0.23	8.07	47.85	203.56	623.52		
diff				-8.08	0.46					-17.75	0.0000

Table 10: Descriptive Statistics by Age Group and ANOVA Test of Cashless Payments

	N	Min	p1	Mean	Std. Err.	p50	SD	p99	Max	F-statistic	Prob > F
Panel A: Overall Cashless Payments by USD Thousand											
15-24 years	35,072	0.00	0.00	71.58	0.88	6.94	164.58	850.48	1,480.91		
25-34 years	35,072	0.16	1.29	267.03	2.26	77.85	423.94	1,950.56	3,075.89		
35-44 years	35,072	0.03	0.47	163.80	1.69	38.50	315.73	1,720.48	3,126.48		
45-54 years	35,072	0.00	0.06	71.37	0.72	15.98	135.53	751.13	1,446.58		
55+ years	35,072	0.00	0.00	35.59	0.34	7.86	63.16	290.97	467.40		
Total	175,360	0.00	0.01	121.87	0.06	22.21	269.89	1,421.51	3,126.48	6,439.33	0.0000
Panel B: Chip-In Payments by USD Thousand											
15-24 years	8,768	0.00	0.00	18.06	0.43	2.56	40.05	214.03	501.68		
25-34 years	8,768	0.16	1.20	121.04	2.09	47.89	195.54	929.38	1,418.43		
35-44 years	8,768	0.08	0.86	100.18	1.89	32.65	177.21	972.73	1,653.74		
45-54 years	8,768	0.00	0.31	55.36	0.98	22.21	91.46	502.88	809.65		
55+ years	8,768	0.00	0.06	32.27	0.54	13.73	50.17	226.18	466.23		
Total	43,840	0.00	0.04	65.38	0.64	18.71	134.06	713.46	1,653.74	1,033.68	0.0000
Panel C: Contactless Payments by USD Thousand											
15-24 years	8,768	0.01	0.15	122.56	2.25	22.49	210.34	946.54	1,314.36		
25-34 years	8,768	1.79	6.36	515.27	6.03	348.36	564.31	2,342.28	3,075.89		
35-44 years	8,768	1.57	4.36	365.23	5.24	180.68	490.51	2,199.22	3,126.48		
45-54 years	8,768	0.42	1.46	171.05	2.27	96.41	212.92	943.40	1,446.58		
55+ years	8,768	0.11	0.62	89.73	0.99	57.14	92.86	338.95	467.40		

Total	43,840	0.01	0.53	252.77	1.90	80.52	397.23	1,945.84	3,126.48	2197.35	0.0000
Panel D: Digital-Wallet Payments by USD Thousand											
15-24 years	8,768	0.00	0.00	128.16	2.39	19.65	223.67	994.04	1,480.91		
25-34 years	8,768	0.20	0.78	355.58	5.13	114.27	479.96	1,972.62	3,062.97		
35-44 years	8,768	0.03	0.20	149.15	2.72	34.01	254.26	1,225.18	1,995.58		
45-54 years	8,768	0.00	0.01	45.05	0.77	10.63	72.22	345.62	565.87		
55+ years	8,768	0.00	0.00	15.12	0.23	4.40	21.58	88.55	160.11		
Total	43,840	0.00	0.00	138.61	1.39	21.99	290.51	1,445.50	3,062.97	2,228.11	0.0000
Panel E: E-commerce Payments by USD Thousand											
15-24 years	8,768	0.00	0.00	17.54	0.32	2.99	29.82	124.74	246.77		
25-34 years	8,768	0.80	2.31	76.21	0.73	67.11	68.72	262.82	565.65		
35-44 years	8,768	0.08	0.65	40.63	0.49	25.69	45.93	187.78	349.68		
45-54 years	8,768	0.00	0.06	14.03	0.21	8.29	19.60	76.95	623.52		
55+ years	8,768	0.00	0.00	5.23	0.09	2.87	8.45	30.77	353.78		
Total	43,840	0.00	0.01	30.73	0.23	8.07	47.85	203.56	623.52	4,383.10	0.0000

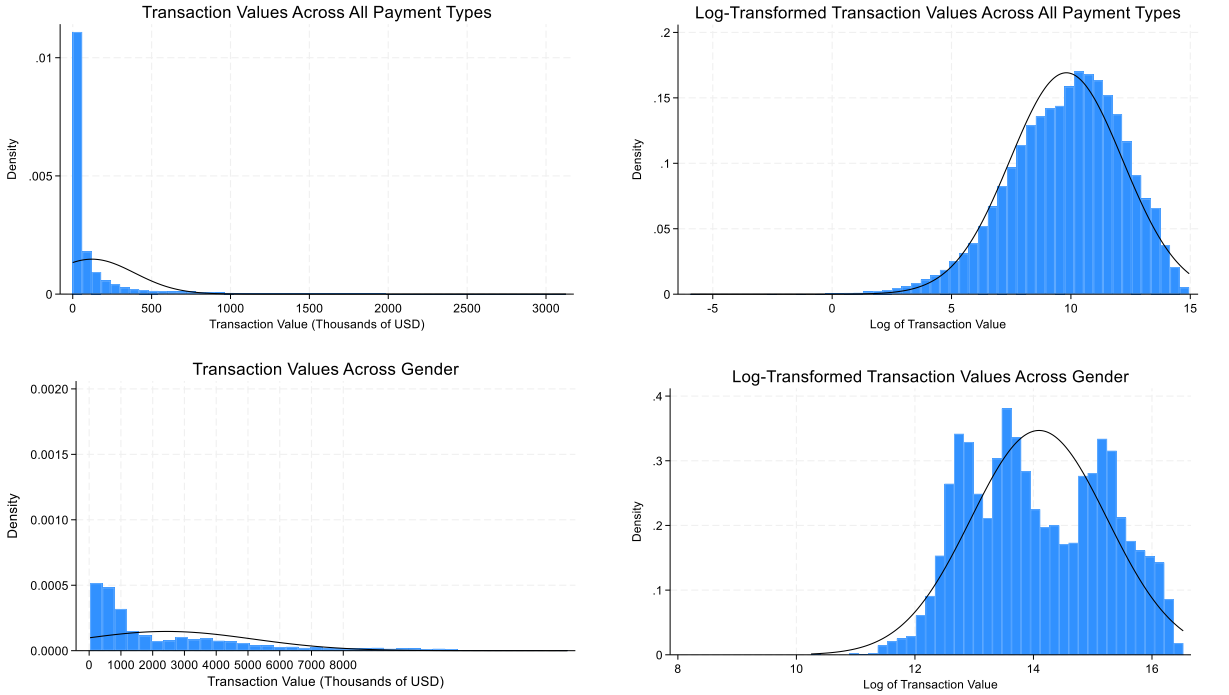
Table 11: Descriptive Statistics of Control Variables of Cashless Payments for Individuals

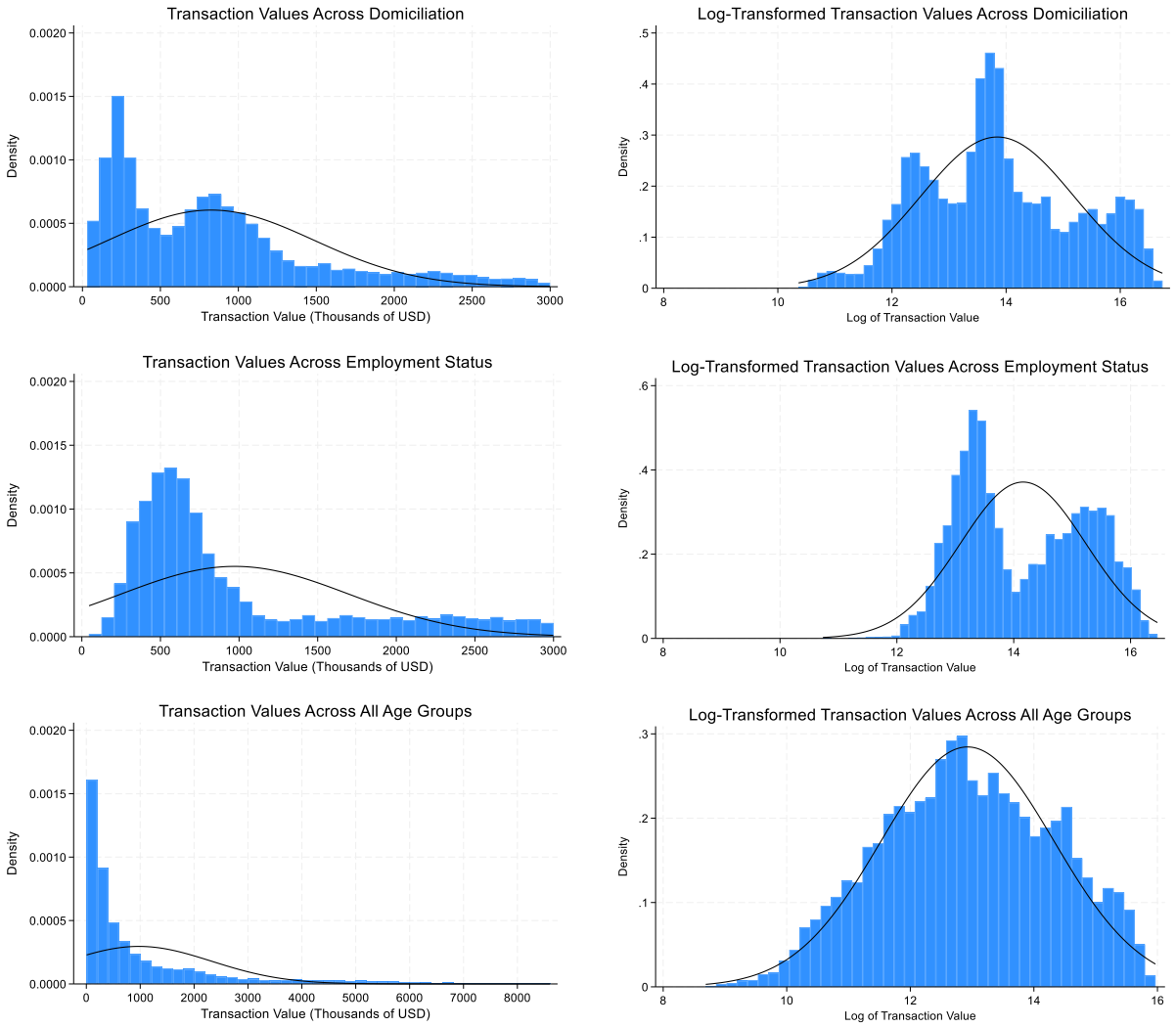
	N	Min	p1	Mean	Std. Err.	p50	SD	p99	Max
COVID 19	1,096	0.00	0.00	45.15	0.97	53.70	32.07	91.67	94.44
GPR	1,096	0.06	0.06	0.23	0.01	0.14	0.21	0.90	0.90
Temperature	1,096	11.29	12.42	25.94	0.21	26.51	6.82	35.21	35.68
Ramadan	1,096	0.00	0.00	0.08	0.01	0.00	0.27	1.00	1.00
Inflation	1,096	-3.21	-3.21	1.74	0.09	1.12	3.06	6.16	6.16
Stock-Market Index	1,096	5,959.7	6,287.4	9,207.3	51.0	8,696.7	1,688.9	12,851.2	13,101.4
From 1 April 2019 to 31 March 2022									

The distribution of transaction values across various demographic groups and payment types is presented in Figure 2, both in their original form and as log-transformed data. The central tendency of the data is highlighted, with most transactions observed to cluster around a specific value range, as indicated by the peaks in the density plots. The distribution is particularly normalized by the log-transformed data, making the central tendency easier to identify and the impact of outliers reduced.

For example, a clear central tendency is observed in the log-transformed density plots of transaction values across employment status, where a higher concentration of transaction values in the mid to high range is shown among employed individuals compared to unemployed individuals. This pattern aligns with the mean values discussed in Table 9. Similarly, distinct preferences in transaction values are revealed across age groups, with younger age groups showing more variation in transaction amounts (Table 10).

Figure 2: Log-Transformation of Cashless Payments of Individuals





3.3.2 Empirical Models

In this study, four empirical models are constructed to analyse the relationship between cashless payment values and various demographic factors, using data from 1 April 2019 to 31 March 2022. These models incorporate key demographic variables, interaction terms, and control variables to account for exogenous influences, enabling a comprehensive examination of financial behaviours in a cashless society.

Given the nature of the data, which includes both cross-sectional (across different demographic groups) and time-series (daily observations over three years) dimensions, a panel regression analysis is employed. This method allows for the analysis of data that varies both over time and across individuals, making it particularly suitable for this study. The inclusion of interaction terms

further enhances the model by allowing the exploration of how the effects of payment types differ across various demographic groups.

3.3.2.1 Model 1 Gender

$$Cashless\ Payment_{pft} = \beta_0 + \beta_1 Female_f + \beta_2 Payment\ Type_p + \beta_3 Female_f * Payment\ Type_p + \beta_4 Covid\ Index_t + \beta_5 Geopolitical\ Risk_{\ t} + \beta_6 Temperature_t + \beta_7 Ramadan_t + \beta_8 Inflation\ Rate_{t-1} + \beta_9 Stock\ Market\ Index_{t-1} + e_{it}$$

Where:

$Cashless\ Payment_{pft}$ represents the transaction value for payment type p, gender f, and time (day) t.

$Female_f$ is a binary variable (1 = Female, 0 = Male).

$Payment\ Type_p$ represents different digital payment methods (Contactless, Digital Wallet, E-commerce, with Chip-and-PIN as the reference category).

$Female_f * Payment\ Type_p$ captures whether gender differences vary across payment types compared to Chip-and-PIN.

Covid Index $_t$, *Geopolitical Risk* $_t$, *Temperature* $_t$, *Ramadan* $_t$, *Inflation Rate* $_{(t-1)}$, *Stock Market Index* $_{(t-1)}$ are control variables accounting for exogenous and macroeconomic factors.

e_{it} represents the error term.

This model examines the role of gender in determining transaction values across different payment types. The interaction term $Female_f * Payment\ Type_p$ allows for an examination of whether gender differences in transaction values vary across different payment types, compared to the reference category (Chip-and-PIN payments). By including control variables such as Covid Index, Geopolitical Risk (GPR), Temperature, Ramadan, Inflation Rate, and Stock Market Index, the model accounts for key external influences on digital payment behaviours. Through this analysis, gender-based differences in financial inclusion are explored.

3.3.2.2 Model 2 Domiciliation

$$Cashless\ Payment_{pdt} = \beta_0 + \beta_1 Foreigner_d + \beta_2 Payment\ Type_p + \beta_3 Foreigner_d * Payment\ Type_p + \beta_4 Covid\ Index_t + \beta_5 Geopolitical\ Risk_t + \beta_6 Temperature_t + \beta_7 Ramadan_t + \beta_8 Inflation\ Rate_{t-1} + \beta_9 Stock\ Market\ Index_{t-1} + e_{it}$$

Where:

$Cashless\ Payment_{pdt}$ represents the transaction value for payment type p, domiciliation d, and time (day) t.

$Foreigner_d$ is a binary variable (1 = Foreigner, 0 = Citizen).

$Payment\ Type_p$ represents different digital payment methods (Contactless, Digital Wallet, E-commerce, with Chip-and-PIN as the reference category).

$Foreigner_d * Payment\ Type_p$ captures whether gender differences vary across payment types compared to Chip-and-PIN.

Covid Index $_t$, $Geopolitical\ Risk_t$, *Temperature* $_t$, *Ramadan* $_t$, *Inflation Rate* $_{(t-1)}$, *Stock Market Index* $_{(t-1)}$ are control variables accounting for exogenous and macroeconomic factors.

e_{it} represents the error term.

This model examines the role of domiciliation in determining transaction values across different payment types. The interaction term $Foreigner_d * Payment\ Type_p$ allows for an examination of whether domiciliation differences in transaction values vary across different payment types, compared to the reference category (Chip-and-PIN payments). By including control variables such as Covid Index, Geopolitical Risk (GPR), Temperature, Ramadan, Inflation Rate, and Stock Market Index, the model accounts for key external influences on digital payment behaviours. Through this analysis, domiciliation-based differences in financial inclusion are explored.

3.3.2.3 Model 3 Employment-Status

$$Cashless\ Payment_{put} = \beta_0 + \beta_1 Unemployed_u + \beta_2 Payment\ Type_p + \beta_3 Unemployed_u * Payment\ Type_p + \beta_4 Covid\ Index_t + \beta_5 Geopolitical\ Risk_t + \beta_6 Temperature_t + \beta_7 Ramadan_t + \beta_8 Inflation\ Rate_{t-1} + \beta_9 Stock\ Market\ Index_{t-1} + e_{it}$$

Where:

$Cashless\ Payment_{put}$ represents the transaction value for payment type p, domiciliation u, and time (day) t.

$Unemployed_u$ is a binary variable (1 = Unemployed, 0 = Employed).

$Payment\ Type_p$ represents different digital payment methods (Contactless, Digital Wallet, E-commerce, with Chip-and-PIN as the reference category).

$Unemployed_u * Payment\ Type_p$ captures whether employment-status differences vary across payment types compared to Chip-and-PIN.

Covid Index $_t$, $Geopolitical\ Risk_t$, *Temperature* $_t$, *Ramadan* $_t$, *Inflation Rate* $_{(t-1)}$, *Stock Market Index* $_{(t-1)}$ are control variables accounting for exogenous and macroeconomic factors.

e_{it} represents the error term.

This model examines the role of employment-status in determining transaction values across different payment types. The interaction term $Unemployed_u * Payment\ Type_p$ allows for an examination of whether employment-status differences in transaction values vary across different payment types, compared to the reference category (Chip-and-PIN payments). By including control variables such as Covid Index, Geopolitical Risk (GPR), Temperature, Ramadan, Inflation Rate, and Stock Market Index, the model accounts for key external influences on digital payment behaviours. Through this analysis, employment-status-based differences in financial inclusion are explored.

3.3.2.4 Model 4 Age Group

$$Cashless\ Payment_{pat} = \beta_0 + \beta_1 Age\ Group_a + \beta_2 Payment\ Type_p + \beta_3 Age\ Group_a * Payment\ Type_p + \beta_4 Covid\ Index_t + \beta_5 Geopolitical\ Risk_t + \beta_6 Temperature_t + \beta_7 Ramadan_t + \beta_8 Inflation\ Rate_{t-1} + \beta_9 Stock\ Market\ Index_{t-1} + e_{it}$$

Where:

$Cashless\ Payment_{pat}$ represents the transaction value for payment type p, Age Group a, and time (day) t.

$Age\ Group_a$ is a categorical variable that represents different age categories: 15-24 years (reference category), 25-34 years, 35-44 years, 45-54 years, 55+ years

$Payment\ Type_p$ represents different digital payment methods (Contactless, Digital Wallet, E-commerce, with Chip-and-PIN as the reference category).

$Age\ Group_a * Payment\ Type_p$ captures whether age group differences in transaction values vary across different payment types, compared to the reference categories (15-24 years for age and Chip-and-PIN for payment type).

Covid Index $_t$, *Geopolitical Risk* $_t$, *Temperature* $_t$, *Ramadan* $_t$, *Inflation Rate* $_{(t-1)}$, *Stock Market Index* $_{(t-1)}$ are control variables accounting for exogenous and macroeconomic factors.

e_{it} represents the error term.

This model examines how age group influences transaction values across different payment types. The reference category for age is individuals aged 15-24 years, while for payment type, Chip-and-PIN payments serve as the reference. The interaction term $Age\ Group_a * Payment\ Type_p$ allows for an examination of whether age-based differences in transaction values vary across different payment types, compared to the reference categories (15-24 years and Chip-and-PIN payments). By including control variables such as Covid Index, Geopolitical Risk (GPR), Temperature, Ramadan, Inflation Rate, and Stock Market Index, the model accounts for key external influences

on digital payment behaviours. Through this analysis, age-based differences in financial inclusion are explored.

3.3.3 Control Factors

3.3.3.1 COVID-19 Pandemic

The COVID-19 pandemic drastically altered consumer behaviour, particularly in the adoption of digital payment methods. To account for these effects, we include the COVID-19 stringency index as a control variable. Jonker et al. (2022) conducted a study in the Netherlands, showing that the pandemic accelerated the shift from cash to contactless payments, especially among older consumers concerned about health risks. This finding is crucial for understanding age-related payment behaviours in our analysis. Similarly, Amankwah-Amoah et al. (2021) emphasized the global acceleration of digital technologies, including digital wallets, due to the pandemic. This rapid digitalization is particularly relevant when examining differences in payment method adoption across gender and employment status. Baker et al. (2020) analysed transaction-level financial data in the United States, documenting initial spending spikes followed by declines as lockdowns were enforced. These changes are essential for understanding transaction value variations in our study. Carvalho et al. (2022) examined the pandemic's impact in Portugal, noting sharper transaction declines in urban areas, particularly in sectors like tourism. This regional variation is vital for analysing differences in payment behaviours between foreigners and citizens.

3.3.3.2 Geopolitical Risk

Geopolitical risk (GPR) is a significant factor influencing financial behaviour and corporate decision-making. To account for its impact, we include the GPR Index as a control variable. Ghirelli et al. (2019) demonstrated that the Economic Policy Uncertainty (EPU) index, closely related to GPR, is highly sensitive to methodological choices, highlighting the importance of accurate GPR measurement in understanding its economic impact. Adra et al. (2023) found that heightened geopolitical risks lead to more conservative corporate payout strategies in the United States, with firms reducing share repurchases during periods of increased GPR. Alsagr et al. (2023) revealed that higher GPR negatively impacts crowdfunding success in developing countries, as perceived risks in uncertain geopolitical environments discourage investment. Similarly, El

Khoury et al. (2023) analysed the impact of the Russia–Ukraine war on financial markets, showing how geopolitical risks cause shifts in the roles of key asset classes, affecting risk management strategies and portfolio allocations in both developed and emerging markets.

3.3.3.3 Temperature

Temperature is a critical environmental factor influencing economic and financial outcomes. To account for its impact, we include temperature as a control variable. Pankratz et al. (2023) studied the effects of high temperatures on firm performance across 93 countries, finding that extreme heat negatively affects revenues and operating income. This underscores the importance of considering temperature fluctuations in financial performance analyses. Asfaw and Maggio (2018) examined gender-differentiated effects of temperature shocks on household welfare in Malawi, showing that temperature shocks reduce consumption, with more severe impacts on households where women manage land. Agarwal et al. (2020) explored the effect of sunshine-induced mood on credit card spending in the United States, documenting that abnormal sunshine increases same-day spending, especially among consumers with higher debt and lower credit quality. Tran (2023) applied a machine-learning-based weather index to study weather's impact on sales in the U.S., finding that extreme heat significantly affects sales, suggesting that temperature variability could increase sales volatility under climate change.

3.3.3.4 Ramadan

Ramadan, a significant period in the Muslim calendar, can notably affect economic and financial behaviours. To account for these effects, we include Ramadan as a control variable. Goodell et al. (2023) provided a comprehensive review of how culture, including religious practices, influences financial decision-making, suggesting that Ramadan can significantly impact financial activities due to changes in social trust and behaviour. Cao et al. (2019) explored the impact of religiosity on trade credit in China, finding that religious practices enhance ethical business behaviour and contract enforcement, relevant to the increased spiritual engagement during Ramadan. Farmaki et al. (2020) examined religion's influence on entrepreneurship, particularly in hospitality and tourism, highlighting that religious periods can affect entrepreneurial motivation and behaviour, often leading to changes in business activities. Demiroglu et al. (2021) specifically investigated

Ramadan's effects on financial decision-making in Turkey, finding that loans originated during Ramadan are more likely to default due to both physiological stress from fasting and spiritual sentiments.

3.3.3.5 Inflation Rate

The inflation rate is a key macroeconomic factor influencing consumer behaviour, investment decisions, and overall economic stability. To account for its impact, we include the inflation rate as a control variable. Ehling et al. (2018) showed that inflation disagreement, not just expected inflation, significantly impacts nominal interest rates and yield volatility. This underscores the importance of considering inflation dynamics in financial models. Akbar (2021) explored the determinants of money demand in Pakistan, highlighting inflation uncertainty as a critical factor, with rising uncertainty directly influencing the precautionary and transactional demand for money. Zheng (2020) examined the relationship between inflation and income inequality, showing that inflation can mitigate income inequality by reducing the relative importance of asset income compared to wage income.

Duca-Radu et al. (2021) investigated how consumers' beliefs about future inflation affect spending behaviour across multiple countries, finding that higher inflation expectations can stimulate consumer spending, particularly when interest rates are at their lower bound.

3.3.3.6 Stock Market Index

The stock market index is a crucial indicator of economic performance, reflecting investor sentiment, corporate profitability, and broader economic conditions. It is essential to control for stock market movements in our models. Swamy (2022) investigated the impact of financial wealth, as measured by stock market capitalization, on household consumption in India, finding a significant positive relationship between stock market wealth and private consumption. Di Maggio et al. (2020) examined the relationship between stock market returns and household consumption in Sweden, revealing that capital gains from stock holdings significantly impact consumption, especially for lower-wealth households. Ahn et al. (2019) explored the effects of stock market uncertainty on economic fundamentals in China, finding that increased stock market uncertainty leads to short-term declines in industrial production and increases in systemic risk. Atmaz and

Basak (2022) developed a model explaining how the presence of no-dividend stocks can affect the overall risk premium and investor behaviour, highlighting the importance of considering stock market dynamics in financial models.

3.3.4 Correlation and Relationship Analysis

Table 12 presents the correlations among demographic factors, payment types, and transaction values. The results show that all demographic factors, including age groups, gender (female), foreigner status, and employment status (unemployed), have statistically significant correlations with transaction values. Notably, the correlation between foreigner status and transaction value is the strongest, with a correlation coefficient of -0.55, indicating a significant negative relationship. This suggests that foreigners tend to have lower transaction values compared to citizens.

Table 12 extends the analysis to include exogenous factors such as the COVID-19 index, GPR index, temperature, Ramadan, inflation, and stock market performance. Here, the COVID-19 index shows a positive correlation with transaction values (0.08), indicating that as COVID-19 restrictions increased, transaction values also rose, possibly due to a shift towards digital transactions during the pandemic. On the other hand, GPR index and temperature exhibit negative correlations with transaction values, suggesting that higher geopolitical risks and temperatures might be associated with lower transaction values.

Table 12: Correlation Matrix of Cashless Payments for Individuals

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
(1) Transactions Value	1											
(2) Payment Types	-0.15***	1										
(3) Female	-0.23***	0.00	1									
(4) Foreigner	-0.55***	0.00	0.00	1								
(5) Unemployed	-0.09***	0.00	0.00	0.00	1							
(6) Age Groups	-0.12***	0.00	0.00	0.00	0.00	1						
(7) COVID 19	0.08***	0.00	0.00	0.00	0.00	0.00	1					
(8) GPR	-0.05***	0.00	0.00	0.00	0.00	0.00	-0.63***	1				
(9) Temperature	-0.03***	0.00	0.00	0.00	0.00	0.00	-0.02***	-0.08***	1			
(10) Ramadan	-0.02***	0.00	0.00	0.00	0.00	0.00	0.03***	0.03***	0.15***	1		
(11) Inflation	0.06***	0.00	0.00	0.00	0.00	0.00	0.55***	-0.51***	-0.09***	-0.05***	1	
(12) Stock Market	0.12***	0.00	0.00	0.00	0.00	0.00	0.29***	-0.10***	-0.13***	-0.12***	0.09***	1

*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Figure 3 present an analysis of the relationship between transaction values and various demographic factors across different payment types. The figures illustrate how transaction values, log-transformed to normalize the distribution, vary over time for different payment methods Chip-In, contactless, digital wallet, and E-commerce within the context of age group, gender, domiciliation status, and employment status.

In the first part of the analysis, the overall trends in transaction values by payment type are depicted, revealing distinct patterns in the use of different payment methods over the study period. The log transformation applied to the data allows for a clearer view of central tendencies and variability, highlighting how certain payment types, such as contactless and digital wallet payments, have seen more consistent growth compared to others.

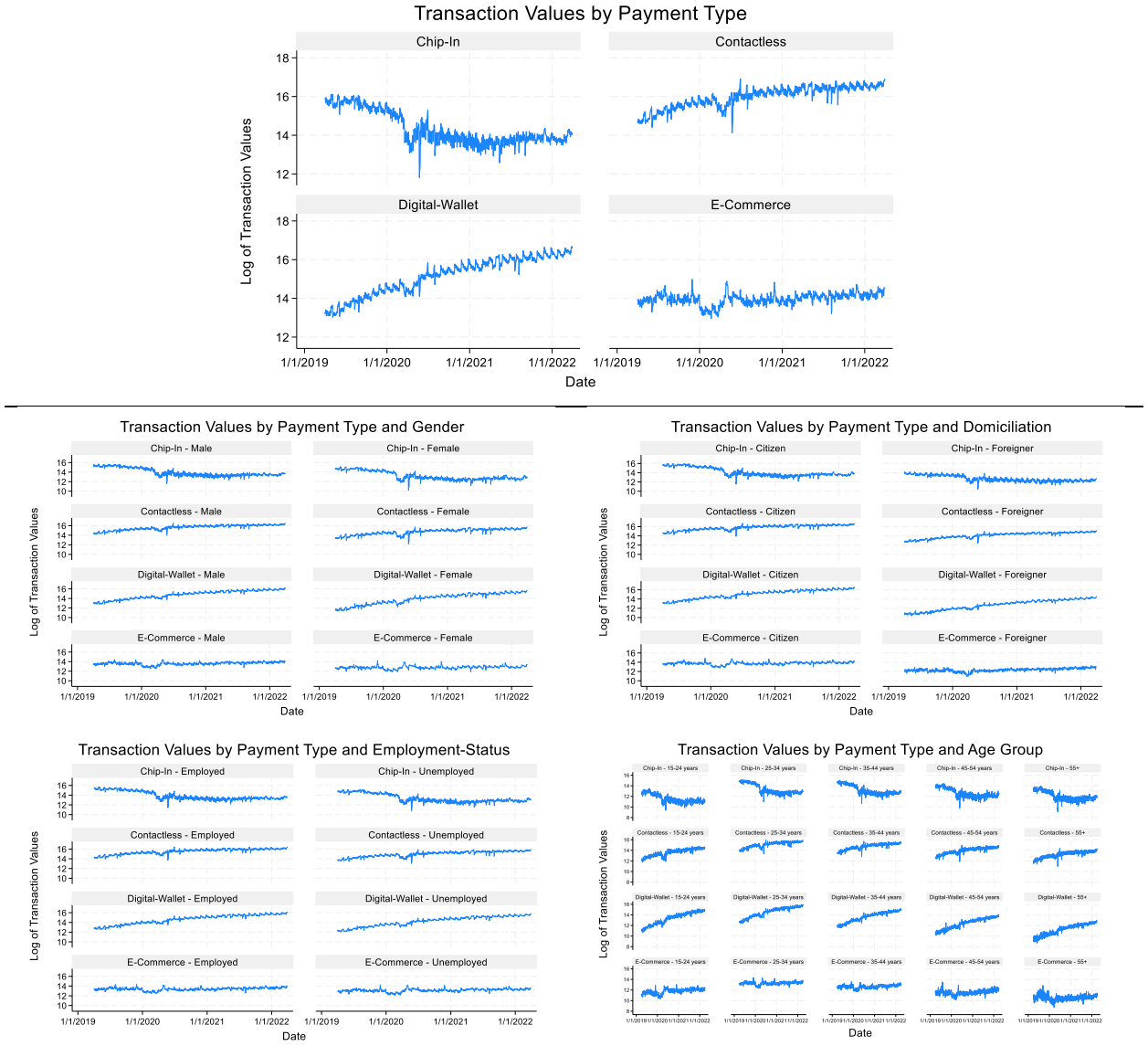
When segmented by age group, the data reveals age-specific behaviours, with younger age groups demonstrating more variability in transaction values, especially in their use of digital wallets and E-commerce platforms. This suggests that younger individuals may be more adaptable to newer forms of payment technologies, reflecting broader trends in digital adoption.

Gender-specific analysis shows that males and females exhibit different transaction behaviours across the various payment types. For instance, males appear to engage more frequently in higher-value transactions across all payment types, with notable differences in the use of contactless and E-commerce payments. This gender-based differentiation underscores the need to consider gender as a significant factor in strategies aimed at enhancing financial inclusion.

Domiciliation status further differentiates transaction patterns, with citizens generally showing higher transaction values compared to foreigners, particularly in the use of contactless and digital wallet payments. This could indicate differences in access or familiarity with certain payment technologies between these groups.

Lastly, the analysis by employment status reveals that employed individuals consistently show higher transaction values across all payment types compared to unemployed individuals. This divergence is most pronounced in the use of digital wallets and contactless payments, suggesting that employment status significantly influences engagement with digital payment methods.

Figure 3: Analysis of Relationships of Cashless Payments of Individuals



3.4 Empirical Results

3.4.1 Results and Discussion

This research aims to explore transaction values as a focused indicator of financial inclusion in a cashless society. It seeks to assess financial behaviours within the formal financial system, using transaction values data of different payment types to evaluate inclusion efforts. The research also monitors digital payment adoption across different demographics to formulate strategies for bridging the digital gap.

The empirical results presented in Table 13 provide valuable insights into the dynamics of transaction values within a cashless society, specifically focusing on the influence of how gender, domiciliation, employment status, and age groups influence transaction values within a cashless society on payment behaviours. These findings are closely aligned with the theoretical framework and hypotheses proposed in Section 3.2.

Table 13: Regression Results for Individual Cashless Payments

	Gender Model 1	Domiciliation Model 2	Job-Status Model 3	Age Group Model 4
Female	-0.792***			
	(0.044)			
Foreigner		-1.393***		
		(0.042)		
Unemployed			-0.559***	
			(0.043)	
Age Group (25-34) years				1.799***
				(0.044)
Age Group (35-44) years				1.668***
				(0.042)
Age Group (45-54) years				1.105***
				(0.041)
Age Group (55+) years				0.563***
				(0.042)
Contactless	1.633***	1.655***	1.577***	2.045***
	(0.032)	(0.035)	(0.033)	(0.033)
Digital-Wallet	0.767***	0.889***	0.677***	1.781***
	(0.037)	(0.040)	(0.038)	(0.040)
E-commerce	-0.406***	-0.411***	-0.534***	0.205***
	(0.031)	(0.035)	(0.031)	(0.031)
Interaction with Contactless				
Female	-0.121**			
	(0.048)			
Foreigner		-0.293***		
		(0.045)		
Unemployed			0.052	

			(0.047)	
Age Group (25-34)				-0.283***
				(0.048)
Age Group (35-44)				-0.510***
				(0.047)
Age Group (45-54)				-0.719***
				(0.046)
Age Group (55+)				-0.826***
				(0.046)
Interaction with Digital-Wallet				
Female	-0.061			
	(0.057)			
Foreigner		-0.944***		
		(0.054)		
Unemployed			0.196***	
			(0.055)	
Age Group (25-34)				-0.614***
				(0.057)
Age Group (35-44)				-1.375***
				(0.056)
Age Group (45-54)				-2.043***
				(0.056)
Age Group (55+)				-2.623***
				(0.056)
Interaction with E-commerce				
Female	-0.037			
	(0.046)			
Foreigner		-0.014		
		(0.044)		
Unemployed			0.290***	
			(0.045)	
Age Group (25-34)				-0.269***
				(0.046)
Age Group (35-44)				-0.777***
				(0.045)
Age Group (45-54)				-1.320***
				(0.044)
Age Group (55+)				-1.781***
				(0.045)
Control Factors				
COVID 19	0.001	0.001***	0.001	0.001***
	(0.0003)	(0.0003)	(0.0003)	(0.0002)
GPR	-0.131**	-0.114**	-0.113**	-0.105***
	(0.059)	(0.056)	(0.057)	(0.037)
Temperature	-0.001	-0.003***	-0.001	-0.0004
	(0.001)	(0.001)	(0.001)	(0.001)
Ramadan	-0.067**	-0.063**	-0.074**	-0.071***
	(0.034)	(0.032)	(0.033)	(0.021)
Inflation	0.019***	0.024***	0.017***	0.018***
	(0.003)	(0.003)	(0.003)	(0.002)
Stock Market Close	0.110***	0.122***	0.108***	0.120***
	(0.004)	(0.004)	(0.004)	(0.003)
Constant	13.01***	13.07***	12.95***	10.41***
	(0.062)	(0.061)	(0.060)	(0.044)
R-squared	0.6089	0.7414	0.5861	0.7447
Adj R-squared	0.6084	0.7410	0.5855	0.7447

Observations	8,768	8,768	8,768	21,920

Male, Citizen, Employed, and Age Group (15-24) are the reference categories for gender, domiciliation, employment status, and age group respectively
Chip-In Payments is the reference category of Payment Types
*Significant: *<0.1, **<0.05, ***<0.01*
Unstandardised coefficients
Robust standard errors in parentheses

3.4.1.1 Gender

The regression results indicate that Females conduct lower-value transactions than Males when using Chip-and-PIN payments, which serves as the reference category. This finding aligns with See-To and Ngai (2019), who suggest that Males prefer payment methods that emphasize immediacy and efficiency, reinforcing a lower sensitivity to the "pain of paying" effect. Given that Chip-and-PIN transactions require authentication but remain widely used for high-value transactions, the results suggest that Males are more inclined to engage in higher-value transactions through this method.

The interaction effects further highlight that the gender difference in transaction values is more pronounced in Contactless payments. Specifically, Females tend to spend even less relative to Males when using Contactless payment methods. This suggests that, while Contactless transactions generally involve higher values, Females demonstrate greater financial caution when using this method compared to Males. This result supports Choudrie et al. (2018) and Thaker et al. (2022), who emphasize that Females are more cautious in adopting financial technologies due to trust and security concerns. The security perception of Contactless payments—where transactions do not require authentication for small-value purchases—could contribute to this lower spending behaviour among Females.

Interestingly, the interaction effects for Digital Wallet and E-commerce payments are not statistically significant, suggesting that gender differences in transaction values for these payment methods are comparable to Chip-and-PIN transactions. This finding contrasts with Choudrie et al. (2018) and Thaker et al. (2022), who argue that Females tend to prefer Digital Wallets due to their enhanced security features. One possible explanation for this discrepancy is that, while Females may indeed prefer Digital Wallets as a secure payment method, the value of their transactions does not significantly differ from that of Chip-and-PIN payments. These findings can be explained through the pain of paying theory (See-To & Ngai, 2019). Digital payment methods reduce the

psychological discomfort associated with spending, but the extent to which this affects Males and Females varies. Since Females prioritize financial security and spending control, lower-value transactions are more likely, particularly for payment methods that do not require direct authentication, such as Contactless. The observed lower transaction values for Females in Contactless payments support this, as spending may be subconsciously limited on methods perceived as less secure. Conversely, Males, with a lower sensitivity to the pain of paying, exhibit higher spending patterns across Chip-and-PIN and Contactless payments.

The role of trust theories (Choudrie et al., 2018; Thaker et al., 2022) also provides insight. The greater emphasis on security and financial control among Females can explain why gender-based differences are not significant for Digital Wallet and E-commerce payments, as these payment methods often incorporate additional security layers such as biometric authentication and one-time passwords. As a result, Females may feel equally comfortable using these methods as they do with traditional Chip-and-PIN transactions. The findings are influenced by the institutional and cultural context of Saudi Arabia, where gender-based differences in financial behaviour are shaped by historical disparities in banking access and Vision 2030's financial inclusion agenda. Historically, Males have had greater access to financial services, which may explain higher-value transactions in Chip-and-PIN and Contactless payments. The preference for lower-value transactions among Females, particularly in Contactless payments, may reflect a cautious approach to spending, reinforced by cultural and societal expectations regarding financial prudence.

Moreover, while Vision 2030 has significantly increased financial participation among Females, the legacy of limited financial independence may still influence spending behaviours. The non-significance of gender differences in Digital Wallet and E-commerce payments suggests that, as Saudi Arabia continues to digitally transform its financial ecosystem, Females are becoming equally active in modern payment methods. The increasing adoption of secure and regulated digital payment infrastructure may be bridging historical gender gaps in transaction behaviour, particularly in online and mobile-based transactions. This study contributes to the literature by demonstrating that gender differences in digital payment behaviours are context-dependent and influenced by the security perception of payment methods. Unlike previous research, which suggested Females prefer Digital Wallets due to security features, the findings indicate that secure authentication mechanisms have equalized gender-based differences in Digital Wallet and E-

commerce transactions. However, gender disparities persist in Contactless payments, highlighting the need for targeted security measures.

The finding that Males conduct higher-value transactions in Chip-and-PIN and Contactless payments aligns with See-To and Ngai (2019), who suggest that Males prioritize efficiency over security. However, this study extends their findings by showing that gender differences in transaction values are even more pronounced in Contactless payments, reinforcing the idea that Females remain more cautious with payment methods that lack strong authentication layers (Choudrie et al., 2018; Thaker et al., 2022). Contrary to Choudrie et al. (2018) and Thaker et al. (2022), who argue that Females prefer Digital Wallets due to their security features, this study finds no significant gender difference in transaction values for Digital Wallet and E-commerce payments. This suggests that, while security remains a priority among Females, the widespread adoption of secure authentication measures, such as biometric verification and one-time passwords, has made Digital Wallets and E-commerce payments equally accessible and trusted across both groups. From an institutional perspective, these findings contribute to the understanding of gendered financial behaviour in Saudi Arabia's evolving digital payment landscape. While Vision 2030 promotes financial inclusion for Females, historical disparities in banking access continue to influence gendered payment behaviours. The non-significance of gender differences in Digital Wallet and E-commerce payments suggests that Saudi Arabia's push for digital transformation is helping bridge historical gender gaps in financial technology adoption.

These findings have important implications for policymakers, Fintech firms, and financial institutions seeking to enhance gender-inclusive digital payment strategies. Since Contactless transactions exhibit the most pronounced gender differences, consumer education programs should emphasize security features to increase adoption among Females. Financial institutions should also enhance security protocols in Contactless transactions, such as implementing two-step authentication for higher-value purchases, to alleviate security concerns and encourage greater participation among Females. Moreover, policymakers should consider tailored financial literacy initiatives that address gender-specific concerns about digital payments, reinforcing confidence in emerging payment methods. By addressing these factors, the financial sector can further advance gender equity in digital transactions, aligning with Saudi Arabia's Vision 2030 financial inclusion goals.

3.4.1.2 Domiciliation

The regression results indicate that Foreigners conduct lower-value transactions than Citizens when using Chip-and-PIN payments, which serves as the reference category. This finding aligns with Choudrie et al. (2018), who argue that Foreigners often face regulatory and institutional constraints in accessing traditional banking services, potentially leading to lower transaction values in Chip-and-PIN payments. Given that Chip-and-PIN transactions require authentication and are widely used for high-value transactions, the results suggest that Citizens are more inclined to engage in higher-value transactions through this method, while Foreigners exhibit more cautious spending behaviour.

The interaction effects further highlight that the difference in transaction values between Citizens and Foreigners is even more pronounced in Contactless and Digital Wallet payments. Specifically, Foreigners tend to spend even less relative to Citizens when using these payment methods. This suggests that, while Contactless and Digital Wallet transactions generally involve higher values, Foreigners demonstrate greater financial caution when using these methods compared to Citizens. This result supports Kumar et al. (2021) and Cruijsen and Knoben (2021), who emphasize that cultural and social influences shape expatriates' financial behaviours. The relative unfamiliarity with local digital payment ecosystems or differences in trust levels may contribute to lower-value transactions among Foreigners when using Contactless and Digital Wallet payments.

Interestingly, the interaction effects for E-commerce payments are not statistically significant, suggesting that transaction values for this payment method are comparable between Citizens and Foreigners. This finding contrasts with See-To and Ngai (2019), who argue that Foreigners tend to prefer digital wallets and online payments due to their perceived security and convenience in managing cross-border transactions. One possible explanation for this discrepancy is that, while Foreigners may indeed favour E-commerce payments for accessibility and ease, the value of their transactions does not significantly differ from those of Chip-and-PIN payments, indicating that online spending behaviours may be relatively similar across both groups. These results align with Choudrie et al. (2018), who argue that Foreigners often face regulatory and institutional constraints in accessing traditional banking services, potentially leading them to engage in lower-value transactions when using traditional card-based payments such as Chip-and-PIN. Similarly, Kumar

et al. (2021) highlight cultural influences on digital payment adoption, which could explain why Foreigners exhibit lower transaction values in Contactless and Digital Wallet payments—possibly due to differences in spending habits or trust in financial technologies compared to Citizens.

Furthermore, the observed reduction in transaction values for Foreigners when using Contactless and Digital Wallets supports the findings of Cruijsen and Knoben (2021), who emphasize the role of social influence in shaping payment preferences. Expatriates may prefer payment methods that align with home-country norms, leading to differences in transaction values. Additionally, See-To and Ngai (2019) suggest that psychological comfort plays a role in payment selection, which may explain why expatriates engage in relatively lower-value transactions with newer payment methods. From a theoretical standpoint, the findings support Digital Divide Theory (Choudrie et al., 2018), which suggests that limited access to financial services for Foreigners influences digital payment behaviour. Since expatriates may have fewer opportunities to establish strong financial relationships with local banks, their preference for lower-value transactions in Chip-and-PIN and Contactless payments may reflect concerns about banking accessibility, transaction costs, or trust. Additionally, Cultural Adaptation Theories (Kumar et al., 2021) suggest that Foreigners adapt payment behaviours based on familiarity and convenience. The observed spending gap for Digital Wallet transactions could indicate that expatriates are less familiar with these technologies or use them differently than Citizens. Moreover, Social Influence Theories (Cruijsen & Knoben, 2021) reinforce this interpretation, as Foreigners may adopt certain digital payment methods based on peer influence but still engage in lower-value transactions due to differences in financial habits.

The Saudi financial landscape provides additional context for these findings. Given the country's large expatriate population and strong reliance on international remittances, Foreigners often prioritize financial flexibility and security in managing transactions across multiple financial systems. The restrictive banking access historically faced by Foreigners may contribute to a cautious approach to spending via Chip-and-PIN and Contactless payments. Additionally, the Saudi government's push for financial inclusion under Vision 2030 has facilitated broader access to digital payment solutions, yet behavioural differences between Citizens and Foreigners persist. The lack of significant differences in E-commerce transactions suggests that online purchases may serve as a universal payment channel, where Foreigners engage in transactions of similar value to Citizens. This may be attributed to the standardization of E-commerce payment experiences and

the growing accessibility of international digital payment platforms that expatriates are familiar with from their home countries.

This study provides new insights into the interaction between domiciliation status and digital payment behaviours in an emerging economy. While previous studies primarily focus on the adoption of digital payments by Foreigners (Choudrie et al., 2018; Kumar et al., 2021), this study extends the discussion by analysing transaction values across different payment methods. The findings indicate that spending disparities between Citizens and Foreigners are not uniform across payment channels, with the largest gaps observed in Contactless and Digital Wallet transactions. This highlights the need for further research into the specific barriers expatriates face in adopting high-value transactions through digital payment solutions in Saudi Arabia, particularly in light of psychological comfort concerns (See-To & Ngai, 2019) and social influences on payment behaviour (Cruijsen & Knoben, 2021).

These findings have important implications for policymakers, Fintech firms, and financial institutions seeking to enhance financial inclusion among Foreigners. Since Contactless and Digital Wallet transactions show the most significant disparities, targeted consumer education programs can help build trust and familiarity with these payment methods. Additionally, financial institutions should enhance security features and reduce perceived risks associated with these transactions by implementing features such as multi-layer authentication for expatriate users. Policymakers should also consider tailored financial literacy initiatives that address cultural and institutional barriers affecting Foreigners' digital payment behaviours. By addressing these factors, the financial sector can further advance financial inclusion and reduce disparities in digital payment adoption, aligning with Saudi Arabia’s Vision 2030 financial inclusion goals.

3.4.1.3 Employment Status

The regression results indicate that Unemployed Individuals conduct lower-value transactions than Employed Individuals when using Chip-and-PIN payments, which serves as the reference category. This finding aligns with Bounie and Camara (2020), who suggest that financial stability and disposable income influence payment preferences, leading Employed Individuals to engage in higher-value transactions through traditional card-based methods that require PIN authentication.

Given that Chip-and-PIN transactions remain a widely used payment method for secure, high-value purchases, the results indicate that employment status significantly affects transaction values in this category. The interaction effects further reveal that the transaction value gap between Employed and Unemployed Individuals is smaller for Digital Wallet and E-commerce payments. Specifically, while Unemployed Individuals generally conduct lower-value transactions, they spend relatively more when using Digital Wallet and E-commerce payments compared to their spending on Chip-and-PIN. This suggests that these payment methods provide a more accessible financial alternative, reducing disparities in transaction values between employment groups. This result supports Chen et al. (2019), who highlight that the perceived inconvenience of handling cash encourages consumers to shift toward digital and card-based payments, particularly for small-value transactions. The findings imply that Unemployed Individuals may favour Digital Wallet and E-commerce payments as convenient and accessible options, despite financial constraints.

Interestingly, the interaction effects for Contactless payments are not statistically significant, indicating that the difference in transaction values between Employed and Unemployed Individuals for this payment method does not significantly differ from Chip-and-PIN transactions. This finding contrasts with Brown et al. (2022), who emphasize that convenience is a key factor in payment adoption, particularly among individuals with regular financial transactions. A possible explanation for this discrepancy is that Contactless transactions have become widely adopted across demographic groups, minimizing transaction value disparities linked to employment status. Moreover, Thaker et al. (2022) suggest that trust and habit influence digital payment adoption, which may explain why Unemployed Individuals do not exhibit a significant difference in spending behaviour when using Contactless payments compared to Chip-and-PIN.

The findings align with Convenience and Technological Adoption Theories (Bounie & Camara, 2020; Brown et al., 2022), which suggest that individuals with stable incomes prefer digital payments that offer speed and ease of use. The fact that Unemployed Individuals engage in relatively higher spending via Digital Wallet and E-commerce payments may be linked to Trust and Habit Theories (Thaker et al., 2022), which argue that digital payment adoption is influenced by perceived security and familiarity. As Unemployed Individuals increasingly interact with digital financial services, confidence in using Digital Wallets and E-commerce platforms may improve, leading to higher-value transactions compared to Chip-and-PIN payments. Moreover, Digital

Divide Theory (Choudrie et al., 2018) helps explain why Unemployed Individuals generally spend less on Chip-and-PIN transactions. This theory highlights disparities in financial access, digital literacy, and trust in technology, which can affect how different employment groups engage with payment methods. Unemployed Individuals may still face barriers such as limited banking access or digital payment infrastructure, restricting their ability to conduct high-value transactions through traditional card-based methods.

Saudi Arabia's financial inclusion policies and Vision 2030 initiatives have played a significant role in driving digital payment adoption across different employment segments. The observed pattern, where Unemployed Individuals allocate relatively higher spending toward Digital Wallet and E-commerce payments, aligns with Saudi Arabia's push for a cashless society and the widespread integration of digital payment platforms. However, traditional banking systems, particularly Chip-and-PIN transactions, may still serve as a barrier for Unemployed Individuals, as they often require formal banking relationships, credit access, or stable income streams. This observation supports the argument that financial inclusion programs must further address accessibility challenges for economically vulnerable groups.

This study provides key insights into how employment status influences digital payment behaviours in Saudi Arabia, offering new perspectives on financial inclusion and payment adoption. The results suggest that while Unemployed Individuals typically conduct lower-value transactions, they spend relatively more when using Digital Wallet and E-commerce payments compared to Chip-and-PIN transactions. This finding supports Chen et al. (2019), who highlight that the inconvenience of handling cash contributes to increased card-based and digital transactions, even among individuals with financial constraints. Additionally, the study finds that transaction value differences between Employed and Unemployed Individuals are not significant for Contactless payments, suggesting that this method is widely adopted across income levels. This contradicts prior research emphasizing financial stability as a key driver of digital payment adoption (Brown et al., 2022), implying that Contactless payments have become normalized regardless of employment status. Furthermore, the findings align with Choudrie et al. (2018) in highlighting the role of the digital divide, as Unemployed Individuals may still face financial and digital literacy barriers that impact their payment behaviours. In the context of Saudi Arabia, the observed shift toward Digital Wallet and E-commerce payments among Unemployed Individuals

suggests that Vision 2030 initiatives and financial inclusion policies are successfully expanding digital payment accessibility, though further efforts are needed to address disparities in traditional banking access.

3.4.1.4 Age group

The regression results indicate that Younger Individuals (aged 15-24) conduct lower-value transactions than Older Individuals (aged 25-34, 35-44, 45-54, and 55+) when using Chip-and-PIN payments, which serves as the reference category. This finding aligns with the literature (Jonker et al., 2022), which suggests that Older Individuals are more likely to engage in traditional payment methods, such as Chip-and-PIN, for higher-value transactions due to their perceived security and familiarity. This pattern reflects the general trend that Older Individuals prefer well-established payment options, reinforcing higher transaction values with Chip-and-PIN payments. The interaction effects further reveal that the age difference in transaction values is more pronounced in Contactless, Digital Wallet, and E-commerce payments. Specifically, Older Individuals (45-55+) conduct relatively lower-value transactions compared to Younger Individuals when using these payment methods. This suggests that, while Contactless payments generally involve higher values, Older Individuals tend to engage in lower-value transactions. This result supports the findings of Brown et al. (2022) and Li et al. (2023), who emphasize that Younger Individuals prioritize convenience and ease of use, making them more likely to adopt and spend higher values with digital payment methods.

For Digital Wallet and E-commerce payments, the interaction effects show a clear decreasing trend in transaction values with age, with the largest reduction observed among Individuals Aged 55+, followed by those aged 45-54, 35-44, and 25-34. This pattern suggests that Younger Individuals, particularly those in the 15-24 and 25-34 age groups, are more likely to use Digital Wallets and engage in E-commerce transactions for higher-value purchases, as these payment methods are perceived as more efficient and user-friendly. The lower transaction values among Older Individuals may be due to a lack of familiarity with these payment technologies or a greater preference for traditional methods that offer a sense of security. These findings can be explained through Convenience Theory (Brown et al., 2022), which suggests that Younger Individuals prioritize fast and seamless transactions, making Contactless, Digital Wallet, and E-commerce

payments more appealing. Psychological Comfort Theory (See-To & Ngai, 2019) further explains that Younger Consumers experience lower "pain of paying," making digital payments more attractive as they minimize psychological discomfort associated with spending.

From a theoretical perspective, Trust Theory (Choudrie et al., 2018; Thaker et al., 2022) also provides insight into these findings. While Younger Individuals are more likely to trust and engage with newer payment technologies, Older Individuals may be more cautious in adopting Contactless, Digital Wallet, and E-commerce payments due to concerns about security and a preference for traditional, well-established methods like Chip-and-PIN. This caution may explain why Older Individuals spend less when using newer payment methods. The findings are influenced by the institutional and cultural context of Saudi Arabia, which plays a significant role in shaping digital payment behaviours. Vision 2030 has played a pivotal role in fostering digital financial services and increasing Fintech adoption, particularly among Younger Consumers. As the country moves toward a more digital economy, Younger Individuals are more likely to engage with Contactless, Digital Wallet, and E-commerce payments, driven by government initiatives and the increasing availability of digital platforms. However, Older Individuals continue to prefer traditional payment methods, which may reflect the legacy of limited familiarity with emerging technologies, despite efforts to promote digital literacy.

Moreover, while Vision 2030 has significantly increased financial inclusion and digital transformation in Saudi Arabia, Older consumers may still face barriers in adopting new technologies. This study highlights the need for targeted strategies to bridge the digital divide, especially for Older Age Groups, in order to foster a more inclusive digital payment landscape. The lower transaction values observed among Older Individuals in Digital Wallet and E-commerce payments suggest that there is still work to be done to increase their comfort and trust in digital payment methods. The novelty of these findings lies in the differential spending patterns across age groups. While much of the existing literature has focused on the adoption of digital payments among Younger Individuals, this study uncovers important nuances in how age influences transaction values across different payment methods. Jonker et al. (2022) emphasize that Younger Individuals are more adaptable to technological changes, a finding supported by the results, which show that Younger Individuals are more likely to engage in higher-value transactions through Digital Wallet and E-commerce payments.

This study extends the literature by revealing that Older Individuals, despite a preference for Chip-and-PIN payments, continue to engage in significant transactions, challenging previous assumptions that older consumers are disengaged from digital finance. Furthermore, the decreasing trend in transaction values with age for Contactless, Digital Wallet, and E-commerce payments highlights the importance of understanding not only Fintech adoption but also spending behaviour. These findings suggest that financial institutions and policymakers should develop targeted strategies to enhance digital literacy and trust-building initiatives among Older Individuals, ensuring broader adoption and confidence in digital payment technologies. By identifying how transaction values differ by age across various payment methods, this study provides valuable insights for both academics and policymakers aiming to foster an inclusive digital financial ecosystem.

3.4.2 Diagnostic Tests

To ensure the reliability and validity of the regression models used in this study, several diagnostic tests were conducted to identify and address potential issues such as multicollinearity, heteroskedasticity, and non-normality of residuals. Addressing these issues is crucial for accurate analysis, as they can distort the estimates and inferences drawn from the models.

Initially, a linear trend variable was included in the regression models to capture time-related effects and control for secular trends, given the time-series nature of the data (Table 14). However, this introduced multicollinearity, potentially inflating the variance of coefficient estimates and making them unstable. The variance inflation factor (VIF) analysis confirmed severe multicollinearity, with the linear trend showing a significantly high VIF. Removing the linear trend reduced the VIF values to acceptable levels, resolving the multicollinearity issue. As a result, the linear trend was excluded from the models, leading to more stable and interpretable coefficient estimates.

Table 14: Multicollinearity Test of Cashless Payments for Individuals

With Linear Trend		Without Linear Trend	
	VIF		VIF
Age Group	1.60	Age Group	1.60
Female	1.00	Female	1.00
Foreigner	1.00	Foreigner	1.00
Unemployed	1.00	Unemployed	1.00
Contactless	1.50	Contactless	1.50
Digital-Wallet	1.50	Digital-Wallet	1.50
E-commerce	1.50	E-commerce	1.50
COVID 19 Index	6.08	COVID 19 Index	2.06
GPR Index	1.87	GPR Index	1.83
Temperature	1.33	Temperature	1.07
Ramadan	1.10	Ramadan	1.05
Inflation Rate	2.59	Inflation Rate	1.57
Stock Market Index	9.30	Stock Market Index	1.14
Linear Trend	22.11		

In addition to multicollinearity, heteroskedasticity was also tested using the Breusch–Pagan/Cook–Weisberg test, as shown in Table 15. Heteroskedasticity, where the variance of the error terms is not constant across observations, can lead to inefficient and biased standard errors, thus compromising the validity of hypothesis tests. Significant heteroskedasticity was indicated across all models, as evidenced by highly significant chi-squared statistics. To address this issue, the regression models were re-estimated using robust standard errors, which adjust for heteroskedasticity and provide more reliable standard errors. This adjustment ensures that the inferences drawn from the regression coefficients are valid and that the models accurately reflect the relationships between variables.

Table 15: Breusch–Pagan/Cook–Weisberg Test of Cashless Payments for Individuals

	$chi^2(1)$	Prob > chi^2
Gender	243.81	0.0000
Domiciliation	91.31	0.0000
Employment Status	170.01	0.0000
Age Group	235.43	0.0000

Furthermore, the normality of residuals was assessed both visually and statistically. Figure 4 provides a visual representation of the residuals for different demographic models (gender, domiciliation, employment status, and age group). The histograms, overlaid with a normal curve, suggest that while the residuals generally follow a bell-shaped distribution, slight deviations from perfect normality, particularly in the tails, were observed.

Figure 4: Residuals Histogram with Normal Curve of Individual Cashless Payments

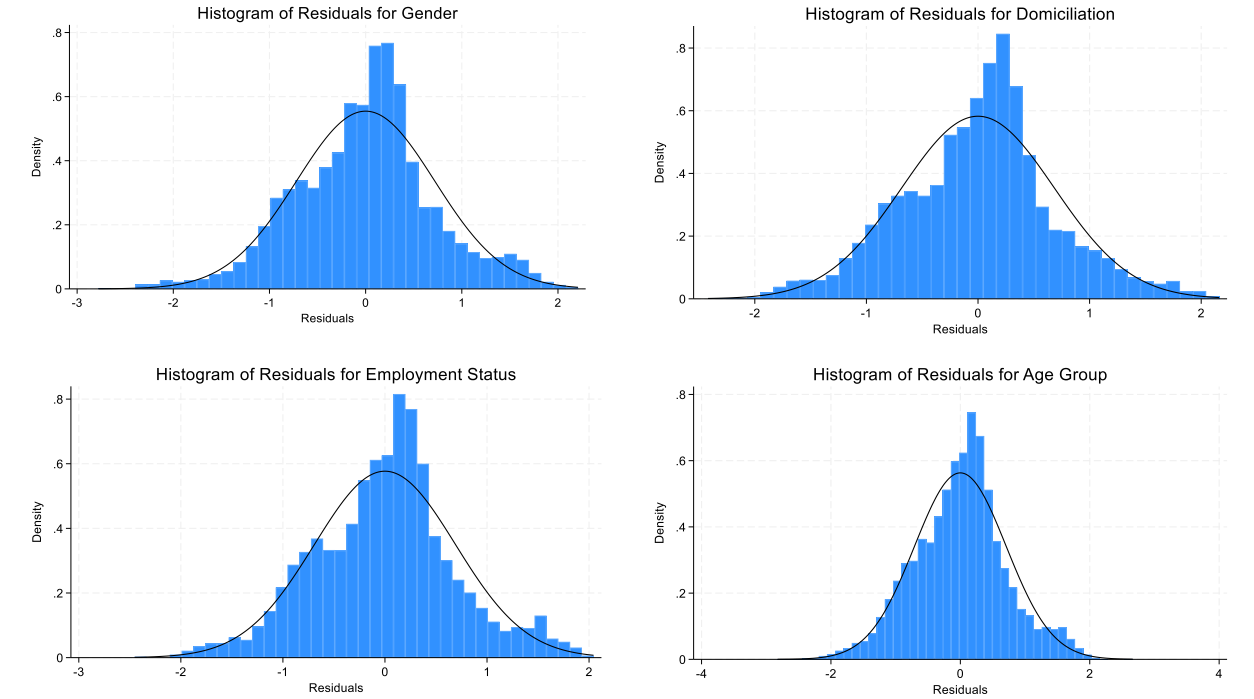


Table 16 presents the results of skewness and kurtosis tests, which formally evaluate whether the residuals deviate from a normal distribution. The tests indicate that while skewness is not a significant issue for most models, kurtosis is significant, suggesting potential non-normality, particularly with heavier tails than a normal distribution would predict. Despite these statistical indications of non-normality, the visual inspection suggests that the residuals are reasonably close to normal, especially given the large sample sizes, which mitigate concerns due to the 'Central Limit Theorem'.

Table 16: Skewness and Kurtosis Tests of Normality of Cashless Payments for Individuals

	Obs.	Pr (skewness)	Pr (kurtosis)	Adj $chi^2(2)$	Prob>chi^2
Gender					
Residuals	8,768	0.1176	0.000	38.22	0.000
Domiciliation					
Residuals	8,768	0.9925	0.000	21.97	0.000
Employment Status					
Residuals	8,768	0.4053	0.000	18.59	0.0001
Age Group					
Residuals	21,920	0.7829	0.000	35.60	0.000

In summary, several key adjustments were made based on the diagnostic tests; the removal of the linear trend variable to eliminate multicollinearity, the use of robust standard errors to correct for heteroskedasticity, and a careful evaluation of the residuals' normality. These adjustments were crucial for enhancing the robustness and credibility of the study's findings, ensuring that the factors influencing transaction values in a cashless society across various demographic groups and payment types were accurately captured. These efforts contribute to the overall robustness of the models and provide a strong foundation for the conclusions drawn from the data.

3.4.3 Robustness Checks

To ensure the robustness of the results on transaction values across gender, domiciliation, employment status, and age group additional regression models were estimated without control variables. This check aimed to determine if relationships between these demographic factors, payment types, and transaction values remain consistent without considering exogenous influences like the COVID-19 pandemic or inflation.

The findings from Table 17 show that the relationships identified in the original model (Table 13) remained stable, even without control variables. The coefficients for female, foreigner, and unemployed remained negative, suggesting these groups continue to engage in lower-value transactions compared to their reference groups. Contactless payments consistently showed a strong positive impact across all groups, while the interaction terms for female and foreigner with contactless and digital wallet options indicated that the benefits of these payment methods are less pronounced for these groups. The coefficients for 25-34 age group continued to show a coefficient of 1.799, indicating that younger adults engage in higher-value transactions compared to the reference group (15-24 years). Payment types, including contactless, digital wallet, and E-commerce, also showed minimal variation, with contactless payments retaining the highest positive impact on transaction values (2.045), confirming the robustness of these relationships.

Table 17: Robustness Checks for Individual Cashless Payments

	Gender Model 1	Domiciliation Model 2	Job-Status Model 3	Age Group Model 4
Female	-0.792***			
	(0.040)			
Foreigner		-1.393***		
		(0.033)		
Unemployed			-0.559***	

			(0.040)	
Age Group (25-34) years				1.799***
				(0.036)
Age Group (35-44) years				1.668***
				(0.035)
Age Group (45-54) years				1.105***
				(0.034)
Age Group (55+) years				0.563***
				(0.034)
Contactless	1.633***	1.655***	1.577***	2.045***
	(0.030)	(0.032)	(0.031)	(0.032)
Digital-Wallet	0.767***	0.889***	0.677***	1.781***
	(0.037)	(0.040)	(0.040)	(0.042)
E-commerce	-0.406***	-0.411***	-0.534***	0.205***
	(0.027)	(0.029)	(0.027)	(0.028)
Interaction with Contactless				
Female	-0.121***			
	(0.045)			
Foreigner		-0.293***		
		(0.042)		
Unemployed			0.052	
			(0.044)	
Age Group (25-34)				-0.283***
				(0.045)
Age Group (35-44)				-0.510***
				(0.044)
Age Group (45-54)				-0.719***
				(0.044)
Age Group (55+)				-0.826***
				(0.044)
Interaction with Digital-Wallet				
Female	-0.061			
	(0.058)			
Foreigner		-0.944***		
		(0.055)		
Unemployed			0.196***	
			(0.055)	
Age Group (25-34)				-0.614***
				(0.057)
Age Group (35-44)				-1.375***
				(0.057)
Age Group (45-54)				-2.043***
				(0.057)
Age Group (55+)				-2.623***
				(0.058)
Interaction with E-commerce				
Female	-0.037			
	(0.039)			
Foreigner		-0.014		
		(0.036)		
Unemployed			0.290***	
			(0.039)	
Age Group (25-34)				-0.269***
				(0.040)

Age Group (35-44)				-0.777***
				(0.039)
Age Group (45-54)				-1.320***
				(0.039)
Age Group (55+)				-1.781***
				(0.040)
Constant	14.02***	14.17***	13.94***	11.55***
	(0.025)	(0.027)	(0.025)	(0.024)
R-squared	0.5722	0.7045	0.5466	0.7156
Adj R-squared	0.5719	0.7043	0.5463	0.7155
Observations	8,768	8,768	8,768	21,920

Male, Citizen, Employed, and Age Group (15-24) are the reference categories for gender, domiciliation, employment status, and age group respectively
Chip-In Payments is the reference category of Payment Types
*Significant: *<0.1, **<0.05, ***<0.01*
Unstandardised coefficients
Robust standard errors in parentheses

In conclusion, the robustness checks confirm that the relationships between these demographic factors, payment types, and transaction values are stable and consistent, regardless of the inclusion of control variables. This supports the validity of the conclusions regarding the impact of age and payment types on transaction values in a cashless society.

3.5 Conclusion and Limitations

3.5.1 Conclusion

This study contributes to the literature on Fintech adoption in Saudi Arabia by examining the determinants of digital payment behaviours across gender, domiciliation, employment status, and age groups. Unlike previous research, which primarily focuses on Fintech adoption rates, this study extends the discussion by analysing transaction values across multiple payment methods, including Chip-and-PIN, contactless, digital wallet, and E-commerce payments. The findings reveal heterogeneous spending behaviours within each demographic group, providing a more granular understanding of digital payment adoption patterns.

To achieve this, four empirical models were developed to analyse the relationship between cashless payment values and various demographic factors, using data from 1 April 2019 to 31 March 2022. These models incorporate key demographic variables, interaction terms, and control variables to account for exogenous influences, enabling a comprehensive examination of financial behaviours in a cashless society. Given the nature of the dataset—comprising both cross-sectional (across demographic groups) and time-series (daily observations over three years) dimensions—a panel regression analysis was employed. This approach allows for the examination of data that varies both over time and across individuals, making it particularly suitable for analysing Fintech adoption patterns. Additionally, interaction terms were included to explore how the effects of different payment types vary across demographic groups, providing deeper insights into digital payment behaviour.

This research leverages a proprietary dataset of over 716 million transactions spanning 36 months, obtained from one of the 10 listed commercial banks in Saudi Arabia. The dataset, which includes 1,096 daily aggregated observations, captures payment behaviours across mada (the local payment provider), Visa or Mastercard, covering transactions both inside and outside Saudi Arabia. The analysis evaluates transaction values as an indicator of financial inclusion, assessing the effectiveness of cashless adoption within the formal financial system.

The study is grounded in financial inclusion theory, which highlights the role of digital payment adoption in expanding financial accessibility, particularly for underbanked populations (Demir et

al., 2022). Financial technologies reduce market frictions, such as transaction costs and barriers to formal financial services, enabling individuals who were previously excluded from traditional banking to participate more effectively in the economy. This theoretical foundation helps explain the variation in transaction values across demographic and socio-economic groups, particularly the higher spending observed among unemployed individuals in digital wallet and E-commerce transactions.

Compared to See-To and Ngai (2019), this study extends the pain of paying theory by demonstrating that gender differences in spending behaviours are most pronounced in contactless payments, where females exhibit greater financial caution than males. While prior studies (Choudrie et al., 2018; Thaker et al., 2022) suggest that females prefer digital wallets due to their enhanced security, the results indicate that secure authentication measures have equalized gender-based differences in transaction values, challenging earlier assumptions. Similarly, this study refines Choudrie et al. (2018) and Kumar et al. (2021) by showing that foreigners conduct lower-value transactions than citizens, particularly in contactless and digital wallet payments. Unlike earlier research, which emphasized regulatory constraints as a barrier for expatriates, these findings suggest that cultural adaptation and social influence (Cruijsen & Knoben, 2021) play a more significant role in shaping expatriate spending behaviours.

For employment status, the results align with Bounie and Camara (2020) and Brown et al. (2022), confirming that financial stability influences digital payment preferences. However, this study extends their findings by revealing that Unemployed Individuals conduct relatively higher-value transactions using digital wallets and E-commerce payments compared to Chip-and-PIN, suggesting that these methods serve as more accessible financial alternatives. This finding is consistent with Chen et al. (2019), who highlight that the perceived inconvenience of handling cash encourages consumers to shift toward digital and card-based payments, even among individuals with financial constraints. Additionally, the results contradict Brown et al. (2022) by showing that contactless payments are widely adopted across employment groups, indicating that financial stability may no longer be a primary driver of contactless payment adoption.

Regarding age, the findings build on Jonker et al. (2022) by demonstrating that while older individuals prefer Chip-and-PIN payments for security reasons, they still engage in digital

payments, albeit at lower transaction values. This contrasts with studies suggesting that older individuals are disengaged from Fintech (Brown et al., 2022; Li et al., 2023), highlighting the need for a more nuanced perspective on digital payment behaviours across different age groups.

These findings contribute to the theoretical understanding of Fintech adoption by refining multiple frameworks. The study extends financial inclusion theory (Demir et al., 2022) by demonstrating how digital payment adoption bridges financial accessibility gaps across demographic groups, particularly among Unemployed Individuals and expatriates. It also incorporates the technology adoption model (TAM) (Bounie & Camara, 2020) to explain how perceived ease of use and perceived usefulness influence digital payment preferences across different socio-economic groups.

The study also extends digital divide theory (Choudrie et al., 2018) by showing that the divide in digital payment adoption is not absolute but varies by payment method. For example, while unemployed individuals spend less via Chip-and-PIN transactions, they engage more with digital wallets and E-commerce payments, suggesting that financial access barriers are partially mitigated by Fintech advancements. The study further contributes to trust theory (Choudrie et al., 2018; Thaker et al., 2022) by demonstrating that trust perceptions influence payment choices differently across demographic groups. While females and older individuals prioritize security in payment selection, foreigners' lower spending in digital payments is more influenced by cultural adaptation and social influence rather than direct trust concerns.

Additionally, this study aligns with behavioural finance theories, particularly the pain of paying theory (See-To & Ngai, 2019; Manshad & Brannon, 2021), by showing that digital payment methods influence spending behaviours by reducing transaction friction. This is evident in the higher transaction values observed among younger individuals in contactless, digital wallet and E-commerce payments, where ease of use and lower psychological friction encourage increased spending. The role of social influence and psychological comfort (Cruijsen & Knoben, 2021) is also evident in how Foreigners demonstrate lower transaction values in digital payments, reflecting a reliance on familiar financial behaviours rather than purely economic constraints.

From a policy perspective, these findings offer actionable insights for financial institutions and regulators aiming to enhance digital financial inclusion in Saudi Arabia. Vision 2030's digital transformation agenda has significantly expanded digital payment adoption; however, the results indicate that certain demographic groups still exhibit lower transaction values in newer payment methods due to perceived risks and unfamiliarity.

Contactless transactions show the most pronounced gender-based disparities, with female users exhibiting lower transaction values compared to their male counterparts. This suggests the need for consumer education programs that prioritize security awareness and trust-building in contactless payment technologies among women. Targeted initiatives that address cultural perceptions and enhance digital confidence can help bridge this gap.

For foreigners, who demonstrate lower-value transactions in contactless and digital wallet payments, tailored financial literacy initiatives should address cultural and behavioural factors influencing digital payment preferences. Expatriate-focused campaigns that emphasize security measures and cross-border usability can foster trust and engagement with Fintech solutions.

For unemployed individuals, digital wallets and E-commerce payments offer more accessible financial alternatives, underscoring the importance of policies that continue to reduce barriers to digital banking. Expanding regulatory frameworks to support alternative payment solutions will further promote financial inclusion. Financial institutions can also enhance digital financial inclusion by improving access to banking services for economically vulnerable populations.

The preference for Chip-and-PIN payments among older individuals (45-55+) reflects a reliance on perceived security and familiarity, while younger individuals (15-24) gravitate towards contactless, digital wallet, and E-commerce transactions due to convenience and technological familiarity. Policymakers should promote digital literacy programs targeting older populations to build confidence and trust in emerging payment technologies. Additionally, implementing robust cybersecurity measures and strengthening consumer protection regulations will encourage digital adoption across all age groups, supporting the transition towards a cashless economy in line with Vision 2030's objectives.

3.5.2 Limitations

Despite the significant contributions of this study, several limitations should be acknowledged.

First, while the analysis leverages a proprietary dataset of 716 million transactions over a 36-month period, the study is limited to one commercial bank in Saudi Arabia. Although the dataset provides a comprehensive view of cashless transaction behaviours, future research could extend this analysis by incorporating data from multiple financial institutions or central bank transaction records to ensure broader generalizability.

Second, the study focuses on four specific payment methods—Chip-and-PIN, contactless, digital wallet, and E-commerce payments. While these represent key digital payment methods in Saudi Arabia, they do not fully capture emerging payment innovations, such as peer-to-peer (P2P) payment systems, including domestic transfers and cross-border remittances. These alternative payment methods play a crucial role in financial inclusion, particularly for unbanked and expatriate populations. Future research could examine how these P2P payment solutions influence consumer behaviour, particularly as Fintech adoption accelerates under Saudi Arabia's Vision 2030 agenda.

Third, although the dataset spans 36 months, covering a critical period of digital transformation and exogenous disruptions, it may not fully reflect longer-term trends or the most recent post-COVID-19 developments in digital payment adoption. As Fintech adoption continues to evolve, future research could incorporate longer timeframes to explore persistent changes in consumer behaviour, particularly regarding trust in digital transactions, evolving regulatory frameworks, and the role of financial literacy.

Finally, the research is context-specific to Saudi Arabia, limiting its direct applicability to other markets. While the findings contribute to broader discussions on Fintech adoption in emerging economies, future studies could conduct cross-country comparisons, particularly in GCC countries, other MENA economies, or high-income digital economies. Investigating how regulatory frameworks, cultural differences, and digital infrastructure impact transaction behaviours across markets could provide valuable comparative insights.

By addressing these limitations, future research can further refine the understanding of digital payment adoption, contributing to more effective financial inclusion policies, enhanced Fintech strategies, and deeper theoretical advancements in consumer financial behaviour.

Chapter 4

Determinants of Cashless Sales at Country, Sectoral and Urban Levels

4 Determinants of Cashless Sales at Country, Sectoral and Urban Levels

Abstract

This study investigates the impact of various factors on cashless sales at point-of-sale (POS) terminals and cash withdrawal transactions at ATMs in Saudi Arabia. Using data from the Saudi central bank spanning January 1999 to December 2023, the research employs the Autoregressive Distributed Lag (ARDL) model and panel data analysis to examine national, sector-specific, and urban financial behaviours influenced by the COVID-19 pandemic, geopolitical risks, temperature variations, and cultural practices such as Ramadan. Additionally, it explores how infrastructural elements like international airports, railway stations, seaports, and distance from capital city affect urban cashless sales. The findings reveal that the COVID-19 pandemic significantly reduced cashless sales but had no statistically significant impact on cash withdrawals. Geopolitical risks decreased both cashless sales and cash withdrawals, while temperature variations initially increased them, with diminishing effects at higher temperatures. During Ramadan, cash withdrawals increased due to heightened religiosity, while cashless sales remained stable. Notably, Ramadan, along with infrastructural developments such as international airports, railway stations, and seaports, positively influenced urban cashless sales. This study fills existing gaps by analysing the underexplored impacts of these factors on financial behaviours in Saudi Arabia. It offers actionable insights for policymakers, urban planners, and financial institutions to support the national Vision 2030 initiative. The research integrates multiple theoretical frameworks and employs robust methodologies, providing valuable contributions to academic literature and practical applications. Despite robust insights, the study acknowledges limitations, including potential generalisability issues and the need for more recent and diverse data. Future research should explore additional infrastructural variables and broader geographic comparisons to enhance the applicability and robustness of the findings.

4.1 Introduction

The global trend towards a cashless society is reshaping economies worldwide, including Saudi Arabia, where the national Vision 2030 initiative has catalysed this transformation. The theory of payment choice underscores this shift, emphasizing the perceived ease and safety of digital payments, particularly accentuated during the COVID-19 pandemic (Jonker et al., 2022). While prior research has extensively examined cashless adoption in high-income economies, gaps remain in understanding how external shocks and structural factors impact financial behaviours in emerging economies like Saudi Arabia.

One major gap in the literature is the lack of comprehensive studies examining the combined impacts of multiple exogenous factors—such as the COVID-19 pandemic (Suder et al., 2024; Jonker et al., 2022), geopolitical risks (Arena & Julio, 2023; Liu & Zhang, 2024), temperature variations (Liang et al., 2024; Martínez-de-Albéniz & Belkaid, 2021; Bertrand & Parnaudeau, 2019; Keleş et al., 2018), and cultural practices like Ramadan (Campante & Yanagizawa-Drott, 2015; Maung et al., 2020)—on financial transactions. While these factors have been explored independently, their simultaneous effects within the Saudi Arabian institutional and economic framework remain underexplored. Additionally, infrastructural factors such as international airports, railway stations, sea ports, and distance from the capital city have not been sufficiently analysed in relation to urban cashless sales, despite evidence that improved connectivity fosters urban economic activities and employment (Wang et al., 2020; Sheard, 2019; Banerjee et al., 2020; Uchida et al., 2024).

This study adopts a theory-building (inductive) approach to investigate the determinants of cashless sales and cash withdrawals at the country, cashless sales sectoral, and urban levels in Saudi Arabia. It examines how exogenous factors—such as pandemics, geopolitical instability, climatic variability, and religious observances—shape financial behaviours at POS terminals and ATMs. Furthermore, it evaluates how infrastructural development affects urban cashless sales, providing novel insights into the spatial and economic dimensions of financial transactions.

The key findings of this study reveal several important trends. The COVID-19 pandemic had a statistically significant negative impact on cashless sales at the country, sectoral, and urban levels,

diverging from global trends where digital payment adoption accelerated (Jonker et al., 2022; Kotkowski & Polasik, 2021). Unlike other studies that documented increased digital transactions, this study assesses payment behaviour before, during, and after the pandemic, showing that Saudi Arabia experienced a decline, potentially due to sectoral shutdowns and economic uncertainty affecting consumer confidence. Geopolitical risks influenced cashless sales and cash withdrawals at the country level, but their effect on sectoral and urban cashless transactions was statistically insignificant (Liu & Zhang, 2024; Arena & Julio, 2023). This suggests that while macroeconomic uncertainty affects financial markets, its direct impact on payment behaviours in Saudi Arabia remains limited, possibly due to strong government intervention and financial stability measures.

The study finds a nonlinear effect of temperature, where moderate increases stimulated cashless sales and withdrawals at all levels, but extreme temperatures reduced transaction volumes (Bertrand & Parnaudeau, 2019; Keleş et al., 2018; Liang et al., 2024). This aligns with the idea that extreme heat affects consumer mobility and retail activity, influencing cashless transaction volumes. Ramadan significantly impacted cash withdrawals and urban cashless sales, but had no effect on cashless transactions at the country or sectoral, and urban levels when infrastructure-related factors were considered (Campante & Yanagizawa-Drott, 2015; Maung et al., 2020). This suggests that while digital payments are increasing, cash remains essential for certain religious and cultural practices.

Infrastructure played a crucial role in shaping urban cashless sales. Cities with international airports, railway stations, and sea ports experienced higher cashless transaction volumes, reinforcing the link between transport connectivity and financial modernization (Wang et al., 2020; Sheard, 2019; Banerjee et al., 2020; Uchida et al., 2024). Conversely, greater distance from the capital city was associated with lower cashless adoption (Jedwab & Storeygard, 2022), highlighting financial inclusion disparities across different regions.

This study makes several significant contributions. The research refines the theory of economic uncertainty measures by demonstrating that uncertainty does not uniformly drive digital adoption, but is mediated by institutional settings and financial responses (Altig et al., 2020). It also advances the theory of payment choice by showing that sectoral and geographic variations play a key role in influencing financial behaviours (Jonker et al., 2022). The findings reinforce the importance of

infrastructure in financial modernization, demonstrating that transport connectivity significantly impacts urban cashless transactions (Wang et al., 2020; Sheard, 2019; Banerjee et al., 2020).

The study employs Autoregressive Distributed Lag (ARDL) modelling, following approaches used in prior research (Mohamed & Saâdaoui, 2023; Kahouli, 2017; Shahzad et al., 2021; Damane, 2022; Swamy, 2022) to examine relationships between financial behaviours and macroeconomic factors, including inflation rate, stock market return, interest rate, GDP growth rate, and unemployment rate. Additionally, panel data analysis investigates sectoral and urban effects.

The findings of this study hold significant implications for policymakers, financial institutions, and fintech firms in Saudi Arabia. As the country moves towards a digital economy under Vision 2030, understanding the drivers of cashless transactions is crucial for designing effective financial policies. Policymakers should invest in digital infrastructure to promote financial inclusion in remote areas. Financial institutions should tailor financial products to accommodate seasonal and climate-related fluctuations in consumer behaviour. Fintech firms should develop innovative payment solutions that address challenges related to economic uncertainty and infrastructural disparities.

By addressing key research gaps, this study provides a comprehensive framework for understanding cashless transactions in an emerging economy. It contributes to both theoretical and empirical discourse by integrating macroeconomic, infrastructural, and cultural perspectives. These findings offer valuable insights into the financial transformation of Saudi Arabia, supporting the nation's transition towards a digitally inclusive economy under Vision 2030.

The remaining sections are organised as follows. Section 4.2 provides a brief review of the theoretical, literature, and hypotheses development. Section 4.3 explains the research methodology, statistics, empirical models, and correlation and relationship analysis. Section 4.4 results and discussion, diagnostic tests, and robustness checks. The final section of the paper draws conclusions and highlights limitations.

4.2 Conceptual Framework and Hypotheses Development

This research explores how the COVID-19 pandemic, geopolitical risks, temperature variations, and Ramadan affected cash and cashless transactions in Saudi Arabia, focusing on the roles of financial institutions, government policies, and economic uncertainty. The theoretical framework integrates key theories for a comprehensive understanding. Additionally, it evaluates how infrastructural development, such as international airports, railway stations, sea ports, and distance from capital city, contributes to urban cashless sales. The primary objective is to assess the economic impacts of financial behaviours related to cashless sales at POS terminals and cash withdrawal transactions at ATMs in Saudi Arabia.

4.2.1 Influencing Factors

4.2.1.1 COVID-19 Pandemic

The COVID-19 pandemic significantly altered payment behaviours by reshaping consumer confidence, transaction costs, and cash management strategies. The theory of cash management (Shy, 2023) explains that the demand for cash is driven by the need to bridge gaps between income and spending. During the pandemic, disruptions in income and heightened transaction costs led to reduced cash withdrawals and increased reliance on cashless payments. Similarly, the theory of ATM cash management (Suder et al., 2024) highlights how banks adopted both reactive and proactive strategies to ensure operational efficiency in ATM cash supply, reflecting changes in consumer cash demand.

Economic uncertainty during the pandemic also played a crucial role in shifting payment patterns. The theory of economic uncertainty measures (Altig et al., 2020) suggests that heightened uncertainty influences consumer confidence and spending decisions. Faced with uncertainty regarding income stability and mobility restrictions, consumers reduced reliance on cash transactions and increasingly opted for digital alternatives. The theory of payment choice (Jonker et al., 2022) further explains that payment decisions are influenced by factors such as age, education, income, transaction size, and perceived ease of use. During the pandemic, health concerns and convenience considerations accelerated the shift toward cashless transactions.

Empirical studies support these theoretical perspectives. Suder et al. (2024) found that stringent COVID-19 measures led to lower average daily withdrawals and reduced variability in cash demand, demonstrating the pandemic's effect on transaction costs and consumer behavior. Similarly, Jonker et al. (2022) identified a significant rise in debit card usage in the Netherlands during lockdowns, reflecting a behavioural shift away from cash. A broader European study by Kotkowski and Polasik (2021) confirmed increased reliance on cashless payments, highlighting the financial inclusion challenges faced by those who traditionally depended on cash. Furthermore, Londoño-Vélez & Querubín (2022) emphasized the difficulties in expanding mobile money adoption among low-income populations, where liquidity constraints and opportunity costs of holding money limited the transition to digital payments.

These findings illustrate that COVID-19 did not merely accelerate existing trends but fundamentally reshaped payment behaviours by reducing cash dependency, increasing the adoption of contactless and digital transactions, and altering consumer confidence in financial transactions. The long-term impact of these shifts depends on the post-pandemic persistence of cashless habits and the adaptability of financial institutions in meeting evolving consumer preferences.

Based on the theoretical framework and literature review, the following hypotheses are developed to understand the impact of the COVID-19 pandemic on cash and cashless transactions in Saudi Arabia.

H1: the COVID-19 pandemic likely led to increased cashless sales and decreased cash withdrawals. The theory of cash management (Shy, 2023) and the theory of ATM cash management (Suder et al., 2024) suggest that disruptions in income and increased transaction costs during the pandemic reduced cash withdrawals. Additionally, the theory of payment choice (Jonker et al., 2022) indicates that perceived ease of use and safety concerns accelerated the adoption of cashless payments.

H2: economic uncertainty during the pandemic probably increased cashless sales and decreased cash withdrawals. The theory of economic uncertainty measures (Altig et al., 2020) explains that increased uncertainty impacts consumer behaviour, making cashless transactions more attractive.

The theory of price incentives in payment choices (Ho et al., 2023) supports that economic incentives promoted cashless payments, further reducing cash withdrawals.

H3: the shift towards cashless sales during the pandemic likely varied across sectors, being more pronounced in those with better digital infrastructure. The theory of payment choice (Jonker et al., 2022) and inventory theories of money demand (Brown et al., 2022) suggest that transaction size and sector-specific factors influence payment behaviour. The theory of financial intermediation (Murinde et al., 2022) highlights that sectors with better digital payment infrastructure were more capable of transitioning to cashless sales.

H4: urban areas probably experienced greater increases in cashless sales compared to rural areas during the pandemic due to better access to digital payment infrastructure and financial services. Urban areas generally have better digital infrastructure (Murinde et al., 2022), facilitating cashless transactions. The theory of welfare impacts of cash transfers (Londoño-Vélez & Querubín, 2022) suggests that digital transfers are more accessible in urban areas, supporting this shift. The theory of economic uncertainty measures (Altig et al., 2020) also indicates that urban consumers, facing greater economic disruptions, shifted more rapidly to cashless payments.

4.2.1.2 Geopolitical Risk

Geopolitical risks influence financial decision-making by increasing economic uncertainty, altering corporate strategies, and shaping consumer behaviour. The theory of geopolitical risk and corporate payouts (Arena & Julio, 2023) suggests that heightened geopolitical uncertainty increases financial distress risk, leading firms to adopt conservative financial strategies, which in turn can influence broader economic confidence and liquidity availability. Similarly, the real options theory (Bernanke, 1983) posits that under heightened uncertainty, economic agents—including consumers and businesses—adopt a "wait and see" approach, reducing capital spending and altering financial transaction patterns.

From a consumer perspective, signalling theory (John & Williams, 1985) suggests that financial stability signals affect consumer trust in financial institutions, influencing their choice of payment methods. During periods of geopolitical instability, concerns over financial security, capital controls, or currency volatility may drive higher reliance on digital payment methods as consumers

seek faster, more secure, and more traceable transactions. The theory of economic consequences of geopolitical risk (Bloom, 2009) highlights broader adverse economic effects, which may lead consumers to shift away from cash due to concerns about access to physical banking infrastructure and ATMs in volatile regions.

Empirical evidence supports these theoretical perspectives. Liu and Zhang (2024) demonstrate that geopolitical risk influences currency markets, which can, in turn, affect cross-border digital transactions and fintech adoption. Jiang et al. (2022) found that geopolitical instability negatively affects tourism stock returns, which may reflect broader uncertainty in travel-related financial transactions, including shifts from physical currency exchange to digital payments. Additionally, Alsagr et al. (2023) noted that geopolitical risks impact crowdfunding success, which highlights broader concerns about alternative financing and fintech platforms during geopolitical instability.

Geopolitical risks can lead to shifts in payment behaviours and fintech adoption through multiple mechanisms. In uncertain environments, cashless transactions may rise due to concerns about physical cash accessibility, increased risk of inflation, and reliance on digital and mobile payments for financial stability. Fintech solutions, such as mobile banking and digital wallets, may experience accelerated adoption as consumers seek alternative financial services that provide flexibility and security in volatile conditions. Conversely, in extreme cases, geopolitical instability may disrupt digital payment infrastructures, leading to temporary reliance on cash or alternative financial mechanisms.

Based on the theoretical framework and literature review, the following hypotheses are developed to understand the impact of geopolitical risk on cash and cashless transactions in Saudi Arabia.

H5: geopolitical risk likely leads to decreased cashless sales and increased cash withdrawals. The theory of geopolitical risk and corporate payouts (Arena & Julio, 2023) and the real options theory (Bernanke, 1983) suggest that increased geopolitical risk heightens cash flow uncertainty and financial distress risk, leading firms and consumers to hold more cash.

H6: geopolitical risk probably negatively influences cashless sales and positively influences cash withdrawals. The theory of economic consequences of geopolitical risk (Bloom, 2009) explains

that increased geopolitical risk impacts consumer behaviour, making cash transactions more attractive during periods of uncertainty.

H7: the impact of geopolitical risk on cashless sales likely varies across sectors, with those exposed to higher risk seeing greater shifts. The real options theory (Bernanke, 1983) and signalling theory (John & Williams, 1985) suggest that sectors with higher uncertainty and financial distress may see a more significant shift in financial behaviours.

H8: urban areas probably experience a greater impact from geopolitical risk compared to rural areas due to better access to digital payment infrastructure and financial services. Urban areas generally have better digital infrastructure (Murinde et al., 2022), facilitating changes in financial behaviours in response to geopolitical risk.

4.2.1.3 Temperature

Firstly, the theory of operations management in extreme weather (Liang et al., 2024) suggests that buffering and bridging strategies help firms mitigate disruptions caused by extreme weather. Secondly, the theory of weather impact on retail operations (Martínez-de-Albéniz & Belkaid, 2021) explains how weather conditions influence consumer behaviour and retail operations. Moreover, information processing theory (Flynn & Flynn, 1999) highlights the importance of timely and authentic information in mitigating disruptions. Furthermore, the theory of economic effects of abnormal weather (Bertrand & Parnaudeau, 2019) emphasizes understanding economic impacts to mitigate business failure risks.

Additionally, the Reference Point Effect Theory (Keleş et al., 2018) explains asymmetric effects on demand due to temperature changes. Lastly, the weather-proximity-cognition framework (Craig, 2019) applies construal level theory to understand how the perceived proximity of weather events influences behaviour.

Empirical evidence includes Bertrand and Parnaudeau (2019) on adverse weather conditions leading to sales losses, Keleş et al. (2018) on temperature changes boosting demand for beverages, and Addoum et al. (2020) on temperature shocks having no significant impact on sales or

productivity. Tran (2023) found severe weather affecting sales volatility, and Pankratz et al. (2023) noted extremely hot days reducing firms' revenues.

Based on the theoretical framework and literature review, the following hypotheses are developed.

H9: extreme temperatures likely lead to decreased cashless sales and increased cash withdrawals. The theory of operations management in extreme weather (Liang et al., 2024) suggests businesses might increase cash reserves during extreme temperatures to manage financial stability. Additionally, the theory of weather impact on retail operations (Martínez-de-Albéniz & Belkaid, 2021) implies that consumers adjust their shopping behaviours based on weather conditions, affecting cashless sales and cash withdrawals.

H10: temperature fluctuations probably negatively influence cashless sales and positively influence cash withdrawals. Information processing theory (Flynn & Flynn, 1999) explains that timely information can mitigate disruptions, suggesting that consumers and businesses might prefer cash transactions during extreme weather due to perceived reliability.

H11: The impact of temperature on cashless sales likely varies across sectors sensitive to weather conditions. The theory of weather impact on retail operations (Martínez-de-Albéniz & Belkaid, 2021) suggests that temperature changes affect the sales of seasonal products, indicating that sectors selling weather-sensitive goods may experience greater shifts in financial behaviours. The reference point effect theory (Keleş et al., 2018) further suggests that consumer response to temperature changes is asymmetrical, with increases in temperature having a stronger impact on demand than decreases.

H12: Urban areas likely experience a greater impact from temperature variations compared to rural areas due to higher footfall and diverse retail environments. The theory of operations management in extreme weather (Liang et al., 2024) and the weather-proximity-cognition framework (Craig, 2019) suggest that urban areas, with higher population density and more complex supply chains, are more susceptible to weather-related disruptions, influencing financial behaviours.

4.2.1.4 Ramadan

Religious observances such as Ramadan influence economic behaviours, including cashless transactions and cash withdrawals, through changes in labour supply, productivity, and financial decision-making. The club good theory of costly religious practices (Campante & Yanagizawa-Drott, 2015) suggests that religious observances, like fasting during Ramadan, impact labor supply and productivity, which in turn affect consumption and financial transactions. Lower productivity and reduced working hours may alter cash withdrawal patterns and slow cashless sales, particularly in sectors reliant on physical transactions.

The theory of religion and entrepreneurship in hospitality and tourism (H&T) (Farmaki et al., 2020) explains how religious values and networks shape entrepreneurial activities. During Ramadan, increased social gatherings and religious tourism may boost cashless transactions in hospitality and retail sectors, particularly through digital payments for food, travel, and charitable donations. Meanwhile, the religiosity and risk aversion theory (Maung et al., 2020) suggests that higher religiosity is associated with conservative financial behaviours, potentially leading to lower engagement with cashless transactions due to a preference for traditional payment methods. Similarly, Gharbi et al. (2020) found that religiosity fosters ethical financial decision-making and risk aversion, which may encourage financial stability but reduce participation in cashless transactions, particularly those perceived as riskier.

Social structures also shape financial behaviours during Ramadan. The social capital theory (Deller et al., 2018) posits that religious congregations foster networks that influence economic decisions. Increased charitable giving (zakat and sadaqah) during Ramadan may lead to higher cash withdrawals for donation purposes, although digital giving platforms may mitigate this effect. The institutional theory (Henley, 2017) highlights how religious affiliation drives entrepreneurial activities, which may increase sector-specific cashless transactions, particularly in industries catering to Ramadan-related consumption patterns.

Empirical studies provide further insights into these dynamics. Campante and Yanagizawa-Drott (2015) found that fasting periods reduce productivity, which may impact economic activity and, consequently, payment behaviours. Deller et al. (2018) observed variations in economic

behaviours linked to religious congregation densities, reflecting differences in financial engagement. Bryan et al. (2021) found that increased religiosity correlates with higher income levels, which could drive discretionary spending and digital transactions in certain sectors. Conversely, Maung et al. (2020) showed that regions with higher religiosity exhibit lower venture capital investments, aligning with the idea of risk aversion in financial decision-making. Gharbi et al. (2020) emphasized that firms in highly religious regions are more likely to adopt conservative financial practices, which may extend to individual financial behaviours, including a reduced reliance on cashless transactions. Additionally, Cao et al. (2019) reported that firms in such regions tend to extend more trade credit, reflecting financial conservatism that may influence broader transactional behaviours.

Overall, Ramadan influences payment behaviours through changes in productivity, consumer spending patterns, risk preferences, and social giving. While digital transactions may increase in specific sectors such as hospitality and E-commerce, cash withdrawals may also rise due to increased charitable donations and traditional spending habits, reflecting the interplay of religious observance and financial decision-making.

Based on the theoretical framework and literature review, the following hypotheses are developed.

H13: Ramadan may lead to increased communal participation and decreased productivity, impacting cashless sales and cash withdrawals. According to the club good theory (Campante & Yanagizawa-Drott, 2015), increased religious engagement during Ramadan could reduce labour supply and productivity, resulting in lower cashless sales and altered cash withdrawals patterns as individuals participate more in communal religious activities.

H14: Religious observances during Ramadan are likely to result in more conservative financial behaviours, leading to decreased cashless transactions and increased cash withdrawals. The religiosity and risk aversion theory (Maung et al., 2020; Gharbi et al., 2020) suggests that heightened religiosity leads to more risk-averse financial decisions, which explains why individuals may prefer cash withdrawals over cashless transactions during Ramadan.

H15: The impact of Ramadan on economic activities likely varies across sectors tied to communal and social activities. The social capital theory (Deller et al., 2018) suggests that religious

congregations build social capital, leading to increased economic activity in sectors like hospitality and retail, where communal gatherings are more frequent, thus affecting sectoral cashless sales.

H16: Urban areas may experience greater economic impacts from Ramadan compared to rural areas due to higher population density and diverse economic activities. According to institutional theory (Henley, 2017), religious affiliation influences entrepreneurial activity, suggesting that urban areas with higher religious engagement might experience stronger effects on cashless sales and withdrawals, due to the concentration of businesses and consumers.

4.2.2 Infrastructure Influencing Factors

4.2.2.1 International Airports

The theory of transport infrastructure and local economy (Wang et al., 2020) posits that transport infrastructure, including airports, significantly influences the economic connectivity and development of cities. Improved transport connectivity fosters sustainable economic development by enhancing city-cluster connectivity and reducing connectivity disparity among cities. This theory suggests that the presence of international airports can enhance urban economic activities, including cashless sales, by improving connectivity and access to international markets.

Furthermore, the centrality index theory (Wang et al., 2020) highlights the importance of central nodes, such as international airports, in the transport network. Cities with major airports serve as central nodes, boosting local economic activities due to increased accessibility and connectivity. This theory implies that urban areas with international airports experience higher cashless sales due to enhanced economic activities and consumer traffic.

Empirical support for these theories is provided by several studies. For instance, Sheard (2019) examined the economic impact of airport size on local employment in U.S. metropolitan areas from 1976 to 2017. The study found that larger airports positively influence local employment, especially in service sectors near the airport. This underscores the potential for airport infrastructure to boost local economic growth, supporting the theory that international airports enhance urban economic activities.

Building on these findings, Uchida et al. (2024) investigated the global impact of new airport investments on urban economic development using night-time light (NTL) intensity as an indicator. Their analysis revealed that new airport construction increases NTL intensity, indicating positive economic impacts for small cities in emerging economies. This empirical evidence supports the notion that international airports stimulate urban economic growth, including cashless sales.

Furthermore, Campante and Yanagizawa-Drott (2018) studied the impact of international long-distance flights on local economic activity using satellite-measured night lights. They found that improving an airport's position within the network of air links positively affects local economies by increasing business connections and capital flows. This fosters local economic development, particularly in high- to middle-income countries, highlighting the economic benefits of enhanced airport connectivity.

Based on the theoretical framework and literature review, the following hypothesis is developed.

H17: The presence of international airports likely leads to increased urban cashless sales. The theory of transport infrastructure and local economy (Wang et al., 2020) suggests that improved connectivity from international airports enhances urban economic activities, including cashless sales. Sheard (2019) provides empirical support, indicating that larger airports boost local employment and economic growth.

4.2.2.2 Railway Stations

The theory of transport infrastructure and local economy (Wang et al., 2020) posits that transport infrastructure, including railway stations, significantly influences the economic connectivity and development of cities. Improved transport connectivity fosters sustainable economic development by enhancing city-cluster connectivity and reducing connectivity disparity among cities. This theory suggests that the presence of railway stations can enhance urban economic activities, including cashless sales, by improving connectivity and access to broader markets.

Furthermore, the new economic geography theory (Chen et al., 2020) highlights transportation cost as a crucial factor affecting the location choice of individuals and firms. Improved

transportation accessibility reduces transportation costs, promoting the movement of factor inputs and influencing the agglomeration and diffusion of economic activities. This theory implies that better rail connectivity can lead to increased urban economic activities and higher cashless sales by reducing transportation costs and improving accessibility.

Additionally, the theory of investment efficiency (Wu et al., 2022) suggests that improved connectivity, such as high-speed rail (HSR), can enhance investment efficiency by reducing information asymmetry and promoting better resource allocation. This theory indicates that cities with better rail connectivity may experience higher investment efficiency, contributing to increased economic activities and cashless sales.

Empirical support for these theories is provided by several studies. For instance, Wang et al. (2020) investigated transport connectivity patterns in three major Chinese economic zones and found that improved rail connectivity benefits centre cities more, emphasizing the importance of balanced transport development for economic activity. These findings suggest that enhancing rail connectivity could similarly improve cashless sales at POS terminals in urban areas.

Building on this understanding, Wu et al. (2022) examined the effect of high-speed rail (HSR) construction on investment efficiency in China, finding that HSR significantly improves investment efficiency, especially for firms with low information transparency. This study underscores how better connectivity can enhance financial efficiency, relevant to improving cashless transaction infrastructure.

Furthermore, Diao (2018) analysed the economic geography impact of China's expanding HSR network, showing that HSR improves city accessibility and attracts significant fixed asset investment, particularly in second-tier cities. However, it also exacerbates spatial inequality. These insights are crucial for planning infrastructure improvements to enhance cashless sales at POS terminals in different regions.

Based on the theoretical framework and literature review, the following hypothesis is developed.

H18: The presence of railway stations likely leads to increased urban cashless sales. The theory of transport infrastructure and local economy (Wang et al., 2020) suggests that improved connectivity

from railway stations enhances urban economic activities, including cashless sales. Chen et al. (2020) and Wu et al. (2022) provide empirical support, indicating that better rail connectivity boosts economic growth and investment efficiency.

4.2.2.3 Sea Ports

To begin with, the theory of transport infrastructure and economic growth (Banerjee et al., 2020) posits that access to transportation infrastructure, including sea ports, significantly influences regional economic outcomes. Improved transport connectivity fosters economic growth by facilitating the movement of goods and factors of production. This suggests that the presence of sea ports can enhance urban economic activities, including cashless sales, by improving connectivity and access to international trade routes.

Empirical support for these theories is provided by several studies. Banerjee et al. (2020) showed that proximity to transportation networks positively affects per capita GDP levels. This underscores the potential for transportation infrastructure, including sea ports, to enhance local economic growth, supporting the theory that sea ports can improve urban economic activities. Building on this, Chengpeng et al. (2018) found that improvements in port infrastructure and sustainability can enhance economic activities. Their findings suggest that similar efforts in Saudi Arabian ports could boost cashless transactions at POS terminals by promoting economic growth through environmental responsibility. Furthermore, Lim et al. (2019) identified key trends and strategies for implementing port sustainability performance. They emphasized promoting green policies and stakeholder collaboration to enhance economic outcomes.

Based on the theoretical framework and literature review, the following hypothesis is developed.

H19: The presence of sea ports likely leads to increased urban cashless sales. The theory of transport infrastructure and economic growth (Banerjee et al., 2020) suggests that improved connectivity from sea ports enhances urban economic activities, including cashless sales. Chengpeng et al. (2018) and Lim et al. (2019) provide empirical support, indicating that sustainable port practices can boost economic growth and enhance economic activities.

4.2.2.4 Distance from Capital City

The theory of transport infrastructure and economic growth (Banerjee et al., 2020) emphasizes that proximity to a capital city significantly affects regional economic performance. Cities closer to the capital often benefit from better access to governmental services, financial resources, and centralized economic activities. These cities typically experience faster economic growth due to their strategic location near the primary political and economic hub. This suggests that cities closer to the capital may also see higher levels of cashless sales, driven by increased economic activity and consumer traffic.

Central place theory (Jedwab & Storeygard, 2022) reinforces this notion, suggesting that major cities, particularly those near the capital, are better positioned to attract economic activities. Their central location and connectivity enable them to serve as economic hubs, drawing in both businesses and consumers. This spatial advantage can lead to increased commerce and higher urban cashless sales, as businesses and consumers in these cities engage more frequently in digital transactions.

Empirical studies further support these theoretical perspectives. Morten and Oliveira (2024) demonstrated that highway expansions in Brazil, which connected the new capital to state capitals, reduced migration and trade costs, ultimately improving welfare in those regions. While this study highlights the role of infrastructure, it also indicates that proximity to the capital city can boost local economic activities, including cashless sales. Similarly, Coşar et al. (2022) found that reduced travel times in Turkey significantly boosted trade, local manufacturing employment, and wages, suggesting that proximity to central economic hubs accelerates local economic growth and, by extension, cashless transactions.

Based on this theoretical framework and the supporting literature, the following hypothesis is proposed.

H20: Proximity to the capital city is positively associated with increased urban cashless sales. Both the theory of transport infrastructure and economic growth (Banerjee et al., 2020) and central place theory (Jedwab & Storeygard, 2022) suggest that cities closer to the capital benefit from heightened economic activities, including cashless sales. The empirical evidence from Morten and

Oliveira (2024) and Coşar et al. (2022) further supports this hypothesis, showing that proximity to central economic hubs drives local economic growth, which may translate into higher volumes of cashless sales.

4.2.3 Control Factors

4.2.3.1 Inflation Rate

The inflation rate is a crucial control factor that influences various economic activities. Several studies have examined its effects, providing valuable insights into how inflation impacts consumer behaviour and financial markets. For instance, Alsagr et al. (2023) found that inflation does not significantly impact crowdfunding success. This suggests that while inflation may affect general economic conditions, it does not directly deter consumer participation in alternative financing platforms.

In contrast, Duca-Radu et al. (2021) and Ryngaert (2022) showed that higher inflation expectations increase consumer spending. Their findings indicate that when consumers anticipate higher prices in the future, they are more likely to spend immediately, thereby driving current economic activity. Additionally, Ehling et al. (2018) highlighted that inflation disagreement affects nominal yields and consumption volatility. This study suggests that differing expectations about inflation can lead to fluctuations in interest rates and consumer spending patterns, contributing to economic instability.

4.2.3.2 Stock-Market

The stock market is another critical control factor that impacts economic activities through its influence on household wealth and consumption patterns. Various studies have provided insights into these dynamics, highlighting how fluctuations in the stock market can drive or hinder economic performance.

For example, Di Maggio et al. (2020) found that stock market gains significantly influence household consumption in Sweden. This indicates that when households perceive an increase in their wealth due to rising stock prices, they are likely to spend more, thus stimulating economic

activity. Similarly, Ahn et al. (2019) showed that stock market uncertainty affects economic activities in China. Their study suggests that volatility and uncertainty in the stock market can lead to cautious behaviour among consumers and investors, potentially slowing down economic growth.

González et al. (2018) highlighted the macroeconomic determinants of stock market betas, providing a deeper understanding of how economic factors influence stock market volatility. This insight is crucial for predicting market movements and their subsequent impact on economic activities. Furthermore, Atmaz and Basak (2022) found that no-dividend stocks impact market performance, indicating that the composition of stock portfolios can affect overall market stability and investor behaviour. This finding underscores the importance of considering the types of stocks in the market when assessing economic outcomes.

Additionally, Swamy (2022) showed a positive relationship between financial wealth and household consumption in India. This study reinforces the idea that increases in financial wealth, often driven by stock market gains, lead to higher consumer spending and economic growth.

4.2.3.3 Interest Rate

The interest rate is another pivotal control factor that significantly influences economic activities. Various studies have explored its impact on consumer behaviour and economic stability. For example, Agarwal et al. (2021) in Turkey found that interest rate hikes reduce consumer spending across both cash and card transactions. This indicates that higher borrowing costs can dampen overall consumer expenditure, affecting economic growth. Similarly, Ryngaert (2022) showed that expectations of future interest rate increases lead to more immediate borrowing and spending. This suggests that consumers and businesses may accelerate their purchasing decisions in anticipation of higher costs, temporarily boosting economic activity before rates actually rise.

Additionally, Akbar (2021) highlighted that higher interest rates reduce money demand in Pakistan. This finding underscores the inverse relationship between interest rates and the desire to hold liquid assets, as higher rates make saving more attractive compared to spending. Furthermore, Ehling et al. (2018) demonstrated that inflation disagreement impacts nominal interest rates and consumption volatility. Their study suggests that differing expectations about inflation can lead to

fluctuations in interest rates, which in turn affect consumer spending patterns and overall economic stability.

4.2.3.4 GDP Growth Rate

Among the control factors influencing economic activities, GDP growth rate is a critical determinant. Various studies have examined its relationship with different aspects of economic behaviour. For instance, Zhang et al. (2019) found that higher adoption of electronic payments in the European Union positively correlates with GDP growth, trade, and consumption. This suggests that the integration of digital payment systems can stimulate economic expansion by facilitating more efficient transactions.

Similarly, Krishna et al. (2022) revealed that national cybersecurity measures enhance digital payment usage, with GDP growth influencing this usage. Their study indicates that as economies grow, the adoption of secure digital payment methods increases, highlighting the importance of cybersecurity in the digital economy.

Furthermore, Alsagr et al. (2023) indicated that while GDP does not directly impact crowdfunding success, it correlates with greater consumer participation. This finding suggests that a growing economy encourages more active engagement in alternative financial platforms, reflecting broader consumer confidence and economic vitality.

4.2.3.5 Unemployment Rate

Among the control factors influencing economic activities, the unemployment rate plays a significant role. Numerous studies have explored its impact, particularly on consumer spending. For instance, Ganong and Noel (2019) analysed the effect of unemployment insurance (UI) benefit exhaustion on consumer spending in the United States, finding significant declines in spending when benefits ceased. Similarly, Gupta and Kishore (2022) observed a substantial drop in household consumption following job loss in India, with urban households being particularly affected.

Additionally, Fagereng et al. (2024) in Norway highlighted that unemployment leads to a lasting reduction in income and consumption, with those having greater liquid assets faring better. This finding suggests that financial resilience can mitigate some negative effects of unemployment. Furthermore, Kekre (2023) showed that increasing unemployment insurance (UI) benefits can stimulate aggregate demand in the U.S., primarily because the unemployed tend to have a higher marginal propensity to consume compared to the employed. This emphasizes UI's role in economic stabilization and highlights the importance of supportive policies during periods of high unemployment.

4.3 Research Methodology

This research explores how the COVID-19 pandemic, geopolitical risks, temperature variations, and Ramadan affected cashless sales and cash withdrawals transactions in Saudi Arabia, focusing on the roles of financial institutions, government policies, and economic uncertainty.

The theoretical framework integrates key theories for a comprehensive understanding. Additionally, it evaluates how infrastructural development, such as international airports, railway stations, sea ports, and distance from capital city, contributes to urban cashless sales.

The primary objective is to assess the economic impacts of financial behaviours related to cashless sales at POS terminals and cash withdrawal transactions at ATMs in Saudi Arabia.

4.3.1 ARDL Analysis

4.3.1.1 Data Description and Statistics

The description and definition of the data used are shown in Table 18. The dependent variables include cashless sales and cash withdrawals. The influencing factors encompass the COVID-19 pandemic, geopolitical risk, temperature, and Ramadan. The control factors are represented by the inflation rate, stock market return, interest rate, GDP growth rate, and unemployment rate.

Table 18: Definitions and Descriptions of Cashless Sales and Cash Withdrawals

	Definitions and Descriptions	Source
Cashless Sales	The data is sourced from the Monthly Statistics Bulletin published by the Saudi Central Bank (SAMA). The cashless sales transactions data includes insert card transactions from January 1999 and contactless and digital wallet transactions from January 2019 onwards. These transactions are conducted exclusively through the mada network, the national payment scheme of Saudi Arabia	SAMA
Cash Withdrawals	The cash withdrawals transactions data includes withdrawals at ATMs from January 1999, encompassing transactions through the mada network as well as other card networks such as Visa and Mastercard. This cash withdrawals transactions data does not include cash deposit transactions	SAMA
COVID-19 Stringency Index	The COVID-19 Stringency Index is a composite measure of nine response metrics: school closures; workplace closures; cancellation of public events; restrictions on public gatherings; closures of public transport; stay-at-home requirements; public information campaigns; restrictions on internal movements; and international travel controls. The index for any given day is	Our World In Data (University of Oxford)

	calculated as the mean score of these nine metrics, each ranging from 0 to 100. A higher score indicates a stricter response, with 100 representing the strictest response	
Geopolitical Risk Index	Dario Caldara and Matteo Iacoviello constructed this measure based on a tally of newspaper articles covering geopolitical tensions. The index captures the evolution and economic effects of adverse geopolitical events, organized into eight categories: war threats, peace threats, military build-ups, nuclear threats, terror threats, beginning of war, escalation of war, and terror acts. The Caldara and Iacoviello GPR Index reflects automated text-search results from the electronic archives of 10 newspapers since 1985 by counting the number of articles related to adverse geopolitical events in each newspaper for each month, expressed as a share of the total number of news articles	EPU
Temperature (Celsius)	The data for the average temperature is sourced from the National Oceanic and Atmospheric Administration (NOAA) and the National Centers for Environmental Information (NCEI). The temperature is reported in Celsius from 32 weather stations across the country	NOAA and NCEI
Ramadan	Ramadan is characterized by its lunar month nature, spanning either 29 or 30 days, differing from the fixed length of calendar months in the Gregorian system. Due to this lunar basis, Ramadan shifts across different months of the Gregorian calendar each year. Ramadan is quantified by calculating the proportion of its days falling within specific calendar months to reflecting the lunar cycle of Ramadan within the context of calendar-based financial data	Researcher calculations, by using Umm Al-Qura Islamic Calendar
Inflation Rate	The inflation rate factor is provided by two data sources. The first source is the International Monetary Fund (IMF), which provides annual data from 1999 to 2012. The IMF defines the inflation rate as the average consumer prices (annual percent change). The second source is the General Authority for Statistics in Saudi Arabia (GASTAT), which provides data on a monthly basis starting from January 2013. GASTAT defines the inflation rate as the average consumer price index rate of change from the same month of the previous year	IMF, and GASTAT
Stock Market Return	The stock market return data is sourced from Tadawul and Investing.com. To calculate the stock market return and assess its variability, the daily closing price index is aggregated to a monthly frequency, providing an average for each month	Tadawul and Investing.com
Interest Rate	The data for the Interest Rate (Repo) is provided by two sources. The first source is Bloomberg, which provides daily data from January 1999 to December 2006. The second source is SAMA, which provides data on a monthly basis starting from January 2007	Bloomberg, and SAMA
GDP Growth Rate	The GDP Growth Rate factor is provided by two data sources. The first source is the IMF. The second source is GASTAT, which provides data on a quarterly basis starting from Q1 2011	IMF, and GASTAT
Unemployment Rate	The data for the Unemployment Rate is provided by three sources. The first source is the World Bank Group (WBG), which provides annual data from 1999 to 2011. The second source is DataStream, which provides quarterly data from Q1 2012 to Q4 2016. The third source is GASTAT, which provides quarterly data starting from Q1 2017	WBG, DataStream, and GASTAT

Regarding the dependent variables the data for cashless sales transactions is sourced from the monthly statistics bulletin published by the Saudi central bank (SAMA). The figures are initially

reported in thousand Riyals and have been converted to million Riyals, and subsequently to million USD. The cashless sales transactions data includes insert card transactions from January 1999 and contactless and digital wallet transactions from January 2019 onwards. These transactions are conducted exclusively through the mada network. Mada is the national payment scheme of Saudi Arabia, enabling electronic payments through various channels, including POS terminals, SoftPOS, automated teller machines (ATMs), and E-commerce websites across Saudi Arabia through a central payment system that re-routes the financial transactions performed by issuer cards.

Moreover, the data for cash withdrawals transactions is also sourced from the monthly statistics bulletin published by SAMA. The figures are initially reported in million Riyals and have been converted to million USD. The cash withdrawals transactions data includes withdrawals at ATMs from January 1999, encompassing transactions through the mada network as well as other card networks such as Visa and Mastercard. This cash withdrawals transactions data does not include cash deposit transactions.

The COVID-19 stringency index is included as an independent variable to measure the impact of government-imposed restrictions on payment behaviours. The data is sourced from Our World in Data (University of Oxford) and originally reported on a daily basis. For consistency with other macroeconomic variables, it has been aggregated to a monthly frequency, covering the period from January 2020 to December 2022. The stringency index is a composite measure of nine policy response metrics: school closures, workplace closures, cancellation of public events, restrictions on public gatherings, closures of public transport, stay-at-home requirements, public information campaigns, restrictions on internal movements, and international travel controls. The index for each day is computed as the mean score of these nine components, scaled from 0 to 100, where higher values indicate stricter policy responses (with 100 representing the strictest response). To assess the effect of COVID-19 on payment behaviours, the stringency index is incorporated into the empirical models to capture how varying levels of restrictions influenced cash withdrawals and cashless transactions. Stricter policies are expected to reduce physical cash withdrawals due to limited mobility and ATM access, while simultaneously increasing reliance on digital and contactless payment methods. This variable allows us to quantify the extent to which policy interventions shaped transaction behaviours during the pandemic.

The data for the Geopolitical Risk (GPR) index is sourced from Economic Policy Uncertainty (EPU) and is reported on a monthly basis, with each observation reflecting the geopolitical uncertainty of the previous month. For instance, the observation for January 1999, reported at the beginning of the month, reflects the geopolitical activity of December 1998. This measure was constructed by Dario Caldara and Matteo Iacoviello, based on an automated text-analysis of newspaper articles covering geopolitical tensions. The index captures the evolution and economic effects of adverse geopolitical events across eight categories: war threats, peace threats, military build-ups, nuclear threats, terror threats, the beginning of war, war escalations, and terror acts. The Caldara and Iacoviello GPR index is derived from 10 major newspapers—including The New York Times, Financial Times, The Wall Street Journal, and The Guardian—by counting the number of articles related to adverse geopolitical events each month, expressed as a share of total news articles. To assess the impact of geopolitical risks on cashless transactions and fintech adoption, the GPR index is incorporated into the empirical models as an independent variable. Higher geopolitical risk levels are expected to influence consumer financial behaviours in multiple ways. During periods of geopolitical instability, consumers may reduce reliance on cash transactions due to concerns about liquidity access, ATM availability, and inflationary pressures. Instead, they may shift towards cashless payment methods such as digital wallets, mobile banking, and fintech platforms for greater security and transaction speed. Moreover, in regions affected by conflict, banking infrastructure disruptions may accelerate fintech adoption as consumers seek alternative financial services. Conversely, extreme geopolitical risks may create uncertainty around financial institutions, leading to a decline in digital transactions if trust in digital banking security is weakened. By incorporating the GPR index into the empirical models, this study quantifies the extent to which geopolitical uncertainty shapes consumer payment behaviours and evaluates its role in shifting transaction preferences between cash and cashless systems.

The data for the average temperature is sourced from the national oceanic and atmospheric administration (NOAA) and the national centers for environmental information (NCEI). The temperature is reported in Celsius on a daily basis from 32 weather stations across the country. This daily data is then aggregated to a monthly frequency to provide a national average.

Finally, Ramadan follows a lunar cycle, lasting 29 or 30 days, and shifts by approximately 10–12 days earlier each year in the Gregorian calendar. Due to this variability, accurately capturing its

effect on financial transactions requires a precise methodological approach. To analyse its impact on cashless sales and cash withdrawals, Ramadan is quantified using the fractional allocation method, which calculates the proportion of its days falling within each Gregorian calendar month. This approach ensures that Ramadan's shifting nature is correctly aligned with monthly financial data, using the Umm Al-Qura Islamic calendar for precise adjustments. By incorporating Ramadan as an independent variable in the empirical models, this study systematically quantifies its effect on payment behaviours while controlling for other economic factors. Ramadan significantly influences consumer spending and transaction patterns through various mechanisms. As a period of fasting, prayer, Quran recitation, charitable giving, and communal activities, Ramadan alters daily routines and financial behaviours. A key financial shift is the increase in cash withdrawals, primarily due to religious donations such as zakat and sadaqah, as individuals withdraw cash to contribute to charity and support social causes. At the same time, cashless transactions rise in key sectors, particularly retail, as spending on food and beverages, clothing and footwear, and jewellery and gifts increases, especially during Iftar (breaking of the fast) and in preparation for Eid-al-Fitr celebrations. However, daytime commercial activity slows due to fasting, leading to lower transaction volumes in some sectors while shifting economic activity to evening and nighttime hours. Beyond short-term spending, Ramadan also affects financial decision-making by reinforcing risk-averse and conservative financial behaviours. The religiosity and risk aversion theory suggests that individuals may be less inclined to engage in riskier financial transactions during Ramadan, potentially leading to a decline in certain types of cashless payments, particularly those linked to investment or high-value discretionary spending. This study accounts for these behavioural shifts by integrating Ramadan as a time-sensitive variable within the empirical models, enabling a robust analysis of how seasonal religious observances shape financial transactions.

Regarding the control factors. Firstly, the inflation rate factor is provided by two data sources. The first source is the international monetary fund (IMF), which provides annual data from 1999 to 2012. The IMF defines the inflation rate as the average consumer prices (annual percent change). This annual data was then converted and distributed on a monthly basis. The second source is the general authority for statistics in Saudi Arabia (GASTAT), which provides data on a monthly basis

starting from January 2013. GASTAT defines the inflation rate as the average consumer price index rate of change from the same month of the previous year.

The stock market return data is sourced from Tadawul and Investing.com. To calculate the stock market return and assess its variability, the daily closing price index is aggregated to a monthly frequency, providing an average for each month.

The data for the interest rate (Repo) is provided by two sources. The first source is Bloomberg, which provides daily data from January 1999 to December 2006. This daily data was then aggregated to a monthly frequency. The second source is SAMA, which provides data on a monthly basis starting from January 2007.

The GDP growth rate factor is provided by two data sources. The first source is the international monetary fund (IMF), which provides annual data from 1999 to 2010. This annual data was then converted and distributed on a monthly basis. The second source is GASTAT, which provides data on a quarterly basis starting from Q1 2011. This quarterly data was then converted and distributed on a monthly basis.

Lastly, the data for the unemployment rate is provided by three sources. The first source is the world bank group (WBG), which provides annual data from 1999 to 2011. This annual data was then converted and distributed on a monthly basis. The second source is DataStream, which provides quarterly data from Q1 2012 to Q4 2016. The third source is GASTAT, which provides quarterly data starting from Q1 2017. The quarterly data from both DataStream and GASTAT was then converted and distributed on a monthly basis.

The descriptive statistics in Table 19 provide an overview of the dataset used to determine cashless sales and cash withdrawals. The dependent variables, cashless sales and cash withdrawals, were recorded on a monthly basis.

Table 19: Descriptive Statistics of Cashless Sales and Cash Withdrawals

	Min	1%	Average	Median	Std.Dev	99%	Max
Cashless Sales	102.50	125.30	3,516.00	2,346.00	3,861.00	14,213.00	14,777.00
Cash Withdrawals	1,533.00	2,120.00	10,374.00	11,446.00	5,193.00	18,706.00	19,531.00
COVID-19 Stringency Index	0.00	0.00	5.47	0.00	16.80	74.85	91.73
Geopolitical Risk Index	0.03	0.04	0.22	0.18	0.18	0.86	1.44
Temperature	13.98	14.55	25.80	26.58	6.62	35.11	35.61

Ramadan	0.00	0.00	0.08	0.00	0.22	0.92	1.00
Inflation Rate	-3.24	-3.02	1.79	1.90	2.27	6.12	6.16
Stock Market Return	-0.26	-0.19	0.01	0.01	0.06	0.16	0.19
Interest Rate	1.00	1.00	3.01	2.00	1.65	7.00	7.00
GDP Growth Rate	-7.10	-5.70	3.17	3.00	4.32	13.45	14.60
Unemployment Rate	4.35	4.35	5.63	5.67	0.72	8.74	8.98
N = 300 (Jan-99 – Dec-23)							

In monetary terms, cashless sales ranged from 102.50 million USD to 14,777.00 million USD, with an average of 3,516.00 million USD and a high standard deviation of 3,861.00 million USD, indicating significant variability. Similarly, cash withdrawals ranged from 1,533.00 million USD to 19,531.00 million USD, with an average of 10,374.00 million USD and a standard deviation of 5,193.00 million USD, indicating high variability.

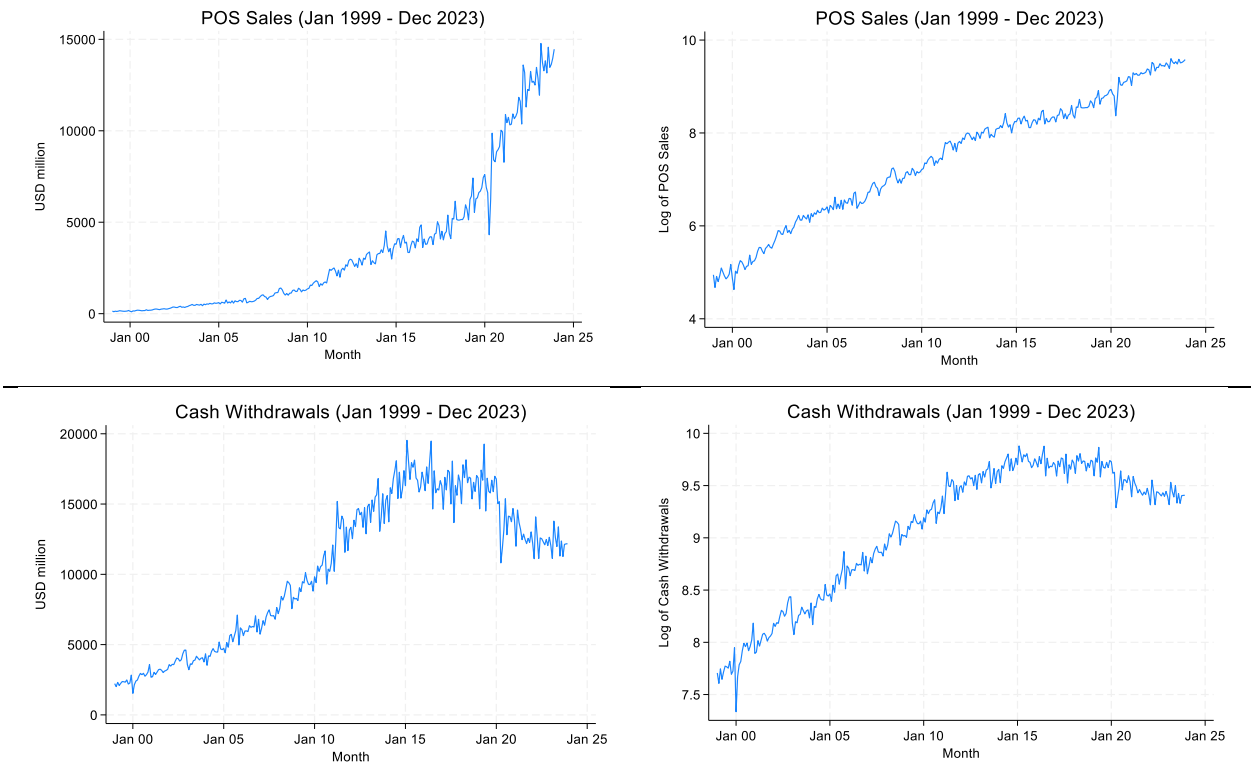
The explanatory independent variables, which are exogenous in nature, showed varying degrees of variability. The COVID-19 stringency index ranged from 0.00% to 91.73%, with an average of 5.47% and a high standard deviation of 16.80%, indicating substantial variability. The geopolitical risk index, reported in both log and percentage terms, showed moderate variability with log values ranging from -3.55 to 0.36 and percentage values from 0.03% to 1.44%. Temperature ranged from 13.98°C to 35.61°C, with an average of 25.80°C and a standard deviation of 6.62°C, indicating significant variability. The Ramadan variable ranged from 0.00 to 1.00, with an average of 0.08 and a standard deviation of 0.22, reflecting its infrequent occurrence.

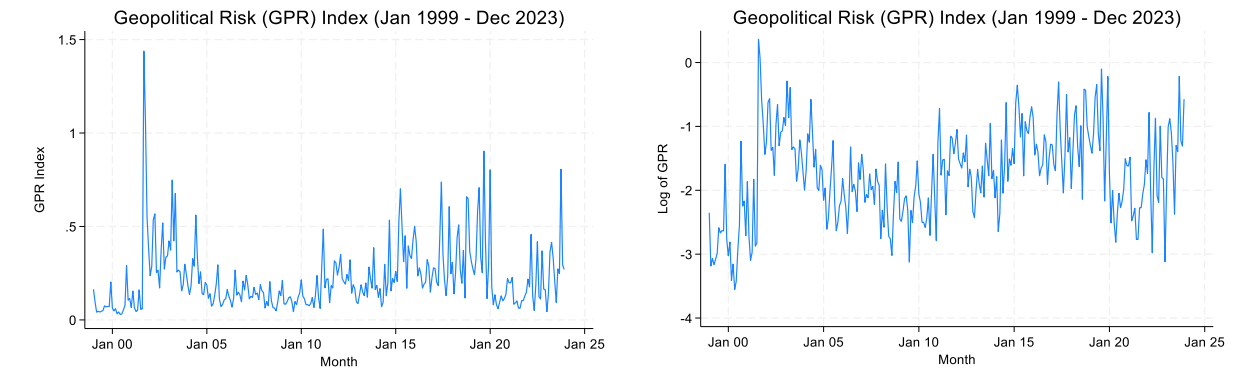
Regarding the control factors, the inflation rate ranged from -3.24% to 6.16%, with an average of 1.79% and a standard deviation of 2.27%, indicating notable variability. The stock market return values ranged from -0.26 to 0.19, with an average of 0.01 and moderate variability (standard deviation of 0.06). Interest rates ranged from 1.00% to 7.00%, with an average of 3.01% and moderate variability (standard deviation of 1.65%). The GDP growth rate exhibited significant variability, ranging from -7.10% to 14.60%, with an average of 3.17% and a standard deviation of 4.32%. The unemployment rate ranged from 4.35% to 8.98%, with an average of 5.63% and low variability (standard deviation of 0.72%).

The dataset spans 300 observations from January 1999 to December 2023, providing a robust foundation for analysing the relationships between these variables and cashless sales and cash withdrawal transactions.

Figure 5 illustrates the trends and volatility of cashless sales, cash withdrawals, and the GPR index, alongside their log-transformed versions. The log-transformed data addresses heteroscedasticity, making trends clearer and more suitable for analysis. The first set of sub-figures shows the raw data, where cashless sales exhibit a steady upward trend with occasional volatility, cash withdrawals rise until 2015 before declining with higher volatility, and the GPR index features spikes during periods of heightened geopolitical risk. The second set of sub-figures presents the log-transformed data, revealing smoother trends for all variables. The log of cashless sales and cash withdrawals highlights more stable growth patterns, while the log of the GPR index reduces extreme volatility, making changes more visible.

Figure 5: Trends, Volatility, and Log-Transformation of Cashless Sales and Cash Withdrawals





Furthermore, to determine cashless sales, and cash withdrawal transactions, I initially had a complex dataset from different sources and periods (Table 18). The dependent variables cashless sales, and cash withdrawal transactions were recorded on a monthly basis. The independent variables included the COVID-19 index, which was initially reported daily and then aggregated to a monthly frequency, and the GPR index, reported monthly at the beginning of each month to reflect the geopolitical activity of the previous month. Temperature data was initially reported daily and aggregated to a monthly frequency. The Ramadan variable was quantified by calculating the proportion of its days falling within specific calendar months to reflect the lunar cycle.

For control factors, the inflation rate data came from two sources: the international monetary fund (IMF) and the general authority for statistics in Saudi Arabia (GASTAT). The IMF provided annual data from 1999 to 2012, defining the inflation rate as the average consumer prices (annual percent change), which was then converted to monthly data. GASTAT provided monthly data starting from January 2013, defining the inflation rate as the average consumer price index rate of change from the same month of the previous year. The stock market return data was sourced from Tadawul and Investing.com, where the daily closing price index was aggregated to a monthly frequency to provide an average for each month.

Interest rate data was provided by Bloomberg (daily data from January 1999 to December 2006, aggregated to a monthly frequency) and SAMA (monthly data starting from January 2007). The GDP growth rate was provided by the IMF (annual data from 1999 to 2010, converted to monthly) and GASTAT (quarterly data starting from Q1 2011, converted to monthly). Unemployment rate data came from three sources: the World Bank Group (WBG) provided annual data from 1999 to 2011 (converted to monthly), DataStream provided quarterly data from Q1 2012 to Q4 2016

(converted to monthly), and GASTAT provided quarterly data starting from Q1 2017 (converted to monthly).

To determine an appropriate model for testing the data, I conducted 'Unit Root Tests' in Table 20, this align with the method used by (Mohamed & Saâdaoui, 2023; Kahouli, 2017; Shahzad, et al., 2021). I found that the variables were integrated in a combination of different orders, I(0) and I(1), without the presence of order two, I(2) (Damane, 2022; Swamy, 2022). Therefore, I used the ARDL model.

Table 20: Unit Root Tests of Cashless Sales and Cash Withdrawals

	Augmented Dickey–Fuller (ADF)		Phillips–Perron (PP)	
	at Level I(0)	First-Difference I(1)	at Level I(0)	First-Difference I(1)
Cashless Sales	0.6196	0.0000***	0.7679	0.0000***
Cash Withdrawals	0.1050	0.0000***	0.2375	0.0000***
COVID-19 Stringency Index	0.1462	0.0000***	0.0825	0.0000***
GPR Index	0.0010***		0.0000***	
Temperature	0.0000***		0.0000***	
Ramadan	0.0000***		0.0000***	
Inflation Rate	0.0285	0.0000***	0.0330	0.0000***
Stock Market Return	0.0000***		0.0000***	
Interest Rate	0.1315	0.0001***	0.5599	0.0000***
GDP Growth Rate	0.0090***		0.0095***	
Unemployment Rate	0.5461	0.0000***	0.7788	0.0000***

The ARDL method works when variables are integrated of different orders, I(0), I(1), or a combination of both. However, the ARDL technique is not valid in the presence of order two, I(2), variables (Damane, 2022; Swamy, 2022).

4.3.1.2 Empirical Model

Generalised Model 1 of Cashless Sales:

$$\begin{aligned} lnCashless\ Sales_t &= \beta_0 + \beta_1 Covid\ Index_t + \beta_2 lnGeopolitical\ Risk_t + \beta_3 Temperature_t \\ &+ \beta_4 Temperature_t^2 + \beta_5 Ramadan_t + \beta_6 Inflation\ Rate_t \\ &+ \beta_7 Stock\ Returns_t + \beta_8 Interest\ Rate_t + \beta_9 GDP\ Growth\ Rate_t \\ &+ \beta_{10} Unemployment\ Rate_t + \beta_{11} Trend + u_t \end{aligned}$$

Where t denotes for month

Error Correction Representation of ARDL Model (Long run model)

$$\Delta lnCashless\ Sales_t$$
$$= \beta_0 - Y_1 ECT_{t-1} + \beta_1 Covid\ Index_t + \beta_2 lnGeopolitical\ Risk_t$$
$$+ \beta_3 Temperature_t + \beta_4 Temperature_t^2$$
$$+ \beta_5 Ramadan_t + \beta_6 Trend + \beta_7 \Delta Inflation\ Rate_t$$
$$+ \beta_8 \Delta Stock\ Returns_t + \beta_9 \Delta Interest\ rate_t + \beta_{10} \Delta GDP\ Growth\ Rate_t$$
$$+ \beta_{11} \Delta Unemployment\ Rate_t + \sum_{j=1}^{p-1} \delta_j \Delta lnCashless\ Sales_{t-j}$$
$$+ \sum_{k=1}^{q-1} \phi_k \%\ \Delta Inflation\ Rate_{t-k} + \sum_{i=1}^{w-1} \varphi_i \Delta Stock\ Returns_{t-i}$$
$$+ \sum_{l=1}^{m-1} \lambda_l \Delta Interest\ rate_{t-l} + \sum_{c=1}^{n-1} \Theta_c \Delta Unemployment\ Rate_{t-c}$$
$$+ \sum_{h=1}^{r-1} \alpha_h \Delta Interest\ rate_{t-h} + u_t$$

Where $ECT_{t-1} = lnCashless\ Sales_{t-1} - \rho_2 Inflation\ Rate_{t-1} - \rho_3 Stock\ Returns_{t-1} - \rho_4 Interest\ Rate_{t-1} - \rho_5 GDP\ Growth\ Rate_{t-1} - \rho_6 Unemployment\ Rate_{t-1}$

Based on the lag length selection criterion using the Akaike Information Criterion (AIC), the cashless sales model was specified with the order (4, 1, 1, 4, 1, 1), representing cashless sales (4), inflation rate (1), stock market return (1), interest rate (4), GDP growth rate (1), and unemployment rate (1).

Generalised Model 2 of Cash Withdrawals:

$$lnCashWithdrawal_t$$
$$= \beta_0 + \beta_1 Covid\ Index_t + \beta_2 lnGeopolitical\ Risk_t + \beta_3 Temperature_t$$
$$+ \beta_4 Temperature_t^2 + \beta_5 Ramadan_t + \beta_6 Inflation\ Rate_t$$
$$+ \beta_7 Stock\ Returns_t + \beta_8 Interest\ Rate_t + \beta_9 GDP\ Growth\ Rate_t$$
$$+ \beta_{10} Unemployment\ Rate_t + \beta_{11} Trend + \beta_{12} Trend^2 + e_t$$

Where t denotes for month

Error Correction Representation of ARDL Model (Long run model)

$$
\begin{aligned}
&\Delta CashWithdrawal_t \\
&\quad = \beta_0 - Y_1 ECT_{t-1} + \beta_1 Covid\ Index_t + \beta_2 lnGeopolitical\ Risk_t \\
&\quad + \beta_3 Temperature_t + \beta_4 Temperature_t^2 \\
&\quad + \beta_5 Ramadan_t + \beta_6 Trend + \beta_7 Trend^2 + \beta_8 \Delta Inflation\ Rate_t \\
&\quad + \beta_9 \Delta Stock\ Returns_t + \beta_{10} \Delta Interest\ rate_t + \beta_{11} \Delta GDP\ Growth\ Rate_t \\
&\quad + \beta_{12} \Delta Unemployment\ Rate_t + \sum_{j=1}^{p-1} \delta_j \Delta CashWithdrawal_{t-j} \\
&\quad + \sum_{k=1}^{q-1} \phi_k \%\ \Delta Inflation\ Rate_{t-k} + \sum_{i=1}^{w-1} \varphi_i \Delta Stock\ Returns_{t-i} \\
&\quad + \sum_{l=1}^{m-1} \lambda_l \Delta Interest\ rate_{t-l} + \sum_{c=1}^{n-1} \Theta_c \Delta Unemployment\ Rate_{t-c} \\
&\quad + \sum_{h=1}^{r-1} \alpha_h \Delta Interest\ rate_{t-h} + u_t
\end{aligned}
$$

Where $ECT_{t-1} = CashWithdrawal_{t-1} - \rho_2 Inflation\ Rate_{t-1} - \rho_3 Stock\ Returns_{t-1} - \rho_4 Interest\ Rate_{t-1} - \rho_5 GDP\ Growth\ Rate_{t-1} - \rho_6 Unemployment\ Rate_{t-1}$

Based on the lag length selection criterion using the Akaike Information Criterion (AIC), the cash withdrawals model was specified as (3, 1, 1, 4, 1, 1), representing cash withdrawals (3), inflation rate (1), stock market return (1), interest rate (4), GDP growth rate (1), and unemployment rate (1).

The Error Correction Representation of the ARDL model (long-run model) aligns with the methodologies used in several studies (Damane, 2022; Kahouli, 2017; Kripfganz & Schneider, 2023; Mohamed & Saâdaoui, 2023; Shahzad et al., 2021; Swamy, 2022).

The potentially nonlinear relationship between temperature and cash withdrawals aligns with Pankratz et al. (2023), and Addoum et al. (2023).

4.3.1.3 Correlation and Relationship Analysis

Table 21 highlights the correlation matrix for both cashless sales and cash withdrawals in relation to various independent variables.

For cashless sales, significant positive correlations are identified with the COVID-19 index, inflation rate, and unemployment rate. In contrast, a significant negative correlation is found with the interest rate. Additionally, variables such as temperature, Ramadan, stock market return, and GDP growth rate exhibit weak or insignificant correlations, indicating limited influence on cashless sales.

Similarly, for cash withdrawals, significant positive correlations are observed with the COVID-19 index, GPR index, inflation rate, and unemployment rate, while stock market return and interest rate show significant negative correlations. Furthermore, other factors, including temperature, Ramadan, and GDP growth rate, demonstrate weak or insignificant relationships with cash withdrawals.

In addition, Figure 6 illustrates the relationships between cashless sales, cash withdrawals, and various explanatory variables. For cashless sales, the upward trend in the fitted line for the COVID-19 index indicates a positive relationship, with a correlation coefficient of 0.42. This suggests that stricter COVID-19 measures are linked to higher cashless sales. Similarly, the log of the GPR index shows a weaker positive correlation (0.28), although the data points exhibit significant variability. Additionally, both average temperature and Ramadan display very weak positive relationships with cashless sales, as evidenced by nearly flat fitted lines. Their correlation coefficients (0.05 for temperature and 0.001 for Ramadan) imply minimal impact on cashless sales, with substantial variability at different levels.

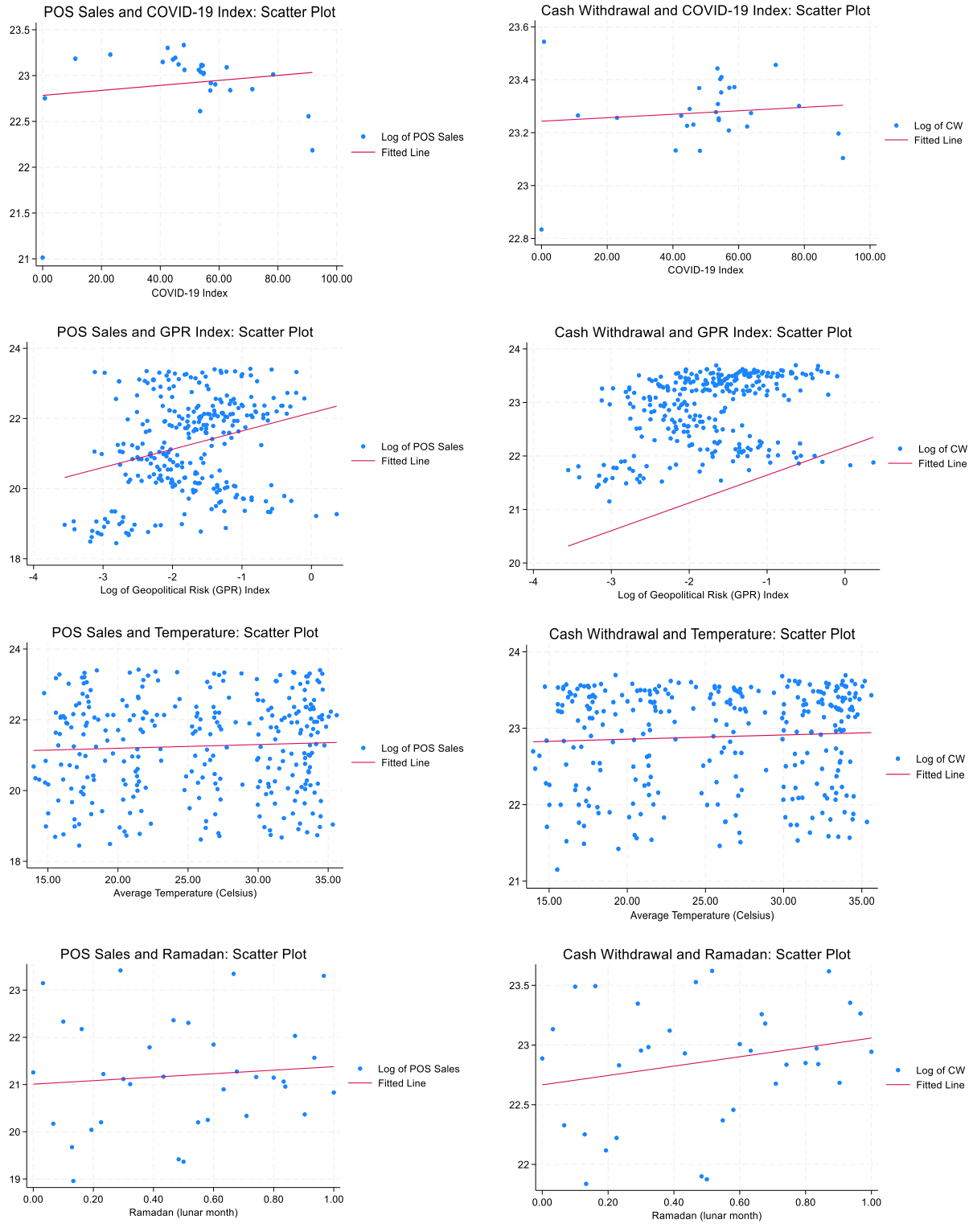
Likewise, for cash withdrawals, a slight upward trend in the fitted line for the COVID-19 index points to a weak positive relationship, supported by a correlation coefficient of 0.20. This indicates that stricter COVID-19 measures correspond to a slight increase in cash withdrawals. Furthermore, the log of the GPR index demonstrates a stronger positive relationship (correlation coefficient of 0.30), suggesting that higher geopolitical risk leads to increased cash withdrawals, despite variability in the data. Similarly, average temperature and Ramadan exhibit very weak positive

relationships with cash withdrawals, as reflected by their nearly flat fitted lines and correlation coefficients of 0.06 and 0.02, respectively. These findings suggest that temperature and Ramadan have minimal influence on cash withdrawals, with high variability across different levels of both variables.

Table 21: Correlation Matrix of Cashless Sales and Cash Withdrawals

	(1) Cashless Sales	(2) Cash Withdrawals	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
(1) Cashless Sales	1										
(2) Cash Withdrawals		1									
(3) COVID-19 Index	0.42***	0.20***	1								
(4) Geopolitical Risk	0.28***	0.30***	-0.17***	1							
(5) Temperature	0.05	0.06	0.04	-0.03	1						
(6) Ramadan	0.001	0.02	0.04	-0.06	0.13**	1					
(7) Inflation Rate	0.36***	0.42***	0.19***	-0.12**	-0.002	-0.01	1				
(8) Stock Market Return	-0.09	-0.13**	0.05	-0.03	-0.03	-0.03	-0.11*	1			
(9) Interest Rate	-0.45***	-0.51***	-0.36***	-0.31***	-0.001	-0.002	-0.15**	-0.08	1		
(10) GDP Growth Rate	0.04	0.07	-0.12**	0.07	-0.01	0.003	0.16***	0.02	-0.17***	1	
(11) Unemployment Rate	0.48***	0.46***	0.67***	0.08	0.06	0.02	0.31***	0.07	-0.56***	0.05	1

Figure 6: Scatter Plots and Relationship Analysis of Cashless Sales and Cash Withdrawals



4.3.2 Panel Analysis

4.3.2.1 Data Description and Statistics

The description and definition of the data used are shown in Table 22. The dependent variables include sectoral cashless sales and urban cashless sales. The influencing factors encompass the COVID-19 pandemic, geopolitical risk, temperature, and Ramadan. The control factors are represented by the inflation rate, stock market return, interest rate, GDP growth rate, and unemployment rate.

Table 22: Definitions and Descriptions of Sectoral and Urban Sales

	Definitions and Descriptions	Source
Cashless Sales by 15 Sectors *Transportation (reference sector)*	The data is sourced from the Monthly Statistics Bulletin published by the Saudi Central Bank (SAMA). The cashless sales transactions by 16 sectors data includes insert card transactions from January 2016 and contactless and digital wallet transactions from January 2019 onwards. These transactions are conducted exclusively through the mada network, the national payment scheme of Saudi Arabia POS sectors including: transportation, health, restaurants and café, hotels, beverage and food, clothing and footwear, recreation and culture, miscellaneous goods and services, electronic and electric devices, furniture, construction and building materials, jewellery, telecommunication, education, and public utilities	SAMA
Cashless Sales in 14 Cities *Riyadh (reference city)*	The data is sourced from the Monthly Statistics Bulletin published by the Saudi Central Bank (SAMA). The cashless sales transactions by 14 main cities data includes insert card transactions from January 2016 and contactless and digital wallet transactions from January 2019 onwards. These transactions are conducted exclusively through the mada network, the national payment scheme of Saudi Arabia. Cities' cashless sales including: Riyadh (the capital), Jeddah, Dammam, AL-Madinah, Makkah, Buraidah, Tabuk, Hail, Abha, Jazan, Najran, Skaka, Arar, and AL-Bahah	SAMA
COVID-19 Stringency Index	The COVID-19 Stringency Index is a composite measure of nine response metrics: school closures; workplace closures; cancellation of public events; restrictions on public gatherings; closures of public transport; stay-at-home requirements; public information campaigns; restrictions on internal movements; and international travel controls. The index for any given day is calculated as the mean score of these nine metrics, each ranging from 0 to 100. A higher score indicates a stricter response, with 100 representing the strictest response	Our World In Data (University of Oxford)
Geopolitical Risk Index	Dario Caldara and Matteo Iacoviello constructed this measure based on a tally of newspaper articles covering geopolitical tensions. The index captures the evolution and economic effects of adverse geopolitical events, organized into eight categories: war threats, peace threats, military build-ups, nuclear threats,	EPU

	terror threats, beginning of war, escalation of war, and terror acts. The Caldara and Iacoviello GPR Index reflects automated text-search results from the electronic archives of 10 newspapers since 1985 by counting the number of articles related to adverse geopolitical events in each newspaper for each month, expressed as a share of the total number of news articles	
Temperature (Celsius)	National average from 32 weather stations, aggregated monthly. Also, the data for the average temperature in Celsius is provided for each of the 14 main cities in the country	NOAA, NCEI, and Meteostat
Ramadan	Ramadan is characterized by its lunar month nature, spanning either 29 or 30 days, differing from the fixed length of calendar months in the Gregorian system. Due to this lunar basis, Ramadan shifts across different months of the Gregorian calendar each year. Ramadan is quantified by calculating the proportion of its days falling within specific calendar months to reflecting the lunar cycle of Ramadan within the context of calendar-based financial data	Researcher calculations Using Umm Al-Qura Islamic Calendar
International Airport	This is a time-invariant variable indicating whether the cities have an international airport. The cities with international airports are Riyadh, Jeddah, Dammam, and Al-Madinah	GACA
Train Station	This is a time-invariant variable indicating whether the cities have a train station. The cities with train stations are Riyadh, Jeddah, Dammam, Al-Madinah, Makkah, Buraidah, Hail, and Skaka	SAR
Sea Port	This is a time-invariant variable indicating whether the cities have a sea port. The cities with sea ports are Jeddah, Dammam, and Jazan	MAWANI
Distance from Capital City	This is a time-invariant variable indicating the distance from the capital city (from nearest to farthest): Buraidah (362 km), Dammam (416 km), Hail (627 km), Al-Madinah (855 km), Makkah (858 km), Jeddah (958 km), Al-Bahah (985 km), Abha (1,016 km), Skaka (1,025 km), Arar (1,058 km), Jazan (1,245 km), Tabuk (1,258 km), and Najran (1,273 km)	GASTAT
Inflation Rate	The inflation rate factor is provided by the General Authority for Statistics in Saudi Arabia (GASTAT), which provides data on a monthly basis starting from January 2013. GASTAT defines the inflation rate as the average consumer price index rate of change from the same month of the previous year	GASTAT
Stock Market Return	The stock market return data is sourced from Tadawul and Investing.com. To calculate the stock market return and assess its variability, the daily closing price index is aggregated to a monthly frequency, providing an average for each month	Tadawul and Investing.com
Interest Rate	The data for the Interest Rate (Repo) is provided by SAMA, which provides data on a monthly basis	SAMA
GDP Growth Rate	The GDP Growth Rate factor is provided by GASTAT, which provides data on a quarterly basis	GASTAT
Unemployment Rate	The data for the Unemployment Rate is provided by two sources. The first source is DataStream, which provides quarterly data from Q1 2016 to Q4 2016. The second source is GASTAT, which provides quarterly data starting from Q1 2017	DataStream, GASTAT

The data for cashless sales transactions is sourced from the monthly statistics bulletin published by the Saudi central bank (SAMA). Initially reported in thousand Riyals, these figures have been

converted to million Riyals and subsequently to million USD. The cashless sales transactions data include insert card transactions from January 1999 and contactless and digital wallet transactions from January 2019 onwards. These transactions are conducted exclusively through the mada network, the national payment scheme of Saudi Arabia, which enables electronic payments through various channels such as POS terminals, Soft-POS, ATMs, and E-commerce websites.

Sectoral cashless sales data covers various categories: transportation (vehicle-related purchases, maintenance, and passenger transport), health (pharmaceuticals, medical equipment, outpatient services, hospital services), restaurants and café (catering and canteen services), hotels (hotel and furnished apartment services), and beverage and food (various food and beverage items). Additionally, it includes clothing and footwear (garments, accessories, cleaning, repair), recreation and culture (media equipment, games, sports, gardening, pets, related services), miscellaneous goods and services (personal grooming, electric appliances, financial services), and other categories such as electronic and electric devices, furniture, construction and building materials, jewellery, telecommunication, education, public utilities, and others.

Urban cashless sales data includes information from 14 cities: Riyadh, Jeddah, Dammam, AL-Madinah, Makkah, Buraidah, Tabuk, Hail, Abha, Jazan, Najran, Skaka, Arar, and AL-Bahah.

The COVID-19 stringency index is included as an independent variable to measure the impact of government-imposed restrictions on payment behaviours. The data is sourced from Our World in Data (University of Oxford) and originally reported on a daily basis. For consistency with other macroeconomic variables, it has been aggregated to a monthly frequency, covering the period from January 2020 to December 2022. The stringency index is a composite measure of nine policy response metrics: school closures, workplace closures, cancellation of public events, restrictions on public gatherings, closures of public transport, stay-at-home requirements, public information campaigns, restrictions on internal movements, and international travel controls. The index for each day is computed as the mean score of these nine components, scaled from 0 to 100, where higher values indicate stricter policy responses (with 100 representing the strictest response). To assess the effect of COVID-19 on payment behaviours, the stringency index is incorporated into the empirical models to capture how varying levels of restrictions influenced cash withdrawals and cashless transactions. Stricter policies are expected to reduce physical cash withdrawals due to

limited mobility and ATM access, while simultaneously increasing reliance on digital and contactless payment methods. This variable allows us to quantify the extent to which policy interventions shaped transaction behaviours during the pandemic.

The data for the Geopolitical Risk (GPR) index is sourced from Economic Policy Uncertainty (EPU) and is reported on a monthly basis, with each observation reflecting the geopolitical uncertainty of the previous month. For instance, the observation for January 1999, reported at the beginning of the month, reflects the geopolitical activity of December 1998. This measure was constructed by Dario Caldara and Matteo Iacoviello, based on an automated text-analysis of newspaper articles covering geopolitical tensions. The index captures the evolution and economic effects of adverse geopolitical events across eight categories: war threats, peace threats, military build-ups, nuclear threats, terror threats, the beginning of war, war escalations, and terror acts. The Caldara and Iacoviello GPR index is derived from 10 major newspapers—including The New York Times, Financial Times, The Wall Street Journal, and The Guardian—by counting the number of articles related to adverse geopolitical events each month, expressed as a share of total news articles. To assess the impact of geopolitical risks on cashless transactions and fintech adoption, the GPR index is incorporated into the empirical models as an independent variable. Higher geopolitical risk levels are expected to influence consumer financial behaviours in multiple ways. During periods of geopolitical instability, consumers may reduce reliance on cash transactions due to concerns about liquidity access, ATM availability, and inflationary pressures. Instead, they may shift towards cashless payment methods such as digital wallets, mobile banking, and fintech platforms for greater security and transaction speed. Moreover, in regions affected by conflict, banking infrastructure disruptions may accelerate fintech adoption as consumers seek alternative financial services. Conversely, extreme geopolitical risks may create uncertainty around financial institutions, leading to a decline in digital transactions if trust in digital banking security is weakened. By incorporating the GPR index into the empirical models, this study quantifies the extent to which geopolitical uncertainty shapes consumer payment behaviours and evaluates its role in shifting transaction preferences between cash and cashless systems.

Temperature data is sourced from the national oceanic and atmospheric administration (NOAA) and the national centers for environmental information (NCEI). This data is reported daily from

32 weather stations across Saudi Arabia and aggregated to a monthly frequency to provide a national average.

For urban cashless sales, the average temperature in Celsius is provided from Meteostat for each of the 14 main cities in the country.

Ramadan follows a lunar cycle, lasting 29 or 30 days, and shifts by approximately 10–12 days earlier each year in the Gregorian calendar. Due to this variability, accurately capturing its effect on financial transactions requires a precise methodological approach. To analyse its impact on cashless sales and cash withdrawals, Ramadan is quantified using the fractional allocation method, which calculates the proportion of its days falling within each Gregorian calendar month. This approach ensures that Ramadan's shifting nature is correctly aligned with monthly financial data, using the Umm Al-Qura Islamic calendar for precise adjustments. By incorporating Ramadan as an independent variable in the empirical models, this study systematically quantifies its effect on payment behaviours while controlling for other economic factors. Ramadan significantly influences consumer spending and transaction patterns through various mechanisms. As a period of fasting, prayer, Quran recitation, charitable giving, and communal activities, Ramadan alters daily routines and financial behaviours. A key financial shift is the increase in cash withdrawals, primarily due to religious donations such as zakat and sadaqah, as individuals withdraw cash to contribute to charity and support social causes. At the same time, cashless transactions rise in key sectors, particularly retail, as spending on food and beverages, clothing and footwear, and jewellery and gifts increases, especially during Iftar (breaking of the fast) and in preparation for Eid-al-Fitr celebrations. However, daytime commercial activity slows due to fasting, leading to lower transaction volumes in some sectors while shifting economic activity to evening and nighttime hours. Beyond short-term spending, Ramadan also affects financial decision-making by reinforcing risk-averse and conservative financial behaviours. The religiosity and risk aversion theory suggests that individuals may be less inclined to engage in riskier financial transactions during Ramadan, potentially leading to a decline in certain types of cashless payments, particularly those linked to investment or high-value discretionary spending. This study accounts for these behavioural shifts by integrating Ramadan as a time-sensitive variable within the empirical models, enabling a robust analysis of how seasonal religious observances shape financial transactions.

Additional urban-specific factors were included as dummy variables. The international airport variable, present in 4 cities Riyadh, Jeddah, Dammam, and Al-Madinah. The Train Station variable, present in 8 cities Riyadh, Jeddah, Dammam, Al-Madinah, Makkah, Buraidah, Hail, and Skaka. The Sea Port variable, present in 3 cities Jeddah, Dammam, and Jazan. The distance from capital city variable, with the capital city as the reference point (0 km), from nearest to farthest: Buraidah (362 km), Dammam (416 km), Hail (627 km), Al-Madinah (855 km), Makkah (858 km), Jeddah (958 km), Al-Bahah (985 km), Abha (1,016 km), Skaka (1,025 km), Arar (1,058 km), Jazan (1,245 km), Tabuk (1,258 km), and Najran (1,273 km).

The inflation rate data is provided by the general authority for statistics in Saudi Arabia (GASTAT) on a monthly basis starting from January 2013. GASTAT defines the inflation rate as the average consumer price index rate of change from the same month of the previous year.

For urban cashless sales, the inflation rate is the average consumer price index rate of change from the same month of the previous year for each of the 14 cities.

Stock market return data is initially reported based on the daily closing prices for each listed company. These companies are grouped according to their relevance in the cashless sales sector, and the data is aggregated to a monthly frequency from December 2015 to December 2023. Out of 233 listed companies, 166 are included.

For urban cashless sales, the stock market return data is sourced from Tadawul and Investing.com, and the daily closing price index is aggregated to a monthly frequency to provide an average for each month.

The data for the interest rate is provided by SAMA on a monthly basis starting from January 2007. The GDP growth rate factor is provided by GASTAT on a quarterly basis starting from Q1 2011, with this quarterly data converted and distributed on a monthly basis. The unemployment rate data is provided by two sources: DataStream (from Q1 2012 to Q4 2016) and GASTAT (starting from Q1 2017). This quarterly data is then converted and distributed on a monthly basis.

The descriptive statistics in Table 23 provide an overview of cashless sales across 15 sectors and urban cashless sales from January 2016 to December 2023.

Table 23: Descriptive Statistics of Sectoral and Urban Cashless Sales

	Obs.	Min	Mean	Std.Dev	Max
Sectoral Cashless Sales Model					
Cashless Sales	1,440	19.17	432.81	437.28	2,503.22
COVID-19 Stringency Index	1,440	0.00	17.09	26.10	91.73
Geopolitical Risk Index	1,440	0.04	0.27	0.18	0.90
Temperature	1,440	14.73	26.04	6.59	35.61
Ramadan	1,440	0.00	0.08	0.22	0.97
Inflation Rate	1,440	-3.24	1.62	2.27	6.16
Stock Market Return	1,434	-0.04	0.00	0.07	2.32
Interest Rate	1,440	1.00	2.43	1.43	6.00
GDP Growth Rate	1,440	-7.10	2.02	3.66	9.10
Unemployment Rate	1,440	4.40	6.01	0.91	8.98
Urban Cashless Sales Models					
Cashless Sales	1,344	9.82	416.77	761.58	4,942.39
COVID-19 Stringency Index	1,344	0.00	17.09	26.10	91.73
Geopolitical Risk Index	1,344	0.04	0.27	0.18	0.90
Temperature	1,344	9.10	26.37	7.44	39.30
Ramadan	1,344	0.00	0.08	0.22	0.97
International Airport	1,344	0.00	0.29	0.45	1.00
Train Station	1,344	0.00	0.57	0.50	1.00
Sea Port	1,344	0.00	0.21	0.41	1.00
Distance from Capital City	1,344	0.00	852.57	361.82	1,273
Inflation Rate	1,344	-18.39	0.59	3.76	15.38
Stock Market Return	1,344	-0.17	0.01	0.05	0.15
Interest Rate	1,344	1.00	2.43	1.43	6.00
GDP Growth Rate	1,344	-7.10	2.02	3.66	9.10
Unemployment Rate	1,344	4.40	6.01	0.91	8.98

From January 2016 to December 2023

Firstly, the sectoral cashless sales ranged from 19.17 million USD to 2,503.22 million USD, with an average of 432.81 million USD and a standard deviation of 437.28 million USD, indicating significant variability across sectors. This wide range suggests diverse levels of cashless financial activity, potentially driven by sector-specific factors such as consumer behaviour, industry size, and digital infrastructure.

Among the explanatory independent variables, the COVID-19 index showed substantial variability, ranging from 0.00 to 91.73, with an average of 17.09 and a standard deviation of 26.10. This reflects the different levels of government-imposed restrictions during the pandemic, which may have significantly impacted sectoral cashless sales. The GPR index, which ranged from 0.04 to 0.90, with a mean of 0.27 and a standard deviation of 0.18, showed moderate variability, suggesting that while geopolitical risk was present, its fluctuations were not extreme during the period. The Temperature variable, with a range from 14.73°C to 35.61°C and an average of 26.04°C, showed notable variation, which could impact sectors sensitive to climatic conditions.

The Ramadan variable, with a mean of 0.08 and a standard deviation of 0.22, indicated that about 8% of the observation period fell within Ramadan, which could affect consumer behaviour and sales patterns in sectors associated with religious or cultural activities.

The macroeconomic control variables showed a range of variability as well. The inflation rate ranged from -3.24% to 6.16%, with an average of 1.62% and a standard deviation of 2.27%, indicating periods of both inflation and deflation during the study period. The stock market return, with a mean of 0.00% and a standard deviation of 0.07%, showed moderate variability, reflecting relatively stable financial market conditions. The interest rate, which ranged from 1.00% to 6.00%, with an average of 2.43%, showed moderate fluctuations, consistent with periods of monetary policy adjustments. The GDP growth rate, with a range from -7.10% to 9.10%, an average of 2.02%, and a standard deviation of 3.66%, highlighted notable economic variability, indicating periods of both downturns and growth. Lastly, the unemployment rate ranged from 4.40% to 8.98%, with a mean of 6.01% and relatively low variability, suggesting stable employment conditions across sectors.

Secondly, the urban cashless sales, covering 14 main cities, ranged from 9.82 million USD to 4,942.39 million USD, with an average of 416.77 million USD and a standard deviation of 761.58 million USD. This large standard deviation points to significant disparities in cashless sales across cities, potentially influenced by varying levels of economic development, population size, and digital infrastructure.

The COVID-19 index and GPR index in the urban model followed similar patterns to those in the sectoral model, indicating significant variability in pandemic restrictions and moderate fluctuations in geopolitical risk across cities. The Temperature, ranging from 9.10°C to 39.30°C with an average of 26.37°C, showed significant variability, which could impact consumer spending patterns depending on the climate of each city. The Ramadan variable followed the same pattern as in the sectoral model, reflecting its infrequent occurrence but potential influence on urban consumption behaviour during religious periods.

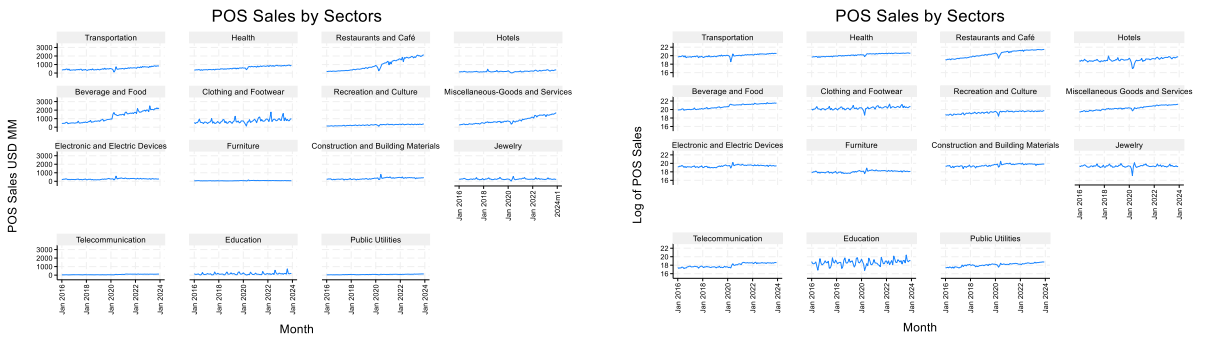
Several urban-specific variables were included as dummy variables to capture the effects of infrastructure. International airports, present in 29% of the cities, train stations in 57%, and sea

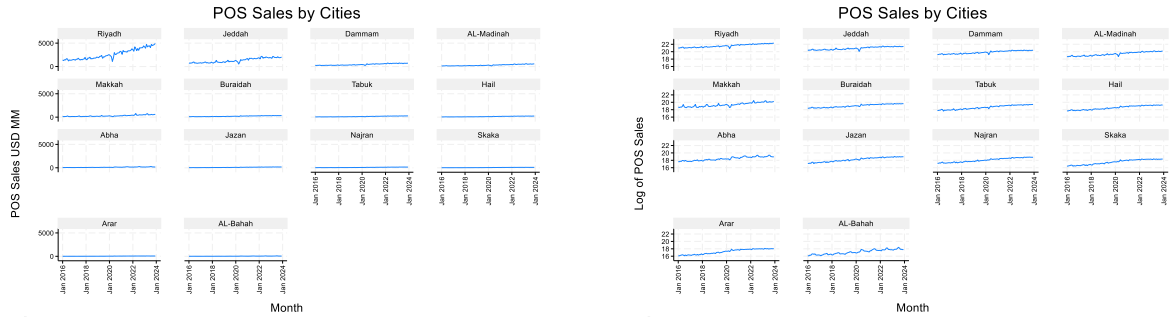
ports in 21%, reflect varying degrees of transportation infrastructure, which could facilitate cashless transactions in cities with more connectivity. The distance from the capital city, ranging from 0 km to 1,273 km with an average of 852.57 km, indicates the geographical spread of cities relative to the capital, which could affect economic and financial activity.

Finally, the macroeconomic control variables for cities showed significant variation. The inflation rate for cities ranged from -18.39% to 15.38%, with an average of 0.59% and a standard deviation of 3.76%, indicating substantial inflationary pressures in certain urban areas. The stock market return had a mean of 0.01% and a standard deviation of 0.05%, reflecting relatively stable market conditions in cities. The interest rate and GDP growth rate followed similar trends to the sectoral model, showing moderate variability, while the unemployment rate, ranging from 4.40% to 8.98% with a mean of 6.01%, indicated stable employment conditions in urban areas.

Figure 7 presents the trends and volatility of sectoral and urban cashless sales, alongside their log-transformed versions. The first set of plots illustrates the raw cashless sales data across various sectors, highlighting overall growth and fluctuations. The second set displays the log-transformed values of sectoral cashless sales, smoothing volatility and providing clearer long-term trends. These visualizations offer insights into sector-specific patterns of cashless transactions over time. Additionally, Figure 7 also shows the trends and volatility of cashless sales across cities. The first set of city-level plots shows the raw cashless sales data, revealing fluctuations and sectoral trends. The second set of city-level plots presents log-transformed sales data, which provide a clearer depiction of long-term trends by reducing volatility.

Figure 7: Trends and Log-Transformation of Sectoral and Urban Cashless Sales





Sectors including; transportation, health, restaurants and café, hotels, beverage and food, clothing and footwear, recreation and culture, miscellaneous goods and services, electronic and electric devices, furniture, construction and building materials, jewellery, telecommunication, education, and public utilities
Cities including; Riyadh (capital city), Jeddah, Dammam, AL-Madinah, Makkah, Buraidah, Tabuk, Hail, Abha, Jazan, Najran, Skaka, Arar, and AL-Bahah

4.3.2.2 Empirical Model

Sectoral Cashless Sales Model 1

$$\begin{aligned} &ln Sectoral\ Cashless\ Sales_{st} \\ &\quad = \beta_0 + \beta_1 Covid\ Index_t + \beta_2 Geopolitical\ Risk_t + \beta_3 Temperature_t \\ &\quad + \beta_4 Temperature_t^2 + \beta_5 Ramadan_t + \beta_6 Inflation\ Rate_{t-1} \\ &\quad + \beta_7 Stock\ Returns_{t-1} + \beta_8 Interest\ Rate_{t-1} + \beta_9 GDP\ Growth\ Rate_{t-1} \\ &\quad + \beta_{10} Unemployment\ Rate_{t-1} + \delta_s + \tau_t + \epsilon_{st} \end{aligned}$$

s denotes for sector, and t denotes for month

δ_s denotes for sector fixed effect

τ_t denotes for time fixed effect

Urban Cashless Sales Model 2:

$$lnUrban\ Cashless\ Sales_{ct} = \beta_0 + \beta_1 Covid\ Index_t + \beta_2 Geopolitical\ Risk_t + \beta_3 Temperature_{ct} + \beta_4 Temperature_{ct}^2 + \beta_5 Ramadan_t + \beta_6 Inflation\ Rate_{ct-1} + \beta_7 Stock\ Returns_{t-1} + \beta_8 Interest\ Rate_{t-1} + \beta_9 GDP\ Growth\ Rate_{t-1} + \beta_{10} Unemployment\ Rate_{t-1} + \tau_t + \sum_{i=2}^{i=14} \theta_i Dummy\ City_i + \epsilon_{ct}$$

Urban Cashless Sales Model 3:

$$lnUrban\ Cashless\ Sales_{ct} = \beta_0 + \beta_1 Covid\ Index_t + \beta_2 Geopolitical\ Risk_t + \beta_3 Temperature_{ct} + \beta_4 Temperature_{ct}^2 + \beta_5 Ramadan_t + \beta_6 International\ Airport_c + \beta_7 Train\ Station_c + \beta_8 Sea\ Port_c + \beta_9 Distance\ from\ Capital_c + \beta_{10} Inflation\ Rate_{ct-1} + \beta_{11} Stock\ Returns_{t-1} + \beta_{12} Interest\ Rate_{t-1} + \beta_{13} GDP\ Growth\ Rate_{t-1} + \beta_{14} Unemployment\ Rate_{t-1} + \tau_t + \epsilon_{ct}$$

Riyadh is the capital city and the reference category, the main cities including Jeddah, Dammam, AL-Madinah, Makkah, Buraidah, Tabuk, Hail, Abha, Jazan, Najran, Skaka, Arar, and AL-Bahah

c denotes for city, and t denotes for time period (month)

τ_t denotes for time fixed effect

The potentially nonlinear relationship between temperature and urban cashless sales aligns with Pankratz et al. (2023), and Addoum et al. (2023).

4.3.2.3 Correlation and Relationship Analysis

The correlation matrix in table 24 provides insights into the relationships between sectoral cashless sales and various independent variables. Overall, significant positive correlations with cashless sales are observed with the COVID-19 index, inflation rate, interest rate, and GDP growth rate. A significant negative correlation is found with the geopolitical risk index. Other variables such as

temperature, Ramadan, stock market return, and unemployment rate show weak or insignificant correlations with cashless sales.

The correlation matrix in table 25 provides insights into the relationships between urban cashless sales and various independent variables. Overall, significant positive correlations with cashless sales are observed with the COVID-19 index, temperature, the presence of an international airport, train station, sea port, inflation rate, and interest rate. Significant negative correlations with cashless sales are found with the geopolitical risk index and distance from capital city. Other variables such as Ramadan, stock market return, GDP growth rate, and unemployment rate show weak or insignificant correlations with cashless sales.

Table 24: Correlation Matrix of Sectoral Cashless Sales

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
(1) Cashless Sales	1									
(2) COVID-19 Index	0.09***	1								
(3) Geopolitical Risk	-0.05**	-0.47***	1							
(4) Temperature	-0.002	0.06**	-0.06**	1						
(5) Ramadan	-0.01	0.09***	0.10***	0.20***	1					
(6) Inflation Rate	0.11***	0.41***	-0.36***	0.02	-0.005	1				
(7) Stock Market Return	-0.03	-0.01	-0.004	0.02	-0.02	0.01	1			
(8) Interest Rate	0.12***	-0.58***	0.25***	-0.002	-0.05**	-0.09***	-0.01	1		
(9) GDP Growth Rate	0.06**	-0.11***	-0.04	-0.09***	-0.04	0.01	0.04	-0.10***	1	
(10) Unemployment Rate	-0.001	0.74***	-0.29***	0.14***	0.05**	0.28***	-0.01	-0.69***	-0.31***	1

Table 25: Correlation Matrix of Urban Cashless Sales

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
(1) Cashless Sales	1													
(2) COVID-19 Index	0.16***	1												
(3) Geopolitical Risk	-0.08***	-0.47***	1											
(4) Temperature	0.21***	0.05*	-0.05**	1										
(5) Ramadan	0.01	0.09***	0.10***	0.17***	1									
(6) International Airport	0.74***	0.000	0.000	0.19***	0.000	1								
(7) Train Station	0.57***	0.000	0.000	0.18***	0.000	0.55***	1							
(8) Sea Port	0.31***	0.000	0.000	0.23***	0.000	0.44***	0.10***	1						
(9) Distance from Capital City	-0.60***	0.000	0.000	-0.05*	0.000	-0.52***	-0.69***	0.03	1					
(10) Inflation Rate	0.32***	0.40***	-0.31***	0.05*	-0.001	0.19***	0.14***	0.00	-0.14***	1				
(11) Stock Market Return	0.03	0.10***	-0.20***	0.01	0.11***	0.000	0.000	0.000	0.000	0.05**	1			
(12) Interest Rate	0.12***	-0.58***	0.25***	0.004	-0.05**	0.000	0.000	0.000	0.000	-0.16***	-0.14***	1		
(13) GDP Growth Rate	0.06**	-0.11***	-0.04	-0.07**	-0.04	0.000	0.000	0.000	0.000	0.06**	-0.05**	-0.10***	1	
(14) Unemployment Rate	0.01	0.74***	-0.29***	0.12***	0.05**	0.000	0.000	0.000	0.000	0.20***	0.24***	-0.69***	-0.31***	1

Figure 8 illustrates the relationship between cashless sales and various explanatory variables COVID-19 Index, geopolitical risk index, average temperature, and the Ramadan period across different sectors, with transportation serving as the baseline. The coefficient plots reveal important insights into how each variable affects sectoral sales.

The COVID-19 index has a significant positive impact on several sectors. For instance, the restaurants and café sector (0.011, p=0.004), beverage and food sector (0.011, p=0.000), and telecommunication sector (0.008, p=0.005) all show increased sales during periods of stricter COVID-19 measures. This indicates that certain sectors may benefit from shifts in consumer behaviour during lockdowns or restricted movement. However, the hotels sector experiences a slight negative impact (-0.006, p=0.091), suggesting that reduced travel and tourism during strict measures might lower sales in this sector.

In terms of geopolitical risk, sectors like restaurants and café (-0.728, p=0.098), beverage and food (-0.681, p=0.043), and telecommunication (-0.615, p=0.037) show a significant decline in sales as geopolitical instability rises. Interestingly, the hotels sector shows the opposite trend, with a positive coefficient (0.503, p=0.082), indicating that it may see increased sales during times of geopolitical unrest. This could be due to changing consumer needs or increased demand for domestic travel and accommodations during periods of global instability.

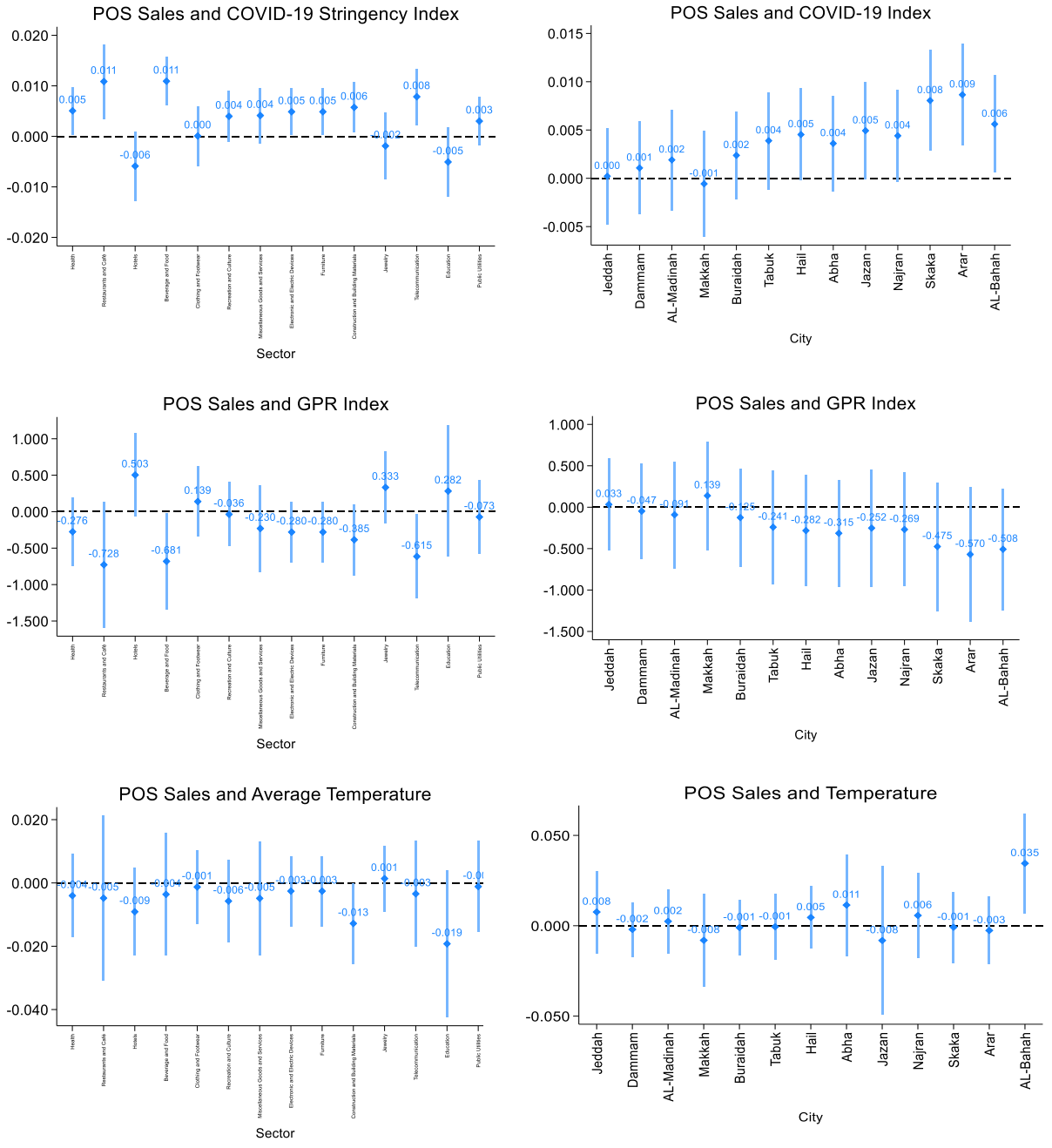
When examining the effects of average temperature, the construction and building materials sector shows a significant negative impact (-0.013, p=0.050), implying that higher temperatures lead to lower sales in this sector. The education sector also suggests a potential negative effect (-0.019, p=0.104), though it falls just outside the threshold for statistical significance.

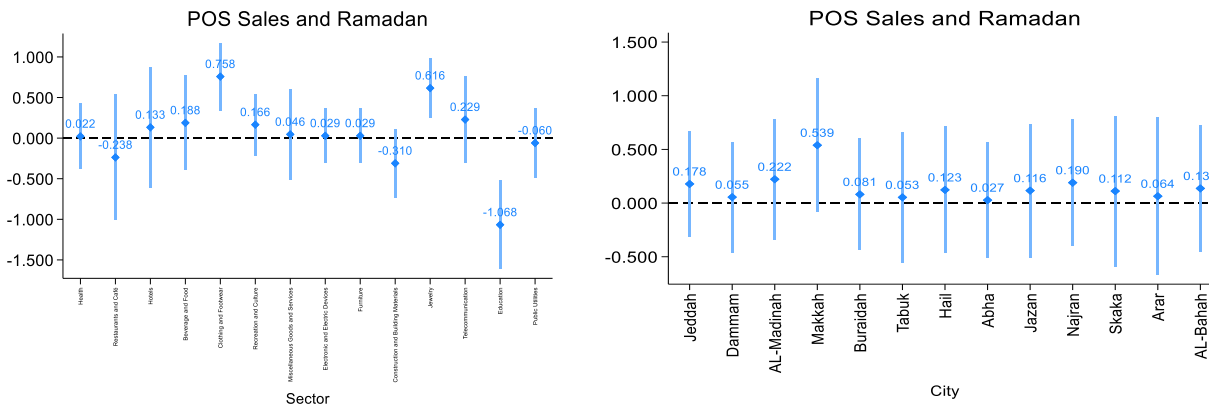
Finally, the Ramadan period exhibits notable sector-specific effects. Sectors such as clothing and footwear (0.758, p=0.000) and jewellery (0.616, p=0.001) experience substantial increases in sales during Ramadan, likely driven by seasonal shopping habits. On the other hand, the education sector shows a significant negative impact (-1.068, p=0.000), suggesting that educational spending decreases during this period, possibly due to school closures or shifts in priorities during Ramadan.

In summary, Figure 8 highlights the varying effects of the COVID-19 Index, geopolitical risk, average temperature, and Ramadan across sectors. Sectors like restaurants and café, beverage and

food, and telecommunication generally benefit from stricter covid-19 measures, while geopolitical risk negatively affects several key sectors. Additionally, higher temperatures and the Ramadan period produce sector-specific effects, with sales increasing in sectors like clothing and footwear but decreasing in sectors like education.

Figure 8: Coefficient Plot of Sectoral and Urban Cashless Sales





Sectors: transportation (reference category), the sectors including; health, restaurants and café, hotels, beverage and food, clothing and footwear, recreation and culture, miscellaneous goods and services, electronic and electric devices, furniture, construction and building materials, jewellery, telecommunication, education, and public utilities
Cities: Riyadh (capital city and reference category), the cities including; Jeddah, Dammam, AL-Madinah, Makkah, Buraidah, Tabuk, Hail, Abha, Jazan, Najran, Skaka, Arar, and AL-Bahah

Figure 8, also presents coefficient plots that examine the relationship between urban cashless sales and various explanatory variables COVID-19 index, GPR index, average temperature, and the Ramadan period across different cities, using Riyadh as the reference category.

Regarding the COVID-19 index, the analysis shows significant positive effects in several cities. Hail (0.005, p=0.063), Jazan (0.005, p=0.056), Najran (0.004, p=0.069), Skaka (0.008, p=0.002), Arar (0.009, p=0.001), and AL-Bahah (0.006, p=0.028) all exhibit significant increases in cashless sales during stricter COVID-19 measures. These findings suggest that tighter COVID-19 restrictions are associated with higher cashless sales in these cities.

In contrast, the GPR index does not show statistically significant effects on cashless sales across any of the cities. The analysis indicates that geopolitical risk does not have a measurable impact on urban cashless sales when compared to the baseline city, Riyadh, within the given significance level.

For temperature, only AL-Bahah exhibits a significant positive relationship (0.035, p=0.014), suggesting that higher temperatures are linked to increased cashless sales in this city. No other cities show statistically significant effects of temperature on cashless sales.

Finally, in terms of the Ramadan period, only Makkah shows a significant positive impact on cashless sales (0.539, p=0.090), indicating that sales increase notably during Ramadan in Makkah.

Other cities do not demonstrate significant effects during Ramadan within the chosen significance threshold.

4.4 Empirical Results

This research explores how the COVID-19 pandemic, geopolitical risks, temperature variations, and Ramadan affected cash and cashless transactions in Saudi Arabia, focusing on the roles of financial institutions, government policies, and economic uncertainty.

The theoretical framework integrates key theories for a comprehensive understanding. Additionally, it evaluates how infrastructural development, such as international airports, railway stations, sea ports, and distance from capital city, contributes to urban cashless sales.

The primary objective is to assess the economic impacts of financial behaviours related to cashless sales at POS terminals and cash withdrawal transactions at ATMs in Saudi Arabia.

4.4.1 ARDL Analysis

4.4.1.1 Results and Discussion

Table 26 representing the results of cashless sales and cash withdrawal transactions.

Table 26: Regression Results of Cashless Sales and Cash Withdrawals

	Cashless Sales Model 1	Cash Withdrawals Model 2
Explanatory Variables (Exogenous)		
COVID-19 Index	-0.002***	-0.001
	(0.001)	(0.001)
Geopolitical Risk	-0.015*	-0.017**
	(0.009)	(0.008)
Temperature	0.018**	0.016**
	(0.009)	(0.008)
$Temperature^2$	-0.0004**	-0.0003*
	(0.0001)	(0.0001)
Ramadan	0.011	0.057**
	(0.030)	(0.025)
Control Factors (Long-term)		
Inflation Rate	0.009**	-0.004
	(0.004)	(0.004)
Stock Market Return	0.165	0.086
	(0.117)	(0.090)
Interest Rate	-0.009	-0.004
	(0.006)	(0.004)
GDP Growth Rate	0.003**	-0.002
	(0.002)	(0.001)
Unemployment Rate	0.029*	-0.010
	(0.016)	(0.015)
Control Factors (Short-term)		

Inflation Rate	0.002	0.005
	(0.008)	(0.010)
Stock Market Return	0.163	0.054
	(0.098)	(0.078)
Interest Rate	-0.064*	-0.024
	(0.053)	(0.028)
GDP Growth Rate	0.001	-0.005*
	(0.004)	(0.006)
Unemployment Rate	-0.063**	-0.078***
	(0.032)	(0.029)
Time Trend	Yes	Yes
$Time^2$ Trend		Yes
Constant	5.290***	5.048***
	(1.223)	(1.336)
R-squared	0.323	0.454
Adj. R-squared	0.266	0.407
Number of Observations	296	296

*Significant: *<0.1, **<0.05, ***<0.01*
Unstandardised coefficients
Robust standard errors in parentheses
Log of Cashless Sales, Cash Withdrawals, and Geopolitical Risk

The COVID-19 Pandemic

The regression results indicate that the COVID-19 Index has a statistically significant negative impact on cashless sales, while its effect on cash withdrawals is insignificant. These findings provide nuanced insights into the relationship between pandemic-related uncertainty and payment behaviour in Saudi Arabia, diverging from global trends observed in other studies.

The decline in cashless sales during the pandemic contrasts with findings from Europe, where studies reported increased digital payment adoption due to health concerns and transaction convenience (Jonker et al., 2022; Kotkowski & Polasik, 2021). The theory of payment choice (Jonker et al., 2022) suggests that crises typically accelerate digital transactions as consumers seek safer and more convenient payment methods. However, Saudi Arabia's experience was different due to institutional and economic factors. Unlike the Netherlands and Europe, where digital payment infrastructure was already dominant, Saudi Arabia was still in the process of transitioning to a cashless economy. Certain sectors experienced reduced transaction volumes during lockdowns, potentially explaining the overall decline in cashless sales.

A key distinction of this study is its longitudinal dataset, covering the period from January 1999 to December 2023, which allows for an assessment of payment behaviour before, during, and post-pandemic. Unlike prior studies that primarily focus on short-term disruptions during lockdown

periods, this study provides a broader perspective on post-pandemic cashless sales trends. Given that lockdowns in Saudi Arabia began in late March 2020 and lasted until December 2022, the findings reflect both immediate disruptions and longer-term shifts in consumer payment preferences. The results show that despite an overall decline in cashless transactions, the role of economic uncertainty and policy-driven interventions was crucial in shaping financial behaviour during this period.

In contrast to the decline in cashless sales, the insignificant effect of COVID-19 on cash withdrawals does not align with findings from Krakow, where stringent pandemic-related measures led to reduced daily withdrawals and lower variability (Suder et al., 2024). This suggests that increased transaction costs and economic uncertainty can influence cash demand, a concept supported by the theory of cash management (Shy, 2023), which predicts that cash demand fluctuates in response to economic disruptions. However, the relatively stable cash withdrawals observed in Saudi Arabia suggest that consumers maintained confidence in ATM liquidity and financial stability, preventing drastic shifts in cash usage. The theory of ATM cash management (Suder et al., 2024) explains how banks strategically adjust cash supply to prevent shortages during economic shocks. The lack of significant fluctuations in Saudi Arabia indicates that financial institutions effectively managed ATM liquidity, ensuring stable access to cash throughout the pandemic.

The unique institutional setting of Saudi Arabia further explains these findings. The country's rapid push toward cashless transactions under Vision 2030 meant that digital payment adoption was already expanding before the pandemic. Government initiatives, such as mandatory digital payment acceptance in key sectors and the expansion of fintech solutions like Mada Pay and STC Pay, reinforced this transition. However, the pandemic may have temporarily disrupted consumer confidence and spending behaviour, contributing to the observed decline in cashless sales. The theory of economic uncertainty measures (Altig et al., 2020) explains that heightened uncertainty can lead to reduced consumer confidence and spending activity, which could have counteracted the anticipated acceleration in cashless transactions. Unlike in Japan, where direct stimulus checks boosted digital payments (Kubota et al., 2021), Saudi Arabia's financial response did not follow the same trajectory. This highlights the importance of institutional and policy responses in shaping financial behaviours during crises.

This study offers novel insights by demonstrating that the impact of the pandemic on cashless transactions is not uniform across economies. While previous research highlights increased digital payment adoption during COVID-19, Saudi Arabia's experience suggests that economic uncertainty and policy-driven financial behaviours can counterbalance global digital payment trends. For example, studies from Europe (Jonker et al., 2022; Kotkowski & Polasik, 2021) report an acceleration in digital payments due to health concerns and lockdown measures. However, the findings of this study diverge from these trends, showing that in Saudi Arabia, cashless sales declined during the pandemic, likely due to financial uncertainty and sector-specific disruptions. This contrasts with Japan, where direct stimulus checks encouraged digital transactions (Kubota et al., 2021), underscoring how different policy interventions influence financial behaviour.

By capturing data spanning multiple decades, this study provides long-term insights into cashless payment adoption, which is rare in prior research that focuses only on the lockdown period (Kotkowski & Polasik, 2021; Suder et al., 2024). The results indicate that while cashless transactions initially declined, policy interventions and financial sector adaptability played a critical role in stabilizing digital payment adoption post-pandemic (Ho et al., 2023). These findings refine the theory of economic uncertainty measures (Altig et al., 2020), illustrating that uncertainty does not always drive higher digital adoption; rather, institutional settings and financial responses play a crucial role in shaping consumer behaviour. Similarly, the theory of ATM cash management (Suder et al., 2024) explains how banks adjust liquidity strategies, which may account for the stable cash withdrawal patterns observed in Saudi Arabia despite the economic downturn.

The study also reinforces the theory of payment choice (Jonker et al., 2022), emphasizing that factors such as perceived ease of use, regulatory incentives, and financial infrastructure shape digital adoption. While many economies experienced accelerated cashless adoption due to health concerns, the findings from Saudi Arabia suggest that these factors were moderated by institutional policies, economic uncertainty, and sector-specific disruptions. The government's role in promoting digital payments under Vision 2030 was a key driver of adoption, yet pandemic-related uncertainty temporarily slowed the transition.

In conclusion, this study contributes to the literature by contrasting Saudi Arabia's payment behaviour with global trends, highlighting how economic uncertainty, institutional policies, and

sector-specific factors influence cashless transactions (Jonker et al., 2022; Kotkowski & Polasik, 2021; Kubota et al., 2021). It also provides long-term insights into post-pandemic payment behaviour, which has been largely overlooked in previous research (Suder et al., 2024; Kotkowski & Polasik, 2021). Additionally, the findings expand theoretical understanding by showing how financial policies, ATM liquidity management, and government incentives interact with digital adoption trends in emerging economies (Altig et al., 2020; Ho et al., 2023; Suder et al., 2024). These results underscore that the transition to a cashless economy is not solely technology-driven but is instead institutionally and behaviourally complex, influenced by financial stability, regulatory interventions, and consumer trust.

The Geopolitical Risk

The results indicate that geopolitical risk has a significant negative impact on both cashless sales and cash withdrawals, providing new insights into how uncertainty affects consumer financial behaviour. These findings contribute to the existing literature on the economic consequences of geopolitical risks and payment behaviours in emerging markets. The observed decline in cashless sales under geopolitical risk aligns with Adra et al. (2023), who found that firms adopt conservative financial strategies when faced with uncertainty. This suggests that both businesses and consumers may reduce digital transactions during periods of geopolitical instability due to liquidity concerns, uncertainty in financial markets, and heightened financial risk aversion. Similarly, Tarkom and Ujah (2023) highlight the role of policy uncertainty in working capital management, which may extend to consumer financial behaviour, leading individuals to prioritize liquidity over electronic payments during geopolitical crises.

One key mechanism through which geopolitical risks impact consumer financial behaviour is through confidence in financial institutions and digital payment systems. Liu and Zhang (2024) found that geopolitical risk influences currency returns, which could contribute to financial market volatility and decreased consumer trust in electronic transactions. Consumers facing uncertainty over economic stability or capital controls may withdraw funds from digital accounts, reduce online transactions, or shift toward more secure and liquid financial options. However, the impact on cash withdrawals deviates from prior expectations. Jiang et al. (2022) found that geopolitical risk negatively affects tourism-related stock returns, reflecting broader uncertainty in investment

decisions. This study extends those insights by demonstrating that geopolitical risk influences not only investment behaviour but also day-to-day consumer payment patterns, leading to a general contraction in financial transactions rather than a substitution effect between cash and digital payments.

The broader implications of geopolitical risk on payment behaviours are also evident in alternative financial platforms. Alsagr et al. (2023) found that geopolitical uncertainty affects crowdfunding success, illustrating how risk-averse behaviour extends across financial activities. This suggests that under geopolitical risk, not only do firms and investors reduce risk exposure, but consumers also respond by limiting discretionary spending and financial transactions, regardless of payment method. Unlike prior assumptions that uncertainty leads to a shift toward cash holdings, this study finds that geopolitical risk results in a wider contraction of financial activity, reinforcing a more cautious approach to personal and business finance.

The findings align with several theoretical perspectives. The theory of geopolitical risk and corporate payouts (Arena & Julio, 2023) suggests that heightened geopolitical uncertainty increases cash flow uncertainty and financial distress risk, leading both firms and individuals to adopt conservative financial behaviours. Similarly, real options theory (Bernanke, 1983) posits that in times of uncertainty, economic agents delay financial commitments, reducing reliance on both digital and cash-based transactions. The signalling theory (John & Williams, 1985) provides a rationale for precautionary financial behaviour in response to geopolitical risk, where both businesses and consumers seek liquidity buffers rather than committing to transactions. Lastly, the theory of economic consequences of geopolitical risk (Bloom, 2009) highlights how uncertainty disrupts normal economic activity, leading to reduced spending, transaction avoidance, and a slowdown in financial engagement.

In the case of Saudi Arabia, where the financial sector is rapidly evolving under Vision 2030, geopolitical risk poses additional challenges to digital transformation and fintech adoption. Given Saudi Arabia's role in global energy markets and regional stability, consumers and businesses may adjust payment behaviours during geopolitical uncertainty due to concerns over economic stability, potential capital flow restrictions, or precautionary savings behaviour. Notably, the results indicate that geopolitical risk does not lead to a simple shift from digital to cash transactions. Instead, both

cashless sales and cash withdrawals decline, suggesting that consumers react to uncertainty by reducing overall financial activity rather than substituting between payment methods. This challenges prior assumptions in the literature that geopolitical uncertainty leads to increased cash withdrawals, instead revealing a more comprehensive contraction in spending and financial engagement.

This study makes a significant contribution by demonstrating that geopolitical risk negatively affects both cashless sales and cash withdrawals, contradicting previous research that suggested a shift toward cash-based transactions under uncertainty. Instead, the findings suggest that geopolitical risk induces broader financial conservatism, where both individuals and firms curtail financial transactions altogether rather than merely switching from digital to cash. The study extends the work of Adra et al. (2023) and Tarkom and Ujah (2023) by demonstrating that geopolitical risk affects not only corporate financial policies but also consumer transaction behaviours. Furthermore, the findings build on Liu and Zhang (2024) by showing that financial volatility under geopolitical risk affects not only currency returns but also everyday payment decisions. Additionally, by incorporating insights from Jiang et al. (2022) and Alsagr et al. (2023), this study highlights that geopolitical uncertainty does not merely influence investment markets or crowdfunding but extends to real-economy activities such as consumer payment transactions.

These findings enhance the understanding of geopolitical risk's impact on financial behaviour in emerging economies. This insight is particularly relevant for policymakers, financial institutions, and fintech developers, as it suggests the need for enhanced economic resilience, stronger financial infrastructure, and payment system stability amid geopolitical uncertainties.

Temperature

The findings indicate that temperature has a nonlinear impact on both cashless sales and cash withdrawals, as evidenced by the significant positive effect of temperature and the significant negative effect of its squared term. These results suggest that while moderate increases in temperature initially lead to higher transactional activity, extreme temperatures eventually reduce both cashless and cash transactions. This finding contributes to the literature on the economic

effects of weather fluctuations by demonstrating their impact on financial transactions rather than just retail sales or productivity.

These results align with previous research highlighting the economic consequences of abnormal weather. Bertrand and Parnaudeau (2019) found that adverse weather conditions lead to sales losses, while Tran (2023) documented increased volatility in sales due to severe weather events. The observed initial increase in cashless sales with rising temperatures supports Keleş et al. (2018), who showed that temperature changes can boost demand for specific goods, such as beverages. However, the negative effect of extreme temperatures, as indicated by the squared term, aligns with Pankratz et al. (2023), who found that extremely hot days reduce firms' revenues. The lack of a consistent linear effect also resonates with Addoum et al. (2020), who reported no significant impact of temperature shocks on sales or productivity, suggesting that the relationship between temperature and financial transactions is more complex than a simple positive or negative correlation.

From a theoretical perspective, these findings support the theory of operations management in extreme weather (Liang et al., 2024), which suggests that firms implement buffering strategies to mitigate financial disruptions caused by extreme temperatures. The increase in transactional activity at moderate temperatures may reflect businesses optimizing cash reserves to maintain liquidity. Additionally, the theory of weather impact on retail operations (Martínez-de-Albéniz & Belkaid, 2021) explains how weather conditions influence consumer behaviour, which is evident in the initial rise in cashless sales and withdrawals. The negative impact of extreme temperatures supports the reference point effect theory (Keleş et al., 2018), which highlights asymmetric effects of temperature fluctuations on demand, indicating that excessive heat or cold may discourage spending altogether.

Furthermore, information processing theory (Flynn & Flynn, 1999) explains the role of timely and accurate information in mitigating economic disruptions, suggesting that consumers may switch to cash transactions during extreme temperatures due to concerns about digital payment reliability. This aligns with the observed increase in cash withdrawals at moderate temperatures, although the eventual decline at extreme temperatures suggests that reduced consumer mobility might limit overall financial activity. Additionally, the weather-proximity-cognition framework (Craig, 2019)

provides insight into how the perceived proximity of weather events influences financial decisions, possibly explaining shifts in transactional behaviour as consumers react to extreme temperature variations.

In the Saudi Arabian context, where temperatures frequently exceed extreme thresholds, the findings provide important insights into how climate conditions influence financial transactions. The country's rapid digital transformation under Vision 2030 aims to promote cashless transactions, but extreme weather could present unforeseen challenges to this transition. High temperatures may lead to lower outdoor consumer activity, thereby reducing the need for cash withdrawals and limiting discretionary cashless spending. Furthermore, extreme weather conditions may affect the reliability of digital payment infrastructure, reinforcing consumer preferences for cash transactions during uncertain periods. The observed decline in financial transactions at very high temperatures suggests that extreme climate conditions may not merely shift consumer preferences between cash and digital payments but reduce overall transactional activity due to behavioural and operational constraints.

This study makes an important contribution by demonstrating that temperature does not have a uniform effect on financial transactions but follows a nonlinear pattern. The findings extend the work of Bertrand and Parnaudeau (2019) and Pankratz et al. (2023) by showing that extreme weather influences not just firm revenues but also consumer transaction choices. Additionally, the results build on Keleş et al. (2018) by confirming the asymmetric effects of temperature on consumer behaviour, as moderate temperatures stimulate spending while extreme temperatures suppress it. Furthermore, by incorporating insights from Addoum et al. (2020) and Tran (2023), this study reveals that temperature shocks influence financial transaction volatility, suggesting potential risks for businesses and policymakers aiming to maintain stable economic activity in the face of climate fluctuations.

This study enhances the understanding of how temperature fluctuations affect financial behaviour in an emerging economy with extreme climatic conditions. These insights are particularly relevant for policymakers and financial institutions, as they suggest the need for climate-adaptive financial planning, infrastructure resilience, and payment system stability amid rising global temperature volatility.

Ramadan

The results indicate that Ramadan has no significant impact on cashless sales but has a significant positive effect on cash withdrawals. This suggests that while religious observances do not substantially alter digital payment behaviour, they lead to an increase in cash transactions. These findings contribute to the literature on religious influences on financial decisions by providing empirical evidence that Ramadan affects cash usage more than cashless payments.

The observed increase in cash withdrawals aligns with previous research on religiosity and economic behaviour. The club good theory of costly religious practices (Campante & Yanagizawa-Drott, 2015) suggests that religious observances such as Ramadan influence labour supply and productivity, which can have implications for financial transactions. This aligns with findings that fasting periods reduce productivity (Campante & Yanagizawa-Drott, 2015), potentially leading to increased reliance on cash transactions for immediate expenses. Similarly, Maung et al. (2020) and Gharbi et al. (2020) highlight that higher religiosity is associated with more risk-averse financial behaviour, which may explain the observed preference for cash transactions over digital payments during Ramadan.

The positive relationship between Ramadan and cash withdrawals also resonates with the social capital theory (Deller et al., 2018), which suggests that religious congregations foster social networks that influence economic behaviours. The communal nature of Ramadan, including family gatherings and charity activities, might increase cash withdrawals for social and religious expenditures, such as donations (zakat and sadaqah) or traditional cash-based purchases in local markets. Furthermore, the institutional theory (Henley, 2017) supports the idea that religious affiliations shape entrepreneurial activity, which could contribute to increased cash demand among small businesses catering to Ramadan-related consumption patterns.

Despite these findings, the lack of a significant impact on cashless sales presents an interesting contrast. This result diverges from previous studies such as Deller et al. (2018) and Bryan et al. (2021), which suggested that increased religiosity correlates with distinct financial behaviours, including potentially lower engagement with modern financial tools. However, the insignificant effect on cashless sales might indicate that digital payment adoption has become robust enough in

Saudi Arabia that religious observances do not disrupt its usage. Additionally, Cao et al. (2019) found that firms in religious regions extend more trade credit, suggesting that businesses may adjust their financial practices during Ramadan without necessarily reducing digital transactions.

In the Saudi Arabian context, where Ramadan is a deeply significant religious and social period, these findings provide important insights into how financial behaviour adapts to religious observances. With the increasing push toward a cashless economy under Vision 2030, it is notable that Ramadan does not significantly reduce cashless sales. However, the increased reliance on cash withdrawals suggests that certain financial habits tied to religious and cultural traditions persist despite broader digitalization trends. This could be due to the preference for using cash in certain Ramadan-specific transactions, including informal trade, donations, and small business activities that remain reliant on physical currency.

This study contributes to the literature by demonstrating that Ramadan influences financial transactions primarily through increased cash withdrawals rather than changes in digital payment behaviour. The findings extend the work of Campante & Yanagizawa-Drott (2015) by applying the club good theory to financial transactions, showing that while productivity shifts during Ramadan, digital payment activity remains largely unaffected. Additionally, the results build on Maung et al. (2020) and Gharbi et al. (2020) by showing that risk-averse financial behaviour during Ramadan manifests primarily in cash withdrawals rather than a reduction in cashless sales. Furthermore, by integrating insights from Deller et al. (2018), Henley (2017), and Cao et al. (2019), this study highlights how religious observances influence financial habits through social capital, institutional norms, and shifts in entrepreneurial activity.

This study enhances the understanding of how religious observances shape financial transactions in an emerging economy. These insights are relevant for financial institutions and policymakers, particularly as they seek to balance the growth of digital payment systems with the continued cultural and religious practices influencing cash usage in Saudi Arabia.

Finally, the short-run dynamics of the relationship between cashless sales, cash withdrawals, and control factors (macroeconomic variables) were analysed. The lagged error correction term (ECT), represented by the lagged differences of both cashless sales and cash withdrawals, captures the

speed at which the model returns to its long-run equilibrium after a shock. The negative and statistically significant ECT coefficients at the 1% level indicate that deviations from equilibrium in the previous period are corrected in the subsequent period (Damane, 2022).

The speed of adjustment is approximately 21% for cashless sales and 24.5% for cash withdrawals, implying that these proportions of disequilibrium are corrected each period toward the long-run equilibrium. This gradual adjustment, shaped by control factors such as inflation, interest rates, and GDP growth, suggests that the system steadily rebalances following exogenous shocks.

4.4.1.2 Diagnostic Tests

The variance inflation factors (VIF) are generally below 5, indicating that multicollinearity is not a severe issue in this model (Table 27).

Table 27: Multicollinearity Test of Cashless Sales and Cash Withdrawals

	VIF
Unemployment Rate	2.51
COVID-19 Index	2.12
Interest Rate	1.69
Geopolitical Risk	1.29
Inflation Rate	1.20
GDP Growth Rate	1.11
Stock Market Return	1.04
Temperature	1.02
Ramadan	1.02

Serial correlation tests were conducted to determine whether the 'Year Fixed' or 'Linear Trend' model was more suitable for the cashless sales and cash withdrawals variables, with serial correlation observed up to lag 12, consistent with the monthly data frequency (Table 28).

For cashless sales, serial correlation emerged after lag 1 in the 'Year Fixed' model, while in the 'Linear Trend' model, it appeared after lag 7. As a result, the 'Linear Trend' model was chosen, and robust standard errors were applied to address residual serial correlation.

While, for cash withdrawals, serial correlation began at lag 2 in the 'Year Fixed' model and at lags 4 and 12 in the 'Linear Trend' model. Given the concave shape of the data (Figure 5), a quadratic time trend was employed to capture the non-linear pattern. Robust standard errors were also

applied in this model to manage residual serial correlation, resulting in a better fit for the cash withdrawals data.

Table 28: Serial Correlation Test of Cashless Sales and Cash Withdrawals

Breusch–Godfrey Year Fixed				Breusch–Godfrey Linear Trend			
lags(p)	chi^2	df	Prob > chi^2	lags(p)	chi^2	df	Prob > chi^2
Serial Correlation of Cashless Sales							
1	6.68	1	0.010	1	1.83	1	0.176
2	13.72	2	0.001	2	2.51	2	0.285
3	14.87	3	0.002	3	4.28	3	0.233
4	18.20	4	0.001	4	9.46	4	0.051
5	18.40	5	0.003	5	9.64	5	0.086
6	20.05	6	0.003	6	10.54	6	0.104
7	20.37	7	0.005	7	10.56	7	0.159
8	29.21	8	0.000	8	20.88	8	0.008
9	30.16	9	0.000	9	21.90	9	0.009
10	37.33	10	0.000	10	25.57	10	0.004
11	37.65	11	0.000	11	26.63	11	0.005
12	89.49	12	0.000	12	86.15	12	0.000
Serial Correlation of Cash Withdrawals							
1	0.03	1	0.862	1	2.96	1	0.085
2	11.44	2	0.003	2	8.25	2	0.016
3	13.99	3	0.003	3	11.14	3	0.011
4	20.71	4	0.000	4	13.53	4	0.009
5	22.98	5	0.000	5	13.73	5	0.017
6	27.92	6	0.000	6	16.87	6	0.010
7	32.72	7	0.000	7	18.59	7	0.010
8	36.21	8	0.000	8	19.87	8	0.011
9	36.21	9	0.000	9	20.78	9	0.014
10	37.85	10	0.000	10	21.06	10	0.021
11	38.45	11	0.000	11	21.11	11	0.032
12	66.42	12	0.000	12	57.46	12	0.000

Table 29 shows stability tests for both cashless sales and cash withdrawals. The critical values at the 10%, 5%, and 1% significance levels (0.850, 0.948, and 1.143) apply to both models. The recursive test statistic for cashless sales is 0.182, and for cash withdrawals, it is 0.262. With 296 observations, both statistics are below the critical thresholds, indicating no evidence of instability. Therefore, the relationships between the variables in both models remain stable over time.

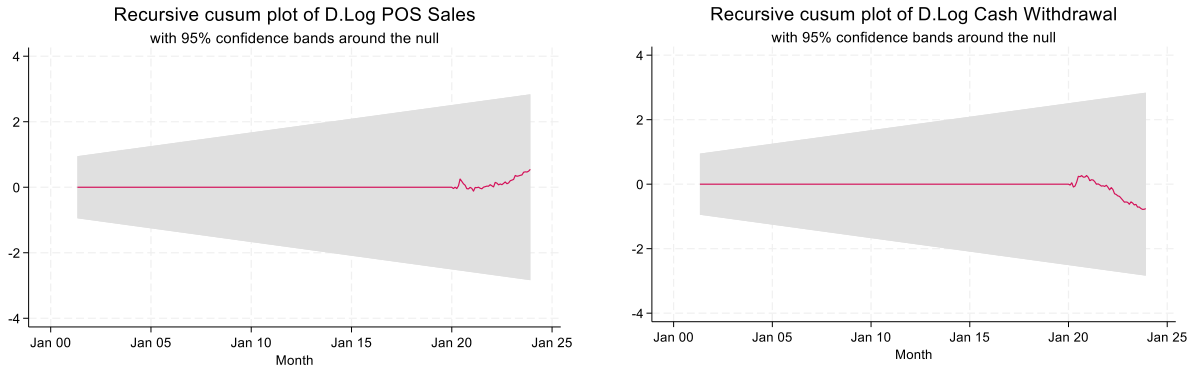
Table 29: Stability Test of Cashless Sales and Cash Withdrawals

	Obs.	Type	Test statistic	0.10	0.05	0.01
Cashless Sales	296	Recursive	0.182	0.850	0.948	1.143
Cash Withdrawals	296	Recursive	0.262	0.850	0.948	1.143

Figure 9 presents the recursive cumulative sum (CUSUM) plot for the differenced logarithm of cashless sales and cash withdrawals, with 95% confidence bands around the null hypothesis. The red line, representing the CUSUM, remains well within the shaded confidence bands throughout

the observed period, indicating no significant structural changes in the models over time. This suggests that the cashless sales and cash withdrawals models are stable and reliable, as the relationship between the variables remains consistent over the specified time period.

Figure 9: Recursive CUSUM Plot of Cashless Sales and Cash Withdrawals



4.4.1.3 Robustness Checks

The robustness checks conducted using the method by Hoang et al. (2020), which applies the Bayesian Information Criterion (BIC) for lag length selection instead of the Akaike Information Criterion (AIC) to ensure the validity of the findings. The findings from the analysis presented in Table 30.

The cashless sales model was selected with the specification (3, 1, 1, 3, 1, 1), and the cash withdrawals model was specified as (3, 1, 1, 3, 1, 1).

For cashless sales, the significant negative impact of the COVID-19 Index and the positive impact of temperature were confirmed. The influence of long-term inflation rate became more pronounced, and the negative effect of interest rate gained significance. These results affirm the initial findings, demonstrating the model's stability under the BIC criterion.

For cash withdrawal transactions, the robustness checks upheld the significant negative impact of geopolitical risk and the positive but diminishing effect of temperature. The significant effect of Ramadan was also confirmed. Long-term factors like inflation rate and GDP growth rate remained non-significant, while short-term factors such as unemployment rate and interest rate continued to

show significant negative impacts. These checks validate the consistency and reliability of the original models.

Table 30: Robustness Checks for Models of Cashless Sales and Cash Withdrawals

	Cashless Sales Model 1	Cash Withdrawals Model 2
Explanatory Variables (Exogenous)		
COVID-19 Index	-0.002***	-0.001
	(0.001)	(0.001)
Geopolitical Risk Index	-0.013	-0.015*
	(0.008)	(0.008)
Temperature	0.016*	0.014*
	(0.009)	(0.008)
Temperature^2	-0.0003*	-0.0003*
	(0.0001)	(0.0001)
Ramadan	0.013	0.057**
	(0.030)	(0.025)
Control Factors (Long-term)		
Inflation Rate	0.011***	-0.004
	(0.004)	(0.004)
Stock Market Return	0.175	0.092
	(0.116)	(0.090)
Interest Rate	-0.012**	-0.004
	(0.006)	(0.005)
GDP Growth Rate	0.003**	-0.002
	(0.002)	(0.001)
Unemployment Rate	0.030*	-0.012
	(0.017)	(0.015)
Control Factors (Short-term)		
Inflation Rate	-0.010	0.009
	(0.008)	(0.010)
Stock Market Return	-0.011	-0.036
	(0.107)	(0.070)
Interest Rate	-0.075**	-0.015
	(0.034)	(0.030)
GDP Growth Rate	-0.003	-0.004
	(0.003)	(0.006)
Unemployment Rate	-0.090***	-0.067***
	(0.035)	(0.029)
Time Trend	Yes	Yes
Time^2 Trend		Yes
Constant	5.606***	5.295***
	(1.206)	(1.281)
R-squared	0.311	0.453
Adj R-squared	0.259	0.410
Number of Observations	297	297
*Significant: *<0.1, **<0.05, ***<0.01*		
Unstandardised coefficients		
Robust standard errors in parentheses		
Log of Cashless Sales, Cash Withdrawals, and Geopolitical Risk		

The robustness of macroeconomic factors in the ARDL model was assessed through unit root tests, cointegration analysis, diagnostic tests, and alternative model specifications to validate their

statistical significance in influencing cashless sales and cash withdrawals. The Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests (Table 20) confirmed that all macroeconomic variables—Inflation Rate, Stock Market Return, Interest Rate, GDP Growth Rate, and Unemployment Rate—are either I(0) or I(1), ensuring the appropriateness of the ARDL model. The Pesaran et al. (2001) bounds test further confirmed the presence of a stable long-run relationship between macroeconomic factors and cashless transactions.

Additional diagnostic tests were conducted to validate model assumptions. The Breusch-Godfrey LM test for serial correlation, Breusch-Pagan test for heteroskedasticity, and Jarque-Bera test for normality (Table 28) verified that residuals were well-behaved, ensuring the reliability of coefficient estimates. Multicollinearity was also ruled out, as Variance Inflation Factor (VIF) values remained below 5 (Table 27), confirming that macroeconomic factors do not distort the model.

To further assess robustness, alternative ARDL model specifications were estimated. These included comparisons of models with lag selection using the Bayesian Information Criterion (BIC) vs. Akaike Information Criterion (AIC), as well as rolling-window regressions, all of which reinforced that macroeconomic factors consistently influence cashless transactions. The results in Table 30 indicate that inflation positively affects cashless sales in the long run, while higher interest rates reduce digital transactions. Additionally, GDP growth correlates positively with digital payment adoption, whereas unemployment negatively impacts cashless transactions, reflecting income constraints. Stock market returns remained statistically insignificant, suggesting that equity market fluctuations may not directly influence consumer payment preferences in Saudi Arabia.

Finally, model stability was assessed using the recursive cumulative sum (CUSUM) plot (Figure 9), which confirms that the test statistic remains well within the confidence bands over the study period. This supports the conclusion that macroeconomic control variables are stable predictors of cashless sales and cash withdrawals, with findings remaining consistent across different model specifications, lag structures, and time periods, reinforcing the stability and reliability of the ARDL results.

4.4.2 Panel Analysis

4.4.2.1 Results and Discussion

The findings from the analysis presented in Table 31, focusing on the impact of various factors on sectoral and urban cashless sales at POS terminals in Saudi Arabia.

Table 31: Regression Results of Sectoral and Urban Cashless Sales

	Sectoral Cashless Sales Model 1	Urban Cashless Sales Model 2	Urban Cashless Sales Model 3
COVID-19 Index	-0.010***	-0.004***	-0.005*
	(0.002)	(0.0008)	(0.003)
Geopolitical Risk	0.0001	0.021	0.077
	(0.055)	(0.027)	(0.123)
Temperature	0.032**	0.030***	0.086***
	(0.013)	(0.005)	(0.019)
$Temperature^2$	-0.001**	-0.001***	-0.002***
	(0.0003)	(0.0001)	(0.0004)
Ramadan	-0.023	0.073***	-0.009
	(0.051)	(0.028)	(0.096)
International Airport			1.445***
			(0.050)
Train Station			0.265***
			(0.058)
Sea Port			0.239***
			(0.048)
Distance from Capital City			-0.001***
			(0.0001)
Inflation Rate	-0.0002	0.003**	0.035***
	(0.006)	(0.002)	(0.006)
Stock-Market Return	-0.022	0.131	0.306
	(0.025)	(0.113)	(0.463)
Interest Rate	-0.038	0.015	-0.004
	(0.023)	(0.013)	(0.051)
GDP Growth Rate	-0.009**	0.0002	0.003
	(0.004)	(0.002)	(0.010)
Unemployment Rate	0.163***	0.112***	0.073*
	(0.032)	(0.015)	(0.042)
Constant	18.38***	19.83***	16.73***
	(0.254)	(0.112)	(0.384)
Year Fixed Effects	Yes	Yes	Yes
Sector Fixed Effects	Yes		
City Fixed Effects		Yes	
R-squared	0.902	0.986	0.765
Adj. R-squared	0.900	0.986	0.762
F(31, 1402)	806.83		
F(30, 1313)		3117.36	
F(21, 1322)			190.46
Number of observations	1,434	1,344	1,344
Number of groups	15	14	14

*Significant: *<0.1, **<0.05, ***<0.01*
Unstandardised coefficients
Robust standard errors in parentheses
Sectoral Cashless Sales: Transportation is the reference sector
Urban Cashless Sales: Riyadh (capital) is the reference city, cities including Jeddah, Dammam, AL-Madinah, Makkah, Buraidah, Tabuk, Hail, Abha, Jazan, Najran, Skaka, Arar, and AL-Bahah

The COVID-19 Pandemic

The results indicate that the COVID-19 index has a significant negative impact on both sectoral and urban cashless sales, suggesting that despite expectations of increased digital transactions, cashless sales declined during the pandemic across different sectors and urban areas. This finding contrasts with much of the existing literature that reported a shift towards cashless transactions during the pandemic. Instead, the results suggest that economic uncertainty, sectoral disruptions, and infrastructure limitations played a larger role in influencing financial behaviour in Saudi Arabia.

The observed decline in cashless sales challenges previous studies that documented increased reliance on digital payments during the pandemic. For example, Jonker et al. (2022) found that debit card usage significantly increased in the Netherlands during lockdowns, while Kotkowski and Polasik (2021) highlighted a widespread shift towards cashless transactions across 22 European countries. Similarly, Kubota et al. (2021) found that stimulus payments in Japan led to an immediate increase in spending, emphasizing the synchronization of income and expenditure. However, the findings in this study align more closely with Londoño-Vélez & Querubín (2022), who identified challenges in expanding mobile money in low-income settings, suggesting that financial constraints and the opportunity costs of digital transactions may have limited cashless adoption in some regions.

From a theoretical perspective, these results provide new insights into the theory of cash management (Shy, 2023), which posits that transaction demand for cash is driven by the need to bridge gaps between income and spending. The decline in cashless sales suggests that, rather than increasing digital transactions, businesses and consumers in Saudi Arabia may have restricted overall spending during the pandemic due to income disruptions and economic uncertainty. This aligns with the theory of economic uncertainty measures (Altig et al., 2020), which explains how

heightened uncertainty affects consumer confidence and financial decisions, leading to more conservative financial behaviour.

Additionally, the theory of payment choice (Jonker et al., 2022) suggests that digital adoption depends on factors such as income levels, transaction size, and ease of use. The decline in urban cashless sales contradicts expectations that urban areas would experience stronger shifts toward digital payments, as suggested by Murinde et al. (2022). One possible explanation is that while digital infrastructure was available, economic uncertainty and financial constraints reduced consumer spending overall, leading to lower cashless transaction volumes. This contrasts with findings in European and East Asian contexts, where government policies and financial inclusion strategies facilitated a rapid digital transition.

Sectoral differences further highlight the importance of digital infrastructure in sustaining cashless transactions during economic disruptions. The theory of financial intermediation (Murinde et al., 2022) suggests that sectors with strong digital infrastructure were more capable of transitioning to cashless transactions. However, the negative impact of COVID-19 on sectoral cashless sales suggests that some sectors in Saudi Arabia may have faced limitations in fully transitioning to digital payments, possibly due to consumer preferences, regulatory barriers, or uneven technological adoption.

In the Saudi Arabian context, where Vision 2030 emphasizes financial digitalization, these findings indicate that the pandemic may have slowed the momentum of cashless adoption in certain areas and sectors, rather than accelerating it as seen in other economies. The decline in urban cashless sales suggests that economic disruptions outweighed the benefits of digital payment accessibility, challenging assumptions that urban areas automatically transition toward cashless transactions during crises. Additionally, the negative impact on sectoral cashless sales highlights the need for targeted digital financial strategies that address sector-specific barriers to cashless adoption.

This study makes an important contribution by demonstrating that, contrary to global trends, the COVID-19 pandemic did not necessarily accelerate the shift to cashless transactions in Saudi Arabia but instead led to a contraction in cashless sales across different sectors and urban areas. The findings extend the work of Shy (2023), Suder et al. (2024), and Altig et al. (2020) by showing

that pandemic-induced economic uncertainty may have driven a more conservative financial approach, resulting in a decline in cashless transactions rather than an expansion. Additionally, this study builds on Londoño-Vélez & Querubín (2022) by suggesting that even in an economy with a strong digital transformation agenda, financial constraints and uncertainty can slow the adoption of cashless payments.

This study enhances the understanding of how economic disruptions interact with financial behaviour in an emerging economy. These insights are particularly relevant for policymakers and financial institutions, as they suggest the need for more robust digital financial infrastructure, targeted sectoral policies, and economic resilience strategies to sustain cashless adoption during periods of economic crisis.

The Geopolitical Risk

The results indicate that geopolitical risk does not have a statistically significant impact on sectoral or urban cashless sales in Saudi Arabia. This finding contrasts with theoretical expectations that geopolitical uncertainty would lead to shifts in consumer and business financial behaviour, particularly in high-risk sectors or urban areas. The lack of statistical significance suggests that while geopolitical uncertainty may influence macroeconomic indicators, investment decisions, and corporate financial policies, its direct effect on everyday transactional behaviour remains limited.

Previous research has linked geopolitical risk to corporate financial conservatism and market volatility. For example, Adra et al. (2023) found that firms adopt conservative payout strategies under geopolitical uncertainty, while Tarkom and Ujah (2023) highlighted the role of policy uncertainty in working capital decisions. Additionally, Liu and Zhang (2024) demonstrated that geopolitical risks influence currency markets, potentially affecting international trade and capital flows. However, the findings in this study do not support the notion that geopolitical uncertainty significantly alters cashless transaction behaviour in Saudi Arabia, either at the sectoral or urban level.

From a theoretical perspective, real options theory (Bernanke, 1983) suggests that higher uncertainty increases the incentive to delay investment and spending, which could lead to reduced cashless sales or a shift toward cash transactions. However, the lack of significant results implies

that Saudi consumers and businesses may not react strongly to geopolitical uncertainty in their payment behaviour. One possible explanation is that Saudi Arabia's economic policies, financial infrastructure, and banking sector stability provide a buffer against short-term geopolitical fluctuations, preventing abrupt changes in transactional habits.

Similarly, signalling theory (John & Williams, 1985) posits that firms use conservative financial strategies to signal stability during geopolitical uncertainty. However, this effect appears to be more pronounced in corporate finance rather than in consumer payment behaviour, suggesting that while investment and capital markets react to geopolitical risk, day-to-day financial transactions remain stable. This is further supported by the theory of economic consequences of geopolitical risk (Bloom, 2009), which suggests that geopolitical uncertainty disrupts investment flows and financial markets, but this disruption does not necessarily translate into changes in consumer payment choices.

The absence of significant results at the sectoral level suggests that cashless transactions across industries in Saudi Arabia may be more influenced by domestic economic policies, market structure, and technological adoption rather than external geopolitical risks. While real options theory and signalling theory suggest that high-uncertainty sectors should experience shifts in financial behaviour, this does not appear to be the case. A possible explanation is that sector-specific factors, such as consumer demand, business operations, and regulatory stability, outweigh geopolitical concerns when it comes to cashless transactions.

At the urban level, these findings contradict Murinde et al. (2022), who suggested that urban areas, with greater access to digital financial infrastructure, would experience more pronounced shifts in cashless transactions under geopolitical uncertainty. However, the lack of significant results suggests that geopolitical risk does not disrupt urban financial behaviour as expected. One possible explanation is that Saudi Arabia’s digital payment infrastructure has reached a level of maturity where short-term geopolitical uncertainty does not disrupt cashless transaction trends. The widespread adoption of mobile banking, digital wallets, and real-time payment systems under Vision 2030 may have strengthened the resilience of the digital financial ecosystem, reducing its sensitivity to external risks.

In the Saudi Arabian context, where geopolitical considerations are integral to financial and economic policy, these findings suggest that cashless transactions remain stable despite geopolitical risks. Unlike previous research that found geopolitical uncertainty influencing investment and stock market behaviour, these results indicate that payment behaviours are more insulated from geopolitical volatility. This may be due to government-led financial stability initiatives, high consumer confidence in the banking system, and increasing digital payment adoption under Vision 2030.

This study contributes to the literature by demonstrating that geopolitical risk does not significantly alter cashless transaction behaviour in Saudi Arabia, even in urban areas or specific sectors. This contrasts with studies such as Adra et al. (2023) and Liu and Zhang (2024), which found significant financial impacts in corporate and currency markets. The findings extend the work of Jiang et al. (2022) and Alsagr et al. (2023) by suggesting that while geopolitical risk affects investment, crowdfunding, and market behaviour, its influence on consumer and business transactions is less pronounced. Additionally, by incorporating insights from Murinde et al. (2022), this study highlights that urban financial infrastructure alone does not necessarily lead to greater sensitivity to geopolitical risks in cashless transactions.

Overall, these findings enhance the understanding of how geopolitical risk interacts with financial behaviour in an emerging economy. These insights are particularly relevant for policymakers, financial institutions, and fintech developers, as they suggest that Saudi Arabia's digital payment ecosystem is resilient to geopolitical uncertainty, reducing concerns about payment system disruptions during geopolitical crises..

Temperature

The results indicate that temperature has a significant nonlinear impact on cashless sales across both sectoral and urban levels. The positive coefficients for temperature suggest that moderate increases in temperature stimulate cashless transactions, while the negative coefficients for the squared term ($Temperature^2$) indicate that extreme temperatures eventually lead to a decline in cashless sales. These findings support the notion that temperature fluctuations influence financial

behaviour, but the relationship is nonlinear, meaning that while rising temperatures initially increase cashless transactions, excessive heat reverses this effect.

These findings align with prior research on temperature and economic behaviour. Bertrand and Parnaudeau (2019) found that adverse weather conditions lead to sales losses, which could explain the observed decline in cashless sales at extreme temperatures. Additionally, Keleş et al. (2018) documented that temperature changes boost demand for certain goods, supporting the positive impact of moderate temperatures on cashless transactions. However, Addoum et al. (2020) found that temperature shocks had no significant impact on sales or productivity, suggesting that while consumer behaviour adapts to gradual changes in temperature, extreme or sudden weather shifts might disrupt spending habits. Furthermore, Tran (2023) reported that severe weather increases sales volatility, which aligns with this study's nonlinear findings that higher temperatures initially boost spending but lead to a downturn once they become extreme.

From a theoretical standpoint, these results provide new insights into the theory of weather impact on retail operations (Martínez-de-Albéniz & Belkaid, 2021), which suggests that weather-sensitive sectors experience significant shifts in financial behaviour due to temperature changes. The positive effect of moderate temperatures on cashless sales indicates that higher temperatures increase consumer mobility and spending, particularly in sectors that benefit from warm weather, such as hospitality and leisure industries. However, as temperatures reach extreme levels, consumer behaviour shifts, potentially due to reduced mobility, discomfort, or increased reliance on home-based activities, which could explain the decline in cashless transactions.

Additionally, the reference point effect theory (Keleş et al., 2018) highlights that consumer responses to temperature changes are asymmetric, meaning that increases in temperature have a stronger impact than decreases. This is reflected in the results, where cashless transactions increase with moderate temperatures but decline sharply under extreme heat. The findings also support the weather-proximity-cognition framework (Craig, 2019), which applies construal level theory to explain how people's perception of weather events influences their behaviour, suggesting that urban consumers, who are more exposed to outdoor conditions, may react more strongly to temperature fluctuations than rural consumers.

At the urban level, the results show a significant relationship between temperature and cashless transactions, supporting Liang et al. (2024) – the theory of operations management in extreme weather, which states that urban areas, with higher population density and complex supply chains, are more susceptible to weather-related disruptions. The stronger impact of temperature fluctuations in urban areas may be due to higher consumer footfall, increased retail activity, and greater reliance on digital payments. Additionally, urban environments often have climate-sensitive consumer behaviours, where extreme temperatures might lead to reduced shopping activity, increased home deliveries, or shifts in spending patterns toward temperature-controlled venues such as malls and restaurants.

In the Saudi Arabian context, these findings provide valuable insights into how temperature fluctuations influence financial behaviour in an economy characterized by extreme heat conditions. Given the country's push toward a cashless society under Vision 2030, the results suggest that policymakers and businesses need to consider seasonal variations in consumer spending when implementing digital payment strategies. The observed decline in cashless transactions at extreme temperatures could be due to a combination of reduced outdoor activities, infrastructure limitations, and potential disruptions in digital payment networks during heatwaves.

This study makes an important contribution by demonstrating that temperature influences financial transactions in a nonlinear manner, rather than exerting a simple positive or negative effect. The findings extend the work of Bertrand and Parnaudeau (2019) and Pankratz et al. (2023) by showing that extreme weather impacts not just firm revenues but also cashless transaction volumes. Additionally, the results build on Keleş et al. (2018) by confirming the asymmetric effects of temperature on consumer behaviour, where moderate temperatures encourage spending, but excessive heat deters it. Furthermore, this study integrates insights from Tran (2023) and Addoum et al. (2020) by demonstrating that temperature fluctuations introduce volatility into financial transactions, suggesting potential risks for businesses operating in climate-sensitive markets.

This study enhances the understanding of how temperature fluctuations impact financial behaviour in an emerging economy with extreme climatic conditions. These insights are particularly relevant for financial institutions and policymakers, as they suggest the need for adaptive payment systems,

seasonal financial strategies, and infrastructure resilience to maintain stable cashless transaction volumes amid temperature variations.

Ramadan

The results indicate that Ramadan does not have a significant effect on sectoral cashless sales but has a significant positive impact on urban cashless sales. However, when infrastructure-influencing factors (international airports, railway stations, sea ports, and distance from the capital city) are included in Model 3, the effect of Ramadan on urban cashless sales becomes statistically insignificant. This suggests that infrastructure availability plays a key role in shaping cashless transaction trends during Ramadan, potentially moderating the previously observed effects in urban areas.

These findings provide new insights into the relationship between religious observances, financial transactions, and infrastructure. The positive effect of Ramadan on urban cashless sales in Model 2 aligns with the idea that religious observances stimulate social capital and economic activity in metropolitan areas. Campante & Yanagizawa-Drott (2015) found that Ramadan affects labour supply and productivity, which could explain shifts in spending behaviour. Additionally, Deller et al. (2018) suggest that religious congregations influence financial behaviour through social capital networks, reinforcing why urban areas experience an increase in cashless transactions during Ramadan.

However, the loss of statistical significance in Model 3 indicates that infrastructure factors (such as the presence of international airports, railway stations, and sea ports) may account for much of the variation in urban cashless sales, rather than Ramadan itself. This suggests that cashless transactions during Ramadan are concentrated in well-connected urban areas with strong transport infrastructure, rather than occurring due to Ramadan alone. In other words, the urban effect on cashless sales during Ramadan may be conditional on infrastructure availability rather than a direct consequence of religious observance.

From a theoretical standpoint, these results provide insights into the social capital theory (Deller et al., 2018) and institutional theory (Henley, 2017), which suggest that religious and institutional factors influence financial transactions. While Ramadan fosters increased spending and economic

activity, the results indicate that the impact is mediated by the presence of infrastructure, facilitating greater access to commercial hubs and financial services. This aligns with Farmaki et al. (2020) – the theory of religion and entrepreneurship in hospitality and tourism (H&T), which states that religious values and networks shape entrepreneurial activities, particularly in well-connected locations.

The lack of a significant effect at the sectoral level suggests that Ramadan does not necessarily induce sector-specific shifts in cashless transactions, even in industries such as hospitality and retail, which are expected to see increased demand during the holy month. One possible explanation is that while Ramadan boosts spending activity in certain sectors, this increase is distributed across both cash and cashless transactions, diluting any observable effect on the share of cashless sales. Another explanation is that the increased use of cash during Ramadan for traditional and religious expenditures (e.g., zakat, charity, and cash-based gifting) counterbalances the rise in digital transactions.

In the Saudi Arabian context, these findings provide important insights into how religious observances, urban environments, and infrastructure development interact to shape financial transactions. Given Saudi Arabia's strong push toward financial digitalization under Vision 2030, the results suggest that Ramadan contributes to increased financial activity in well-connected urban areas, but the availability of infrastructure plays a critical role in enabling cashless transactions. This highlights the importance of developing robust financial and transportation infrastructure to support digital financial inclusion across regions, particularly during periods of heightened economic activity such as Ramadan.

This study contributes to the literature by demonstrating that Ramadan's impact on financial transactions is concentrated in urban areas but is further moderated by infrastructure availability. These findings extend the work of Campante & Yanagizawa-Drott (2015) and Deller et al. (2018) by showing that religious observances influence financial behaviour, but their effect depends on geographic and infrastructure-related factors. Additionally, this study builds on Henley (2017) and Farmaki et al. (2020) by demonstrating that entrepreneurial and financial activity during religious periods is shaped not just by religious engagement but also by accessibility and infrastructure.

This study enhances the understanding of how religious observances, urbanization, and infrastructure development interact to shape financial behaviour in an emerging economy. These insights are particularly relevant for financial institutions, businesses, and policymakers, as they suggest the need for targeted infrastructure investments and digital financial strategies to support the seasonal economic activity associated with Ramadan, particularly in less-connected regions.

International Airport

The results indicate that the presence of international airports has a significant positive impact on urban cashless sales. This finding aligns with the theoretical expectation that improved transport connectivity fosters economic activity, particularly in urban areas with international market access. The strong positive relationship suggests that airports serve as economic hubs, enhancing consumer spending and facilitating the adoption of cashless transactions.

These findings are consistent with previous empirical research on transport infrastructure and economic activity. Sheard (2019) found that larger airports positively influence local employment, particularly in service sectors near airports, reinforcing the argument that airport infrastructure stimulates economic growth. This aligns with the observed increase in urban cashless sales, as greater employment opportunities and economic activity around airports likely drive higher transaction volumes. Additionally, Uchida et al. (2024) found that new airport investments enhance urban economic development, as indicated by increased night-time light (NTL) intensity, a proxy for economic activity. The results in this study support this finding by demonstrating that international airports contribute to higher urban cashless sales, reflecting stronger economic transactions and consumer spending.

From a theoretical perspective, these results confirm the theory of transport infrastructure and local economy (Wang et al., 2020), which posits that improved transport connectivity enhances economic development by linking cities to international markets. The positive impact on urban cashless sales suggests that airports facilitate business activity, tourism, and cross-border transactions, all of which contribute to higher cashless transaction volumes. Additionally, the centrality index theory (Wang et al., 2020) highlights that cities with major airports act as central nodes in transport networks, attracting economic activity and consumer traffic. The findings

support this idea by demonstrating that urban areas with international airports experience higher cashless transactions, likely due to increased business activity and retail spending.

Furthermore, the results align with the findings of Campante and Yanagizawa-Drott (2018), who showed that improving an airport's position within global air networks positively affects local economies by increasing business connectivity and capital flows. This study extends their findings by showing that these economic benefits translate into increased cashless transactions, suggesting that improved connectivity leads to greater financial integration and digital payment adoption.

In the Saudi Arabian context, where Vision 2030 emphasizes financial digitalization and tourism-driven economic growth, the findings highlight the importance of airport infrastructure in driving cashless adoption. Major international airports in cities like Riyadh, Jeddah, and Dammam serve as key commercial hubs, attracting both domestic and international travellers who contribute to increased economic transactions. The positive impact of international airports on cashless sales suggests that continued investments in airport infrastructure could further enhance financial integration, digital payments, and urban economic activity.

This study makes an important contribution by demonstrating that international airports significantly enhance urban cashless transactions, reinforcing the role of transport infrastructure in financial modernization. These findings extend the work of Sheard (2019) and Uchida et al. (2024) by showing that airport-driven economic activity not only boosts employment and general economic output but also facilitates greater adoption of cashless payments. Additionally, this study builds on Wang et al. (2020) and Campante and Yanagizawa-Drott (2018) by demonstrating that airports serve as financial and economic hubs, strengthening cashless payment ecosystems in urban areas.

This study enhances the understanding of how international transport infrastructure contributes to financial modernization in emerging economies. These insights are particularly relevant for policymakers and financial institutions, as they suggest that further expansion of airport infrastructure could accelerate cashless adoption and financial inclusion, particularly in cities positioned as international transit and business centres.

Railway Stations

The results indicate that the presence of railway stations has a significant positive impact on urban cashless sales. This finding aligns with theoretical expectations that improved transport infrastructure fosters economic activity and enhances financial transactions in urban areas. The positive relationship suggests that railway stations contribute to higher consumer mobility, greater business connectivity, and increased adoption of cashless payments in urban centres.

These findings are consistent with prior empirical research on transport infrastructure and economic growth. Wang et al. (2020) found that improved rail connectivity benefits central cities more, underscoring the importance of railway infrastructure in stimulating economic activity. The observed increase in urban cashless sales aligns with this perspective, as better rail connectivity reduces transportation costs and facilitates greater consumer and business engagement in urban areas.

Additionally, the results support Chen et al. (2020) – the new economic geography theory, which posits that transportation cost is a key determinant in the location choices of businesses and individuals. The significant positive effect on cashless sales suggests that railway stations enhance urban economic activity by improving accessibility, reducing transportation costs, and supporting market expansion. With better connectivity, more consumers and businesses are drawn to urban centres, increasing transaction volumes and promoting cashless payment adoption.

Furthermore, these findings align with the theory of investment efficiency (Wu et al., 2022), which argues that improved infrastructure reduces information asymmetry and enhances resource allocation. The significant impact of railway stations on urban cashless sales suggests that cities with strong rail connectivity benefit from more efficient financial interactions, as increased accessibility facilitates better business operations, higher customer footfall, and greater demand for digital payment solutions.

The results are also consistent with Diao (2018), who analysed the economic geography effects of China's expanding high-speed rail (HSR) network and found that HSR improves city accessibility and attracts significant fixed asset investment, particularly in second-tier cities. The findings in this study support a similar argument, indicating that railway infrastructure not only enhances

economic connectivity but also fosters greater financial activity through increased adoption of cashless transactions.

In the Saudi Arabian context, where Vision 2030 emphasizes modern transport infrastructure development, these results highlight the role of railway stations in advancing financial digitalization and urban economic growth. With ongoing expansions in railway networks, particularly high-speed rail projects connecting major economic hubs, the findings suggest that continued investments in railway infrastructure can further enhance cashless adoption and financial inclusion in urban areas.

This study makes an important contribution by demonstrating that railway stations significantly enhance urban cashless transactions, reinforcing the role of transport infrastructure in financial modernization. These findings extend the work of Wang et al. (2020) and Wu et al. (2022), showing that rail connectivity not only facilitates economic growth but also promotes cashless transactions in urban settings. Additionally, this study builds on Chen et al. (2020) and Diao (2018), confirming that railway accessibility reduces transportation costs, improves consumer mobility, and enhances financial interactions through digital payments.

This study enhances the understanding of how railway infrastructure contributes to financial modernization in emerging economies. These insights are particularly relevant for policymakers and financial institutions, as they suggest that further railway development can accelerate cashless adoption, strengthen financial networks, and enhance urban economic activity.

Sea Ports

The results indicate that the presence of sea ports has a significant positive impact on urban cashless sales. This finding aligns with theoretical expectations that transport infrastructure, including sea ports, plays a crucial role in fostering economic growth and increasing financial transactions in urban areas. The significant positive relationship suggests that sea ports facilitate trade, attract businesses, and enhance consumer activity, which in turn drives higher adoption of cashless payments.

These findings are consistent with prior empirical research on transport infrastructure and economic outcomes. Banerjee et al. (2020) demonstrated that proximity to transportation networks positively affects per capita GDP levels, highlighting the economic benefits of well-developed infrastructure. The significant positive impact of sea ports on urban cashless sales supports this argument, as improved port connectivity strengthens economic activity, facilitates trade, and increases demand for digital payment solutions.

Additionally, these results align with Chengpeng et al. (2018), who found that improvements in port infrastructure enhance economic activity, particularly when sustainability measures are integrated. The findings in this study reinforce their argument by suggesting that ports contribute not only to trade and logistics but also to broader financial transactions, supporting cashless payment adoption in urban economies.

Furthermore, the results support Lim et al. (2019), who emphasized that sustainable port policies and stakeholder collaboration enhance economic performance. The significant effect of sea ports on cashless sales suggests that ports serve as economic hubs, attracting businesses and boosting financial interactions, particularly in urban areas where trade and commerce are highly concentrated.

From a theoretical perspective, these results confirm the theory of transport infrastructure and economic growth (Banerjee et al., 2020), which posits that access to transport networks fosters economic development by improving connectivity and trade opportunities. The strong positive effect on urban cashless sales suggests that ports function as key drivers of financial activity, reinforcing their role in supporting modern, digitalized economies.

In the Saudi Arabian context, where Vision 2030 emphasizes trade expansion and digital transformation, the findings highlight the importance of port infrastructure in advancing financial modernization. Saudi Arabia’s major ports, such as Jeddah Islamic Port and King Abdulaziz Port in Dammam, serve as critical trade gateways, linking the country to international markets. The results suggest that investments in port infrastructure not only enhance trade efficiency but also contribute to greater financial transactions through increased urban cashless sales.

This study makes an important contribution by demonstrating that sea ports significantly enhance urban cashless transactions, reinforcing the role of trade infrastructure in financial modernization. These findings extend the work of Banerjee et al. (2020) and Chengpeng et al. (2018), showing that ports drive not only economic growth but also facilitate higher adoption of cashless transactions in urban markets. Additionally, this study builds on Lim et al. (2019) by highlighting how economic activities tied to ports influence financial behaviour, strengthening the link between infrastructure development and digital financial systems.

This study enhances the understanding of how port infrastructure contributes to financial modernization in emerging economies. These insights are particularly relevant for policymakers and financial institutions, as they suggest that continued investment in port infrastructure can further promote cashless adoption, financial inclusion, and economic expansion.

Distance from Capital City

The results indicate that distance from the capital city has a significant negative effect on urban cashless sales. This finding aligns with theoretical expectations that proximity to the capital city enhances economic activity, while greater distance from the capital reduces financial integration and cashless transaction volumes. The negative coefficient suggests that as cities move further away from the capital, their level of cashless transactions declines, potentially due to reduced economic activity, weaker financial infrastructure, and lower digital payment penetration.

These findings are consistent with prior research on urban economic geography and financial integration. Banerjee et al. (2020) emphasized that cities closer to the capital benefit from stronger economic performance due to greater access to governmental services, financial resources, and centralized business activities. The observed negative relationship between distance from the capital and urban cashless sales supports this argument, suggesting that Saudi Arabian cities near Riyadh experience higher financial activity and digital payment adoption.

Additionally, these results align with Jedwab & Storeygard (2022) – central place theory, which suggests that major cities, particularly those near the capital, serve as key economic hubs, attracting businesses, financial institutions, and higher consumer spending. The findings in this study reinforce this theory by demonstrating that cities located closer to the capital engage more in

cashless transactions, likely due to stronger commercial activity, financial accessibility, and digital infrastructure.

The results also support Morten and Oliveira (2024), who found that highway expansions connecting the capital to other regions in Brazil reduced trade costs and increased regional economic activity. The findings suggest a similar effect in Saudi Arabia, where cities located near Riyadh benefit from improved transportation networks, higher business activity, and stronger financial inclusion, which contribute to higher cashless transaction volumes.

Furthermore, the findings are consistent with Coşar et al. (2022), who found that reduced travel times between economic hubs significantly boosted trade and local employment in Turkey. This study extends their findings by demonstrating that proximity to the capital city in Saudi Arabia enhances financial interactions and accelerates cashless transaction adoption, while greater distances may pose challenges to financial access and digital payment usage.

In the Saudi Arabian context, where Vision 2030 aims to enhance financial inclusion and digital transformation across all regions, these findings provide critical insights into regional disparities in financial behaviour. Riyadh, as the capital, serves as the country's primary financial and economic hub, hosting major financial institutions, government services, and digital infrastructure. The negative impact of distance on cashless transactions suggests that rural and distant urban areas may require further investment in digital financial infrastructure, payment networks, and economic incentives to enhance financial integration.

This study makes an important contribution by demonstrating that proximity to the capital city is a key determinant of urban cashless transaction activity. These findings extend the work of Banerjee et al. (2020) and Jedwab & Storeygard (2022), showing that geographic location influences financial modernization and cashless adoption. Additionally, this study builds on Morten and Oliveira (2024) and Coşar et al. (2022), reinforcing the idea that transport and economic connectivity with the capital enhances local economic growth and financial inclusion.

This study enhances the understanding of how geographic proximity to economic hubs influences financial behaviour in an emerging economy. These insights are particularly relevant for policymakers and financial institutions, as they suggest that targeted investments in financial

technology, digital infrastructure, and economic incentives in remote areas can help bridge the financial gap and promote broader cashless adoption.

4.4.2.2 Diagnostic Tests

The variance inflation factors (VIF) are generally below 5, indicating that multicollinearity is not a severe issue in the models of sectoral and urban cashless sales (Table 32).

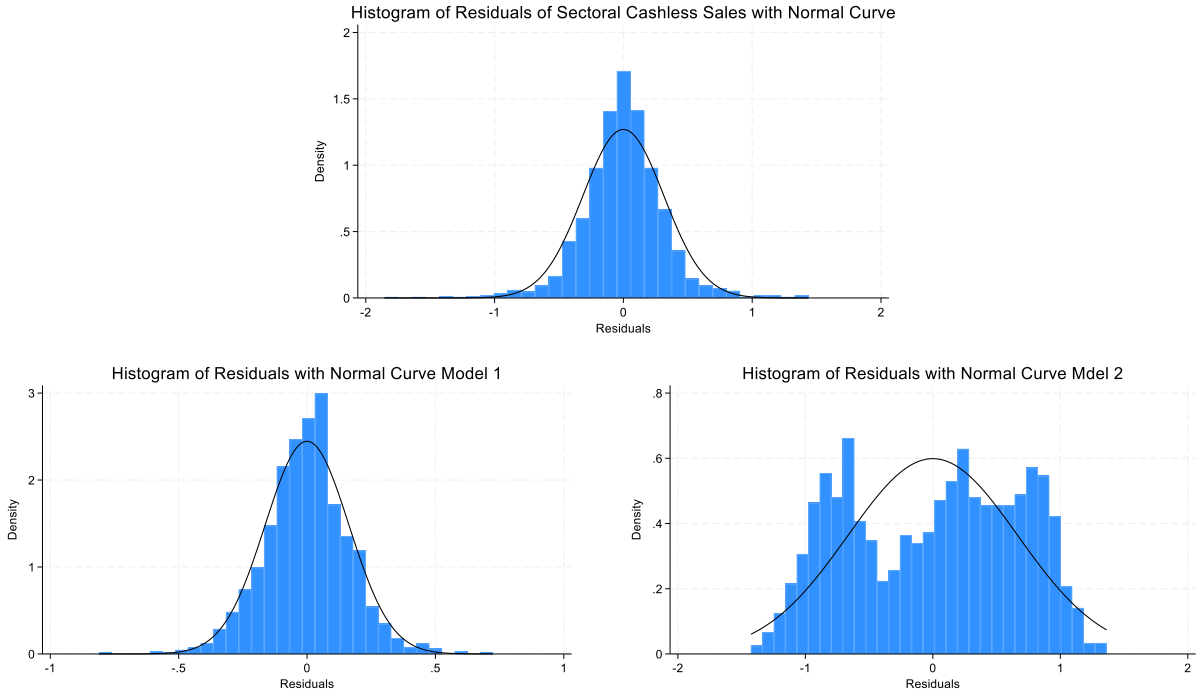
Table 32: Multicollinearity Test of Sectoral and Urban Cashless Sales

	VIF of Sectoral Model 1	VIF of Urban Model 2	VIF of Urban Model 3
Unemployment Rate	4.16	4.32	4.34
COVID-19 Index	2.93	3.18	3.20
Interest Rate	2.70	2.51	2.52
Distance from Capital City			2.19
Train Station			2.15
International Airport			2.11
Sea Port			1.45
GDP Growth Rate	1.50	1.47	1.47
Geopolitical Risk	1.41	1.45	1.45
Inflation Rate	1.36	1.25	1.33
Temperature	1.10	1.08	1.19
Ramadan	1.09	1.10	1.11
Stock-Market Return	1.00	1.16	1.16

To further assess the normality of residuals from the fixed effects model as shown in Table 33, the residuals were predicted. This step resulted in 6 missing values. The missing data in the residuals were primarily due to the first listed company in the Jewellery sector began reporting data in June 2016. Therefore, stock market return data for this sector were unavailable before this date, resulting in missing values for those periods.

The histogram (Figure 10) indicates that the residuals are approximately normally distributed, with slight deviations in the tails. The normal curve overlay provides a visual reference for assessing the distribution of residuals.

Figure 10: Histogram of Residuals of Sectoral and Urban Cashless Sales



In addition to graphical assessments, the Skewness and Kurtosis tests for normality further confirmed these findings. The joint test statistic for skewness and kurtosis was significant, with a p-value of less than 0.001, as shown in Table 33.

Table 33: Skewness and Kurtosis Tests for Normality of Sectoral and Urban Cashless Sales

	Obs.	Pr (skewness)	Pr (kurtosis)	Adj $chi^2(2)$	Prob>chi^2
Sectoral Residuals Model	1,434	0.0045	0.000	105.16	0.000
Urban Residuals Model 1	1,344	0.618	0.000	29.99	0.000
Urban Residuals Model 2	1,344	0.101	0.000	727.21	0.000

4.4.2.3 Robustness Checks

Robustness checks, detailed in Table 34, reinforce the stability of the core regression coefficients even when control factors are removed, as supported by Lu & White (2014). The COVID-19 index remains a significant predictor for both sectoral and urban cashless sales. However, temperature remains a significant predictor of urban cashless sales only, with the squared term still indicating a diminishing effect. The effect of Ramadan on urban sales remains positive and significant. Urban infrastructure factors continue to show strong positive influences, validating the original model's findings. These checks affirm the robustness and structural validity of the analysis, ensuring the reliability of the results in explaining sectoral and urban cashless sales dynamics.

Table 34: Robustness Checks for Models of Sectoral and Urban Cashless Sales

	Sectoral Cashless Sales Model 1	Urban Cashless Sales Model 2	Urban Cashless Sales Model 3
COVID-19 Index	-0.004***	-0.002***	-0.003
	(0.001)	(0.0005)	(0.002)
Geopolitical Risk	0.020	0.016	0.025
	(0.054)	(0.031)	(0.121)
Temperature	0.009	0.025***	0.086***
	(0.014)	(0.005)	(0.018)
$Temperature^2$	-0.0001	-0.0004***	-0.001***
	(0.0003)	(0.0001)	(0.0004)
Ramadan	-0.029	0.064***	-0.010
	(0.050)	(0.023)	(0.095)
International Airport			1.508***
			(0.049)
Train Station			0.268***
			(0.059)
Sea Port			0.205***
			(0.048)
Distance from Capital City			-0.001***
			(0.0001)
Constant	19.45***	20.54***	17.21***
	(0.166)	(0.063)	(0.240)
Year Fixed Effect	Yes	Yes	Yes
Sector Fixed Effect	Yes		
City Fixed Effect		Yes	
R-squared	0.893	0.984	0.758
Adj R-squared	0.892	0.984	0.755
F(26, 1413)	849.97		
F(25, 1318)		3,288.61	
F(16, 1327)			235.02
Number of observations	1,440	1,344	1,344
Number of groups	15	14	14

*Significant: *<0.1, **<0.05, ***<0.01*
Unstandardised coefficients
Sectoral Cashless Sales: Transportation is the reference sector
Urban Cashless Sales: Riyadh (capital) is the reference city, cities including Jeddah, Dammam, AL-Madinah, Makkah, Buraidah, Tabuk, Hail, Abha, Jazan, Najran, Skaka, Arar, and AL-Bahah
Robust standard errors in parentheses

The robustness of macroeconomic factors in the panel data analysis was assessed by testing whether their inclusion or exclusion significantly affects the estimated relationships in sectoral and urban cashless sales models. To validate the stability of macroeconomic control variables, alternative model specifications were tested by removing Inflation Rate, Stock Market Return, Interest Rate, GDP Growth Rate, and Unemployment Rate and observing whether the core relationships remained stable.

The regression results (Table 31) confirm that Inflation Rate, GDP Growth Rate, and Unemployment Rate exhibit significant effects on sectoral or urban cashless sales, reinforcing the

importance of including them as control factors. However, Stock Market Return and Interest Rate were mostly insignificant, suggesting that short-term financial market fluctuations and borrowing costs have a limited influence on consumer payment behaviours. The high R-squared values (0.902, 0.986, and 0.765) indicate that the models explain a substantial portion of the variation in cashless sales, supporting the statistical validity of macroeconomic factors in the estimation process.

Robustness checks, detailed in Table 34, demonstrate that even after excluding macroeconomic factors, the COVID-19 Index remains a significant predictor in all models, confirming its strong influence on cashless payment behaviours. Additionally, temperature remains significant in urban models, with the squared term indicating a diminishing effect, consistent with prior literature. The influence of Ramadan on urban sales remains positive and significant, validating seasonal spending patterns. Furthermore, urban infrastructure factors (international airports, train stations, and seaports) continue to show strong positive effects, reinforcing the importance of city-level economic characteristics in shaping digital transactions.

To ensure statistical robustness, diagnostic tests were conducted. The Variance Inflation Factor (VIF) test (Table 32) confirmed that macroeconomic factors do not suffer from multicollinearity, as all VIF values remained below 5. Residual diagnostics, including histogram analysis (Figure 10) and Skewness-Kurtosis tests (Table 33), confirmed slight deviations from normality, but these deviations do not affect the validity of the model due to the large sample size and the central limit theorem. Additionally, fixed effects models were used to control for unobserved heterogeneity across sectors and cities, and robust clustered standard errors were applied to address potential serial correlation and heteroskedasticity.

Overall, the robustness checks confirm that macroeconomic factors contribute significantly to explaining cashless sales variations, but their exclusion does not distort the key relationships in the models. The stability of the COVID-19 Index, Ramadan, and urban infrastructure effects across different model specifications reinforces the structural validity of the panel data models, ensuring that findings remain consistent, reliable, and theoretically grounded.

4.5 Conclusion and Limitations

4.5.1 Conclusion

This study examined the determinants of cashless sales and cash withdrawals in Saudi Arabia using both ARDL and panel data analyses. By integrating exogenous factors—such as the COVID-19 index, geopolitical risk, temperature, Ramadan, infrastructure-related factors (international airports, train stations, and sea ports), and distance from the capital city—alongside macroeconomic controls, including inflation rate, stock-market return, interest rate, GDP growth rate, and unemployment rate, this study provides a comprehensive view of financial behaviour in an emerging market. The findings demonstrate that financial transactions are shaped by economic fluctuations and structural changes, reinforcing the dynamic nature of payment behaviours in response to exogenous shocks and systemic transformations (Jonker et al., 2022; Murinde et al., 2022; Shy, 2023).

This study reveals that, contrary to global trends, the COVID-19 pandemic had a negative impact on cashless sales in Saudi Arabia, underscoring the role of economic uncertainty, sectoral disruptions, and institutional factors in shaping financial behaviour (Altig et al., 2020; Ho et al., 2023; Kubota et al., 2021). This finding suggests that digital payment adoption is not solely technology-driven but is contingent on broader economic conditions.

Similarly, while geopolitical risk significantly influenced cashless sales at the national level, its impact was less pronounced at the sectoral and urban levels. This indicates that financial conservatism during periods of uncertainty affects both cash and digital transactions, but its effects vary by economic scale and transaction type (Adra et al., 2023; Tarkom & Ujah, 2023; Liu & Zhang, 2024).

Environmental factors also played a role, with temperature fluctuations exhibiting non-linear effects on financial behaviour. This highlights the need for climate-adaptive financial strategies (Bertrand & Parnaudeau, 2019; Keleş et al., 2018; Martínez-de-Albéniz & Belkaid, 2021).

Ramadan's financial impact varied by geographic and economic context. At the national level, it increased cash withdrawals but had no effect on cashless sales, reflecting a preference for cash in

religious transactions (Deller et al., 2018; Maung et al., 2020; Gharbi et al., 2020). However, in urban areas, Ramadan boosted cashless sales—except when infrastructure factors (airports, railways, and seaports) were considered. This suggests that economic activity, rather than religious observance alone, drives the increase in cashless transactions. The loss of significance when infrastructure is included explains much of the variation. These findings align with social capital and institutional theories, demonstrating that Ramadan's financial impact depends on economic infrastructure (Deller et al., 2018; Henley, 2017).

Moreover, the study highlights the importance of infrastructure in shaping cashless transactions. The presence of international airports, railway stations, and sea ports significantly contributed to urban cashless sales, reinforcing the role of trade and transport hubs in driving digital payment adoption (Sheard, 2019; Wang et al., 2020; Wu et al., 2022; Chengpeng et al., 2018; Banerjee et al., 2020). Conversely, greater distance from the capital city negatively impacted urban cashless transactions, pointing to regional disparities in financial integration (Jedwab & Storeygard, 2022; Morten & Oliveira, 2024; Coşar et al., 2022). These findings emphasize the need for targeted policies to bridge the financial inclusion gap in less-connected areas.

This study contributes to the theoretical understanding of financial behaviour in digital payment ecosystems by integrating macroeconomic, institutional, and environmental perspectives. While prior research predominantly focuses on technology adoption theories, this study demonstrates that digital payment adoption is not merely a function of technological accessibility but is deeply embedded in economic stability, sectoral dynamics, and institutional structures (Murinde et al., 2022; Jonker et al., 2022).

Furthermore, the findings challenge conventional assumptions in financial inclusion theory, which often assumes that crises accelerate digital payment adoption. Instead, this study provides counter-evidence showing that economic uncertainty may hinder digital transactions, particularly in economies where cash remains a key component of financial resilience (Altig et al., 2020; Ho et al., 2023).

Additionally, this research advances the understanding of environmental finance by demonstrating how climatic factors influence financial transactions. While previous studies have focused on

climate risk in broader economic contexts, this study provides empirical evidence of temperature effects on digital payment adoption, which has practical implications for financial service providers operating in regions with extreme weather conditions (Bertrand & Parnaudeau, 2019; Keleş et al., 2018).

The findings offer several key policy insights. The impact of the COVID-19 pandemic on cashless sales highlights the importance of financial stability measures during crises. Policymakers should consider targeted interventions such as stimulus measures and liquidity support to sustain digital transactions in times of economic uncertainty (Altig et al., 2020; Ho et al., 2023). Strengthening financial resilience in high-risk periods can help maintain the momentum of digital payment adoption.

The findings on geopolitical risk suggest that economic policies should focus on enhancing financial stability during periods of uncertainty. Strengthening financial regulation, improving consumer confidence, and reinforcing banking sector stability can mitigate the adverse effects of geopolitical instability (Adra et al., 2023; Liu & Zhang, 2024).

The nonlinear relationship between temperature and financial transactions underscores the need for climate-adaptive financial strategies. Financial institutions should integrate weather-sensitive financial planning to ensure service availability and digital payment infrastructure reliability during extreme temperature conditions (Keleş et al., 2018).

Cultural and religious considerations should also be incorporated into financial policies. The findings related to Ramadan indicate that banks and digital payment providers should develop services tailored to religious observances while promoting digital alternatives that align with traditional financial practices (Campante & Yanagizawa-Drott, 2015; Deller et al., 2018; Henley, 2017; Cao et al., 2019).

The significant positive impact of international airports, railway stations, and sea ports on cashless transactions suggests that transport infrastructure plays a key role in financial modernization. Integrating financial technology solutions within major transport hubs can further accelerate digital payment adoption, enhancing economic activity in key trade and transit locations (Sheard, 2019; Wang et al., 2020).

The negative effect of distance from the capital city on cashless transactions underscores the need to address regional disparities in digital payment adoption. Investments in fintech, mobile banking solutions, and regional financial services can help bridge the financial gap in less-connected areas, ensuring broader financial inclusion (Banerjee et al., 2020; Morten & Oliveira, 2024).

4.5.2 Limitations

Despite its robust insights, this study has certain limitations that provide avenues for future research.

First, data constraints may limit the generalizability of findings. Although the dataset spans a long historical period (January 1999–December 2023 for ARDL; January 2016–December 2023 for Panel analysis), more granular transaction data (e.g., daily or weekly records) could provide deeper insights into short-term behavioural shifts. Moreover, aggregate-level data may not fully capture variations across different demographic groups or income levels, which future research could explore through micro-level consumer surveys or firm-specific transaction records.

Methodologically, while ARDL and panel models offer robust insights into long-term and short-term dynamics, they assume linear relationships. However, financial behaviour may involve non-linear interactions that could be better captured using models such as the Nonlinear Autoregressive Distributed Lag (NARDL) approach (Damane, 2022). Additionally, while the study controls for major macroeconomic factors, potential endogeneity concerns remain. Future studies could address these using instrumental variable approaches or incorporating consumer sentiment indices.

Another limitation is that this study focuses exclusively on Saudi Arabia. While the findings provide valuable insights for an emerging economy with a rapidly evolving financial infrastructure, they may not be directly applicable to economies with different regulatory, technological, or institutional environments. Comparative studies across multiple countries could broaden the understanding of how financial systems adapt to digital transformation in different contexts.

Finally, while this study extensively examines macroeconomic and institutional factors, it does not incorporate behavioural and psychological dimensions of digital payment adoption. Future

research could integrate behavioural finance theories to explore how perceptions of security, trust, and financial literacy influence digital payment behaviours, particularly among different consumer demographics.

By acknowledging these limitations, this study provides a transparent foundation for future research while reinforcing its contributions to the literature on financial behaviour and digital payment adoption. The findings offer valuable insights for policymakers, financial institutions, and urban planners, supporting the development of strategies that enhance financial inclusion and digital transformation in emerging economies.

Chapter 5

Conclusion

5 Conclusion

This thesis has examined the determinants of FinTech adoption, cashless payments, and digital financial transactions in Saudi Arabia, contributing to the growing body of literature on financial inclusion and digital transformation. By integrating demographic, socio-economic, financial, and macroeconomic perspectives, this research provides valuable insights into financial behaviour in an emerging market. Compared to prior studies, this thesis advances knowledge by incorporating a multi-dimensional analysis of FinTech adoption, combining survey-based insights with large-scale transactional data to examine both individual and aggregate payment behaviours. The findings highlight new patterns in digital payment adoption that were previously unexplored, particularly regarding gender-based financial behaviour, expatriate engagement, and the role of infrastructure in shaping cashless transactions.

The findings of Chapter 2 confirm that gender, domiciliation status, employment status, age, and education level, alongside financial inclusion, financial literacy, financial well-being, financial service costs, and consumer protection, significantly influence FinTech adoption in Saudi Arabia. Women are less likely to adopt FinTech, reinforcing prior research on gender disparities in digital finance (Chen et al., 2023; Kara et al., 2021). Meanwhile, non-citizens (foreigners) exhibit higher adoption rates, aligning with studies that highlight FinTech's role in financial access for marginalized groups (Bhagat & Roderick, 2020). Employment status influences adoption, as unemployed individuals engage less with digital financial services (Sha'ban et al., 2020; Danisman & Tarazi, 2020). Education level also plays a critical role, with higher educational attainment positively correlated with FinTech engagement, as educated individuals tend to have greater financial literacy and digital competence, facilitating adoption (Alhassan et al., 2021; Danisman & Tarazi, 2020).

Financial inclusion, literacy, and well-being are strong predictors of FinTech adoption (Demir et al., 2022; Panos & Wilson, 2020), reinforcing the need for enhanced financial education. Higher traditional financial service costs drive adoption, confirming affordability as a key factor (Chen et al., 2020; Allen et al., 2022). Interestingly, consumer protection shows limited influence, suggesting that convenience and accessibility outweigh regulatory concerns (Rösner et al., 2020; Fu & Mishra, 2022). These results extend financial inclusion theory by demonstrating that

accessibility alone is insufficient; financial literacy, trust, and education also play critical roles (Meoli et al., 2022; Prete, 2022).

Chapter 3 builds upon existing research by analysing transaction values across Chip-and-PIN, contactless, digital wallet, and E-commerce payments. Gender differences are most pronounced in Chip-and-PIN and contactless transactions, supporting the pain of paying theory (See-To & Ngai, 2019). While prior studies (Choudrie et al., 2018; Thaker et al., 2022) suggest that females prefer digital wallets due to security, this study shows that authentication measures have minimized gender-based transaction differences. However, females exhibit a preference for Chip-and-PIN transactions over contactless payments, indicating a greater emphasis on security in face-to-face transactions. Foreigners conduct lower-value transactions in contactless and digital wallets due to cultural adaptation and social influence (Cruijsen & Knoben, 2021). However, their Chip-and-PIN transactions tend to be of higher value than their contactless transactions, suggesting that security concerns and trust in authentication methods influence their transaction choices. Employment status remains a strong determinant, confirming that financial stability influences digital payment preferences (Bounie & Camara, 2020; Brown et al., 2022). Unemployed individuals conduct higher-value transactions via digital wallets and E-commerce, indicating that these methods serve as accessible financial alternatives (Chen et al., 2019). However, unemployed individuals use Chip-and-PIN transactions less frequently, suggesting that the lack of financial stability may limit access to traditional banking services that require authentication. Age is also a significant factor in digital payment behaviours.

Younger individuals (15–24 years old) prefer contactless, digital wallet, and E-commerce payments, as they value speed and convenience in transactions (Jonker et al., 2022). In contrast, older individuals (45-55+) conduct higher-value transactions in Chip-and-PIN payments, reinforcing prior findings that security and authentication are greater concerns for this demographic (Li et al., 2023). Middle-aged individuals (35–44 years old) demonstrate a more balanced mix of payment preferences. Unlike younger consumers who prioritize speed, they adopt both contactless and Chip-and-PIN transactions at moderate levels, with notable engagement in E-commerce transactions. From a policy perspective, consumer education programs should focus on enhancing security awareness and trust in contactless payment technologies, particularly for female users. Financial literacy initiatives for expatriates could improve digital payment

engagement, while promoting Chip-and-PIN transactions as a secure alternative for older individuals may help increase their adoption of cashless payments. Additionally, regulatory support for alternative payment methods would facilitate greater financial inclusion (Manshad & Brannon, 2021; See-To & Ngai, 2019).

At the country level, Chapter 4 employed ARDL and panel data analyses to assess the impact of COVID-19, geopolitical risk, temperature, Ramadan, infrastructure, and distance from the capital city on cashless sales and cash withdrawals. Unlike global trends, the findings reveal that the COVID-19 pandemic negatively impacted cashless sales in Saudi Arabia, emphasizing the role of economic uncertainty in digital payment adoption (Altig et al., 2020; Ho et al., 2023). Geopolitical risk influences financial behaviour at the national level but has a lesser impact at the sectoral and urban levels (Adra et al., 2023; Tarkom & Ujah, 2023; Liu & Zhang, 2024). Temperature fluctuations also play a role, supporting climate-adaptive financial strategies (Bertrand & Parnaudeau, 2019; Keleş et al., 2018).

At the national level, Ramadan increases cash withdrawals but does not affect cashless sales, indicating a preference for cash in religious transactions (Deller et al., 2018; Maung et al., 2020; Gharbi et al., 2020). In urban areas, it boosts cashless sales unless infrastructure—airports, railways, and seaports—is considered, suggesting economic activity, not religious observance alone, drives this effect (Campante & Yanagizawa-Drott, 2015; Deller et al., 2018). The loss of significance with infrastructure factors explains much of the variation. These findings support social capital and institutional theories, showing that Ramadan's financial impact depends on infrastructure (Deller et al., 2018; Henley, 2017). This finding underscores the need for financial institutions to anticipate transaction volume spikes during religious periods and adapt their digital payment infrastructure accordingly.

Infrastructure significantly influences cashless transactions, with international airports, railway stations, and sea ports driving digital payment adoption (Sheard, 2019; Wang et al., 2020; Wu et al., 2022). Distance from the capital city negatively affects urban cashless sales, highlighting regional financial inclusion disparities (Jedwab & Storeygard, 2022; Morten & Oliveira, 2024; Coşar et al., 2022). Policymakers should invest in FinTech infrastructure to address these regional gaps and ensure nationwide financial integration.

This thesis extends financial inclusion theory by demonstrating that accessibility alone is insufficient for FinTech adoption; financial literacy, trust, and education play equally critical roles (Meoli et al., 2022; Prete, 2022; Panos & Wilson, 2020; Demir et al., 2022). While previous studies have emphasized financial infrastructure as a driver of digital payment adoption (Wang et al., 2020; Sheard, 2019; Wu et al., 2022), this study integrates behavioural insights by showing that gender, expatriate status, and employment stability significantly mediate the impact of infrastructure on cashless transactions.

Additionally, this research contributes to social capital theory by revealing how expatriate engagement in digital finance is shaped by cultural adaptation and social networks rather than financial necessity alone (Cruijsen & Knoben, 2021). Prior studies have focused on general trust in digital finance, but this thesis demonstrates that trust in authentication methods—particularly in Chip-and-PIN transactions—varies significantly across gender and employment status, reinforcing the importance of security concerns in shaping payment preferences (See-To & Ngai, 2019).

Furthermore, this study expands institutional theory by illustrating how regulatory environments and economic shocks (e.g., COVID-19, geopolitical risk) influence digital payment behaviours differently across national, sectoral, and urban contexts (Altig et al., 2020; Liu & Zhang, 2024; Adra et al., 2023; Tarkom & Ujah, 2023). While previous research highlights the role of economic crises in accelerating digital adoption, the findings in this thesis show that macroeconomic uncertainty can both facilitate and inhibit cashless payment adoption, depending on factors such as financial stability and regulatory confidence (Deller et al., 2018; Ho et al., 2023). These contributions provide a deeper understanding of digital financial behaviour in emerging economies and offer a framework for evaluating FinTech adoption beyond traditional economic models.

Among the policy recommendations, the following are expected to have the most significant impact:

Financial Literacy and Trust-Building Initiatives – Targeted financial literacy programs for women, expatriates, and older individuals can enhance digital financial confidence (Meoli et al., 2022; Prete, 2022; Rösner et al., 2020). These programs can help overcome gender-based financial

barriers, improve expatriate engagement in digital payments, and enhance digital financial inclusion among older individuals by addressing their unique challenges.

Regulatory Support for Alternative Payment Methods – Expanding frameworks to integrate digital wallets and E-commerce payment solutions can improve financial access (Chen et al., 2020; Allen et al., 2022; Panos & Wilson, 2020). These measures ensure that digital financial services are more inclusive and affordable for lower-income groups.

Regional Financial Inclusion Strategies – Investments in Fintech infrastructure and mobile banking can drive nationwide digital adoption (Banerjee et al., 2020; Morten & Oliveira, 2024). By addressing regional disparities, policymakers can enhance digital financial accessibility in remote and underserved areas.

Among the policy recommendations, the following are expected to have the most significant impact: financial literacy and trust-building initiatives, regulatory support for alternative payment methods, and regional financial inclusion strategies. Of these, financial literacy and trust-building initiatives are likely to have the greatest impact, as they directly address the core barriers to digital financial adoption across gender, expatriate, and age groups. By improving financial confidence and digital competence, these initiatives can drive widespread adoption and ensure long-term engagement with digital financial services.

While this study provides critical insights, some limitations must be acknowledged.

Chapter 2 examines Fintech adoption in Saudi Arabia but has limitations. Data collection during COVID-19 may restrict applicability to stable economic conditions, highlighting the need for longitudinal studies. The country-specific focus limits generalizability, as Saudi Arabia's Vision 2030 context differs from other emerging markets. Additionally, key factors like marital status, digital infrastructure, and multilingual accessibility were not considered. Future research should address these gaps, particularly for expatriates and digitally marginalized groups.

Chapter 3 is based on 716 million transactions over 36 months but is limited to a single Saudi bank, affecting generalizability. Including data from multiple institutions or central banks would enhance robustness. The study covers four payment methods—Chip-and-PIN, contactless, digital

wallets, and E-commerce—but excludes emerging options like P2P payments and cross-border remittances, crucial for financial inclusion. While the dataset captures digital transformation, it may not reflect long-term or post-COVID-19 shifts. Future research should analyse broader timeframes and conduct cross-country comparisons, particularly within the GCC.

Chapter 4 covers a long historical period (1999–2023 for ARDL; 2016–2023 for panel analysis) but could benefit from more granular transaction data. Aggregate data may overlook demographic and income-based variations, which micro-level studies could address. The reliance on ARDL and panel models assumes linear relationships, while financial behaviour may be better captured using Nonlinear ARDL (NARDL) models. Endogeneity concerns could be mitigated through instrumental variable approaches. The study's focus on macroeconomic and institutional factors excludes behavioural and psychological aspects, which future research could explore using behavioural finance theories. Comparative studies across multiple economies could further contextualize findings.

If this research were to be undertaken again, I would prioritize a broader comparative approach across multiple emerging markets to enhance generalizability. A mixed-methods approach incorporating qualitative data, such as interviews and focus groups, would provide deeper insights into behavioural motivations behind FinTech adoption. Furthermore, integrating consumer sentiment indices and real-time transaction data would allow for a more dynamic analysis of digital financial behaviour, capturing short-term fluctuations and external shocks more effectively.

Future research should focus on three key areas: (1) Expanding the geographical scope by conducting comparative cross-country analyses to assess FinTech adoption in different regulatory environments; (2) Enhancing methodological approaches by incorporating real-time transaction data and behavioural finance theories to capture evolving digital payment behaviours; and (3) Investigating new financial technologies, such as peer-to-peer payments and cross-border remittances, which remain underexplored yet crucial for financial inclusion in emerging markets. Addressing these areas will provide deeper insights into the long-term sustainability and evolution of digital financial ecosystems.

References

Addoum, J. M., Ng, D. T. & Ortiz-Bobea, A., 2020. Temperature Shocks and Establishment Sales. *The Review of Financial Studies,* 33(3), pp. 1331-1366.

Addoum, J. M., Ng, D. T. & Ortiz-Bobea, A., 2023. Temperature shocks and industry earnings news. *Journal of Financial Economics,* Volume 150, p. 1–45.

Adra, S., Gao, Y., Huang, J. & Yuan, J., 2023. Geopolitical risk and corporate payout policy. *International Review of Financial Analysis,* Volume 87, p. 102613.

Agarwal, S., Chomsisengphet, S., Meier, S. & Zou, X., 2020. In the mood to consume: Effect of sunshine on credit card spending. *Journal of Banking and Finance,* Volume 121, p. 105960.

Agarwal, S., Chomsisengphet, S., Yildirim, Y. & Zhang, J., 2021. Interest Rate Pass-Through and Consumption Response: The Deposit Channel. *The Review of Economics and Statistics,* 103(5), p. 922–938.

Ahn, K., Lee, D., Sohn, S. & Yang, B., 2019. Stock market uncertainty and economic fundamentals: an entropy-based approach. *Quantitative Finance,* 19(7), pp. 1151-1163.

Akbar, M., 2021. Effects of inflation uncertainty and exchange rate volatility on money demand in Pakistan: Bayesian econometric analysis. *International Journal of Finance & Economics,* pp. 1-18.

Alhassan, A., Li, L., Reddy, K. & Duppati, G., 2021. The relationship between political instability and financial inclusion: Evidence from Middle East and North Africa. *International Journal of Finance and Economics,* Volume 26, p. 353–374.

Allen, F. et al., 2016. The foundations of financial inclusion: Understanding ownership and use of formal accounts. *Journal of Financial Intermediation,* Volume 27, p. 1–30.

Allen, F., Gu, X. & Jagtiani, J., 2022. Fintech, Cryptocurrencies, and CBDC: Financial Structural Transformation in China. *Journal of International Money and Finance,* Volume 124, p. 102625.

Alsagr, N., Cumming, D. J., Davis, J. G. & Sewaid, A., 2023. Geopolitical risk and crowdfunding performance. *Journal of International Financial Markets, Institutions & Money,* Volume 85, p. 101766.

Altig, D. et al., 2020. Economic uncertainty before and during the COVID-19 pandemic. *Journal of Public Economics,* Volume 191, p. 104274.

Amankwah-Amoah, J., Khan, Z., Wood, G. & Knight, G., 2021. COVID-19 and digitalization: The great acceleration. *Journal of Business Research,* Volume 136, p. 602–611.

Anaza, N. A., Bennett, D. H. S., Andonova, Y. & Anaza, E., 2022. DPS 2.0: on the road to a cashless society. *Marketing Letters,* Volume 33, p. 693–704.

Arena, M. P. & Julio, B., 2023. Litigation Risk Management Through Corporate Payout Policy. *Journal of Financial and Quantitative Analysis,* 58(1), pp. 148-174.

Arner, D., Barberis, J. & Buckley, R., 2016. The evolution of Fintech: A new post-crisis paradigm. *Georgetown Journal of International Law,* Volume 47, pp. 1271-1319.

Asfaw, S. & Maggio, G., 2018. Gender, Weather Shocks and Welfare: Evidence from Malawi. *The Journal of Development Studies,* 54(2), pp. 271-291.

Atmaz, A. & Basak, S., 2022. Stock Market and No-Dividend Stocks. *The Journal of Finance,* 77(1), pp. 545-599.

Auer, R. & Tercero-Lucas, D., 2022. Distrust or speculation? The socioeconomic drivers of U.S. cryptocurrency investments. *Journal of Financial Stability,* Volume 62, p. 101066.

Baker, S. et al., 2020. How Does Household Spending Respond to an Epidemic? Consumption during the 2020 COVID-19 Pandemic. *The Review of Asset Pricing Studies,* Volume 10, p. 834–862.

Banerjee, A., Duflo, E. & Qian, N., 2020. On the road: Access to transportation infrastructure and economic growth in China. *Journal of Development Economics,* Volume 145, p. 102442.

Bech, M. & Hancock, J., 2020. *Innovations in payments,* Basel: Bank for International Settlements.

Bernanke, B. S., 1983. Irreversibility, uncertainty, and cyclical investment. *Quarterly Journal of Economics,* 98(1), pp. 85-106.

Bertrand, J.-L. & Parnaudeau, M., 2019. Understanding the economic effects of abnormal weather to mitigate the risk of business failures. *Journal of Business Research,* Volume 98, p. 391–402.

Bhagat, A. & Roderick, L., 2020. Banking on refugees: Racialized expropriation in the fintech era. *Environment and Planning A: Economy and Space,* 52(8), p. 1498–1515.

BIS, 2020. *Central banks and payments in the digital era,* Basel: Bank for International Settlements.

Bloom, N., 2009. The Impact of Uncertainty Shocks. *Econometrica,* 77(3), pp. 623-685.

Bounie, D. & Camara, Y., 2020. Card-sales response to merchant contactless payment acceptance. *Journal of Banking and Finance,* Volume 119, p. 105938.

Brown, M., Hentschel, N., Mettler, H. & Stix, H., 2022. The convenience of electronic payments and consumer cash demand. *Journal of Monetary Economics,* Volume 130, p. 86–102.

Bryan, G., Choi, J. J. & Karlan, D., 2021. Randomizing religion: the impact of Protestant evangelism on economic outcomes. *The Quarterly Journal of Economics,* 136(1), p. 293–380.

Caglayan, M., Talavera, O., Xiong, L. & Zhang, J., 2020. What does not kill us makes us stronger: the story of repetitive consumer loan applications. *The European Journal of Finance,* 28(1), pp. 46-65.

Campante, F. & Yanagizawa-Drott, D., 2015. Does religion affect economic growth and happiness? Evidence from Ramadan. *The Quarterly Journal of Economics,* 130(2), p. 615–658.

Campante, F. & Yanagizawa-Drott, D., 2018. Long-Range Growth: Economic Development in the Global Network of Air Links. *The Quarterly Journal of Economics,* 133(3), pp. 1395-1458.

Cao, C., Chan, K. C., Hou, W. & Jia, F., 2019. Does religion matter to informal finance? Evidence from trade credit in China. *Regional Studies,* 53(10), pp. 1410-1420.

Carvalho, B., Peralta, S. & Santos, J., 2022. Regional and sectorial impacts of the Covid-19 crisis: Evidence from electronic payments. *Journal of regional science,* Volume 62, p. 757–798.

Chengpeng, W., Di, Z., Xinping, Y. & Zaili, Y., 2018. A novel model for the quantitative evaluation of green port development – A case study of major ports in China. *Transportation Research Part D,* Volume 61, pp. 431-443.

Chen, H., Huynh, K. P. & Shy, O., 2019. Cash versus card: Payment discontinuities and the burden of holding coins. *Journal of Banking and Finance,* Volume 99, p. 192–201.

Chen, S. et al., 2023. The fintech gender gap. *Journal of Financial Intermediation,* Volume 54, p. 101026.

Chen, X., Huang, B. & Ye, D., 2020. Gender gap in peer-to-peer lending: Evidence from China. *Journal of Banking and Finance,* Volume 112, p. 105633.

Chen, Z., Li, Y. & Wang, P., 2020. Transportation accessibility and regional growth in the Greater Bay Area of China. *Transportation Research Part D,* Volume 86, p. 102453.

Choudrie, J., Junior, C.-O., McKenna, B. & Richter, S., 2018. Understanding and conceptualising the adoption, use and diffusion of mobile banking in older adults: A research agenda and conceptual framework. *Journal of Business Research,* Volume 88, p. 449–465.

Collins, J. M. & Urban, C., 2020. Measuring financial well-being over the lifecourse. *The European Journal of Finance,* 26(4-5), pp. 341-359.

Coşar, A. K., Demir, B., Ghose, D. & Young, N., 2022. Road capacity, domestic trade and regional outcomes. *Journal of Economic Geography,* Volume 22, pp. 901-929.

Craig, C. A., 2019. The Weather-Proximity-Cognition (WPC) framework: A camping, weather, and climate change case. *Tourism Management,* Volume 75, p. 340–352.

Cruijsen, C. v. d. & Knoben, J., 2021. Ctrl+C Ctrl+Pay: Do People Mirror Electronic Payment Behavior of their Peers?. *Journal of Financial Services Research,* Volume 59, p. 69–96.

Damane, M., 2022. Investigating the determinants of commercial bank interest rate spreads in Lesotho: Evidence from autoregressive distributed lag (ARDL) and non-linear ARDL approaches. *International Journal of Finance and Economics,* Volume 27, p. 4256–4278.

Danisman, G. O. & Tarazi, A., 2020. Financial inclusion and bank stability: evidence from Europe. *The European Journal of Finance,* 26(18), p. 1842–1855.

Deller, S. C., Conroy, T. & Markeson, B., 2018. Social capital, religion and small business activity. *Journal of Economic Behavior and Organization,* Volume 155, p. 365–381.

Demir, A., Pesqué-Cela, V., Altunbas, Y. & Murinde, V., 2022. Fintech, financial inclusion and income inequality: a quantile regression approach. *The European Journal of Finance,* 28(1), pp. 86-107.

Demiroglu, C., Ozbas, O., Silva, R. C. & Ulu, M. F., 2021. Do Physiological and Spiritual Factors Affect Economic Decisions?. *The Journal of Finance,* LXXVI(5), pp. 2481-2523.

DeSimone, J. A., Harms, P. D. & DeSimone, A. J., 2015. Best practice recommendations for data screening. *Journal of Organizational Behavior,* 36(2), pp. 171-181.

Di Maggio, M., Kermani, A. & Majlesi, K., 2020. Stock Market Returns and Consumption. *The Journal of Finance,* LXXV(6), pp. 3175-3219.

Diao, M., 2018. Does growth follow the rail? The potential impact of high-speed rail on the economic geography of China. *Transportation Research Part A,* Volume 113, pp. 279-290.

Dobbie, W., Liberman, A., Paravisini, D. & Pathania, V., 2021. Measuring Bias in Consumer Lending. *Review of Economic Studies,* Volume 88, p. 2799–2832.

Dogan, E., Madaleno, M. & Taskin, D., 2021. Which households are more energy vulnerable? Energy poverty and financial inclusion in Turkey. *Energy Economics,* Volume 99, p. 105306.

Duca-Radu, I., Kenny, G. & Reuter, A., 2021. Inflation expectations, consumption and the lower bound: Micro evidence from a large multi-country survey. *Journal of Monetary Economics,* Volume 118, pp. 120-134.

Ehling, P., Gallmeyer, M., Heyerdahl-Larsen, C. & Illeditsch, P., 2018. Disagreement about inflation and the yield curve. *Journal of Financial Economics,* Volume 127, pp. 459-484.

El Khoury, R., Nasrallah, N., Hussainey, K. & Assaf, R., 2023. Spillover analysis across FinTech, ESG, and renewable energy indices before and during the Russia–Ukraine war: International evidence. *Journal of International Financial Management & Accounting,* Volume 34, p. 279–317.

Fagereng, A., Onshuus, H. & Torstensen, K. N., 2024. The consumption expenditure response to unemployment: Evidence from Norwegian households. *Journal of Monetary Economics,* p. 103578.

Farag, H. & Johan, S., 2021. How alternative finance informs central themes in corporate finance. *Journal of Corporate Finance,* Volume 67, p. 101879.

Farmaki, A., Altinay, L., Christou, P. & Kenebayeva, A., 2020. Religion and entrepreneurship in hospitality and tourism. *International Journal of Contemporary Hospitality Management,* 32(1), pp. 148-172.

Flynn, B. B. & Flynn, E. J., 1999. Information-Processing Alternatives for Coping with Manufacturing Environment Complexity. *Decision Sciences,* 30(4), pp. 1021-1052.

FSB, 2017. *Financial Stability Implications from FinTech,* Basel: Financial Stability Board.

FSDP, 2022. *Financial Sector Development Program: Program Charter 2022,* Riyadh: Financial Sector Development Program.

Fu, J. & Mishra, M., 2022. Fintech in the time of COVID-19: Technological adoption during crises. *Journal of Financial Intermediation,* Volume 50, p. 100945.

Ganong, P. & Noel, P., 2019. Consumer Spending during Unemployment: Positive and Normative Implications. *American Economic Review,* 109(7), p. 2383–2424.

Gharbi, I., Hamed-Sidhom, M., Hussainey, K. & Ganouati, J., 2020. Religiosity and financial distress in U.S. firms. *International Journal of Finance & Economics,* Volume 26, p. 3902–3915.

Ghirelli, C., Pérez, J. & Urtasun, A., 2019. A new economic policy uncertainty index for Spain. *Economics Letters,* Volume 182, p. 64–67.

Goldstein, I., Jiang, W. & Karolyi, G., 2019. To FinTech and Beyond. *The Review of Financial Studies,* 32(5), pp. 1647-1661.

González, M., Nave, J. & Rubio, G., 2018. Macroeconomic determinants of stock market betas. *Journal of Empirical Finance,* Volume 45, pp. 26-44.

Goodell, J. W., Kumar, S., Lahmar, O. & Pandey, N., 2023. A bibliometric analysis of cultural finance. *International Review of Financial Analysis,* Volume 85, p. 102442.

Gujarati, D. & Porter, D., 2009. *Basic Econometrics.* 5th ed. New York: McGraw-Hill/Irwin.

Gupta, M. & Kishore, A., 2022. Unemployment and Household Spending in Rural and Urban India: Evidence from Panel Data. *The Journal of Development Studies,* 58(3), pp. 545-560.

Henley, A., 2017. Does religion influence entrepreneurial behaviour. *International Small Business Journal,* 35(5), pp. 597-617.

Hoang, T. H. V., Shahzad, S. J. H. & Czudaj, R. L., 2020. Renewable energy consumption and industrial production: A disaggregated time-frequency analysis for the U.S.. *Energy Economics,* Volume 85, p. 104433.

Ho, C.-Y., Kim, N., Rong, Y. & Tian, X., 2023. Promoting Mobile Payment with Price Incentives. *Management Science,* 68(10), pp. 7614-7630.

Jedwab, R. & Storeygard, A., 2022. The Average and Heterogeneous Effects of Transportation Investments: Evidence from Sub-Saharan Africa 1960–2010. *Journal of the European Economic Association,* 20(1), pp. 1-38.

Jiang, Y., Tian, G., Wu, Y. & Mo, B., 2022. Impacts of geopolitical risks and economic policy uncertainty on Chinese tourism-listed company stock. *International Journal of Finance & Economics,* Volume 27, p. 320–333.

John, K. & Williams, J., 1985. Dividends, Dilution, and Taxes A Signalling Equilibrium. *The Journal of Finance,* XL(4), pp. 1053-1070.

Jonker, N., Cruijsen, C. v. d., Bijlsma, M. & Bolt, W., 2022. Pandemic payment patterns. *Journal of Banking and Finance,* Volume 143, p. 106593.

Kahn, C. M. & Roberds, W., 2009. Why pay? An introduction to payments economics. *Journal of Financial Intermediation,* Volume 18, p. 1–23.

Kahouli, B., 2017. The short and long run causality relationship among economic growth, energy consumption and financial development: Evidence from South Mediterranean Countries (SMCs). *Energy Economics,* Volume 68, p. 19–30.

Kara, A., Zhou, H. & Zhou, Y., 2021. Achieving the United Nations' sustainable development goals through financial inclusion: A systematic literature review of access to finance across the globe. *International Review of Financial Analysis,* Volume 77, p. 101833.

Kekre, R., 2023. Unemployment Insurance in Macroeconomic Stabilization. *Review of Economic Studies,* Volume 90, p. 2439–2480.

Keleş, B., Gómez-Acevedo, P. & Shaikh, N. I., 2018. The impact of systematic changes in weather on the supply and demand of beverages. *International Journal of Production Economics,* Volume 195, p. 186–197.

Koomson, I. & Danquah, M., 2021. Financial inclusion and energy poverty: Empirical evidence from Ghana. *Energy Economics,* Volume 94, p. 105085.

Kotkowski, R. & Polasik, M., 2021. COVID-19 pandemic increases the divide between cash and cashless payment users in Europe. *Economics Letters,* Volume 209, p. 110139.

Kripfganz, S. & Schneider, D. C., 2023. ardl: Estimating autoregressive distributed lag and equilibrium correction models. *The Stata Journal,* 23(4), p. 983–1019.

Krishna, B., Krishnan, S. & Sebastian, M. P., 2022. Examining the Relationship between National Cybersecurity Commitment, Culture, and Digital Payment Usage: An Institutional Trust Theory Perspective. *Information Systems Frontiers.*

Kubota, S., Onishi, K. & Toyama, Y., 2021. Consumption responses to COVID-19 payments: Evidence from a natural experiment and bank account data. *Journal of Economic Behavior and Organization,* Volume 188, pp. 1-17.

Kumar, V., Nim, N. & Agarwal, A., 2021. Platform-based mobile payments adoption in emerging and developed countries: Role of country-level heterogeneity and network effects. *Journal of International Business Studies,* Volume 52, p. 1529–1558.

Liang, C. et al., 2024. Combating extreme weather through operations management: Evidence from a natural experiment in China. *International Journal of Production Economics,* Volume 267, p. 109073.

Li, J., Luo, S. & Zhou, G., 2023. Electronic payment, natural environment and household consumption: Evidence from China household finance survey. *International Review of Financial Analysis,* Volume 85, p. 102472.

Lim, S., Pettit, S., Abouarghoub, W. & Beresford, A., 2019. Port sustainability and performance: A systematic literature review. *Transportation Research Part D,* Volume 72, pp. 47-64.

Liu, X. & Zhang, X., 2024. Geopolitical risk and currency returns. *Journal of Banking and Finance,* Volume 161, p. 107097.

Londoño-Vélez, J. & Querubín, P., 2022. The Impact of Emergency Cash Assistance in a Pandemic: Experimental Evidence from Colombia. *The Review of Economics and Statistics,* 104(1), p. 157–165.

Lubis, A., Alexiou, C. & Nellis, J., 2019. *Payment system innovations and financial intermediation: The case of Indonesia,* Tokyo: Asian Development Bank Institute.

Lu, X. & White, H., 2014. Robustness checks and robustness tests in applied economics. *Journal of Econometrics,* Volume 178, pp. 194-206.

Manshad, M. S. & Brannon, D., 2021. Haptic-payment: Exploring vibration feedback as a means of reducing overspending in mobile payment. *Journal of Business Research,* Volume 122, p. 88–96.

Martínez-de-Albéniz, V. & Belkaid, A., 2021. Here comes the sun: Fashion goods retailing under weather fluctuations. *European Journal of Operational Research,* Volume 294, p. 820–830.

Maung, M., Tang, Z. & Xu, X., 2020. Religion and venture investing: A cross-country analysis. *Financial Review,* Volume 55, p. 433–460.

Meade, A. & Craig, S. B., 2012. Identifying careless responses in survey data. *Psychological methods,* 17(3), p. 437–455.

Meoli, M., Rossi, A. & Vismara, S., 2022. Financial literacy and security-based crowdfunding. *Corporate Governance: An International Review,* Volume 30, p. 27–54.

Mohamed, H. & Saâdaoui, F., 2023. Exploring sustainable energy consumption and social conflict risks in Turkey: Insights from a novel multiresolution ARDL approach. *Risk Analysis,* p. 1–19.

Morgenstern, O., 1963. *On the Accuracy of Economic Observations.* 2 ed. Princeton: Princeton University Press.

Morten, M. & Oliveira, J., 2024. The Effects of Roads on Trade and Migration: Evidence from a Planned Capital City. *American Economic Journal: Applied Economics,* 16(2), pp. 389-421.

Murinde, V., Rizopoulos, E. & Zachariadis, M., 2022. The impact of the FinTech revolution on the future of banking: Opportunities and risks. *International Review of Financial Analysis,* Volume 81, p. 102103.

Pankratz, N., Bauer, R. & Derwall, J., 2023. Climate Change, Firm Performance, and Investor Surprises. *Management Science,* 69(12), pp. 7352-7398.

Panos, G. A. & Wilson, J. O. S., 2020. Financial literacy and responsible finance in the FinTech era: capabilities and challenges. *The European Journal of Finance,* 26(4-5), pp. 297-301.

Philippas, N. D. & Avdoulas, C., 2020. Financial literacy and financial well-being among generation-Z university students: Evidence from Greece. *The European Journal of Finance,* 26(4-5), pp. 360-381.

Prete, A. L., 2022. Digital and financial literacy as determinants of digital payments and personal finance. *Economics Letters,* Volume 213, p. 110378.

Rösner, A., Haucap, J. & Heimeshoff, U., 2020. The impact of consumer protection in the digital age: Evidence from the European Union. *International Journal of Industrial Organization,* Volume 73, p. 102585.

Ryngaert, J. M., 2022. Inflation disasters and consumption. *Journal of Monetary Economics,* Volume 129, p. S67–S81.

Sahay, R. et al., 2015. *Financial inclusion: Can it meet multiple macroeconomic goals?,* Washington, D.C.: International Monetary Fund.

SAMA, 2019. *SAMA assures: the promotion of financial inclusion in the kingdom is a strategic goal we aim to achieve.* [Online]
Available at: http://www.sama.gov.sa/en-us/news/pages/news28042019.aspx
[Accessed 17 March 2020].

Schomburgk, L. & Hoffmann, A., 2023. How mindfulness reduces BNPL usage and how that relates to overall well-being. *European Journal of Marketing,* 57(2), pp. 325-359.

Scott, S. V. & Zachariadis, M., 2012. Origins and development of SWIFT, 1973–2009. *Business History,* 54(3), p. 462–482.

See-To, E. W. & Ngai, E. W., 2019. An empirical study of payment technologies, the psychology of consumption, and spending behavior in a retailing context. *Information & Management,* Volume 56, p. 329–342.

Sha'ban, M., Girardone, C. & Sarkisyan, A., 2020. Cross-country variation in financial inclusion: a global perspective. *The European Journal of Finance,* 26(4-5), p. 319–340.

Shahzad, S. J. H., Hurley, D. & Ferrer, R., 2021. U.S. stock prices and macroeconomic fundamentals: Fresh evidence using the quantile ARDL approach. *International Journal of Finance & Economics,* Volume 26, p. 3569–3587.

Sheard, N., 2019. Airport Size and Urban Growth. *Economica,* Volume 86, pp. 300-335.

Shy, O., 2023. Cash is Alive: How Economists Explain Holding and Use of Cash. *Journal of Economic Literature,* 61(4), p. 1465–1520.

stc pay, 2021. *Approval Transfer stc pay Digital Bank.* [Online]
Available at: https://stcpay.com.sa/news-item/approval-transfer-stc-pay-digital-bank/
[Accessed 18 August 2023].

Suder, M. et al., 2024. Effectiveness of ATM withdrawal forecasting methods under different market conditions. *Technological Forecasting & Social Change,* Volume 200, p. 123089.

Swamy, V., 2022. Financial wealth effects and consumption expenditure. *International Journal of Finance & Economics,* Volume 27, pp. 1933-1946.

Tarkom, A. & Ujah, N. U., 2023. Global policy uncertainty and working capital management: Does national culture matter?. *Technological Forecasting & Social Change,* Volume 196, p. 122869.

Thaker, H. M. T., Subramaniam, N. R., Qoyum, A. & Hussain, H. I., 2022. Cashless society, e-wallets and continuous adoption. *International Journal of Finance & Economics,* 28(3), pp. 3349-3369.

Tran, B. R., 2023. Sellin' in the Rain: Weather, Climate, and Retail Sales. *Management Science,* 69(12), pp. 7423-7447.

Uchida, K., Kato, H., Murakami, J. & Takeuchi, W., 2024. Does new airport investment promote urban economic development?: Global evidence from nighttime light data. *Transportation Research Part A,* Volume 180, p. 103948.

Vives, X., 2019. Digital Disruption in Banking. *Annual Review of Financial Economics,* Volume 11, p. 243–72.

Wang, K., Jiang, C., Ng, A. K. & Zhu, Z., 2020. Air and rail connectivity patterns of major city clusters in China. *Transportation Research Part A,* Volume 139, pp. 35-53.

Wu, Y., Lee, C.-C., Lee, C.-C. & Peng, D., 2022. Geographic proximity and corporate investment efficiency: Evidence from high-speed rail construction in China. *Journal of Banking and Finance,* Volume 140, p. 106510.

Yang, T. & Zhang, X., 2022. FinTech adoption and financial inclusion: Evidence from household consumption in China. *Journal of Banking and Finance,* Volume 145, p. 106668.

Zhang, Y. et al., 2019. Retail payments and the real economy. *Journal of Financial Stability,* Volume 44, p. 100690.

Zheng, Z., 2020. Inflation and income inequality in a Schumpeterian economy with menu costs. *Economics Letters,* Volume 186, p. 108524.