Lisbon School of Economics & Management
Universidade de Lisboa

MASTER

INFORMATION SYSTEMS MANAGEMENT

MASTER´S FINAL WORK

THESIS

FROM BRANCHES TO SCREENS: UNDERSTANDING MOBILE BANKING APP USAGE THROUGH BUSINESS INTELLIGENCE AND MACHINE LEARNING

GONÇALO COSTA BOAVIDA

JUNE - 2025

Lisbon School of Economics & Management
Universidade de Lisboa

MASTER
INFORMATION SYSTEMS MANAGEMENT

MASTER´S FINAL WORK
THESIS

FROM BRANCHES TO SCREENS: UNDERSTANDING MOBILE BANKING APP USAGE THROUGH BUSINESS INTELLIGENCE AND MACHINE LEARNING

GONÇALO COSTA BOAVIDA

SUPERVISION:
PROFESSOR RUI MANUEL TRIGO PEREIRA GUEDES

JUNE - 2025

ACRONYMS

AI Artificial Intelligence.

BI Business Intelligence.

DIT Diffusion of Innovation Theory.

DT Decision Tree.

E-SERVQUAL Electronic Service Quality.

GDPR General Data Protection Regulation.

ML Machine Learning.

RISK Perceived Risk.

SVM Support Vector Machines.

TAM Technology Acceptance Model.

TPB Theory of Planned Behavior.

UI User Interface.

UMAP Uniform Manifold Approximation and Projection for Dimension Reduction.

UTAUT Unified Theory of Acceptance and Use of Technology.

DECLARATION OF HONOUR

I hereby declare that this master's dissertation "From Branches to Screens: Understanding Mobile Banking App Usage Through Business Intelligence and Machine Learing" is the result of my own work and independent research, conducted in accordance with the academic standards and ethical guidelines of ISEG – Lisbon School of Economics & Management, Universidade de Lisboa. All sources used and contributions from others have been duly acknowledged throughout the document.

Furthermore, I confirm that all data collected and analyzed in this dissertation were used strictly for academic and research purposes only. No data were used for commercial, financial, or any other non-institutional objectives. The study complies with the principles of confidentiality and data protection, and the insights generated serve solely to advance theoretical understanding and contribute to the academic field of digital banking.

ABSTRACT

This thesis investigates the key factors influencing the adoption and use of mobile banking applications in Portugal, addressing persistent research gaps in consumer behavior and perception amid the sector's rapid digitalization. While research typically focuses on institutional data, this study centers on the user experience, employing a mixed-methods approach that combines qualitative interviews with a nationwide survey.

Based on established technology adoption models, such as UTAUT, Perceived Risk Theory, and Diffusion of Innovation Theory, the study takes a user-focused and data-driven perspective. Qualitative findings highlighted concerns around security, usability, and trust, which helped shape the survey design. The results confirmed widespread use of mobile banking for day-to-day tasks, with security emerging as the main factor driving adoption.

To enrich the analysis, Business Intelligence tools and Machine Learning techniques, including Random Forest and K-Means clustering, were used to uncover behavioral patterns and segment users into three groups: Full Digital Users, Conscious Skeptics, and Digitally Hesitant Users. These profiles offer useful insights into different user needs and expectations.

Overall, the study contributes not just to academic knowledge but also provides practical insights for financial institutions looking to improve digital services. By helping to understand user behavior more deeply, it supports the development of more inclusive, trustworthy, and user-friendly mobile banking solutions in Portugal.

KEYWORDS: Mobile Banking, Technology Adoption, Consumer Behavior, Business Intelligence, Machine Learning

RESUMO

Esta dissertação investiga os principais factores que influenciam a adoção e utilização de aplicações bancárias em Portugal, abordando lacunas persistentes na investigação sobre o comportamento e perceção do consumidor no contexto da rápida digitalização do sector. Embora a investigação se centre normalmente em dados institucionais, este estudo centra-se na experiência do utilizador, utilizando uma abordagem de métodos mistos que combina entrevistas qualitativas com um inquérito a nível nacional.

Com base em modelos de adoção de tecnologia estabelecidos, como o UTAUT, a Teoria do Risco Apercebido e a Teoria da Difusão da Inovação, o estudo adopta uma perspetiva centrada no utilizador e orientada para os dados. As evidências qualitativas destacaram preocupações em torno da segurança, da usabilidade e da confiança, que ajudaram a moldar a conceção do inquérito. Posteriormente, os dados recolhidos confirmaram a utilização generalizada da banca móvel para tarefas quotidianas, com a segurança a emergir como o principal fator que impulsiona a adoção.

Para enriquecer a análise, foram utilizadas ferramentas de Inteligência Empresarial e técnicas de Aprendizagem Automática, incluindo Floresta Alteatória e agrupamento em K-Means, para descobrir padrões de comportamento e segmentar os utilizadores em três grupos: Utilizadores Totalmente Digitais, Cépticos Conscientes e Utilizadores Digitalmente Hesitantes. Estes perfis oferecem informações úteis sobre as diferentes necessidades e expectativas dos utilizadores.

De um modo geral, o estudo contribui não só para o conhecimento académico, mas também fornece informações práticas para as instituições financeiras que procuram melhorar os serviços digitais. Ao ajudar a compreender mais profundamente o comportamento dos utilizadores, o estudo apoia o desenvolvimento de soluções bancárias móveis mais inclusivas, fiáveis e fáceis de utilizar em Portugal.

PALAVRAS-CHAVE: Banca Móvel, Adoção de Tecnologia, Comportamento do Consumidor, Inteligência Empresarial, Aprendizagem Automática

LIST OF FIGURES

LIST OF TABLES

ACKNOWLEDGEMENTS

The completion of this Master's thesis in Information Systems Management has been both a challenging and rewarding experience. I would like to take this moment to convey my gratitude to all those who supported and inspired me throughout this journey.

First and above all, I am profoundly thankful to my parents and to my girlfriend, who, above all, has been my unwavering and unconditional support during this entire process. They have constant encourage, patient, and belief in me have been essential to reaching this milestone.

I also wish to dedicate a special thought to my grandparents, particularly those who are no longer with us, because they have always been a source of inspiration and motivation, instilling in me the the importance of education.

A heartfelt thank you to ISEG for providing an enriching academic environment, and to the professors who guided and supported me throughout the Master's program. I am also grateful for the countless opportunities to grow both personally and professionally, and for the wonderful people I have met along the way, friendships and memories that I will cherish for life.

Finally, I would like to express my heartfelt gratitude to Caixa Geral de Depósitos for granting access to the data that was fundamental to the development of this thesis. I am also thankful to all my colleagues at work for their continuous support, collaboration, and the many opportunities I have been given.

1 INTRODUCTION

The widespread digitalization of the banking sector has significantly transformed how financial services are delivered and experienced. In Portugal, mobile banking applications have become increasingly popular, enabling users to conduct everyday transactions, manage personal finances, and access services with greater flexibility and efficiency.

This thesis begins with an overview of mobile banking in the Portuguese context and identifies research gaps in the current academic literature, particularly concerning user adoption of mobile banking Apps user experience in Portugal. To address these gaps, this study applies mixed-methods combining approaches: qualitative interviews were first conducted to explore user perceptions, followed by a structured questionnaire designed to capture usage patterns and attitudes across a broader sample.

1.1 Motivations

The banking sector has long stood out as an area of both academic and professional relevance, making it a natural focus for this research. This interest was further reinforced through professional experience as a Business Intelligence technician at one of the largest banks in Portugal.

In this professional context, the main activities involve the use of internal data to construct user profiles based on predefined metrics, with a particular focus on the individual (retail) banking segment, an area of notable strategic and analytical interest. On a daily basis, tools such as MicroStrategy and Tableau are used to build and deliver dashboards that support decision-making across different departments. These platforms are essential for transforming raw data into actionable insights, making them central to the reporting and analytical workflow.

However, this work has also exposed a significant limitation: while internal data offers valuable operational insights, it often lacks the depth required to fully capture customer perceptions, motivations, and behavioral patterns from a user-centered perspective.

Given the centrality of retail banking in current responsibilities, this research was motivated by the need to deepen knowledge in this specific area. A better understanding of the factors that drive individuals to adopt banking applications is essential, not only to complement the operational view with a behavioral dimension but also to support the design of more effective and inclusive digital strategies in the financial sector.

1.2 Research Gaps Identified

Although mobile banking has become increasingly relevant, significant research gaps remain,particularly within the Portuguese context,regarding the behavioral factors that influence its adoption. Most existing studies rely on internal institutional data, which, while valuable, often overlook users perceptions, motivations, and concerns. As a result, there is limited understanding of how individuals actually experience and interact with digital banking platforms.

This study addresses that gap through a user-centered approach that combines qualitative interviews with a nationwide survey. It explores behavioral and contextual factors such as trust, perceived risk, ease of use, and digital literacy, drawing on established theoretical models including UTAUT, Diffusion of Innovation Theory, and Perceived Risk Theory. This framework makes it possible to examine not only how people use mobile banking but also why they choose to adopt,or avoid it.

Another shortcoming of current research is the lack of publicly available, up-to-date data on mobile banking usage in Portugal. While banks possess operational metrics, these seldom capture users' emotions or expectations. This dissertation bridges that gap by linking institutional perspectives with real consumer insights, offering a more comprehensive and human understanding of digital adoption.

Finally, few studies in Portugal have applied Machine Learning techniques to segment mobile banking users. By integrating Business Intelligence and Machine Learning tools, this research contributes practical value and demonstrates how data-driven methods can help financial institutions better understand and support distinct user profiles.

n summary, this work contributes to both theory and practice by offering a deeper and more nuanced view of the adoption of mobile banking, one that can support better digital strategies and promote more inclusive financial services.

1.3 Research Questions and Objectives

This study is guided by four research questions, formulated to address the key gaps identified:

- **Q1:**What factors influence the adoption and usage patterns of mobile banking applications in Portugal?
- **Q2:**What are the most common usage behaviors, preferences, and satisfaction levels among consumers using mobile banking applications?

- **Q3:**How do users perceive the relative advantages of mobile banking compared to traditional banking channels, and how do these perceptions shape their behavior?
- **Q4:** How do consumers evaluate the security and trustworthiness of financial transactions performed through mobile banking applications?

The primary objective of this dissertation is to identify and analyze the factors that promote or hinder the adoption of mobile banking applications among Portuguese retail banking clients. Anchored in established theoretical models of technology adoption, the study adopts a user-centered perspective and emphasizes the importance of understanding consumer perceptions, motivations, and behaviors.

In addition to this, the research aims to explore how mobile banking apps are used in practice, and how users evaluate their experience in terms of convenience, trust, and satisfaction. Although the focus is specifically on mobile applications, the study also considers the role of other banking channels, such as physical branches and online banking platforms, to better contextualize the strengths and areas for improvement of mobile solutions.

A further objective is to examine the potential of applying Machine Learning techniques to classify users and detect behavioral patterns that may inform more targeted engagement and personalization strategies. By combining qualitative insights with quantitative analysis, the study seeks to make a modest but meaningful contribution to the growing body of knowledge on digital banking and to offer evidence-based recommendations for improving user experience and supporting digital inclusion within the Portuguese banking sector.

1.4 Dissertation structure

The thesis is organized into five chapters, each contributing to a comprehensive understanding of the adoption and usage of mobile banking applications in Portugal.

The first chapter, introduces the research topic, including the motivation behind the study, the research gaps identified, the questions to be answered, and the objectives guiding the investigation.

The second chapter presents a systematic literature review, covering the evolution of the banking sector, particularly in Portugal, and examining the main theoretical frameworks related to mobile banking adoption.

The third chapter details the methodological approach, which adopts a mixed-methods design. It outlines the procedures for data collection through qualitative interviews and a

subsequent quantitative survey, explains the coding and analysis processes, and describes the data cleaning and preparation for further statistical and machine learning analysis.

The fourth chapter presents and interprets the results. This includes descriptive and inferential analysis of the survey data using business intelligence tools (such as Tableau), as well as the application of machine learning models (via Google Colab) to identify behavioral patterns and user segments.

Finally, the fifth chapter discusses the key findings in light of the research questions and theoretical models. It also addresses the study's limitations, such as the geographic concentration of the sample, and proposes insights for future research. Additionally, it offers practical recommendations for the banking sector in adapting mobile solutions to different user profiles.

Throughout the development of this dissertation, various digital tools were employed to enhance both the writing process and the management of references. The document was written and formatted using Overleaf, a collaborative LaTeX editor, which facilitated version control and structural consistency. Mendeley was used as a reference management tool to organize and cite relevant literature efficiently, and Grammarly supported the revision process by helping to ensure clarity and correctness in written English.

2 SYSTEMATIC LITERATURE REVIEW

This chapter covers the literature review that will provide a basis for understanding the main themes in the technological development of mobile banking, as well as the theories and studies related to the adoption of the service, including the impact of Business Intelligence and Machine Learning.

2.1 The Banking Sector in the Digital Age

The banking sector, one of the oldest in human history, has undergone profound transformations, particularly in the digital era. Recent literature highlights how technological advancement has enabled personalized engagement through innovations such as the Internet of Things and advanced analytics. For banks, this represents a major opportunity to enhance profitability and strengthen relationships across diverse customer segments (Amalia et al. 2023).

Currently, the banking industry is experiencing a paradigm shift driven by digitalization, in which dependence on physical branches is rapidly giving way to seamless digital experiences. The rise of mobile banking applications, fintech startups, and the growing involvement of technology giants in financial services are central to this evolution. It is therefore essential to understand how customers' expectations are being redefined, as they increasingly demand personalized, convenient, and efficient banking services in a world characterized by connectivity and constant innovation. This shift underscores the need for financial institutions to adapt proactively, leveraging technology to deliver customer-centric services while navigating regulatory challenges and competitive pressures (Cherkasova et al. 2023).

2.1.1 Digital Evolution of the Banking Sector in Portugal

The Portuguese banking sector has undergone substantial transformations over the past three decades, aligning with global trends. Following a period of strong growth in the 1990s characterized by consolidations and mergers, the sector faced significant challenges during the global financial crisis, impacting both international and local dynamics (Banco de Portugal 2023*a*). By 2010, there was a proliferation of new agencies, particularly in smaller municipalities, but this was followed by a decline in the number of branches and a reduction in the workforce, which is now marked by an aging demographic and extensive experience (Banco de Portugal 2023*b*).

In spite of the difficulties, lower margins, workforce reorganization, the industry has achieved a significant capital base, mostly through client deposits and bonds. This finan-

cial resistance reveals the industry's capability of responding to shifting regulations and economic conditions, both at home and abroad.

Nevertheless, the finance sector is not static. It attempts to foresee changes and events occurring in its external environment and adapts in advance to these likely eventualities. One factor that has accelerated, or perhaps hastened, these adaptation strategies is the progress made in technology. Changes in consumer patterns during the COVID-19 pandemic can also be viewed as a significant stimulus toward the finance industry's adoption of new, advanced payment methods (Banco de Portugal 2023*a*).

2.1.2 The Rise and Impact of Mobile Banking

The banking sector has seen dramatic shifts that have molded the international financial landscape and resulted in the appearance of groundbreaking practices. These innovations have propelled mobile banking to the forefront, and it now serves as a linchpin in the sector and its development. Defined as a way of carrying out financial services using mobile communication technologies and devices (Umer & Kesavapattapa 2025), mobile banking differs from traditional Internet or home banking and offers immediate access and mobility. This innovation simplifies financial management, ensures unhindered access to information and is accelerated by efficiency, the volume of information and low operating costs. However, the main barriers to its adoption are the security of personal information and financial insecurity (Hilal & Varela-Neira 2022).

The emergence of mobile banking is a continuation of the evolution of the banking sector and digital banking. Initially leading the way with ATMs, internet banking and then mobile devices, banks began to focus their operations on easy-to-use cell phones. Launched in 2000 with basic SMS-based functionalities, mobile banking gained momentum with smartphones and their widespread use. Its evolution into software programs (Apps) for smartphones and tablets, supported by the development of mobile devices, has considerably improved user experiences (King 2018).

The shift to mobile banking benefits not only consumers, but also banks, which promotes improved customer service, savings, increased market share and brand reinforcement. It provides a dynamic service delivery channel that includes payments, real time banking and access to financial information and meets the needs of consumers in a technologically developing world (King 2018). However, in Portugal, the banking sector and its direction of development reflect innovation, as well as market dynamics and regulatory challenges (Banco de Portugal 2019). The embrace of mobile banking as an additional form of online banking demonstrates how the industry has evolved and is now able to keep pace with cutting-edge technological advances (Shankar & Rishi 2020).

The trend of technological evolution is being followed by the banking sector in Portugal, which is concentrating its efforts on automated solutions, such as the ATM, and self-service channels, such as internet banking and mobile banking. Even so, digital banking is growing significantly in use and popularity among Portuguese banking consumers. Of course, all sectors are faced with the occurrence of cybercrime, and the banking sector is no exception. Phishing and online bank robbery attempts have caused some in the Portuguese public to be apprehensive about the security of online banking and its automated cousins. Still, the engagement with these channels is strong, and most banking consumers have high hopes for the future of mobile banking among younger age groups (Instituto Nacional de Estatística 2020).

2.2 Explaining Mobile Banking Adoption through Theory

Mobile banking has transformed the world of banking (Gupta 2013). It offers convenience and nearly universal accessibility as compared to traditional methods of banking. But it isn't entirely clear why some customers have adopted this service while others have stayed with more traditional banking methods. A number of different theoretical models have attempted to explain and understand this phenomenon.

2.2.1 Unified Theory of Acceptance and Use of Technology (UTAUT)

The UTAUT, developed by Venkatesh, provides a valuable framework for understanding why individuals adopt and use new technologies, particularly in the context of mobile banking. Its relevance to mobile banking is multifaceted. First, UTAUT is based on robust social science foundations, drawing on established models like the TPB and the TAM. These models emphasize important aspects of user acceptance, such as perceived ease of use and behavioral intentions. However, UTAUT builds upon these frameworks by introducing additional factors like "performance expectancy," which is especially pertinent to mobile banking, where users prioritize efficiency and convenience (Venkatesh et al. 2003).

UTAUT is considered superior to TPB and TAM because it integrates the primary components of both models into a single, practical framework, which enhances its applicability in predicting and analyzing technology acceptance. While TPB focuses on attitudes, subjective norms, and perceived behavioral control, and TAM centers on perceived ease of use and usefulness, UTAUT offers a more comprehensive, integrative approach (Min et al. 2008). It captures the broader range of factors influencing technology use, including social influences and facilitating conditions. In the case of mobile banking, where applications like MB WAY or Apple Pay are frequently used for transactions,

UTAUT framework effectively explains how factors such as social influence and performance expectancy shape user behavior. This makes UTAUT a highly relevant theoretical tool for examining the diverse and complex motivations behind mobile banking adoption, offering a nuanced understanding of the factors that drive users to integrate mobile banking services into their daily financial routines (Konteos et al. 2022).

2.2.2 Perceived Risk (RISK)

In the context of mobile banking, perceived risk is a critical factor influencing user adoption. According to Zhang and Yu, perceived risk encompasses the uncertainty associated with using the technology, particularly the potential for negative outcomes. In mobile banking, this risk is typically related to concerns over security, the protection of personal and financial data, and the reliability of digital platforms. These perceived vulnerabilities can strongly influence a user's decision to adopt or reject mobile banking services. A high perception of risk tends to reduce trust in the technology, thereby acting as a significant barrier to its adoption and continued use (Zhang & Yu 2020). Thus, addressing and minimizing perceived risk is essential for increasing user confidence and fostering broader adoption of mobile financial services.

2.2.3 Trust

Trust plays a pivotal role in the adoption and sustained use of mobile banking. It is shaped by the perceived reliability, integrity, and competence of the service provider. According to Natalya and Tsenivati, trust is built on three primary dimensions: honesty, which reflects the reliability and transparency of actions; integrity, which denotes consistency and ethical behavior; and competence, the ability of the provider to deliver secure and effective services. These elements contribute to reducing user uncertainty and enhancing the perceived credibility of mobile banking platforms. Establishing and maintaining trust is therefore essential for encouraging long-term engagement and user satisfaction (Natalia & Tesniwati 2021).

2.2.4 Eletronic Service Quality (E-SERVQUAL)

The E-SERVQUAL model offers a comprehensive framework for evaluating the quality of electronic services, which is particularly relevant in the mobile banking context. The model encompasses key dimensions such as efficiency, reliability, responsiveness, privacy, and user satisfaction. Efficiency pertains to ease of use and intuitive navigation, while reliability refers to consistent and error-free performance. Responsiveness captures

the timeliness and effectiveness of customer support, and privacy involves safeguarding personal and financial data. Satisfaction reflects the overall alignment of the service with user expectations. Collectively, these factors influence users' perceptions of service quality, which in turn affect their trust, loyalty, and intention to continue using mobile banking applications (Parasuraman et al. 2005).

2.2.5 Diffusion of Innovation Theory (DIT)

The ease and access to banking services provided by mobile devices illustrate the influence of Roger's (Rogers 2003*a*) Diffusion of Innovations (DI) Theory on mobile banking, which is a "technological innovation that offers ease and access to banking services" via mobile phones. The basic premise of Rogers' DI Theory is that certain new ideas, or innovations, take on a life of their own and spread throughout society. One reason for their spread is that they often offer what Rogers calls "relative advantage". In the case of mobile banking, relative to traditional banking, it provides more convenience, efficiency, and accessibility (Laukkanen 2007).

In addition, DIT categorizes consumers into different adoption groups, from innovators and pioneers to laggards, with differences related to socioeconomic status and personality, communication, and behavioral variables (Rogers 2003*b*). This demonstrates how the perception of relative advantage and other attributes of innovation influence the adoption of mobile banking by different segments of society over time.

In conclusion, as digital transformation continues to reshape the financial sector, these theories not only explain current user behaviors but also help anticipate future trends. This insight is crucial for understanding the evolving landscape of financial services.

2.3 Banking Apps as a Key Pillar of Customer Experience in the Financial Sector

The classic view of bank branches as the main point of sale has been updated. Nowadays, most customers prefer not to spend time in a physical branch. Terms such as omnichannel and digital service express how banks do business with their customers today through a broader, integrated strategy to meet their service needs. This is a major development in the banking sector, focusing on improving the customer experience through technological enhancements, the driving force behind a fundamental redefinition of the banks' financial and operational strategies (Komulainen & Makkonen 2018).

2.3.1 From Traditional Products to Data-Driven Digital Experiences

The professional experience in the banking sector as an analyst up to the time of writing this thesis has reinforced the conviction that data is of paramount importance: "AI is the new electricity and data is the new oil" (Taffel 2021). Just as oil once fueled industrial growth, data now fuels innovation. For banks to remain relevant, it is essential not only to apply data-driven solutions but also to exercise common sense in understanding customer behavior (Bhageshpur 2019). A concrete example of this data-driven evolution is the redesign of Caixadirecta, the mobile banking app of Caixa Geral de Depósitos. This institution has adopted an omnichannel strategy, positioning the app as the core platform for services ranging from simple transactions to complex operations such as investments, credit simulations, and integrations with third-party services like MB WAY (Caixa Geral de Depósitos 2024).

However, while data-driven personalization offers many benefits, it also presents significant challenges, particularly in terms of data privacy and security. As noted by The Economist, data security and privacy have become central concerns in the digital age (The Economist 2019). This concern is echoed in findings from the European Parliament, which indicate that 61% of Europeans support technological progress, and 88% view artificial intelligence positively, provided that such technologies are managed responsibly (Parlamento Europeu 2020). In this context, regulations such as the GDPR underscore the necessity of robust security practices and compliance frameworks to maintain user trust in data management.

This evolution in banking services goes beyond product offerings and reflects a transformation in user experience. According to the article "Is digital transformation profitable for banks?" (Citterio et al. 2024), traditional banks are actively investing in digital transformation initiatives. Although commonly labeled "digital banking," much of this effort still involves physical branches in an omnichannel strategy. Investments span user interface improvements across mobile Apps, AI-powered chatbots, and even in-person interactions. Ultimately, these digital strategies aim not just at convenience, but at fostering long-term customer relationships built on trust and engagement.

2.4 Enhancing Banking Intelligence through Machine Learning Integration

2.4.1 Artificial Intelligence as a Driver of Innovation in Banking

"The future of banking is about bringing together our people, our technology and our digital capabilities so that they are collectively delivering seamlessly and flawlessly – at the same pace at which customer needs are changing," said Khalfan, head of digitization

and payments at Toronto-Dominion Bank (Kahlfan 2021).

Today's digital consumers expect to receive not only services but also truly personalized experiences. A critical player in this arena is AI, which the European Union defines as the capacity of machines to imitate the core human abilities of reasoning, learning, and creativity (Lazo & Ebardo 2023*a*). When it comes to the financial sector, AI assumes center stage and is without a doubt the most important transformative force in play today, as it propels innovation, drives operational efficiency, and enhances customer experience, among other things. At the same time, AI is the lifeblood of managing financial risks and shoring up security against various threats to cyber-safety.

It is also worth noting that AI is the biggest part of the broader Machine Learning (ML) field and sits at the very top of the foundation that ML models build on to "learn" and make data-driven, "smart," useful decisions (Lazo & Ebardo 2023*b*).

2.4.2 Machine Learning as a Transformative Force in Banking

The subfield of artificial intelligence known as machine learning has become an important instrument for data analysis and autonomous decision-making. It is the bedrock upon which many innovations, like virtual assistants, predictive analytics, and autonomous vehicles, are built. Despite their differences, these innovations share the reliance on vast amounts of high-quality data and the computational power necessary to achieve high performance (Pugliese et al. 2021).

In the financial sector, ML has revolutionized traditional processes such as credit risk assessment and fraud detection, and improved customer service through (Hoang & Wiegratz 2022) experiences. Case studies show how ML algorithms can improve operations and strategic decisions at banking institutions, creating a data-driven, customer-focused future (Alnaser et al. 2023).

2.4.3 Business Intelligence for Operational Efficiency

Transforming complex business data into useful information requires strategies and technologies. BI is the term when such strategies and technologies successfully coalesce. It's when the latest data warehouse, extraction, transformation and loading (ETL), and data mining technologies work together effectively to provide business services with the latest actionable information. BI can make any department,from logistics to finance to customer service, more operationally efficient and better at decision-making (Ross 2023).

The study conducted by Rikhardsson (Rikhardsson & Yigitbasioglu 2018), showed how integrating BI into organizational structures improves organizational efficiency and

adapts to market dynamics and follows opportunity for competitive advantage and organizational success.

2.4.4 Advancing Banking through Machine Learning and Business Intelligence

The combination of Machine Learning (ML) and Business Intelligence (BI) has become fundamental to the ongoing transformation of the financial industry (Ma et al. 2023). While BI traditionally focuses on collecting, processing, and visualizing past data, ML extends this capability by introducing predictive and prescriptive analytics. Together, these tools enable institutions not only to understand historical performance but also to forecast trends, identify emerging risks, and make data-driven strategic decisions.

For example, Mahil Carr's study demonstrated the effectiveness of ML in profiling mobile banking users in India through techniques such as Decision Trees, Logistic Regression, and Support Vector Machines. These methods revealed distinct user characteristics and produced "if-then" decision rules that clarify the factors distinguishing adopters from non-adopters, supporting more personalized customer engagement strategies (Carr et al. 2013).

Incorporating machine learning, particularly decision tree algorithms, into BI systems allows banks to identify potential mobile banking customers and cluster them based on behavioral similarities. By gaining a clearer understanding of these customer segments, banks can communicate more effectively, optimize marketing strategies, and enhance overall service personalization.

3 METHODOLOGY

Theoretical models, such as the Unified Theory of Acceptance and Use of Technology (UTAUT), serve as excellent foundations for understanding why consumers choose to adopt (or not adopt) mobile banking applications. From these theories, it is possible to identify key factors that influence the adoption of such services. However, these models alone do not provide a comprehensive explanation.

This research aims to contribute novel insights to the scientific field by employing a mixed approach, which integrates qualitative and quantitative techniques to analyze in-depth user behavior in the context of mobile banking services. The mixed-methods approach was chosen to provide both exploratory depth (through qualitative interviews) and confirmatory insights (through a quantitative survey), enabling a more nuanced understanding of user behavior. According to Molina-Azorín (2016), the use of mixed methods allows researchers to gain a more comprehensive understanding of complex phenomena, challenging researchers to develop skills in different methodologies and effectively integrate various data sources. This integration of both qualitative and quantitative methods enhances the overall richness of the findings and provides a more holistic view of the subject matter.

As can be seen in Figure 2, the study began with an in-depth literature review to establish a theoretical framework and understand existing knowledge about behavioral attitudes toward mobile banking. During this phase, Mendeley was used as a reference management tool to organize and cite the relevant literature efficiently.

Based on this foundation, the research proceeded with the collection of qualitative data through face-to-face in-depth interviews, during November of 2024 with ten participants, selected through convenience sampling, ensuring representing different backgrounds and demographic segments, due to the open questions developed. These interviews, with an average duration of 12 minutes, were designed to explore various aspects of mobile banking usage, including user motivations, challenges, and overall experiences with the applications.

The interviews were audio recorded with participant consent. To streamline the transcription process, a custom Python script was developed using automatic speech recognition libraries, which converted the audio recordings into textual transcripts. This automated process ensured efficient and accurate transcription of the qualitative data. The resulting transcripts were then imported into MAXQDA software, where a thematic coding approach was applied. MAXQDA was selected for its robust capabilities in supporting qualitative and mixed methods research, including thematic coding and visual analysis

tools (Kuckartz & Rädiker 2019). Predefined categories, based on the literature review, were used to identify common topics across interviews, which provided a foundation for the development of the quantitative questionnaire.

The patterns and themes identified from the qualitative phase directly informed the design of the structured questionnaire, which helped refine the questions and ensure the findings were validated with a larger sample. A word frequently analyzed was performed to determine the most frequently used terms, helping to highlight the most discussed codes and topics. The results revealed that the most prominent concerns included user experience (18.1%), security (14.9%), and the future of banking applications (13.8%).

The ethical aspects of the study were given rigorous attention from the very start. Before any data were collected, the participants were told, not just informed but really engaged, in the reasons for and the content of the study. They signed a consent form as illustrated in Figure 1, that ensured their being part of the study was voluntary, and they were told that they could back out at any time.

Based on the literature review presented in the previous chapter, eight research hypotheses were developed to address the study's research question, with the independent variables, fundamental to concluding the topic under analysis, constructed based on the categories of the questions in the questionnaire, as outlined below:

- RISK - represents the perceived risk that the application may have (measures the level of risk, trust, and credibility of the application);
- TRUST - represents the degree of confidence users have in the application's reliability, security, and ability to safeguard their personal and financial information;
- Service Quality Dimensions (for E-SERVQUAL) - encompass tangibility, reliability, responsiveness, assurance, and empathy, measuring the extent to which the application delivers a high-quality user experience;
- Effort Expectancy (for UTAUT) - captures the perceived ease of use and the level of effort required to navigate and operate the application effectively.
- Facilitating Conditions (for UTAUT)- represent the availability of resources, support, and infrastructure that enable users to adopt and use the application seamlessly.
- Social Influence (for UTAUT) - measures the extent to which individuals perceive that important others (e.g., friends, family) think they ought to use the application.
- Performance Expectancy (for UTAUT) - evaluates the degree to which users believe the application will enhance their financial management and banking efficiency.

- Relative Advantage (for DIT) - reflects the perceived benefits and superiority of the application compared to traditional banking methods or competing technologies.

The research hypotheses and all the insights gained during the qualitative phase informed the development of a structured quantitative questionnaire. Drawing from relevant studies, such as Factors Influencing Mobile Banking Usage Behavior in Indonesia (Amalia et al. (2023)) and Factors of the Acceptance and Use of Mobile Banking Applications Mobile Health: A Self-Assessment (Wang & Qi (2021)), the questionnaire was meticulously designed to capture a comprehensive range of user attitudes and behaviors.

The questionnaire developed was put online via the website (https://docs.google.com/forms/). In the first phase, pretests were carried out, where five people answered the questionnaire accompanied by the author so that it would be possible to identify difficulties in filling it in and the average time it would take to complete. After making some changes to improve the Portuguese so that the questions were easier to understand, and after identifying that the average time was nine minutes, the questionnaire was distributed randomly on different online platforms in order to disseminate the questionnaire to as many people as possible.

The survey was composed of 25 dynamic questions. These questions were tailored based on the answers provided by the respondents. It was asked both users and nonusers of mobile banking to participate. The survey was completed by 174 individuals residing in Portugal and aged 18 and above. It was considered 163 of their responses to be valid. Using this sample, it can be possible to have 95% confidence that we were able to achieve results that accurately reflect the population that was studied, with an approximate margin of error of 7.7%. To ensure consistency in the analysis, only responses collected during the main data collection period, between February and April 2025, were considered for the quantitative analysis.

The final stage of this research involved the use of Python for advanced data analysis, This overall process is visually summarized in Figure 3. Python facilitated two key processes. First, it enabled a comparative analysis between the survey dataset and data made available by an important institution in Portugal, allowing for an assessment of whether the collected data accurately reflects real-world trends relevant to financial institutions. Second, it permitted that a robust customer profile requires not only understanding consumer behavior but also capturing their perspectives on the future and the digital tools they engage with. To achieve this, machine learning techniques were applied to model and predict consumer profiles.

In sum, the qualitative phase not only supported the development of the quantita-

tive survey but also validated initial findings from the interviews. So this multi-layered methodology will be presented in the following chapter, where both qualitative and quantitative findings are explored and interpreted concerning the research objectives.

4 DATA ANALYSIS & RESULTS

Building on the mixed-methods approach outlined in the methodology, this chapter synthesizes the findings from both qualitative and quantitative analyses to address the core research questions.

The qualitative phase, comprising in-depth interviews analyzed through MAXQDA, revealed key themes such as security concerns, user experience, and trust insights that directly informed the design of the subsequent quantitative survey. A complete thematic coding analysis of the interview data was performed in this software, based on predefined and emergent categories. This process allowed for the identification of the most recurrent topics across participant responses, such as user experience (18.1%) as seen in Figure 4, security (14.9%), and the future of banking applications (13.8%). These insights not only helped shape the structure of the quantitative questionnaire but also served as a foundation for aligning theoretical constructs with actual user perceptions.

The survey, distributed to a geographically and demographically diverse sample (n=163 valid responses), enabled statistical validation of these themes while uncovering broader trends. The answers collected were exported to Excel and subjected to a cleaning process that included eliminating invalid answers, guaranteeing the reliability and consistency of the data analyzed. This database supported statistical analysis and graphical representations of the results.

This chapter presents the sociodemographic profile of respondents (age, gender, location) and their general usage patterns. It then examines how the nine hypothesized factors shape adoption, integrating direct quotes from interviews to contextualize quantitative results. Finally, the discussion highlights actionable insights for financial institutions and aligns findings with prior literature.

All supplementary data, including visualizations and raw analysis outputs, are available in the Appendix.

4.1 Mapping the Mobile Banking User Base

The research sample consisted of 163 respondents, the majority were women, representing 56.44%(n = 92), while men accounted for 43.56%(n = 71) as it is possible to see in Figure 5.

Table I represents the age of the inquire, the majority were between 25 and 44 years old (42.33%, n = 69), followed by those aged 18 to 24 (30.67%, n = 50). Respondents aged 45 to 64 made up 20.86% (n = 34), while only 6.13% (n = 10) were over 65 years

old.

With regard to geographical distribution, 43.56% of respondents resided in Lisbon, Table III, followed by Porto (9.20%) and Aveiro (7.98%). Although other regions accounted for smaller shares, a detailed breakdown is provided in the appendix. The geographical diversity of the sample likely captures a wider range of perspectives.

The most frequently mentioned bank was Caixa Geral de Depósitos, used by 28.24% of respondents, followed by Millennium BCP (12.16%) and Santander Totta (11.76%). Digital banking platforms, such as Revolut, were mentioned 26 times (10.2%). Other traditional banks, including BPI and ActivoBank, represented 9.02% and 7.45% of responses, respectively.

As shown in Table II, 90.8% of participants reported using mobile banking apps or services such as MB WAY or Revolut. A small proportion (0.63%) used only these banking Apps without relying on "traditional" banking applications, while 4.29% reported using only their bank's mobile application.

Although the vast majority of respondents reported using mobile banking applications, a small subset, of only 9 individuals, indicated that they do not currently use such services. Given the limited size of this subgroup, caution is warranted when interpreting these findings, as they may not fully capture the broader reality of nonusers. Within this group, the most frequently selected response regarding what banks could do to encourage adoption was a lack of interest, reported by 66.7% of nonusers.

Nonetheless, it is important to note that the questionnaire includes a dedicated section on "Future Perspectives and Innovations in Mobile Banking Applications," which provides additional context and nuance regarding nonusers' expectations and potential motivators for future adoption. This complementary analysis will be explored in a subsequent section.

Among the 154 respondents eligible to answer the question about, the frequency of use across different banking channels, physical branches emerged as the least utilized channel, with an average score of 1.16. Specifically, 101 respondents provided ratings, and 81.2% (n=82) rated their frequency of in-person visits to agencies at the lowest level (1), while only 5 respondents gave high scores (4 or 5). Figure 6 provides a comparative overview of usage frequencies across different banking channels, illustrating the stark contrast between traditional services such as ATMs and physical agencies and digital platforms like mobile banking Apps and MB WAY.

A similar pattern was observed for ATM use, which had an average score of 1.79. Out of 99 respondents, 63.6% (n=63) rated their frequency at 1, although 10 respondents gave

higher ratings (4 or 5), suggesting occasional reliance on ATMs, as shown in Table IV.

In contrast, mobile banking applications showed significantly higher utilization, with an average score of 3.79. Among the 150 respondents who rated this channel, 42% (n=63) were assigned the maximum score (5), highlighting frequent and habitual use. Even more notable was the use of complementary platforms such as MB WAY and Apple Pay, which achieved an average score of 4.42. Of the 146 respondents who rated these services, 62.3% (n=91) gave the highest score, demonstrating strong adherence to digital payment tools.

Interestingly, the use of online banking via browser-based platforms revealed a more moderate engagement, with an average score of 2.45 across 121 respondents. This indicates that, even though mobile banking applications are widely adopted, this does not automatically translate into frequent use of "traditional" online banking channels, suggesting different usage preferences or needs across digital platforms.

Correlation analysis also revealed a strong association (66%) between respondents who frequently use mobile banking applications and those who also use platforms like MB WAY, as shown in Figure 7, suggesting complementary digital financial behaviors within this user group. By comparison, a lower correlation (55%) was found between respondents who frequently use ATMs and those who visit physical branches, indicating a distinct behavioral pattern among users who rely more on traditional banking channels.

In addition to these behavioral correlations, further analysis examined the year respondents began using mobile banking applications about whether they felt the COVID-19 pandemic influenced their usage. Among the 154 respondents, 90 (58.4%) answered "Yes" and 64 (41.6%) answered "No". Those who perceived an impact ("Yes") showed a clear concentration of adoption around 2020–2021, suggesting the pandemic accelerated their onboarding, as shown in Figure 8. In contrast, the "No" group showed a more dispersed pattern, with usage peaking slightly later. These results highlight how external events like the pandemic can drive digital adoption among specific user segments, while others follow different paths.

With regard to frequency of use, 29.2% of respondents reported using their banking Apps every day, while 27.3% use them approximately three times a week.

The most common feature is the consultation of account balances and statements, as it is possible to see in Figure 9, which achieved a high average score of 4.2 out of 5, with 84 respondents rating it at the maximum level. This was followed closely by the payment of services and bills (mean score of 4.1), and internal transfers between accounts (3.8). These results suggest that users tend to rely on mobile banking for straightforward, day-

to-day tasks that replace previously manual or in-branch processes.

Payment in establishments also demonstrated relatively frequent use, with a mean score of 3.7, suggesting that mobile Apps are increasingly integrated into day-to-day transactions. Meanwhile, financial management functionalities, such as budgeting tools or expenditure tracking, obtained a moderate average of 3.6 in 5. This reflects a growing interest in using digital platforms for broader personal finance oversight. Supporting this, 78.1% of respondents indicated in another question that mobile banking Apps had changed the way they manage their finances. This suggests that, beyond transactional utility, these applications are increasingly playing a strategic role in users' financial behavior.

In contrast, more complex or specialized features such as investment management (2.5) and currency exchange (1.6) showed significantly lower levels of both average usage and frequency. Although some respondents reported frequent use of these services, the overall engagement remains limited, indicating that these functionalities may be either less relevant to most users or perceived as less intuitive. In the end, no substantial alternative functionalities were suggested by respondents, reinforcing the idea that current use is concentrated on a core set of practical, familiar features.

Despite high levels of adoption, several respondents reported negative experiences with mobile banking applications, particularly related to login failures, App crashes, and technical unavailability during critical moments, such as when paying bills or making purchases. Some even had to visit physical branches to resolve issues.

Although some technical issues were reported, particularly regarding access and availability, users generally perceive mobile banking applications as secure. The average rating for perceived security was 4.2 out of 5, which we can see in Figure 10, with most respondents indicating that they read, at least occasionally, the security alerts provided by their banking Apps.

However, when assessing the responsiveness of banks in addressing security-related incidents, such as account access problems or suspicious activity, the average score dropped to 3.7, as shown in Figure 11. While still moderately positive, this lower rating suggests that institutional support in high-risk situations is not always perceived as good. In terms of improvements, users suggested stronger authentication measures, better transaction notifications, and enhanced privacy protection. These suggestions reflect a growing demand for security.

The impact of digitalization in banking was widely acknowledged by respondents, with the term "convenience" being most commonly associated with mobile banking ap-

plications, particularly among active users. When asked to describe banking Apps in a single word, 85 respondents cited convenience, followed by practicality, reflecting a perception that digital tools simplify and accelerate financial tasks. Conversely, nonusers were more likely to associate these Apps with security and complexity, highlighting ongoing concerns or barriers to adoption.

These perceptions were echoed in how respondents evaluated the broader effects of digitalization. Among survey respondents, 66.25% felt that banking services had become more convenient, while only 3.75% believed the quality had deteriorated. Moreover, when asked about the impact of the decrease in the number of open branches, nearly half of all respondents,42.94%, reported no major impact from the closure of physical branches, 17.8% stated that it made it harder to resolve problems, and 13,5% said it encouraged them to use more digital services. These results suggest that while digitalization has improved efficiency and access for many, it may also exacerbate exclusion or dissatisfaction among users who prefer traditional service models or face barriers to digital use.

This tension between digital efficiency and reduced human contact is also reflected in users' experiences with customer support in mobile banking applications. When asked how they would rate this support, the answers revealed great diversity, with an overall average of 3.62 on a scale of 0 to 5. The most frequent rating was "0", given by 48 respondents, which indicates a lack of contact with the service.

Among those who interacted with the support, 3 respondents rated it 1, and 13 rated it 2, revealing dissatisfaction associated with slow response times, instability of the application, and difficulty in accessing human support. Among the 31 respondents who gave a rating of 3, suggestions for improvement focused on the clarity of responses and the desire for multi-channel access. On another spectrum, 44 respondents gave a score of 4, and 23 rated 5, showing satisfactory levels, although not across the board. These results point to a clear opportunity for improvement in support channels, through more effective, empathetic, and accessible solutions, especially in a scenario of growing dependence on digital services.

Following the analysis of support experiences, respondents were asked which technological advancements they would like to see implemented in mobile banking applications. The results point to a strong desire for enhanced usability and security. The most frequently selected option was the improvement of the user interface, cited by 89 respondents, followed by enhancements in biometric security, mentioned by 81 participants as in Figure 12. These preferences suggest that users not only seek a more intuitive but also secure experience.

This outlook on the future of banking Apps was further supported by responses to the

question regarding their long-term role. A clear majority, 91.8% of respondents believe that mobile applications will become the primary way to interact with banking services, while only 8.2% do not share this view.

In alignment with this expectation, participants were also asked what non-banking functionalities they would like to see integrated into mobile banking applications. The most frequently mentioned feature was personal finance management, selected by 105 respondents (27.2%), followed by investment functionalities such as stocks, funds, or cryptocurrencies (19.4%), and financial education tools (18.9%). To a lesser extent, travel and accommodation booking features were selected by 24 respondents (6.2%).

4.2 From Branches to Apps: Evidence of Digital Transformation in Banking

This section compares the respondents' findings with data provided by Caixa Geral de Depósitos on the use of mobile banking. By comparing the patterns observed in the sample are consistent with broader banking trends, particularly in terms of the growing shift from traditional banking channels to digital platforms.

In terms of frequency, the data shows that mobile banking applications are used significantly more than traditional banking methods. In the survey, mobile banking channels received an average usage score of 3.79 out of 5, indicating regular and frequent engagement among users. The data from the institution shows a comparable shift, with the Caixadirecta App, where the number of transactions increased to more than 38 million in 2024, compared to just over 1 million in 2015, representing an increase of approximately 3,700%.

This shift is further supported by the survey results, which indicate that users rely heavily on mobile banking for routine tasks, such as internal transfers between accounts, which received a mean score of 3.8. This suggests that mobile banking is becoming one of the preferred methods for managing everyday financial activities, replacing more traditional banking methods.

In comparison, the number of transactions at branches fell from 32 million in 2015 to just over 13 million in 2024, representing a drop of approximately 54.4%. Similarly, survey respondents rated their in-person visits to branches with an average score of 1.16 (out of 5), with 81.2% indicating very infrequent visits. These findings suggest a major shift from in-person banking to digital banking solutions.

Both data sets also indicate that the COVID-19 pandemic was a key driver in speeding up the use of mobile banking. According to the survey, 58.4 percent of respondents reported that the pandemic prompted them to increase their use of mobile banking appli-

cations. This trend is reflected in the data provided, which shows a sharp rise in digital engagement during and after the pandemic period. The number of digital customers defined as clients using at least one digital channel increased from approximately 1.69 million in 2020 to 2.22 million in 2024, representing a growth of around 31.36%. Furthermore, the share of digital customers compared to the total customer base has also grown significantly, from 47% in 2019 to more than 70% in 2024, further illustrating the rapid shift towards digital banking.

More significantly, a shift is visible within Caixa Geral de Depósitos digital services themselves. While online banking accesses via browser dropped from about 5.1 million in 2018 to 3.3 million in 2024, a decrease of nearly 35.29%, furthermore the use of the Caixadirecta App soared from 8.1 million accesses in 2018 to over 36 million in 2024, an increase of more than 344%. This migration from browser-based platforms to mobile applications further supports the survey findings and demonstrates a clear preference for mobile-first solutions among users.

The findings from the survey and the data from the institution strongly suggest that the sample accurately reflects broader trends in the digitalization of banking in Portugal. The significant migration from physical branches to mobile and online banking confirms that mobile banking platforms like Caixadirecta App are becoming the dominant channels for financial transactions, in line with global trends toward greater digital engagement.

4.3 Behavioral Segmentation and Adoption Patterns Revealed by Machine Learning

To complement the traditional quantitative analysis, a predictive and exploratory approach was developed using ML techniques, with two main objectives: (1) to identify the most determining factors in the use of mobile banking applications, and (2) to discover distinct behavioral patterns among users, in line with the theoretical models presented in the methodology and literature review.

The database collected via questionnaire was initially subjected to a rigorous preparation process. Categorical variables such as “Gender” and ‘Age’ were transformed using LabelEncoder, and missing values were treated differently, using “Not applicable” for qualitative variables and the median for quantitative variables. The chosen target variable was ’Do you use banking apps?’, representing the adoption of digital banking services. The database was then submitted to the "setup()" process of the PyCaret library, where multiple models were compared. The Random Forest Classifier algorithm performed better and was used as a base model for the interpretative analysis.

Analysis of the importance of the variables revealed that the perception of security was the most decisive factor, as like in Figure 13, with a relative importance of 20.8%,

followed by the frequency of transfers through mobile applications, with 11.8%. These results confirm the theoretical relevance of the RISK, TRUST, and Performance Expectancy Dimensions (UTAUT) for the adoption of these applications. The observed correlation between the security variable and the use of apps was consistent with the qualitative findings, reinforcing the idea that without trust and the perception of protection, there is no sustained adoption.

During the analysis, a significant imbalance was identified in the distribution of the variable 'Do you use banking apps?', with a strong predominance of users over non-users. This disparity limited the applicability of supervised models focused on predicting non-adoption with statistical precision. To avoid this limitation and still identify relevant behavioral patterns, we opted for an unsupervised approach focused on the theoretical dimensions of technological adoption. A clustering analysis based on the eight categories mentioned in the methodology, to segment the participants in a meaningful way.

After normalizing the data using StandardScaler and applying dimensionality reduction with UMAP, the K-Means clustering algorithm identified three distinct user profiles, which were labeled based on their average behavioral patterns across the eight theoretical dimensions. These profiles are visually represented in a radar chart like Figure 14, which highlights their key differences:

Cluster 0 – Full Digital Users: stand out for their low effort expectancy, strong social influence, and low perceived risk, showing high readiness to adopt and use mobile banking technologies. They score high in Facilitating Conditions, indicating strong technological comfort;

Cluster 1 – Conscious Skeptics: present high scores across almost all theoretical dimensions, including TRUST, RISK, and Performance Expectancy. This group is particularly interesting because although they perceive risk, they still recognize utility and innovation potential (high DIT scores). Their balanced but high profile reflects a critical but engaged stance, users who demand excellence and security but are not averse to technology;

Cluster 2 – Digitally Hesitant Users: display high Perceived Risk and Effort Expectancy, combined with very low scores in Facilitating Conditions, Performance Expectancy, and DIT. They also show low trust in institutional responses (low TRUST and E-SERVQUAL), suggesting that their resistance is rooted in usability concerns and service perception. This group represents a digitally excluded or disengaged segment that requires targeted support and trust-building interventions;

The dimension that most differentiate clusters is Perceived Risk, followed by Effort

Expectancy and Facilitating Conditions, confirming their central role in the theoretical frameworks used.

In summary, the combination of supervised and unsupervised ML techniques enabled a robust, theory-driven behavioral segmentation that goes beyond binary adoption, and supports a multi-layered understanding of user behavior.

5 CONCLUSION

This study aimed to identify and understand the key drivers influencing the adoption and usage of mobile banking applications in Portugal, using a mixed-methods research strategy grounded in established theoretical frameworks such as UTAUT, RISK, E-SERVQUAL, TRUST and DIT. Through a sequential combination of qualitative and quantitative methods, and supported by advanced data analysis and machine learning, this dissertation offers both theoretical contributions and practical insights for the digital banking sector.

The results indicate that the adoption of mobile banking applications in Portugal is high (94.5%), with most users relying on these tools for frequent, everyday financial operations. The most commonly used functionalities, such as checking balances (4.23/5), bill payments (4.10/5), and account transfers (3.77/5), reflect a clear migration from traditional, in-branch services to mobile-first solutions. This shift is mirrored in the data from the institution discussed in chapter 4.2, where mobile app transactions rose by over 3,700% between 2015 and 2024, while in-branch transactions declined by more than 50%.

Beyond frequency, the study examined perceptions and motivations. Security emerged as the most decisive factor in mobile banking adoption. The average perceived security score (4.2/5) was the strongest predictor of app usage in the Random Forest model (20.8% importance). However, perceived responsiveness to security incidents scored lower (3.7/5), suggesting that although users trust the digital environment, they often feel underserved when issues occur. This highlights an important gap between trust in technology and trust in institutional support.

The application of machine learning techniques enabled the segmentation of user profiles based on behavioral indicators, leading to the identification of three distinct groups:

Full Digital Users - demonstrate high trust, low effort expectancy, and strong engagement with digital tools;

Conscious Skeptics - are informed and technologically capable but remain critically engaged, demanding high standards of service quality and transparency;

Digitally Hesitant User - display digital exclusion tendencies, driven by perceived risk, high effort expectancy, and low confidence in institutional support.

These insights offer banks a roadmap for personalized communication, user segmentation, and targeted feature development. For instance, Full Digital Users may benefit from advanced financial tools, while Conscious Skeptics might respond positively to initiatives that increase transparency and control over data. Meanwhile, Digitally Hesitant

Users may require onboarding support, simplification of app interfaces, and reassurance through better customer service.

Furthermore, the research uncovered how the COVID-19 pandemic acted as an accelerator of digital banking. A significant portion of users (58.4%) reported that the pandemic influenced their adoption of mobile banking, particularly between 2020 and 2021. This aligns with both survey data and institutional records, indicating that moments of systemic disruption can significantly reshape digital behavior.

The study also addressed user expectations for the future. Participants expressed strong interest in integrating non-banking features, such as personal finance management (27.1%), investments (19.4%), and financial education (18.9%). This reveals a shift in expectations: banking apps are no longer seen merely as transaction tools, but as platforms for holistic financial well-being. This reinforces the strategic need for banks to rethink their digital ecosystems, not only as service channels but as loyalty-building environments.

From an academic perspective, this dissertation contributes by combining multiple adoption models with real-world behavioral data collected during the study, offering a layered and user-centered analysis that goes beyond descriptive statistics. Importantly, it brings the voice of the consumer into a space traditionally dominated by internal metrics, thus helping to fill an identified gap in the Portuguese context.

While the scope of this study is naturally limited by sample size and geographic focus, the findings represent a small but meaningful contribution to ongoing discussions about digital transformation in banking. By integrating consumer insights with data-driven profiling, this research aims to support more inclusive, trustworthy, and effective digital strategies for the Portuguese banking sector.

An interactive dashboard has also been made available via Tableau, as referenced in the appendix, to encourage transparency and allow stakeholders to explore the data in greater depth.

5.1 Limitations

Although this study provides substantial insights into the adoption and use of mobile banking applications in Portugal, some limitations must be acknowledged.

Firstly, the majority of participants were from Lisbon, which can bring some difficulties does not fully captured the behavioral nuances of populations in rural or less urbanized regions. Urban users tend to have higher levels of digital literacy and more consistent access to technological infrastructure, which may skew results toward a more

digitally engaged user base.

Secondly, while the 163 valid responses suffice for exploratory and machine learning analyses, the small number of nonusers (n = 9) limits statistical power and restricts broader insights into resistance or digital exclusion among Portuguese mobile banking users.

Lastly, due to time constraints, the study relied on a cross-sectional design rather than a longitudinal approach. This means behavioral trends were captured at a single point in time, rather than over an extended period. As user attitudes toward digital banking continue to evolve, particularly in response to external events like a pandemic or new technological developments, a longitudinal perspective would provide a more dynamic view of adoption patterns.

5.2 Suggestions for Further Research

To build on the findings of this study, future researches should consider several avenues for expansion and refinement.

First, conducting longitudinal studies would allow to observe behavioral changes over time and evaluate the long-term impact of digital transformation and technological innovations in banking.

Second, expanding the geographical scope to include participants from rural areas and inland regions of Portugal would provide a more representative national picture of mobile banking usage. Comparing urban and rural adoption patterns could also shed light on digital inequality and access barriers.

Third, deep collaboration with multiple financial institutions could allow access to anonymized usage data that complements survey-based perceptions. Such partnerships would increase the robustness of predictive models and allow for triangulation between actual behavioral data and self-reported attitudes.

Finally, future research could focus on the impact of emerging technologies, such as voice-enabled banking, facial recognition, or AI-powered financial coaching, on trust and engagement. Understanding how these technologies influence both digital native and digitally hesitant users would be valuable for shaping inclusive innovation strategies.

REFERENCES

Alnaser, F. M., Rahi, S., Alghizzawi, M. & Ngah, A. H. (2023), 'Does artificial intelligence (ai) boost digital banking user satisfaction? integration of expectation confirmation model and antecedents of artificial intelligence enabled digital banking', *Heliyon* **9**(8). Accessed on May 20, 2025.

Amalia, R. R., Sumarsono, S. & Fernando, V. (2023), 'Factors affecting behavior to use mobile banking in indonesia', *Journal of Positive School Psychology* **7**(3), 408. Accessed on May 22, 2025.

Banco de Portugal (2019), 'Comunicado do banco de portugal sobre a comercialização de produtos e serviços bancários nos canais digitais em portugal'. Accessed on May 22, 2025.
URL: *https://www.bportugal.pt/comunicado/comunicado-do-banco-de-portugal-sobre-comercializacao-de-produtos-e-servicos-bancarios*

Banco de Portugal (2023*a*), 'Balanço do setor bancário em portugal: Nota de informação estatística de 2022'. Accessed on May 1, 2025.
URL: *https://bpstat.bportugal.pt/conteudos/noticias/1833*

Banco de Portugal (2023*b*), 'Banco de portugal atualiza séries longas do setor bancário português'. Accessed on May 8, 2025.
URL: *https://bpstat.bportugal.pt/conteudos/noticias/1955*

Bhageshpur, K. (2019), 'Data is the new oil — and that's a good thing'. Accessed on May 13, 2025.
URL: *https://www.forbes.com/councils/forbestechcouncil/2019/11/15/data-is-the-new-oil-and-thats-a-good-thing/*

Caixa Geral de Depósitos (2024), 'Caixadirecta app – nova experiência digital'. Accessed on May 22, 2025.
URL: *https://www.cgd.pt/Particulares/Contas/Caixadirecta/Pages/refresh-app-caixadirecta.aspx*

Carr, M., Ravi, V., Reddy, G. S. & Veranna, D. (2013), 'Machine learning techniques applied to profile mobile banking users in india', *International Journal of Information Systems in the Service Sector* **5**(1), 88. Accessed on February 30, 2025.

Cherkasova, Y., Oware, K. & Osei, L. (2023), 'Unlocking the full potential of digital transformation in banking: A bibliometric review and emerging trend', *Future Business Journal* **9**(1). Accessed on May 1, 2025.

Citterio, A., King, T. & Locatelli, R. (2024), 'Is digital transformation profitable for banks? evidence from europe', *Finance Research Letters* **70**, 2–3. Accessed on April 28, 2025.

Gupta, S. (2013), 'The mobile banking and payment revolution'. Accessed on May 24, 2025.
URL: *https://www.europeanfinancialreview.com/the-mobile-banking-and-payment-revolution/*

Hilal, A. & Varela-Neira, C. (2022), 'Understanding consumer adoption of mobile banking: Extending the utaut2 model with proactive personality', *Sustainability* **14**(22). Accessed on May 20, 2025.

Hoang, D. & Wiegratz, K. (2022), 'Machine learning methods in finance: Recent applications and prospects', *European Financial Management* **29**(5), 24–27. Accessed on May 5, 2025.

Instituto Nacional de Estatística (2020), 'Inquérito à utilização de tecnologias da informação e da comunicação pelas famílias – 2020'. Accessed on April 22, 2025.

Kahlfan, R. (2021), 'Td: Artificial intelligence for digital customer experience'. Accessed on May 15, 2025.
URL: *https://stories.td.com/ca/en/article/from-response-to-recovery-ai-and-the-new-digital-customer-experience*

King, B. (2018), *Bank 4.0: Banking Everywhere, Never At A Bank*, Wiley, Hoboken, NJ.

Komulainen, H. & Makkonen, H. (2018), 'Customer experience in omni-channel banking services', *Journal of Financial Services Marketing* **23**(3), 190–199. Accessed on May 24, 2025.

Konteos, G., Saprikis, V., Avlogiaris, G. & Papathomas, A. (2022), 'An extended utaut model to explore the influential factors towards m-banking apps' use', *International Journal of Business and Management* **17**(7), 31. Accessed on March 2, 2025.

Kuckartz, U. & Rädiker, S. (2019), *Analyzing Qualitative Data with MAXQDA: Text, Audio, and Video*, Springer, Cham, pp. 95–110. Accessed on May 24, 2025.

Laukkanen, T. (2007), 'Measuring mobile banking customers' channel attribute preferences in service consumption', *International Journal of Mobile Communications* **5**(2), 124–126. Accessed on January 23, 2025.

Lazo, M. & Ebardo, R. (2023*a*), 'Artificial intelligence adoption in the banking industry: Current state and future prospect', *Journal of Innovation Management* **11**(3), 55–56. Accessed on April 6, 2025.

Lazo, M. & Ebardo, R. (2023*b*), 'Artificial intelligence adoption in the banking industry: Current state and future prospect', *Journal of Innovation Management* **11**(3), 65. Accessed on April 6, 2025.

Ma, X., Hao, Y., Li, X., Liu, J. & Qi, J. (2023), 'Evaluating global intelligence innovation: An index based on machine learning methods', *Technological Forecasting and Social Change* **194**. Accessed on May 20, 2025.

Min, Q., Ji, S. & Qu, G. (2008), 'Mobile commerce user acceptance study in china: A revised utaut model', *Tsinghua Science and Technology* **13**(3), 259. Accessed on January 2, 2025. See p. 259 for UTAUT model comparison.

Molina-Azorín, J. F. (2016), 'Mixed methods research: An opportunity to improve our studies and our research skills', *European Journal of Management and Business Economics* **25**(2), 37–38. Accessed on May 8, 2025.

Natalia, O. & Tesniwati, R. (2021), 'The effect of perception of trust, perception of ease of use, perception of benefits, perception of risk and perception of service quality on interest in using mobile banking bank independent in bekasi city', *International Journal of Science, Technology & Management* **2**(5), 1727–1728. Accessed on March 21, 2025. See pp. 1727–1728 for discussion on trust dimensions.

Parasuraman, A., Zeithaml, V. A. & Malhotra, A. (2005), 'E-s-qual: A multiple-item scale for assessing electronic service quality', *Journal of Service Research* **7**(3), 217–220. Accessed on March 22, 2025.

Parlamento Europeu (2020), 'O que é a inteligência artificial e como funciona?'. Accessed on May 2025.
URL: *https://www.europarl.europa.eu/topics/pt/article/20200827STO85804/o-que-e-a-inteligencia-artificial-e-como-funciona*

Pugliese, R., Regondi, S. & Marini, R. (2021), 'Machine learning-based approach: Global trends, research directions, and regulatory standpoints', *Data Science and Management* **4**, 20–21. Accessed on March 30, 2025.

Rikhardsson, P. & Yigitbasioglu, O. (2018), 'Business intelligence & analytics in management accounting research: Status and future focus', *International Journal of Accounting Information Systems* **29**, 43–44. Accessed on March 9, 2025.

Rogers, E. M. (2003*a*), *Diffusion of Innovations, 5th Edition*, 5 edn, Simon and Schuster. Accessed on January 10, 2025.

Rogers, E. M. (2003*b*), *Diffusion of Innovations, 5th Edition*, 5 edn, Simon and Schuster. Accessed on January 10, 2025.

Ross, P. (2023), 'The power of business intelligence—and how to put it into practice'. Accessed on March 21, 2025.
URL: *https://www.forbes.com/councils/forbesagencycouncil/2023/08/29/the-power-of-business-intelligence-and-how-to-put-it-into-practice/*

Shankar, A. & Rishi, B. (2020), 'Convenience matter in mobile banking adoption intention?', *Australasian Marketing Journal (AMJ)* **28**(4). Accessed on January 1, 2025.

Taffel, S. (2021), 'Data and oil: Metaphor, materiality and metabolic rifts', *New Media & Society* **25**(5), 1–4. Accessed on May 15, 2025.

The Economist (2019), 'Surveillance is a fact of life, so make privacy a human right', *The Economist* . Accessed on May 12, 2025.
URL: *https://www.economist.com/open-future/2019/12/13/surveillance-is-a-fact-of-life-so-make-privacy-a-human-right*

Umer, K. N. & Kesavapattapa, R. J. (2025), 'A study on the impact of mobile banking on consumer satisfaction in emerging markets', *International Journal of Advanced Research* **12**, 619–621. Accessed on May 9, 2025.

Venkatesh, V., Morris, M. G., Davis, G. B. & Davis, F. D. (2003), 'User acceptance of information technology: Toward a unified view', *Management Information Systems Quarterly* **27**(3), 425–428. Accessed on May 28, 2025.

Wang, C. & Qi, H. (2021), 'Influencing factors of acceptance and use behavior of mobile health application users: Systematic review', *Healthcare* **9**(3), 4–8. Accessed on May 13, 2025.

Zhang, X. & Yu, X. (2020), 'The impact of perceived risk on consumers' cross-platform buying behavior', *Frontiers in Psychology* **11**. Accessed on March 25, 2025.

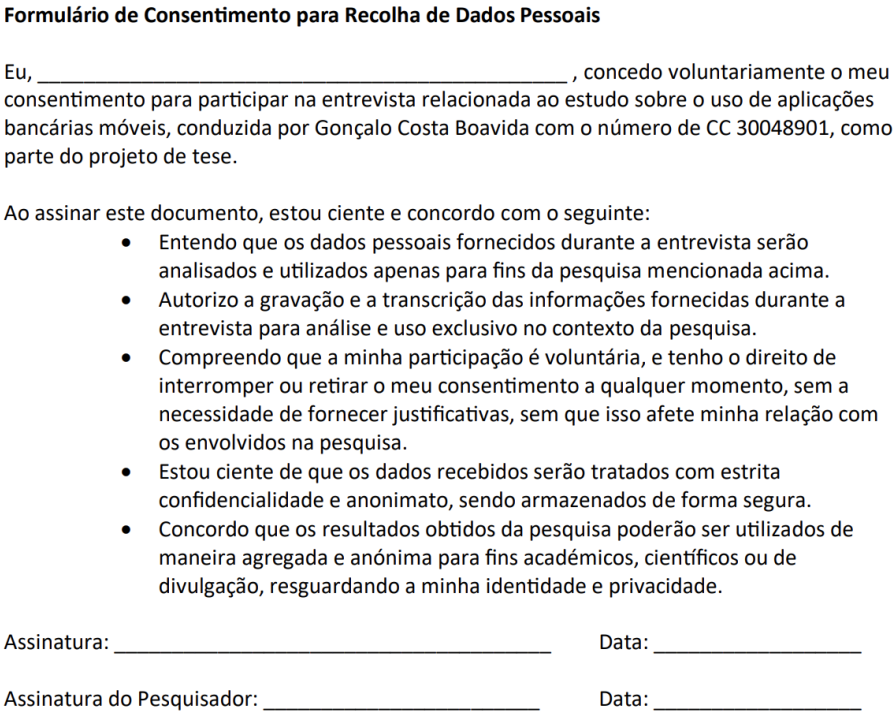
APPENDIX

The online questionnaire used for the qualitative part of this research can be accessed here:

`https://forms.gle/p5XZQsvupDFTWjUn6`

The Tableau dashboard developed for this thesis can be accessed here:

`https://l1nq.com/tableau-tese-goncalo-cboavida`



Formulário de Consentimento para Recolha de Dados Pessoais

Eu, _____ , concedo voluntariamente o meu consentimento para participar na entrevista relacionada ao estudo sobre o uso de aplicações bancárias móveis, conduzida por Gonçalo Costa Boavida com o número de CC 30048901, como parte do projeto de tese.

Ao assinar este documento, estou ciente e concordo com o seguinte:

- Entendo que os dados pessoais fornecidos durante a entrevista serão analisados e utilizados apenas para fins da pesquisa mencionada acima.
- Autorizo a gravação e a transcrição das informações fornecidas durante a entrevista para análise e uso exclusivo no contexto da pesquisa.
- Compreendo que a minha participação é voluntária, e tenho o direito de interromper ou retirar o meu consentimento a qualquer momento, sem a necessidade de fornecer justificativas, sem que isso afete minha relação com os envolvidos na pesquisa.
- Estou ciente de que os dados recebidos serão tratados com estrita confidencialidade e anonimato, sendo armazenados de forma segura.
- Concordo que os resultados obtidos da pesquisa poderão ser utilizados de maneira agregada e anónima para fins académicos, científicos ou de divulgação, resguardando a minha identidade e privacidade.

Assinatura: _____ Data: _____

Assinatura do Pesquisador: _____ Data: _____

FIGURE 1: Consent form for the collection of personal data used in the qualitative interviews.

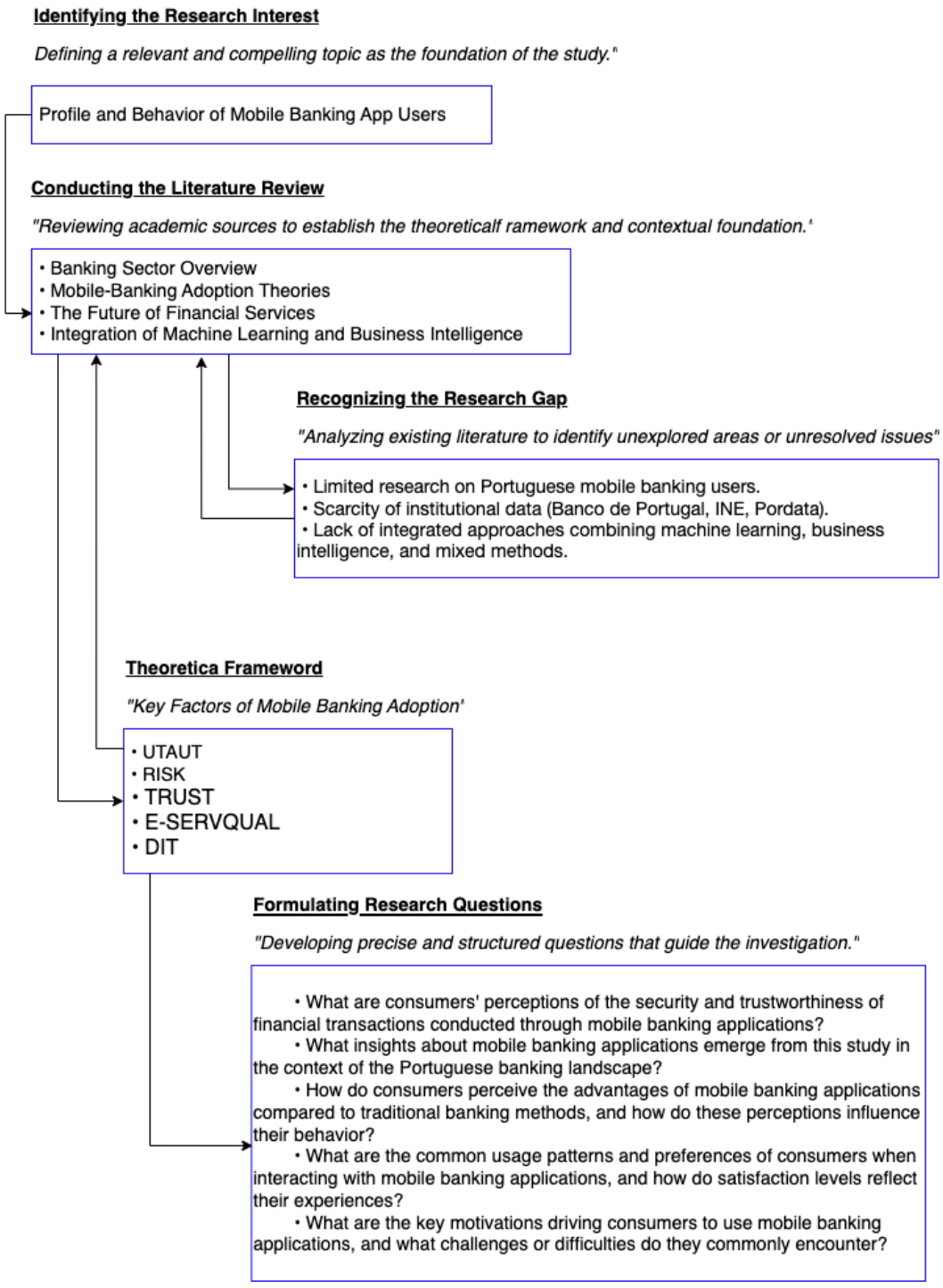


FIGURE 2: Structuring the Research from Foundation to Inquiry

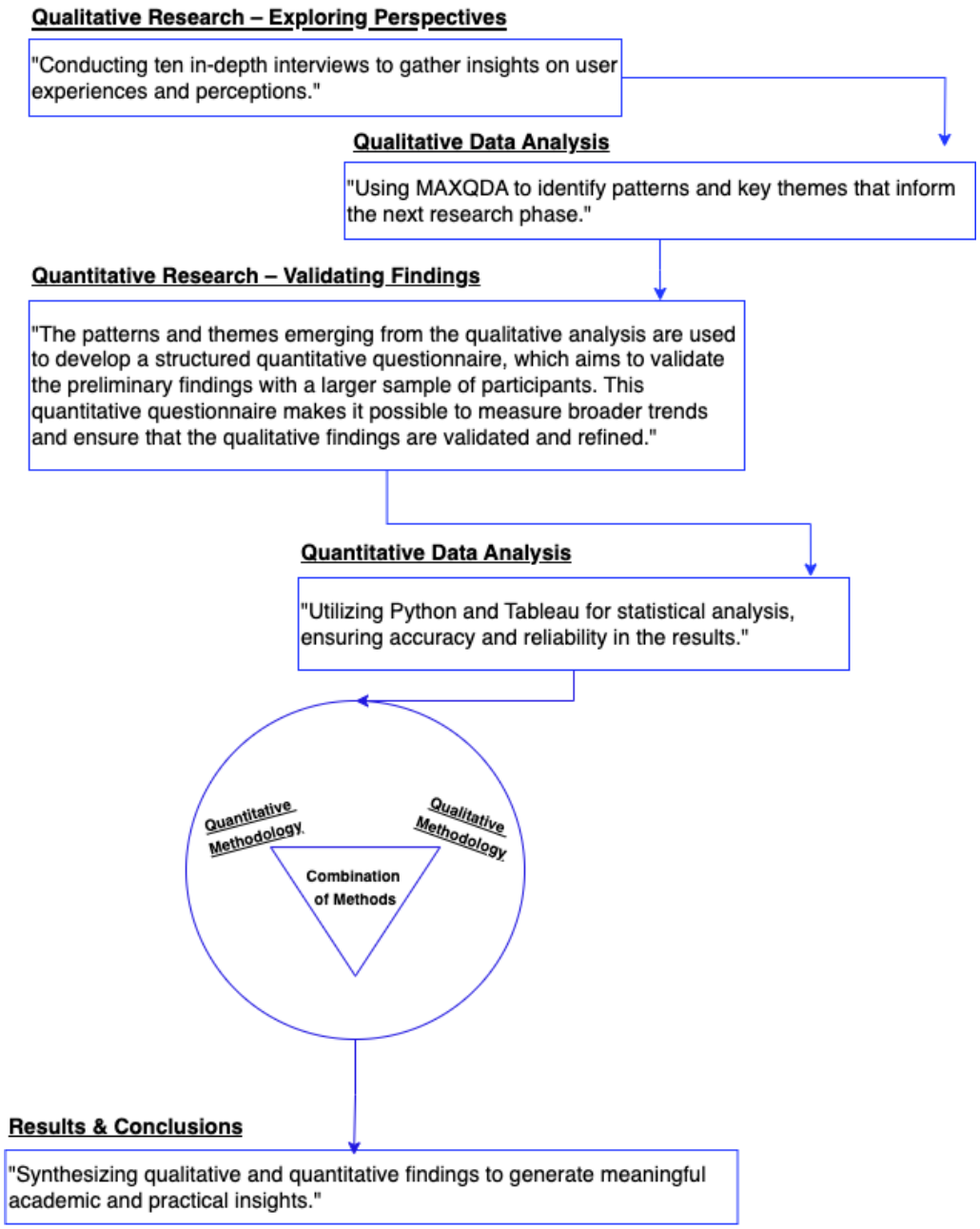


FIGURE 3: Mixed-Methods Process Connecting Qualitative and Quantitative Research

Age Range	Quantity	Percentage (%)
18 – 24	50	30.67
25 – 44	69	42.33
45 – 64	34	20.86
> 65	10	6.13

TABLE I: Distribution of participants by age range

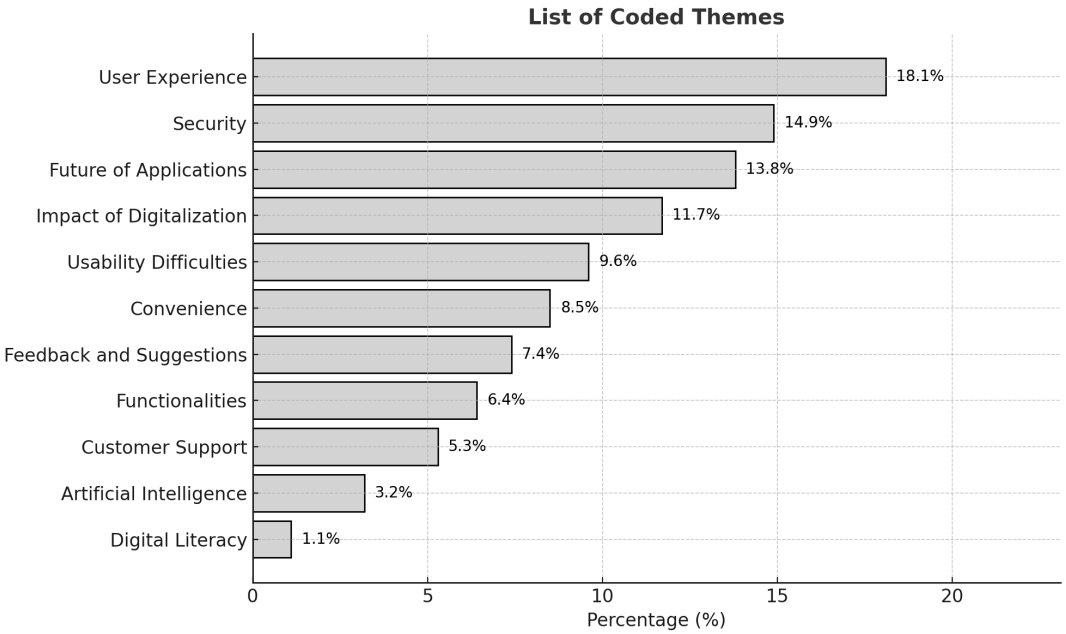


FIGURE 4: Distribution of coded themes from qualitative interviews, analyzed using MAXQDA.

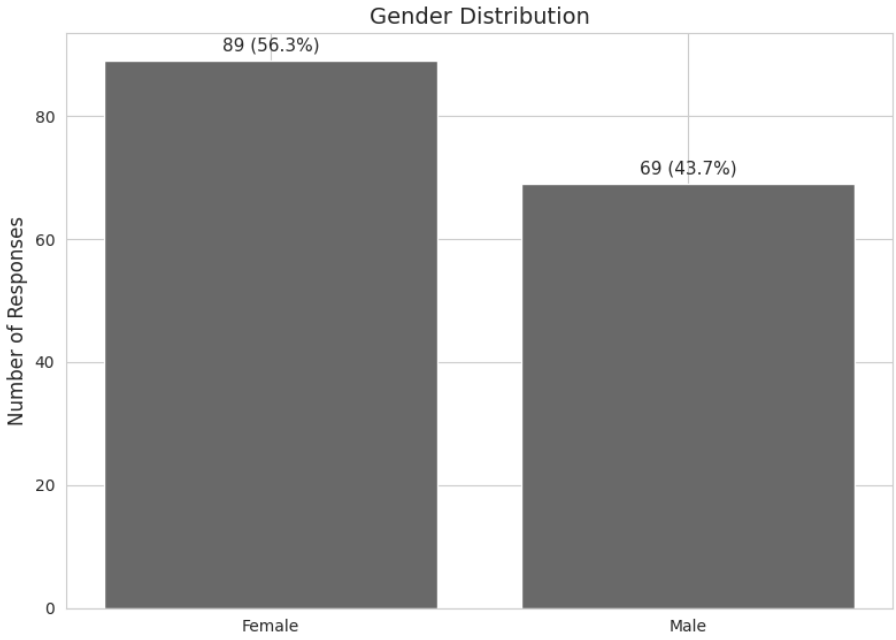


FIGURE 5: A Gender Snapshot of Survey Respondents

Use of apps	Answer	Quantity	Percentage (%)
Transfer applications such as MB WAY and Revolut	Yes	148	90.8
	No	15	9.2
Banking applications	Yes	154	94.5
	No	9	5.5

TABLE II: Distribution of participants' usage of transfer and banking applications

Municipality of residence	Quantity	Percentage (%)
Aveiro	13	7.98
Açores	6	3.68
Braga	4	2.45
Bragança	6	3.68
Castelo Branco	1	0.61
Coimbra	10	6.13
Faro	3	1.84
Leiria	5	3.07
Lisboa	71	43.56
Madeira	6	3.68
Portalegre	1	0.61
Porto	15	9.20
Santarém	2	1.23
Setúbal	4	2.45
Viana do Castelo	2	1.23
Vila Real	7	4.29
Viseu	4	2.45
Évora	3	1.84

TABLE III: Distribution of participants by municipality residence

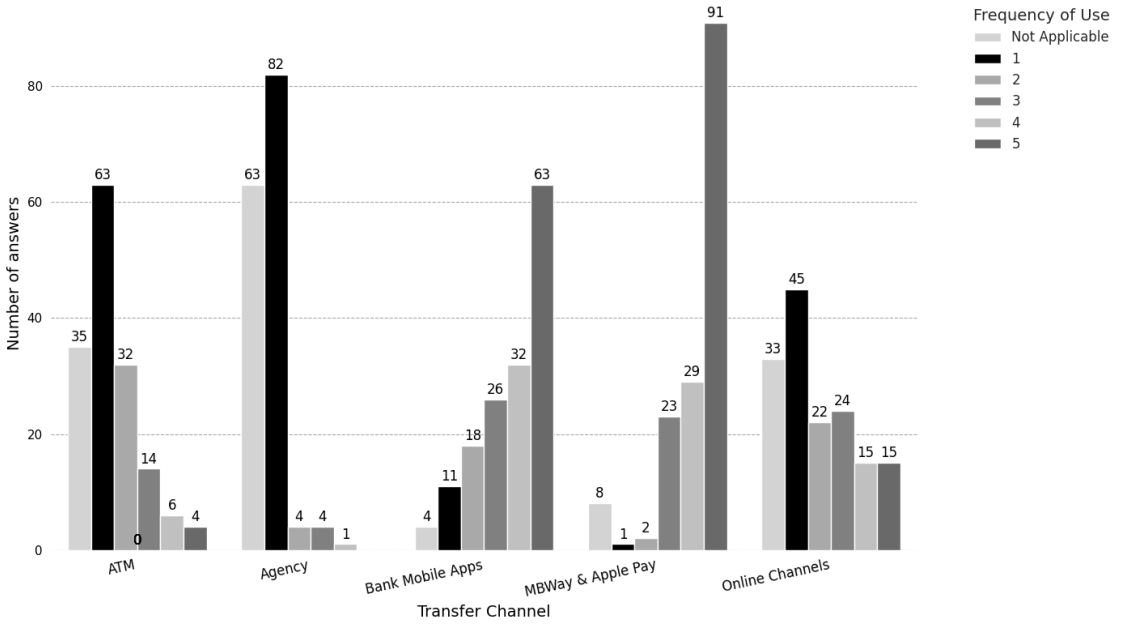


FIGURE 6: Distribution of the frequency of use of the different banking channels (physical and digital) by participants

Transfer Channel	**Average Use**
ATM	1.79
Agency	1.16
Bank Mobile Apps	3.79
MB WAY & Apple Pay	4.42
Online Channels	2.45

TABLE IV: Average Use of Transfer Channels

FIGURE 7: Channel Usage Patterns and Their Correlations

FIGURE 8: How the Pandemic Affected the Start of Mobile Banking Use.

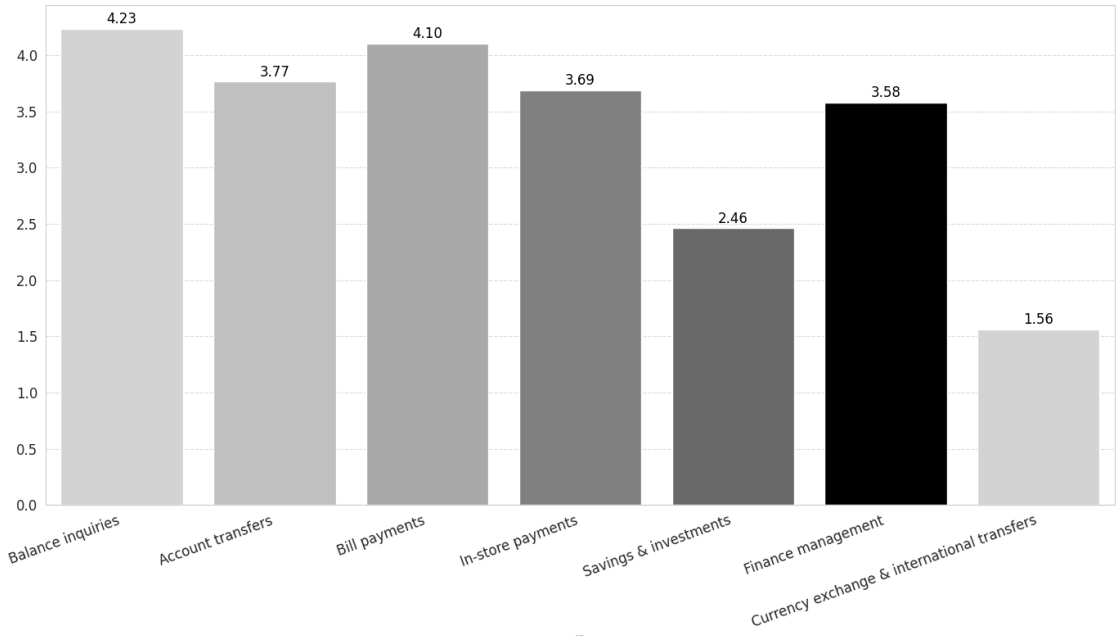


FIGURE 9: User Opinions on User Sense of Security in Mobile Banking Apps

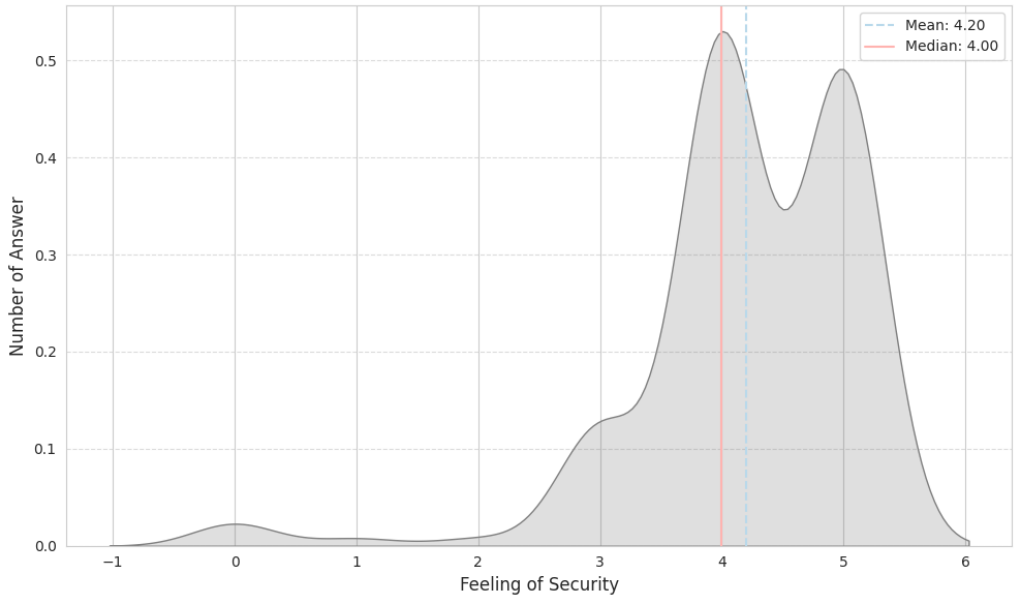


FIGURE 10: How Safe Users Feel with Mobile Banking

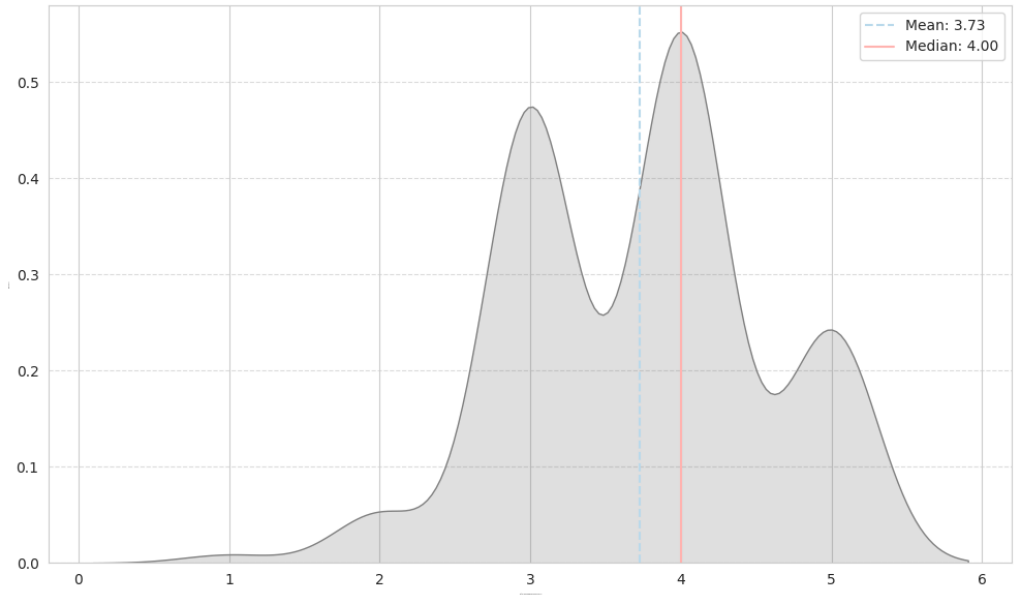


FIGURE 11: User Opinions on How Banks Handle Security Problems.

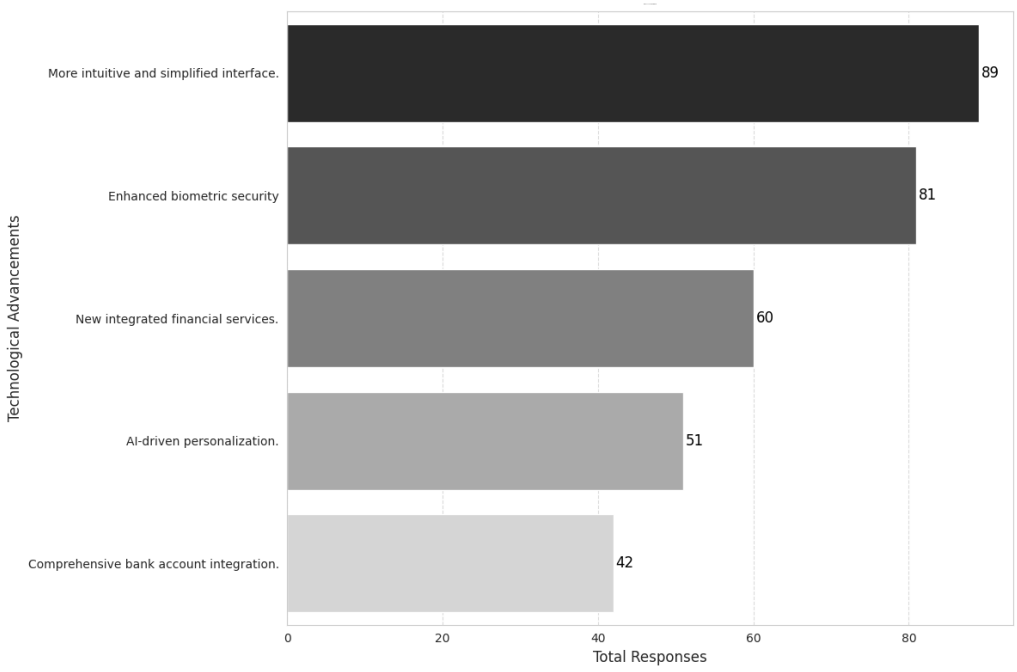


FIGURE 12: Most frequently desired technological advancements in mobile banking Apps (selected by more than 10 respondents)

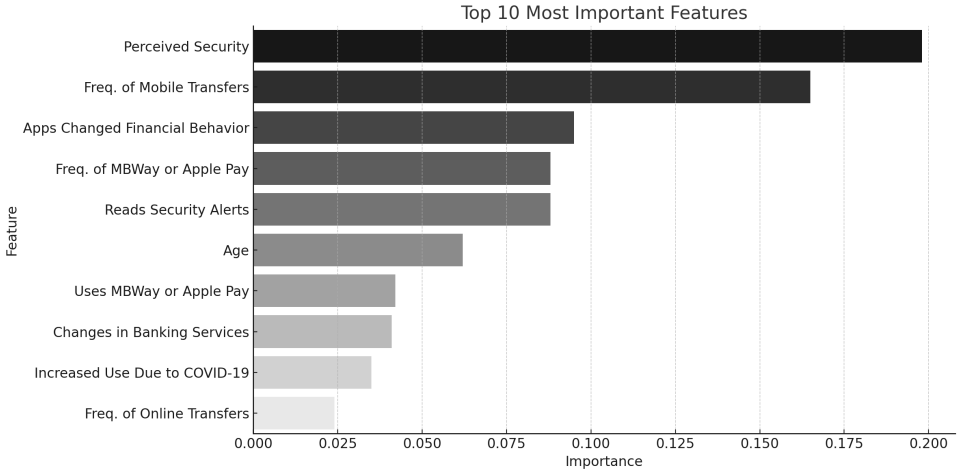


FIGURE 13: Top 10 most important features for predicting mobile banking app usage, based on the Random Forest model.

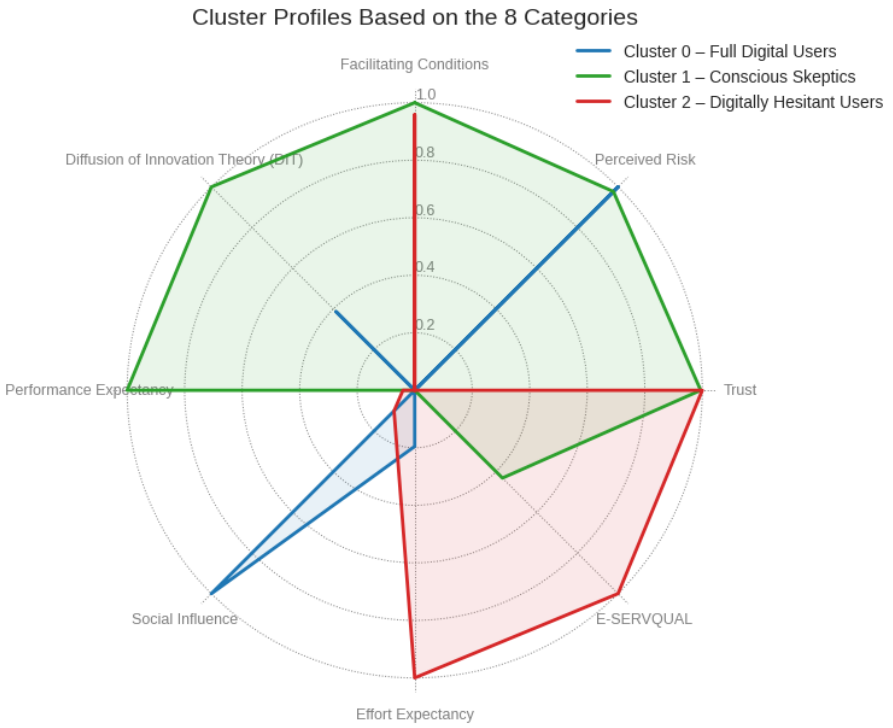


FIGURE 14: Radar chart showing the profiles of three user clusters based on the eight theoretical categories.