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AI Strategies for Financial Inclusion: A Multi-Analytical Approach to Mobile Financial Services Acceptance

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Summary of the Doctoral Dissertation

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ABSTRACT

Technological advancements, including artificial intelligence (AI), have emerged with considerable advantages in the recent commercial market, transforming the financial industry and facilitating financial inclusion. The widespread Internet-enabled phones, smartphones, and tablets associated with fast and reliable communications networks have encouraged banks and service providers to provide a new range of digital financial services that can be accessed through mobile phones. However, the success of technology remains not measured by how sophisticated it is but by how simply it merges with social life and derives its value from its usage on humanity.

Despite widespread access to Internet-enabled devices, the adoption of mobile financial services (MFS) remains surprisingly low, highlighting the need for a deeper understanding of mobile services acceptance.

Motivated by these challenges, this doctoral dissertation intends to understand the drivers of MFS better and, to some extent, mobile-based money services acceptance and use at the individual level to increase the adoption rate. To achieve these objectives, we developed five studies; three in the mobile financial services field and two regarding mobile money services. We started chapter two using a systematic literature review with weight analysis on the MFS sample of mainstream empirical published between 2011–2021 covering the COVID-19 pandemic period. Using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) format in chapter three, this framework-based review critically analyses the trend of technology acceptance model (TAM) –MFS-based studies of empirical research published from the last two decades in numerous scientific journals. In chapter four, the cross-sectional data from Togo were used to combine acceptance with trust and perceived risk at the multi-dimensional, simultaneously capturing success and resistance factors towards MFS adoption while prioritizing the major categories of this technology. In chapter five, the study develops a model to identify the direct and indirect effects and predict the drivers leading to the intention to adopt mobile money by extending self-efficacy, technology anxiety, and personal innovativeness with the technology acceptance model (TAM). In the sixth, as in the following study, we return to the multi-dimensional perceived risk factors in mobile money service to predict the resistance to adopting this technology during the COVID-19 pandemic.

Besides the weight analysis and the PRISMA framework-based, while providing a solid foundation and benchmark methodology for the studies, this dissertation includes structural equation modeling (SEM) in all the studies, explicitly relating it with (i) multiple criteria decision-making (MCDM) techniques in the fourth chapter, and (ii) an artificial neural network (ANN) in the fifth and sixth chapters.

Cconsidering the finding of all studies, the intention best drivers were (i) perceived risk, found significant in three studies, (ii) attitude, found significant in two studies with higher relative importance compared to personal innovativeness, (iii) subjective norms, perceived security, and trust were significant in two studies, and regarding the perceived risk best drivers were (i) perceived privacy risk, found significant in two studies with higher relative importance compared to time risk, monetary risk, and security risk. Regarding the studies individually, the dispositional trust and general trust effects on adopting MFS were found to be the most dominant drivers to explain the MFS use behavior, offering new direction on how the trust particular individuals' propensity

to trust influences the usage behavior. Concerning the MFS classification, the study confirms the relevance of mobile money as the most chosen MFS category, followed by mobile payment and mobile banking, and recommends the inclusion of mobile money as a revolutionary tool for expanding access to financial services in low-resource environments. Personal innovativeness not only influences attitude but also has a direct and substantial relationship in predicting intention to use mobile money with a higher relative importance score, which indicates its importance in shaping attitude and intentions and furthers our understanding of the role of personality traits in innovation adoption. Perceived privacy risk as the most significant predictor of the overall perceived risk in mobile money is confirmed, showing that, to be mitigated efficiently, institutions can provide guidelines within privacy policies to support users in improving their security and privacy behaviors. Identifying individuals more likely to adopt MFS can be beneficial for marketing purposes, such as market segmentation and targeted marketing. The dissertation offers a framework on the most frequently used constructs in literature to comprehend how individuals behave towards accepting technology, categorized into three dimensions: Technological – Personal – Environmental (TPE) factors.

In summary, this work, driven by AI strategies, significantly contributes to both academic and practical fields by leveraging AI strategies to understand and predict MFS adoption. It introduces novel frameworks for categorizing MFS constructs, validate the effectiveness of SEM-ANN methodologies, and identify key predictors of adoption, including perceived usefulness, ease of use, and trust. These insights offer valuable guidance for financial stakeholders to enhance MFS adoption rates, tailor services, and expand financial inclusion efforts.

Keywords: Mobile, financial services, money, acceptance, TAM, SEM, MCDM, ANN, AI

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List of Acronyms

AGFI	Adjusted Goodness-of-Fit Index
AHP	Analytic Hierarchy Process
AMOS	Analysis of Moment Structure
ANN	Artificial Neural Network
ASV	Average Shared Variance
AVE	Average Variance Extracted
CB-SEM	Covariance-Based Structural Equation Modeling
CFA	Confirmatory Factor Analysis
CFI	Comparative Fit Index
CI	Consistency Index
CLF	Common Latent Factor
CMB	Common Method Bias
CR (AHP)	Consistency Ratio
CR (SEM)	Composite Reliability
DTPB	Decomposed Theory of Planned Behavior
EFA	Exploratory Factor Analysis
E-TAM	Extended Technology Acceptance Model
FFBP	Feed-forward Back propagation
GFI	Goodness-of-Fit Index
GOF	Goodness of Fit Index
IS	Information System
KMO	Kaiser-Meyer-Olkin
MATLAB	Matrix Laboratory
MB	Mobile Banking
MCDM	Multiple Criteria Decision Making
MFS	Mobile Financial Services
MMS	Mobile Money Services
MMT	Mobile Money Transfer
MP	Mobile Payment
MSV	Maximum Shared Variance
NFI	Normed Fit Index
PLS-SEM	Partial Least Square Structural Equation Modeling
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
ReLU	Rectified Linear Unit
RMS or RMR	Root Mean Square Residual
RMSE	Root-Mean-Square-Error
RMSEA	Root Mean Square Error of Approximation
SEM	Structural Equation Modeling
SLR	Systematic Literature Review
TAM	Technology Acceptance Model
Tanh	Hyperbolic Tangent
TLI	Tucker-Lewis Index
TOPSIS	Technique for Order Preference by Similarity to an Ideal Solution
TPB	Theory of Planned Behavior
TRA	Theory of Reasoned Action
UTAUT	Unified Theory of Acceptance and Use of Technology
x^2	Chi Square
x^2/DF	Normed Chi-Square

1 Research Background and Significance

Technological advancements, including artificial intelligence (AI), have revolutionized various sectors, notably the financial industry, by facilitating financial inclusion. The proliferation of Internet-enabled devices such as smartphones and tablets, coupled with fast and reliable communications networks, has driven banks and service providers to offer a wide array of digital financial services accessible through mobile phones. Despite these technological advancements, the true measure of success lies not in the sophistication of the technology but in its seamless integration into daily life and its ability to enhance human value.

Digital financial services (DFS), leveraging AI, are a crucial driver of economic growth (Kim et al., 2018). These services utilize digital technologies to promote financial inclusion by providing financial services to underserved populations. Mobile devices have become essential for consumers to access these services, including banking, payments, budgeting, and shopping. For many, especially the poorest populations, mobile phones are the first means of continuous communication and access to banking services. Mobile technology can make room for addressing two primary questions simultaneously: from the demand perspective, it represents an opportunity for financial inclusion among a population that is underserved by traditional banking services. From the supply side, it opens up the possibility for financial institutions to provide a great diversity of services at low cost to large customers of the poorest sections of society and people living in remote areas.

During the early 2000s, most mobile financial services providers could not meet market expectations due to their limited capability of handling data via mobile networks. As a result, the adoption rate of these services was lower than expected. To address this issue, mobile phone manufacturers introduced smartphones in 2006, which had enhanced web browsing and data transfer capabilities, better usability, enhanced information security, and a connected developer and mobile app ecosystem. The introduction of 3G, 4G, and 5G telecom network technologies, along with the transaction-making capabilities of internet banking, further improved the capabilities of smartphones, leading to increased demand for more advanced mobile financial services. Mobile financial services (MFS) is a broad term that includes various financial services that can be conducted on a mobile phone (Gbongli et al., 2020). It includes three leading forms: mobile banking, mobile payment, and mobile money transfer (Gbongli et al., 2020) (FIRPO, 2009). Mobile banking enables customers to interact with the bank through mobile phones, such as opening new accounts, obtaining account information, transferring funds, and making financial investments. Mobile payment allows users to make person-to-business payments for goods and services through mobile phones at the point of sale or remotely. Mobile money refers to the service allowing users to transfer money between people with less access to bank accounts (Kim et al., 2018) (Gbongli et al., 2019). Customers are gradually adopting these services as it increases their convenience by excluding the need for coins and cash for small transactions.

According to a report by GSMA (2021), registered mobile money accounts reached 1.2 billion in 2020, with 5.2 million unique agent accounts globally and 310 mobile money deployments in 96 countries. The report also showed a 17 percent year-on-year increase in accounts and a 22 percent growth in total mobile money transaction values to $767 billion. With over $2 billion being processed daily and the industry doubling in value since 2017, the GSMA predicts that this value will exceed $3 billion daily by 2022, indicating significant growth

opportunities in mobile money. However, the adoption rate remains low, highlighting the need for a deeper understanding of mobile services acceptance.

In Togo, despite the promising potential of mobile money services, the penetration rate is only 45%, compared to Ghana's 60% (Fiacre, 2018). This underscores the need to continually evaluate customers' readiness to adopt technology-based MFS that benefit both consumers and service providers. Two mobile telecommunication companies, Moov and Togocel, offer mobile money services in Togo, known as Flooz (launched in 2013) and T-Money (launched in 2016), respectively. The national social security fund (CNSS) has also encouraged employers to pay their social security contributions via these services (CNSS, 2019). However, data from BCEAO in 2018 shows that only 35% of the 3.9 million mobile money accounts in Togo are active, representing just 29% of the adult population. This indicates a partial understanding of the factors influencing MFS acceptance (Hassan Hosseini et al., 2015).

The slow adoption of mobile financial services can be attributed to several factors. Firstly, people have been hesitant to use mobile channels as they already have access to self-service channels like ATMs and Internet banking, as well as full-service channels like branches and call centers. The limited screen size of mobile phones has also hindered their usefulness (Ghose et al., 2013). The second reason is the perception of risk associated with using mobile financial services (MFS), particularly in developing countries like Togo, where privacy and security concerns are high (Gbongli et al., 2017). Customers may be uncertain or anxious about using MFS, leading further to slowing adoption (L. C. Hsu et al., 2019) (Gbongli et al., 2016). This concern is not limited to developing countries; even in developed countries like Hungary, fraud risk in electronic payment transactions has been reported (Kovács & David, 2016). Despite these challenges, some emerging economies, such as the Philippines and Kenya, have successfully embraced MFS. According to recent research, in Kenya, M-Pesa, a mobile money service, has even been credited with lifting 2% of households out of poverty(Suri & Jack, 2016).

Various studies have examined the adoption of mobile financial services (MFS) using both qualitative and quantitative methods (Jadil et al., 2021) (Gbongli, 2022a). However, there has been a scant attempt to provide an integrative model that can explain the factors affecting MFS adoption comprehensively. The literature on MFS adoption is fragmented, which makes it challenging to build upon existing knowledge and advance research in the area. Given the complex nature of MFS as a combination of mobile and financial services, it is crucial to comprehensively understand the most significant drivers of mobile financial services (MFS) acceptance and use.

The following are the main motivational factors for undertaking this research:

1. While earlier studies have identified some drivers of MFS acceptance, adoption rates remain lower than expected. They have only been adopted by a few users (Deb & Agrawal, 2017) (Thakur & Srivastava, 2014) (Zhou, 2012), revealing that novel constructs or relationships need to be discovered to advance knowledge in this area.
2. Trust and risk might be critical determinants of MFS acceptance due to the inherent uncertainty of the mobile situation (Lin, 2011). Given that risk perception may be higher than in traditional branch services (Koenig-Lewis et al., 2010), these constructs should be assessed together with adopting theoretical models.
3. Mobile money services are closely related to mobile banking and payment and are integrated parts of mobile financial services, which makes it sometimes hard to distinguish one from another.
4. Mobile money and mobile payment is a relatively novel field of study, under-explored

compared to related research areas, including e-commerce or Internet banking, where studies have been extensively conducted and, therefore, must be investigated more.

5. Focusing on a single method to understand the potential drivers of MFS adoption may misrepresent the fundamental factors. Integrating multiple decision-making theories and predicting methodologies to assess the drivers of MFS digitalization for financial inclusion, particularly in developing countries, is essential. This practice can also seize a broader range of perspectives that a single technique might not capture

The MFS ecosystem in Togo lacks adequate customer empowerment for active participation and overcoming financial inclusion barriers. Therefore, Togo was chosen as an appropriate experimental field to assess and predict the key antecedents influencing users' behavioral intention to adopt MFS. Togo is an emerging economy located in sub-Saharan West Africa with a population of over 7.5 million people (UNdata, 2017). It shares borders with Burkina Faso to the north, Benin to the east, Ghana to the west, and the Gulf of Guinea to the south. In 2017, the country's economic growth rate was 4.5%, lower than the preceding year's growth rate of 5%. However, the economy made a substantial recovery in 2021, with a projected GDP growth rate of 4.8%, up from 1.8% in 2020. The recovery was primarily propelled by extractive industries and manufacturing on the supply side and private consumption and investment on the demand side (AfDB Group, 2022). According to the most recent report by the UN Development Program in 2022, Togo ranks 162 out of 191 countries on the Human Development Index (UNDP, 2022).

2 Technology Adoption Models and Theories

Studying the adoption of information technology contributes to assessing the acceptance rate, the drivers of acceptance, and the inhibitors factors users face in accepting this constantly evolving technology. The research on adopting new technology has led to advancing several concepts, theories, and models. Among these models that have been developed over the years, five theoretical currents prevail in the literature (Hoehle et al., 2012), including the innovation characteristics of the diffusion of innovations theory (DOI) (Rogers, 2003), the theory of reasoned action (TRA) (Hill et al., 1977), theory of planned behavior (TPB) (Ajzen, 1991), technology acceptance model (TAM) (Davis, 1989), and theory of perceived Risk (TPR) (Featherman & Pavlou, 2003). In 2003 (Venkatesh et al., 2003a) compared the similarities and differences among the eight models earlier used in the information system area, all of which had their roots in sociology, psychology, and communications. These models are (i) TRA, (ii) TAM, (iii) TPB, (iv) Model of PC Utilization (Thompson et al., 1991), (v)DOI, (vi) Motivational Model (MM) (Davis et al., 1992), (vii) Social Cognitive Theory (Compeau & Higgins, 1995), and (viii) an integrated model of technology acceptance and planned behavior.

TAM is probably one of the most widely cited models in technology acceptance (P. F. Wu, 2009). Since its advent, the TAM model has gradually drawn scholars' attention, being incrementally tested and applied to several technologies, from both individual and organizational use, within single or multiple countries. As TAM overlooked the social influence of adopting technology, it has some limitations in being applied beyond the workplace. Moreover, some variables as external constructs must be integrated into TAM to offer a more consistent prediction of system use (Taherdoost & Masrom, 2009) (Taherdoost et al., 2009). As the inherent motivations are not revealed in TAM, the application of TAM in a customer context where the acceptance and use of information technologies are not only to fulfill tasks but also to satisfy emotional needs may be restricted. TAM has been extended and adapted to the previous model version to the individual context referred to as ETAM to solve these issues. It

has been proposed in two distinctive works. The first study emphasized perceived usefulness antecedents and BI (behavioral intention), regarded as TAM2. TAM2 was suggested by explicitly integrating two groups of constructs: social influence (image, subject norms, and voluntariness) and cognitive (result demonstrability, job relevance, and output quality) to TAM to enhance the predictive power of perceived usefulness. From this end, for both voluntary and mandatory environments, TAM2 outperformed. The only exception is associated with the subjective norm, which influences mandatory environments but does not in voluntary environments. The second study investigated constructs that impact perceived ease of use. The antecedents of perceived ease of use have been divided into adjustments and anchors. The general beliefs concerning the use of computer systems have been placed in anchors set (enjoyment and objective usability). In contrast, beliefs built on direct experience of a given system are incorporated in adjustments set (external control, computer self-efficacy, computer anxiety, and computer playfulness).

In this work, we apply TAM and other well-known constructs, including self-efficacy, technology anxiety, and personal innovativeness. Moreover, this study adopts a multidimensional trust and perceived risk model, as described in the following chapter.

3 COVID-19's Impact on Togo's Financial Market: A Socioeconomic Overview

COVID-19, the novel coronavirus, has significantly impacted the global economy, including Togo's financial market. The virus first emerged in Wuhan, China, in December 2019 and quickly spread worldwide, leading to widespread lockdowns and economic disruptions. The Togolese government also imposed measures to control the spread of the virus, which had a significant impact on the country's financial market. In this section, we will discuss the major effects of COVID-19 on the financial market in Togo and provide an overview of the current socioeconomic situation in Togo.

3.1 Effects of COVID-19 on the Financial Market in Togo

The COVID-19 pandemic has led to a significant slowdown in economic activity in Togo, directly impacting the financial market. The Togolese stock exchange, Bourse Régionale des Valeurs Mobilières (BRVM), has experienced a decline in trading activity due to the pandemic. Investors have been more cautious and risk-averse, which has led to a decline in investment activity. The pandemic also led to a decrease in foreign investment in Togo, further exacerbating the economic impact of the virus on the country. Furthermore, the pandemic has reduced consumer demand for products and services, resulting in decreased profits for businesses, consequently leading to a decrease in the market value of their stocks.

Another major impact of the pandemic on Togo's financial market was the decline in economic activity in the country. With many businesses forced to close due to the pandemic and the measures taken by the government to control its spread, the country's GDP growth rate slowed down. According to the 2020 World Bank report in Togo (Banque Mondiale, in the French language), a significant proportion of jobs have been impacted by the pandemic, with approximately 62% affected. The employment rate in the service sector has been most severely impacted, with a 49% reduction, while the industrial sector has experienced a decline of 13%. The report also highlights a 30% reduction in workers in retail and leisure industries and a 12% decrease in workplace attendance compared to pre-COVID-19 pandemic levels (Banque Mondiale, 2020). In their 2021 study, Dandonougbo et al. (2021) investigated the impact of COVID-19 on household food security and income variation in Togo. The study employs probit and multinomial logit models, utilizing data gathered from 1405 households across 44 districts within 6 health regions. The study's findings suggest that households whose heads have lost their jobs are more vulnerable to experiencing a decline in income and, subsequently, a decrease

in their food intake.

The results indicate that cash transfers to vulnerable populations have a positive effect but are not statistically significant in influencing income changes. Moreover, the study also discovers that households that receive social benefits and whose heads possess higher levels of education are more likely to withstand the adverse impacts of the pandemic. Lastly, for households that have been moderately or severely affected by the crisis, the authors find a high probability of reducing their food consumption. Based on their results, they recommend extending social benefits to informal sector actors and accelerating the implementation of the single social register to target vulnerable households better. This decline in economic activity led to a decrease in government revenues and an increase in public debt, which strained the country's financial system.

The decline in economic activity has also affected the banking sector in Togo. The pandemic has led to increased loan defaults as many businesses have been unable to repay their loans due to reduced revenues. This has put pressure on the banking sector, which has been forced to increase provisions for loan losses. Furthermore, the pandemic has decreased deposits, as individuals and businesses have become more cautious with their money.

To counteract the economic impact of the pandemic, the Togolese government implemented a range of measures, including economic stimulus packages and monetary policy interventions. These measures aimed to support the financial sector, provide relief to businesses and households, stimulate economic growth, and encourage digital payments to reduce the use of cash, which could potentially reduce the spread of the virus. The government also worked to improve the country's healthcare system to control the spread of the virus and reduce the impact of the pandemic on the economy.

3.2 The Recent Togolese Socioeconomic Situation

Togo is a small West African country with about 8 million people. Over the past few years, the country has made some progress in improving its socioeconomic situation, although many challenges still need to be addressed.

The Togolese economy has been growing steadily over the past few years, with an average annual growth rate of approximately 5% (AfDB Group, 2022). One of the key drivers of Togo's economy is agriculture, which accounts for around 40% of GDP and employs most of the population. The government has implemented several policies to promote agricultural development, including establishing agricultural cooperatives and distributing fertilizers and other inputs to farmers. Togo has a significant industrial sector, with phosphate mining and cement production playing a significant economic role. In addition to agriculture, Togo has been developing its infrastructure, particularly its transportation networks. The country has invested heavily in building new roads and improving its ports, which has helped to facilitate trade and attract foreign investment.

Despite these positive developments, Togo still faces a number of challenges. Poverty remains a major issue, with around 55% of the population living below the poverty line. Unemployment is a significant problem, particularly among young people, with an estimated 30% of the country's youth unemployed (World Bank, 2021). Furthermore, Togo has struggled with political instability in recent years, which has affected its economic growth. The government has been criticized for lacking transparency and accountability, and widespread protests have called for political and economic reforms.

The COVID-19 pandemic has also had a significant impact on the Togolese economy. The pandemic has caused a decline in economic activity, reduced government revenues, and led to an increase in public spending on health and social welfare programs. The Togolese government has implemented various measures to mitigate the impact of the pandemic on the economy. These measures include tax relief, financial support to businesses, and increased health and

social welfare program spending. The government has also encouraged digital payments to reduce the use of cash, which could potentially reduce the spread of the virus.

Regardless of the challenges posed by the pandemic, Togo has continued to implement various economic reforms to promote economic growth and development. The government has implemented reforms to improve the business environment, attract foreign investment, and promote regional integration. Togo is also a member of the West African Economic and Monetary Union (WAEMU), which has helped to promote regional economic integration and stability.

In conclusion, while Togo has made some progress in improving its socioeconomic situation, much work must be done to address the country's poverty and unemployment challenges and promote greater political stability and accountability. The COVID-19 pandemic has significantly impacted the Togolese economy, including the financial market. Its impact on the financial market in Togo leads to a decline in stock prices, a decrease in economic activity, and a strain on the country's financial system. The Togolese government has implemented various measures to mitigate the pandemic impact on the economy, but the long-term effects of the pandemic on the economy remain uncertain. Togo's economy has been growing steadily over the past few years, and the government has continued to implement economic reforms to promote economic growth and development.

4 Study Selection and Focus

The research literature on MFS (mobile banking, mobile payment, and mobile money) can be classified into three types of studies: (Donner & Tellez, 2008) (a) those that explain or predict the adoption of MFS; (b) those that assess the systems" impact on people and economies; and (c) a relative few that try to understand the use of such systems in social, economic, and cultural contexts. Alternates of this trichotomy, which distinguishes adoption studies from impact studies and from "use" studies, have been documented before (Orlikowski & Iacono, 2001) (Sein & Harindranath, 2004); this dissertation mainly selects the study on explaining and predicting the antecedents of MFS adoption in Togo, one of the developing countries.

While most studies investigated MFS adoption in a single country (although the countries studied in the corresponding case are diverse), some studies compared it between developed and developing countries. Therefore, Frimpong et al. (2020) focused on a cross-national investigation of trait antecedents of mobile-banking adoption between the participants of the UK and Ghana (a neighboring country of Togo) through the survey data from 1,340 participants. The results indicated that intrinsic traits are more substantial in explaining consumers' attitudes toward mobile banking in Ghana than in the United Kingdom. However, no significant variance between the two countries was observed concerning the mediation effect of consumers' attitudes on the intention to use mobile banking. Moreover, a sample with 375 complete responses from US and Brazilian students revealed that trust and perceived ease of use are relevant factors to understanding mobile banking use in both countries (Malaquias & Hwang, 2019). Although economic and financial development is so closely linked, the results of the comparisons derived from developed and developing countries offer some information that the factors affecting mobile financial services are more influenced by the advancement of information technology, which has a significant impact on the creation of more flexible payment methods and user-friendly financial services.

Afawubo et al. (2020) investigated the socio-economic determinants of mobile money adoption and households' vulnerability to shocks in Togo. They found that mobile money increases households' ability to deal with some life emergencies, primarily environmental and agricultural vulnerabilities. When assessing whether better access to mobile networks is associated with increased mobile money adoption, Naito & Yamamoto (2022), using evidence

from the micro-data of six Developing Countries, found that the overall mobile money adoption rate does not appear to affect how mobile networks impact on the use of mobile money. This suggests that the obstacle to using mobile money is not likely to come from the poor infrastructure but other reasons such as the reliability of mobile network providers, inconvenience, or culture.

Based on the viewpoints outlined above, this dissertation's core focus, as depicted in **Figure 1**, is to investigate and predict the main drivers of acceptance of mobile financial services (i.e., mobile banking, mobile payment, and mobile money) with a specific prominence on mobile money services for promoting financial inclusion in Togo. The work is only emphasized at the individual level of adoption; no firm or business level will be explored or studied. Interrelated IT acceptance fields and subjects, entailing Internet banking, mobile services, financial services, m-commerce, or mobile apps, are explicitly excluded from the study.

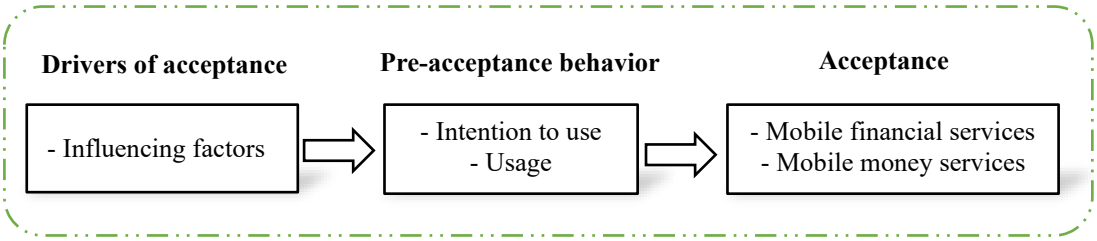


Figure 1 Research focus
Source: own elaboration

Mobile banking can be understood as a set of execution of financial services in the course of which, within an electronic procedure, the users apply mobile communication techniques involving the use of portable devices (Pousttchi & Schurig, 2004) or as a service whereby users utilize a mobile phone to access banking services and perform financial transactions (J. Anderson, 2010). Mobile payments are made or enabled via digital mobility technologies, from handheld devices, with or without mobile telecommunications networks. Ghezzi et al. (2010) recapitulate the notion of mobile payment as a process in which at least one phase of the transaction is conducted through a mobile device up to securely processing a financial transaction over a mobile network or via various wireless technologies. Mobile money services (MMS) use mobile phones to transfer money (Upadhyay & Jahanyan, 2016). Mobile money is run by mobile network operators (MNOs) and consists of transactions conducted through mobile phone networks to access customers' stored funds sustained by the MNOs. It uses nonbanking tools to extend financial services to subscribers that banks cannot reach (Malinga & Maiga, 2020).

To enhance our understanding of mobile banking, mobile payment, and mobile money acceptance, it becomes vital to study them in different contexts, samples, and groups. If possible, use different theoretical frameworks and methodologies to ascertain relevant determinants that can add to the existing knowledge. For this purpose, our dissertation comprises five studies (as depicted in **Figure 2**), three focusing on mobile financial services and two on mobile money services. Additionally, our work represents the global distribution of mobile financial services through various systematic literature reviews.

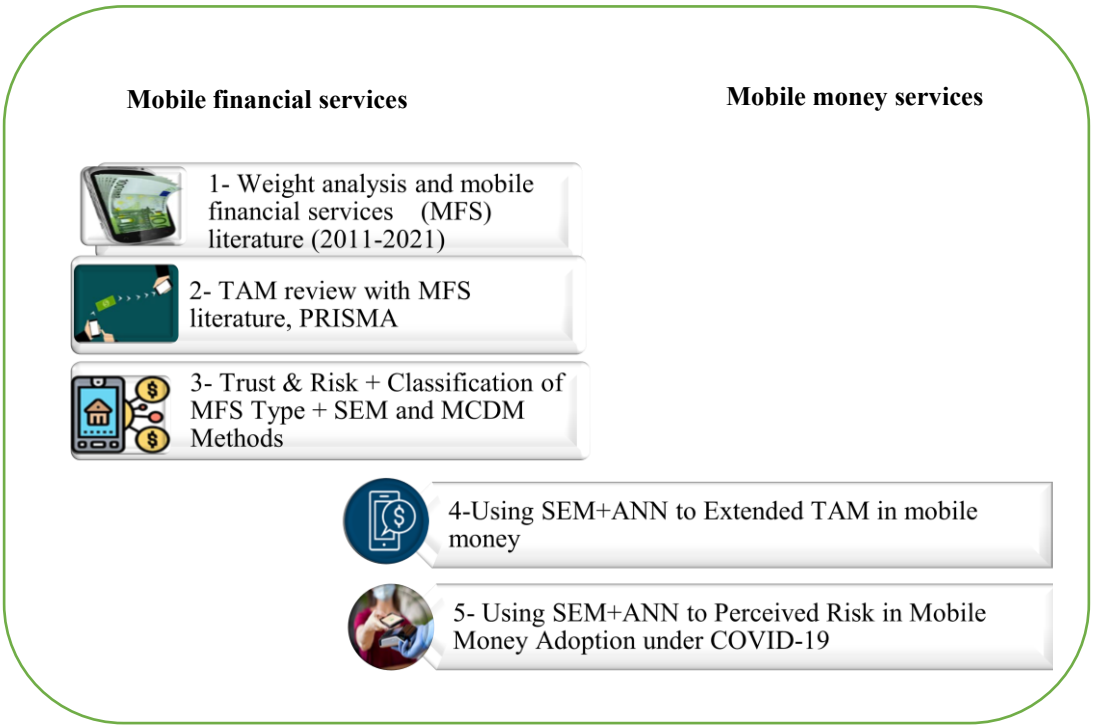


Figure 2 List of studies, theoretical models, methodologies, and constructs used
Source: own elaboration

5 Dissertation Purpose and Aim

This study explores mobile financial services (MFS) and mobile money services in Togo, focusing on identifying influential factors that impact consumers' intention to adopt these services. It consists of five publications that address various research problems, with each chapter dedicated to a separate study. **Figure 3** provides an overview of the research problems, objectives, and published papers entailed in achieving these objectives.

The dissertation comprises six main chapters following the introduction chapter (Chapter 1). The dissertation begins from **Figure 4** with a systematic literature review (SLR) and weight analysis. This analysis identifies the most commonly used drivers, theories, and models in mobile financial studies over the past decade. Like any typical research project, this work began with a literature review, which is the foundation for the theoretical background reviewed in the subsequent chapters. This exercise helped update the current state-of-the-art knowledge whenever possible. However, due to our schedule, this part of the study was completed last, making it the final component of the overall research paper.

Chapter 3 extensively reviews studies on applying the technology acceptance model (TAM) in the context of mobile financial services (MFS). We analyze various aspects, including the drivers of MFS adoption, analysis methods, TAM's progress over the years, countries involved, and sample sizes. The findings highlight the significance of consumers' perception of MFS and the credibility of technology acceptance theories in explaining users' intentions toward adopting new technologies.

Following the literature review in chapters 2 and 3, the remaining chapters are based on empirical studies (quantitative survey data) in MFS or mobile money services.

In Chapter 4, we examine the multidimensional impact of trust and risk in mobile financial services (MFS), considering both factors' influence on the intention to use MFS and the factors contributing to success and resistance to MFS adoption. Additionally, we categorize different types of MFS based on the preferences of experts and experienced users.

In Chapter 5, we expand the technology acceptance model (TAM) to focus on mobile money services (MMS) specifically. By integrating the conventional constructs of TAM, we identify potential drivers for adopting MMS.

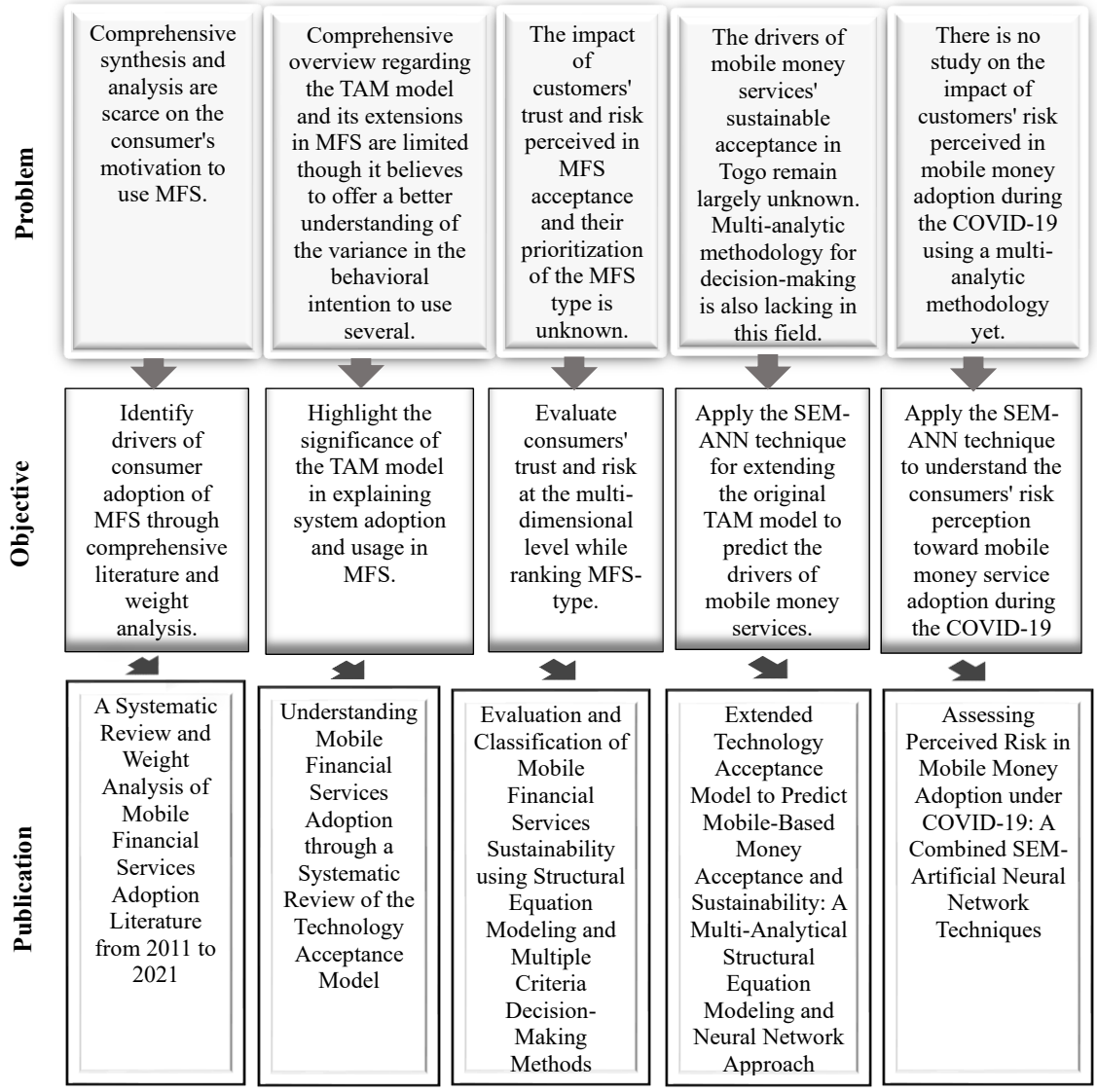
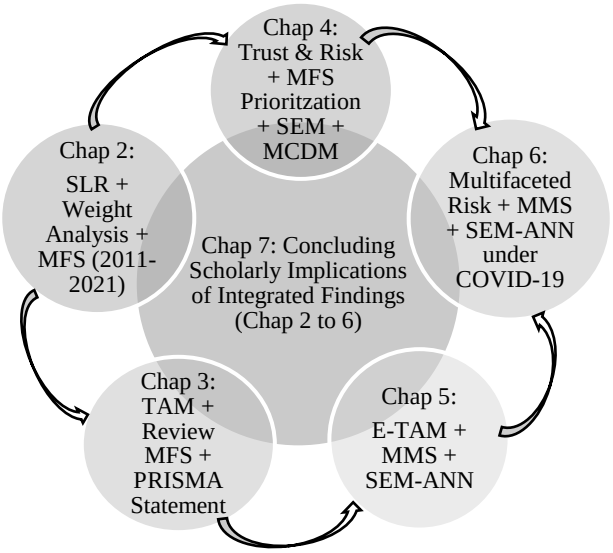


Figure 3 Overview of the dissertation structure from the research problems, goals, and publications
Source: own elaboration

Building upon the findings of Chapters 4 and 5, Chapter 6 examines the adoption of mobile money services from a multidimensional risk perspective during the COVID-19 pandemic using SEM-ANN approach. Due to limited studies utilizing integrated methodologies like structural equation modeling and neural network prediction during this crisis, it presents an exciting area for further research. The chapter highlights the motivation for consumers to engage in contactless activities, including MMS, due to the pandemic's impact on income support and social distancing measures. Assessing various risk factors influencing consumer decisions on MMS adoption during this period becomes crucial.

In the dissertation's final chapter, the main conclusion drawn from the studies presented in the previous chapters is summarized and emphasized as the most important outcome. The chapter also includes an analysis of how variations in timing, samples, and scientific methodology employed in the conducted research works and publications affect the consistency and compatibility of the results. Research contributions, limitations, and suggestions for future work are also discussed.



Abbreviations & Acronyms List

ANN	Artificial Neural Network
E-TAM	Extended Technology Acceptance Model
MCDM	Multiple Criteria Decision Making
MFS	Mobile Financial Services
MMS	Mobile Money Services
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
SEM	Structural Equation Modeling
SLR	Systematic Literature Review
TAM	Technology Acceptance Model

Figure 4 Thesis Scheme Map
Source: own elaboration

6 Methodology

The research methodology integrates the approach, techniques, and procedures adopted to meet the research objectives, hypothesis, and investigations of concerns. Therefore, it summarizes this thesis's main theories, models, and statistical and mathematical techniques. This process starts with the publications.

6.1 Method and Theoretical Frameworks

Regarding the method implemented, we adopted a controlled and structural approach to conducting research by ascertaining a clear research subject, building suitable hypotheses, and embracing an appropriate research methodology (Carson et al., 2001). A specific design using cross-sectional survey methodology was developed and supported in several survey instruments for each research topic in studying mobile financial service adoption. This design aimed to correlate the score of all independent determinants that impact mobile financial services or mobile money acceptance. From The theoretical framework perspective, both the multi-dimensional trust and multi-facet perceived risk model was used in Chapter four, the technology acceptance model (TAM) integrated with self-efficacy, technology anxiety, and personal innovativeness in Chapter five, and the multi-dimensional perceived risk model under COVID-19 in Chapter six.

6.2 Quantitative Research Methods

Our research paper on chapters two and three summarizes existing studies on the drivers of MFS acceptance at various levels, using a systematic review approach to ensure that the review process is reliable and replicable. Unlike traditional literature reviews, systematic reviews follow strict guidelines to minimize the impact of subjective judgment and produce a comprehensive review. Reliability is crucial given the importance of review results in informing decisions with significant environmental and socioeconomic implications (e.g.,(Halme et al., 2010))

To achieve this, chapter two of our paper used a systematic literature review (SLR) methodology, including weight analysis, to analyze MFS adoption literature published between 2011 and 2021. In chapter three, we employed a systematic literature review of the technology acceptance model, following the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) statement (Moher et al., 2009) to understand MFS adoption. The PRISMA

statement provides an evidence-based approach to identify, screen, select, and include relevant studies in a literature review, ensuring that the review process is transparent and reliable for future research. It is an evidence-based minimum set of items to support researchers in improving systematic reviews and meta-analysis reporting.

Chapter four of our study utilized a cross-sectional design to evaluate trust and perceived risk in multi-dimensional decision-making for MFS alternatives in Togo. We used a data set of a two-type survey from March to May 2017, consisting of 538 MFS users (for SEM methodology) and 74 respondents involving only experienced MFS users and experts of MFS (for MCDM methodology). Data were collected from the busiest and most crowded places of the capital town, Lomé, such as Assivito, Dekon, Be, and Université de Lomé-Togo, to ensure a representative sample of potential and current MFS users. We used two phases technique for data analysis where structural equation modeling (SEM) was adopted initially and followed by Technique for Order Preference by Similarity to Ideal Solution (TOPSIS). First, we used SEM to analyze the structural relationships between variables and test hypotheses. Based on J. C. Anderson & Gerbing (1988a) recommendation, the analysis was conducted in two steps, including a reliability and validity assessment of the measurement model and a structural model assessment. we used five different fit indices (Browne & Cudeck, 1993), including CFI, TLI, RMSEA, and SRMR, to evaluate the model's goodness of fit.

The SEM-TOPSIS method allowed us to evaluate trust and perceived risk in multi-dimensional decision-making for MFS alternatives while using TOPSIS and AHP to prioritize the output. After applying the SEM technique, we used two multiple-criteria decision-making (MCDM) techniques, TOPSIS and Analytic Hierarchy Process (AHP), to prioritize the output. Developed by C.-L. Hwang & Yoon (1981), TOPSIS is based on the distance between an ideal and non-ideal solution, while AHP is built on weighted aggregation obtained by pairwise comparisons and decision-making preferences (Taslicali & Ercan, 2006). The results of TOPSIS and AHP were consistent and agree with each other, with mobile money transfer identified as the most appropriate MFS alternative, followed by mobile payment and mobile banking.

In chapter five, the study utilized a method known as SEM combined with ANN (artificial neural networks) to extend the technology acceptance model and predict mobile-based money acceptance and sustainability. This approach was applied to a survey of 539 actual and prospective mobile money users in Lome-Togo between January and February 2019. The theoretical model and guidelines for data analysis were tested using SEM and PLS (partial least square) (J. C. Anderson & Gerbing, 1988). Although SEM is commonly used to verify hypothesized relationships, it may oversimplify complex decision-making processes and detect only linear models. Given that SEM is generally applied to verify hypothesized relationships, it has seldom been integrated with other artificial intelligence algorithms (C. I. Hsu et al., 2009) (Wong et al., 2011) when users are making technology adoption decisions, as SEM may often oversimplify the complexities involved and merely detect linear models.

To address this issue, ANN was used to model linear and non-linear relationships without necessitating any distribution assumptions (L. Y. Leong et al., 2013). ANN offers more accurate predictions than traditional regression techniques such as MRA, MDA, or SEM (Morris et al., 2003). However, a two-step SEM-ANN approach was used since ANN is unsuitable for hypotheses testing and examining causal relationships (L.-Y. Leong et al., 2013). In the first step, SEM was used to identify significant determinants, and in the second step, ANN was used to build models based only on these determinants. This approach allowed for better in-depth research results than the single-step SEM approach. This study is among the few that combine SEM with ANN to examine mobile money adoption and sustainability in a developing country context.

Chapter six used a survey from Lome-Togo and the SEM-ANN method to examine the supporting model and potential impact of perceived risk on mobile money adoption during

COVID-19. The study collected data from 275 respondents between September and November 2021 and adhered to the same SEM-ANN guidelines as in previous studies.

7 Thesis Structure

This dissertation is built from a collection of separated research (with slight modification) on interrelated subjects, namely mobile financial services in general and mobile money services to some extent, reported separately. It reveals a synopsis per paper, theories and models adopted, and methods (mainly statistical or mathematical) applied. The studies were reported independently in various chapters, and each has undergone a rigorous double-blinded review process before publication in international journals (see **Table 1**).

Table 1 Research studies current stage

Chapter	Study name	Theories, models, and methods	Data	Current stage
2	A Systematic Review and Weight Analysis of Mobile Financial Services Adoption Literature from 2011 to 2021	• systematic literature review (SLR) • Weight analysis	Number of papers: 329 (search results), 207 (filtered), 61 (included)	Published in the Review of Business & Management' TMP
3	Understanding Mobile Financial Services Adoption through a Systematic Review of the Technology Acceptance Model	• systematic review (PRISMA)	Number of papers: 217 (search results), 209 (filtered), 24 (included)	Published in the Open Journal of Business and Management
4	Evaluation and Classification of Mobile Financial Services Sustainability Using Structural Equation Modeling and Multiple Criteria Decision-Making Methods	• Multi-dimensional trust • Multi-facet Perceived Risk • SEM • TOPSIS • AHP	538 MFS users with SEM, and 74 both experienced MFS users and experts in Togo for TOPSIS and AHP, Togo	Published in the Journal of Sustainability [SSCI Journal]
5	Extended Technology Acceptance Model to Predict Mobile-Based Money Acceptance and Sustainability: A Multi-Analytical Structural Equation Modeling and Neural Network Approach	• Extended technology acceptance model (TAM) • SEM • ANN	539 actual and prospective users of mobile-based money, Togo	Published in the Journal of Sustainability [SSCI Journal]
6	Assessing Perceived Risk in Mobile Money Adoption under COVID-19: A Combined SEM-Artificial Neural Network Techniques	• Multidimensional perceived risk • SEM • ANN	275 respondents, Togo	Published in the International Journal of Research – GRANTHAALAYAH

SEM: Structural equation modeling, AHP: Analytic hierarchy process, TOPSIS: Technique for order of preference by similarity to an ideal solution, ANN: Artificial neural network.

Source: own elaboration

The thesis's concluding chapter summarizes key findings, compares them to existing research, and highlights the contributions made in chapters two to six. It also acknowledges limitations and suggests future research directions to enhance understanding mobile financial service adoption. Notably, all chapters underwent a rigorous blinded review process and were published in reputable international journals, reflecting a positive indication of the work' quality developed.

8 Results of Analysis

The results of the five publications provide the answer to the research problem so that the outlined objectives previously mentioned can be achieved.

❖ The paper on the research problem regarding the comprehensive synthesis and analysis of the consumer's motivation to use mobile financial services (MFS) provided three main points: The results indicate that the unified theory of acceptance and usage of technology (UTAUT) followed by the technology of acceptance model (TAM) are the core conceptual frameworks and models adopted to understand consumer's MFS adoption. We found that consumer attitude, perceived ease of use, performance expectancy, habit, social norms, and perceived usefulness are the best behavioral intention predictors within the consumer context. The critical technological factors of using MFS were also derived from the most common drivers of MFS adoption literature.

Of particular interest to managers is that attitude toward adoption has been found to play a crucial role in technology acceptance. Therefore, products with ease of use, low-performance expectancy, and usefulness are unlikely to influence consumer attitudes and intentions to adopt. Firms should keep this in mind, especially during the product design stage. It is believed that the results of this systematic review will provide an inclusive source for conducting further research in mobile financial services (MFS). It should be noted that the results depend significantly on the criteria for searching and selecting the literature (cf. (Gbongli, 2022a) paper under review or Chapter 2 of the Thesis).

❖ For the research problem regarding the scarcity of a comprehensive overview of the TAM model and its extensions in MFS, the results revealed that compatibility and perceived security emerged as TAM's most common external factors influencing the adoption of mobile financial services, followed by subjective norm and trust. Information technology corporations (system analysts and developers) and financial organizations can utilize the findings related to the influential factors as lessons learned. Therefore, this review can support improving the currently implemented solutions and consider enhancements in future technology to be more compatible, secure, and innovative. This can also encourage end-users to gain the maximum benefits without fear of making mistakes. It is essential to mention that the results obtained are subjected significantly to the criteria for searching and selecting the literature (cf. Gbongli (2022) or Chapter 3 of the Thesis).

❖ Concerning the research problem on the impact of customers' trust and risk perceived in MFS acceptance and their prioritization of the MFS type, our findings confirm most of the hypotheses derived from the literature. Notably, there is strong support for the dispositional trust influence on the general trust and the perceived privacy risk on the aggregate risk. Trust has a negative relationship with perceived risk. All the antecedents of perceived risk and trust validated the proposed relationship except for perceived time risk. It is found that mobile money transfer (MMT) occurred as the core application used, followed by mobile payment (MP) and mobile banking (MB). This research offers a novel and practical modeling and classification concept for researchers, company managers, and experts in the areas of Information Technology. The results are based on survey data and undertook a research model, which simultaneously captured success and resistance factors towards MFS intention and use behavior and classified MFS-type based on the experts' and experienced users' preference (cf. (Gbongli et al., 2020)).

Regarding the research problem on the overarching research question of what drivers affecting mobile money services' sustainable acceptance in Togo and the lack of TAM with its extended constructs, a structural equation modeling–artificial neural networks (SEM–ANN) multi-analytic methodology for decision-making is calculated (cf. (Gbongli et al., 2019)). There were two stages applied in the data analysis. During the first stage, the structural equation model (SEM) is used to understand the significant influence of predictors on mobile money transfer (MMT) acceptance. The second stage adopted the artificial neural network (ANN) model to identify the importance of the predictors. Therefore, the performance results between the two approaches were checked to determine whether there are differences in factors predicting the adoption of mobile money transfers. Below, the relationships between the variables are being explained in detail on which the proposed research is developed.

- ✓ Mobile money self-efficacy (SEMM)

Self-efficacy denotes a self-confidence regarding the possession of the required skills to complete a task; it is the people's judgment of their capabilities to organize and execute courses of action required to attain designated types of performances (Bandura, 1997). Dominant in Bandura's concept of self-efficacy, it is the clue that this personal belief remains the main basis and a direct element of an individual's behavior and actions. It conceptualizes the individual perception of internal control (Venkatesh, 2000) (Taylor & Todd, 1995). This implies that mobile money services consumers are more likely to pursue activities within their arrays of perceived competencies, and is an important factor in understanding individual responses to new technology (Lewis & Loker, 2014). Self-efficacy has been included in studies of the acceptance of mobile data services (Yang, 2010); online shopping (Faqih, 2013); and information communication of technology (ICT) (Hatlevik et al., 2018), particularly in mobile money transfer (Baganzi & Lau, 2017). Therefore, the following hypotheses are presented:

H1a. M-money self-efficacy has a significant link on perceived ease-of-use of m-money service.

H1b. M-money self-efficacy has a significant link on m-money perceived usefulness.

- ✓ New technology anxiety (TAMM)

Technology anxiety is an apprehensive belief showing the consumer's state of mind concerning his ability and willingness to adapt when considering using technology in general (Venkatesh & Bala, 2008) (Meuter et al., 2003). Fast changes in technology bring challenges to companies due to consumers' resistance to espousing new technology (Fournier & Mick, 1998). In the transition to new technology products, consumers might come across various difficulties, such as unable to operate products correctly (Cui et al., 2009) (Parasuraman, 2000), which results lead to technology anxiety. Technology anxiety, conceived as an anchoring belief, impact the perceived ease-of-use of a system (Venkatesh & Bala, 2008) (Venkatesh & Davis, 2000); therefore, customers who are anxious about the application of IT may not perceive mobile money transfer as easy to use. Technology anxiety has a negative influence on the acceptance of self-service technology (SST) usage (Demoulin & Djelassi, 2016) and the adoption of new technological forms, such as mobile service industries (L. C. Hsu et al., 2019). Hence, we proposed the following hypotheses:

H2a. Technology anxiety has a significant link on m-money perceived ease-of-use.

H2b. Technology anxiety has a significant link on m-money perceived usefulness.

- ✓ Perceived ease-of-use (PEMM), perceived usefulness (PUMM), and attitudes (ATMM) toward mobile money services

The traditional TAM integrates perceived ease-of-use (PE) of technology and perceived usefulness (PU) of the technology as two main constructs. Alike with the concept in Davis et

al. (Davis et al., 1989), PU in this research denotes the extent to which a person believes that using mobile money will enhance his or her performance. Mobile money is supposed to provide diverse benefits to its users such as general convenience, simplification of payment as compared to other forms of payments, all of which might endorse a positive attitude towards and a higher intention to use mobile-based money transfer payment (Chauhan, 2015). PE of mobile money denotes the consumers' perception of the effort and time that has to be expended in to use mobile money service and the degree to which the technology is understandable or not. The mobile money interface should be simple and easy to comprehend, considering the low rate of technological sophistication and literacy rates in Togo (Mas & Morawczynski, 2009). Previous studies have consistently recognized PE to have direct effects on PU and attitude (Chauhan, 2015) (Yousafzai et al., 2007). A study employing TAM reveals that there is a positive relationship between PU and PE (Van der Heijden, 2003) (Yang, 2012). The ease-of-use of a mobile money system can impact its usefulness and user's attitude. Hence, the following hypotheses are posited as follow:

H3a. M-money perceived ease-of-use has a significant link on attitude towards m-money.

H3b. M-money perceived ease-of-use has a significant link on m-money perceived usefulness.

H4. M-money perceived usefulness has a significant link on attitude towards m-money.

- ✓ Personal innovativeness (PIMM)

Agarwal and Prasad (Agarwal & Karahanna, 2000) (p. 206) explained personal innovativeness as "the willingness of an individual to try out any new information technology"; it remains conceptualized as an attribute being not impacted by environmental or internal factors. Individual innovativeness prevails as a determined trait that is reflective of an individual's primary nature when exposed to innovation (Yi et al., 2006). Innovativeness can be grouped under the personality characteristics that outline the degree to which individuals accept and adopt new ideas, products, and systems (Midgley, 1978). It has been used to predict technological innovations' adoption among consumers (Wood & Swait, 2002). Towards the innovation diffusion concepts (Rogers, 2003) people react differently to a novel idea, practice, or object due to their differences in individual innovativeness, a willing tendency regarding adopting an innovation. In the earlier work, J. Fang et al. (2009) assessed the psychological variables (trust in sponsor and personal web innovativeness) entail in a decision for or against participation in web surveys. Their findings revealed that both variables exerted direct determinant effects rather than moderate effects on participation attitude and perceived behavioral control, which in turn significantly influenced participation intention. From this end, personal innovativeness would influence attitude and intention in the context of consumer participation in mobile money services.

Several empirical studies have found a significant relationship between personal innovativeness and behavioral intention (Lian & Lin, 2008) (Tan et al., 2014). Thus, we propose:

H5a. Personal innovativeness has a significant link on the attitude of using m-money.

H5b. Personal innovativeness has a significant link on the intention of using m-money.

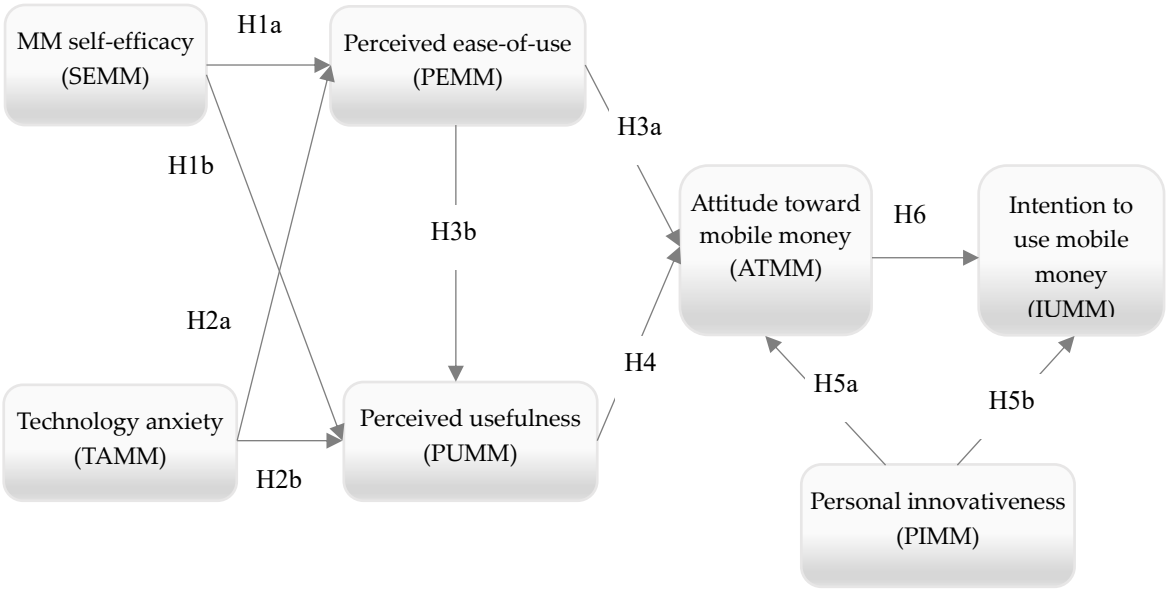
- ✓ Attitudes (ATMM) and intentions of use (IUMM)

The relationship between attitude and intention emphasized in the TAM proposes that attitude acts as an evaluative predisposition to behavior. The attitude towards using mobile money transfer (MMT) has been considered as the extent to which an individual perceives a positive or negative feeling related to MMT. Prior studies on TAM and in other consumer fields have found a link between attitudes and intentions (Yousafzai et al., 2007) (Yang & Jolly, 2009). A plethora of studies established that consumers with a positive attitude towards a

technology incline to have a higher intention to use it (Marangunić & Granić, 2015) (Tao et al., 2018). Indeed, past studies have been confirmed attitude as the most influential predictor of intention to use IT in the original TAM (Yousafzai et al., 2007) (Teo & Zhou, 2014) (B. Wu & Chen, 2017). From this perspective, it is highly important to educate the users of mobile money at the point of sale. Based on these discussions, we, therefore, posit that:

H6. Attitude towards m-money has a significant link on m-money behavioral intention.

Figure 5 shows the proposed research model.



Notes: **Model: A** (Input neuron: SEMM, TAMM; Output neuron: PEMM). **Model: B** (Input neuron: SEMM, PEMM; Output neuron: PUMM). **Model: C** (Input neuron: PEMM, PUMM, PIMM; Output neuron: ATMM). **Model: D** (Input neuron: PIMM, ATMM; Output neuron: IUMM).

Figure 5 Proposed research model
Source: own elaboration

*Structural equation modeling (SEM) analysis***:** The data collected point to good reliability (with latent construct values exceeding the minimum threshold level of 0.70 (Bagozzi et al., 1988)), and validity (convergent validity with AVE values more than 0.5, which are in line with the threshold recommended by Fornell & Larcker (1981),) see **Table 2**. All correlations were smaller relative to the square root of average variance employed along the diagonals, suggesting satisfactory discriminant validity (Fornell & Larcker, 1981) (See **Table 3**).

Table 2 Construct reliability and validity assessment

Constructs	**Items**	**Loadings[1]**	**AVE[2]**	**CR[3]**	**α[4]**
Mobile money self-efficacy (SEMM)	SEMM1	0.922	0.745	0.897	0.85
	SEMM2	0.817			
	SEMM4	0.846			
Mobile money technology anxiety (TAMM)	TAMM1	0.935	0.821	0.932	0.896
	TAMM2	0.838			
	TAMM3	0.942			

To continue **Table 2**: Construct reliability and validity assessment

Constructs	**Items**	**Loadings[1]**	**AVE[2]**	**CR[3]**	**α[4]**
Perceived ease-of-use mobile money (PEMM)	PEMM1	0.885	0.744	0.897	0.828
	PEMM2	0.91			
	PEMM3	0.789			
Mobile money perceived usefulness (PUMM)	PUMM1	0.879	0.726	0.888	0.815
	PUMM2	0.887			
	PUMM3	0.786			
Attitude toward mobile money (ATMM)	ATMM1	0.87	0.662	0.886	0.83
	ATMM2	0.829			
	ATMM3	0.795			
	ATMM4	0.755			
Personal innovativeness in mobile money (PIMM)	PIMM1	0.847	0.67	0.89	0.838
	PIMM2	0.811			
	PIMM3	0.717			
	PIMM4	0.891			
Mobile money usage intention (IUMM)	IUMM1	0.852	0.72	0.911	0.871
	IUMM2	0.889			
	IUMM3	0.765			
	IUMM4	0.882			

[1]All item Loading > 0.5 indicates indicator Reliability (Hulland, 1999); [2]All Average Variance Extracted (AVE)> 0.5 as an indication of Convergent Reliability (Bagozzi et al., 1988); [3]All Composite Reliability (CR)>0.7 indicates internal Consistency (Gefen et al., 2000); [4]All Cronbach's alpha > 0.7 indicates indicator Reliability (Bernstein & Nunnally, 1994).

Source: own research result

Table 3 Discriminant validity (Fornell–Larcker criterion test)

Constructs	**ATMM**	**SEMM**	**TAMM**	**IUMM**	**PEMM**	**PUMM**	**PIMM**
Attitude toward mobile money (ATMM)	**0.814**						
Mobile money self-efficacy (SEMM)	0.245	**0.863**					
Mobile money technology anxiety (TAMM)	0.174	0.03	**0.906**				
Mobile money usage intention (IUMM)	0.309	0.218	0.018	**0.848**			
Perceived ease-of-use mobile money (PEMM)	0.556	0.194	0.125	0.306	**0.863**		
Mobile money perceived usefulness (PUMM)	0.435	0.227	-0.001	0.187	0.379	**0.852**	
Personal innovativeness in mobile money (PIMM)	0.355	0.098	0.156	0.246	0.362	0.219	**0.819**

Source: own research result

To assess the structural model, collinearity issues, significance, and relevance of the model paths, coefficients of determination (R^2), predictive sample reuse technique (Q^2), and the effect size (f^2) were tested (see **Table 4**). Variance inflation factors (VIF) and tolerance for each set of predictors were analyzed to remove any suspicion of collinearity concerns, and their values were found below the suggested thresholds of 5 and 0.2, respectively (J.F. Hair et al., 2017). According to Joe F. Hair et al. (2011), in the marketing field, the coefficients of determination (R^2) value of 0.25 is weak, 0.50 is moderate, and 0.75 is substantial. **Figure 5** shows the model with the latent variables and the coefficients. The Q^2 can effectively be employed as a criterion

for predictive relevance (Chin et al., 2008). According to Fornel & Cha (1994), a Q^2 greater than 0 implies the model has predictive relevance, while a Q^2 less than 0 implies that the model lacks predictive relevance. The effect size (f^2) of the variables of interest was investigated to assess the impact of each exogenous latent construct on the endogenous latent construct if deleted from the model (**Table 4**). The f^2 values of 0.35 indicate a strong effect, 0.15 is a moderate effect, and 0.02 is a weak effect, according to Cohen (1988) and J.F. Hair et al. (2017). The R^2, Q^2, and f^2 test results indicated a good fit of the model and that the finding and conclusions drawn from this research are relatively robust.

Table 4 Coefficient of determination (R2), predictive sample reuse technique (Q2) and effect size (f2)

Endogenous construct	**R^2**	**Q^2**	**Relationship**	**f^2**	**Decision**
ATMM	0.505	0.241	PEMM→ATMM	0.327	Large
			PUMM→ATMM	0.108	Moderate
			PIMM→ATMM	0.035	Weak
IUMM	0.146	0.077	ATMM →IUMM	0.082	Weak
			PIMM →IUMM	0.024	Weak
PEMM	0.058	0.032	SEMM →PEMM	0.042	Weak
			TAMM →PEMM	0.018	No effect
PUMM	0.223	0.110	SEMM →PUMM	0.029	Weak
			TAMM →PUMM	0.005	No effect
			PEMM→PUMM	0.215	Moderate

Source: own research result

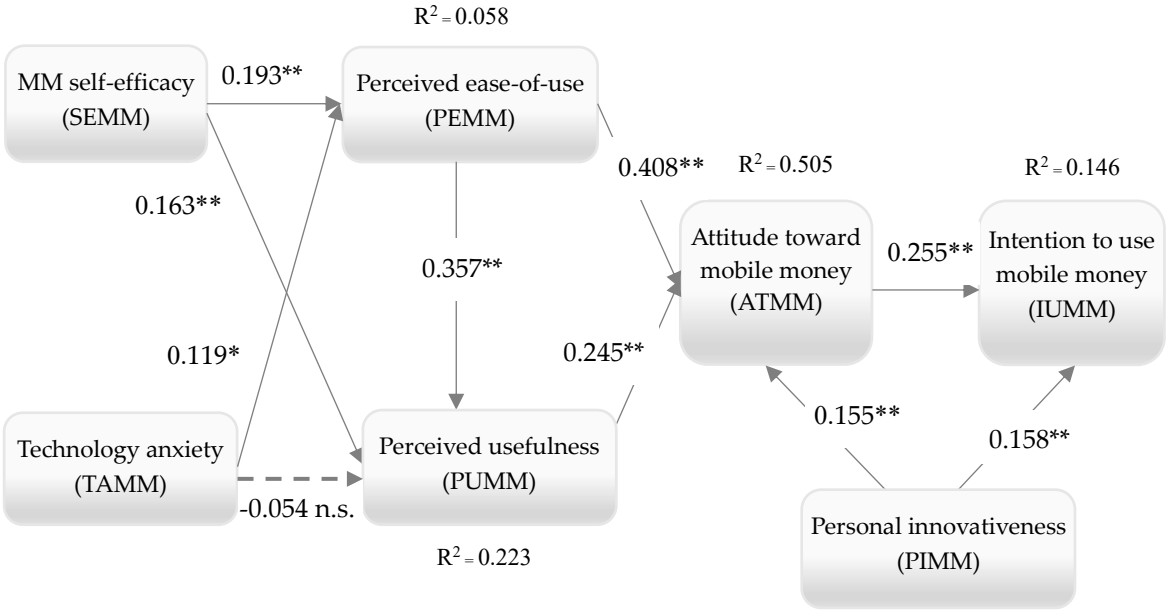


Figure 6 SEM path analysis results.

Notes: ** P<0.01, *P<0.05, n.s.= No statistically significant effect.

For the paths of the model, **Table 5** shows the results for the estimated regression coefficients with standard errors and t-values. All calculated coefficients are significant at $p < 0.05$. Most of the hypothesized relationships regarding the direct effect were significant, except for H2b ($\beta_{TAMM \rightarrow PUMM} = -0.054$, $t = 1.08$, $p > 0.05$). The results confirm the statistical significance of nine out of the ten tested direct effects. Regarding the indirect relationship, seven hypotheses were statistical significance amongst the eight tested indirect effects (i.e., mediating effect). H3a ($\beta_{PEMM \rightarrow ATMM} = 0.408$, $t = 8.397$, $p < 0.001$) was the most significant based on path coefficients.

This implies that mobile money users rely on the perceived ease-of-use with low perceived usefulness during mobile money adoption. Based on H5a ($\beta_{PIMM \rightarrow ATMM} = 0.155$, $t = 4.173$, $p < 0.01$) and H5b ($\beta_{PIMM \rightarrow IUMM} = 0.158$, $t = 3.248$, $p < 0.01$), personal innovativeness contributes significantly to both user's attitude and intention to adopt mobile money service. As shown in **Table 5**, the positive and statistically significant direct effect of H5b ($\beta_{PIMM \rightarrow IUM} = 0.158$, $t = 3.248$, $p < 0.01$) and the positive and statistically significant indirect effect of H9a ($\beta_{PIMM \rightarrow ATMM \rightarrow IUMM} = 0.04$, $t = 3.103$, $p < 0.01$) support the complementary mediation effect (J.F. Hair et al., 2017) of the attitude of users on the relationship between personal innovativeness and intention to use. Similarly, the positive and statistically significant direct effect of H3a ($\beta_{PEMM \rightarrow ATMM} = 0.408$, $t = 8.397$, $p < 0.01$) together with the positive and statistically significant indirect effect of H8 ($\beta_{PEMM \rightarrow PUMM \rightarrow ATMM} = 0.088$, $t = 4.214$, $p < 0.01$) patronize the complementary mediation of the perceived usefulness regarding the relationship between perceived ease-of-use and attitude (cf. (Gbongli et al., 2019)).

Table 5 Result of hypotheses testing

Hypothesis	Relationship	β	SE	t-Values	95% CI LL	95%CI UL
Direct effect						
H1a	SEMM -> PEMM	0.193	0.048	3.965**	0.109	0.267
H1b	SEMM -> PUMM	0.163	0.042	3.794**	0.09	0.231
H2a	TAMM -> PEMM	0.119	0.051	2.337*	0.031	0.201
H2b	TAMM -> PUMM	-0.054	0.046	1.08	-0.131	0.02
H3a	PEMM -> ATMM	0.408	0.048	8.397**	0.33	0.487
H3b	PEMM -> PUMM	0.357	0.049	7.187**	0.277	0.435
H4	PUMM -> ATMM	0.245	0.05	4.899**	0.158	0.327
H5a	PIMM -> ATMM	0.155	0.037	4.173**	0.096	0.214
H5b	PIMM -> IUMM	0.158	0.048	3.248**	0.078	0.242
H6	ATMM -> IUMM	0.255	0.046	5.475**	0.174	0.326
Indirect Effect						
H7a	SEMM -> PEMM -> ATMM	0.078	0.023	3.428**	0.042	0.116
H7c	TAMM -> PEMM -> ATMM	0.049	0.021	2.254**	0.014	0.083
H7b	SEMM -> PUMM -> ATMM	0.041	0.013	2.935**	0.02	0.063
H7d	TAMM -> PUMM -> ATMM	-0.013	0.011	1.099	-0.028	0.008
H8	PEMM -> PUMM -> ATMM	0.088	0.021	4.214**	0.057	0.126
H9c	PEMM -> ATMM -> IUMM	0.104	0.023	4.502**	0.068	0.143
H9b	PUMM -> ATMM -> IUMM	0.064	0.018	3.497**	0.037	0.097
H9a	PIMM -> ATMM -> IUMM	0.04	0.013	3.103**	0.02	0.062

Notes: ** P < 0.01, *P < 0.05; SEMM = Mobile money self-efficacy; TAMM = Mobile money technology anxiety; PEMM = Perceived ease-of-use mobile money; PUMM = Mobile money perceived usefulness; PIMM =Personal innovativeness in mobile money; ATMM = Attitude toward mobile money; IUMM = Mobile money usage intention.

Source: own research result

Artificial neural networks (ANNs) and sensitivity analysis: In this study, the extensive neural network model –multilayer perceptron (MLP) with the feedforward backpropagation (FFBP) training algorithm– was applied (Chong, 2013) (Yadav et al., 2016) in SPSS 21 using the sigmoid activation function for hidden and output layers (Liébana-Cabanillas et al., 2017) (Ooi & Tan, 2016). Sigmoid function and their combinations, largely work better in the context of classifiers and sometimes prefer when the researcher expects an output or intermediate layer of the net to represent the probability of an event. Based on the output value range of sigmoid, the normalizing output of each neuron can be assessed as well.

$$\text{Sigmoid}(x) = \frac{1}{1+e^{-x}} \quad (1)$$

The accuracy of the network models is assessed by RMSE (Chong, 2013), which is computed as the difference between actual and predicted values of the dependent constructs, i.e., consumer's intention to use mobile-based money services. The summary of RMSE values for all four ANN models is provided in **Table 6**. The RMSE values achieved through all four neural network models for training and testing data points are very small. Hence, the results are relatively accurate (Liébana-Cabanillas et al., 2017) (Sharma, 2019). The number of non-zero synaptic weights linked to the relevant hidden units is used to validate the relevance of the variables. Hence, all factors are relevant in predicting the dependent variable. The normalized or relative importance values were computed as the ratio of the relative importance of each variable with its largest importance and expressed in percentage form (Liébana-Cabanillas et al., 2017).

From **Table 7**, the sensitivity analysis performance was then computed by averaging the importance of the input variables in predicting the output for the ten networks (Chong, 2013). Therefore, the relative strengths of the causal relationships were assessed and grounded on the normalized importance from the sensitivity analysis (Tan et al., 2014).

The result revealed SEMM as the critical determinant in predicting PEMM, followed by TAMM in model A. In model B, PEMM is the most prominent predictor for PUMM, followed by SEMM. For model C, the order of importance towards ATMM in descending order is PEMM, followed by PUMM and PIMM. Last but not least, ATMM was the most effective in predicting IUMM, followed by PIMM. Remarkably, the ANN models (See **Figure 7**) can learn complex linear and non-linear relationships among decision variables compared to structural models, which only detect linear relations (Sharma, 2019).

Table 6 RMSE values of ten artificial neural networks

	Model: A		Model: B		Model: C		Model: D	
Network	Input neuron: SEMM, TAMM		Input neuron: SEMM, PEMM		Input neuron: PEMM, PUMM, PIMM		Input neuron: PIMM, ATMM	
	Output neuron: PEMM		Output neuron: PUMM		Output neuron: ATMM		Output neuron: IUMM	
	Training	Testing	Training	Testing	Training	Testing	Training	Testing
ANN1	0.1369	0.0495	0.1387	0.0375	0.0969	0.0367	0.1472	0.0579
ANN2	0.1390	0.0511	0.1321	0.0555	0.0972	0.0369	0.1498	0.0505
ANN3	0.1358	0.0521	0.1425	0.0306	0.1033	0.0254	0.1490	0.0554
ANN4	0.1395	0.0432	0.1413	0.0479	0.1088	0.0405	0.1505	0.0539
ANN5	0.1396	0.0415	0.1364	0.0441	0.1037	0.0342	0.1510	0.0516
ANN6	0.1371	0.0489	0.1379	0.0379	0.1004	0.0318	0.1543	0.0424
ANN7	0.1385	0.0472	0.1387	0.0355	0.1025	0.0234	0.1499	0.0524
ANN8	0.1400	0.0525	0.1430	0.0427	0.0977	0.0385	0.1485	0.0554
ANN9	0.1383	0.0533	0.1353	0.0459	0.1033	0.0239	0.1499	0.0522
ANN10	0.1415	0.0515	0.1351	0.0464	0.1021	0.0365	0.1522	0.0476
Mean RMSE	0.1386	0.0491	0.1381	0.0424	0.1016	0.0328	0.1502	0.0519
Standard deviation	0.0017	0.0040	0.0035	0.0072	0.0037	0.0064	0.0020	0.0044

Notes: SEMM = Mobile money self-efficacy; TAMM = Mobile money technology anxiety; PEMM = Perceived ease-of-use mobile money; PUMM = Mobile money perceived usefulness; PIMM =Personal innovativeness in mobile money; ATMM = Attitude toward mobile money; IUMM = Mobile money usage intention.

Source: own research result

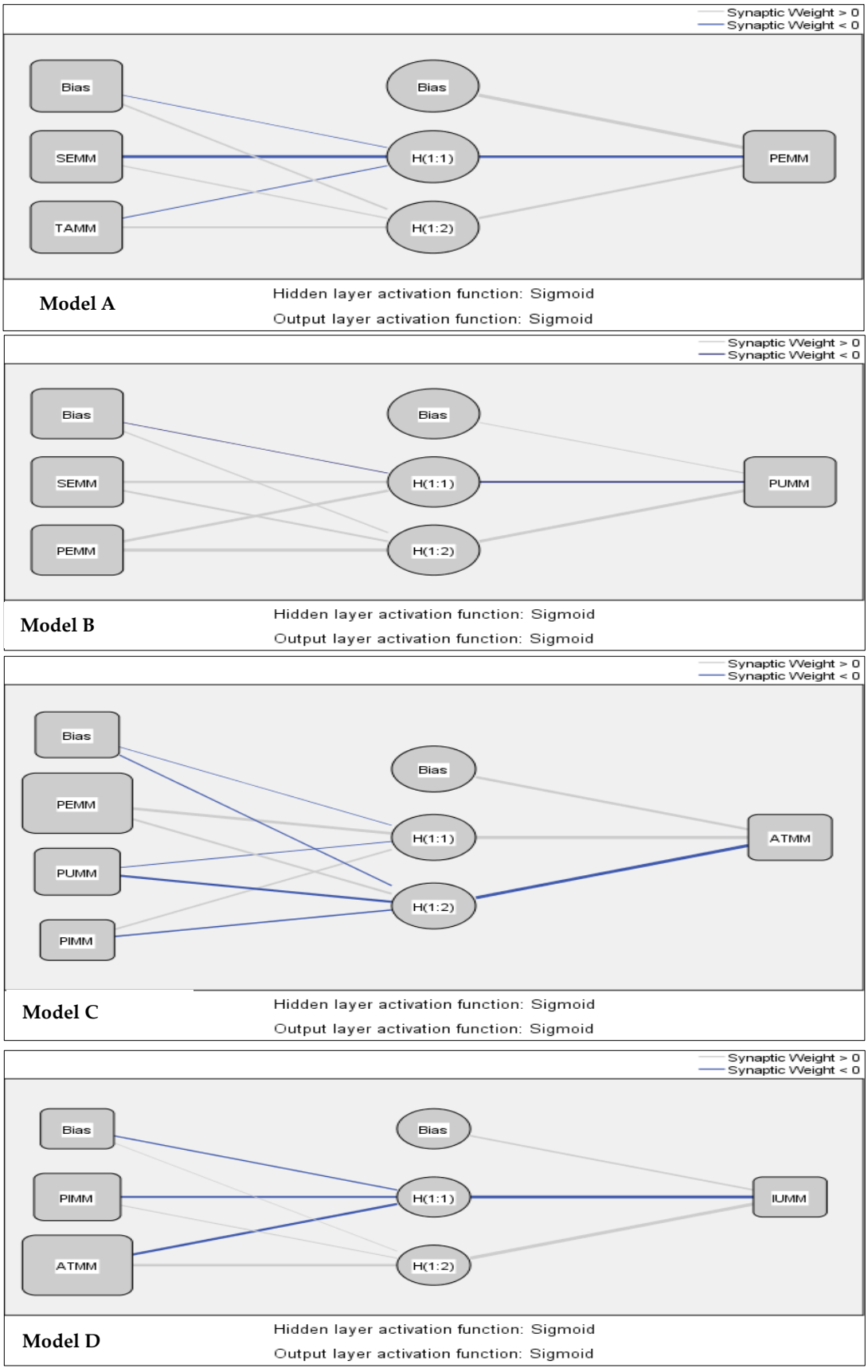


Figure 7 Artificial neural network used in this study
Source: own research result

Table 7 Neural network sensitivity analysis

Network	Model A		Model B		Model C			Model D	
	Output neuron: PEMM		Output neuron: PUMM		Output neuron: ATMM			Output neuron: IUMM	
	Relative importance		Relative importance		Relative importance			Relative importance	
	SEMM	TAMM	SEMM	PEMM	PEMM	PUMM	PIMM	PIMM	ATMM
ANN1	0.562	0.438	0.334	0.666	0.495	0.310	0.194	0.405	0.595
ANN2	0.612	0.388	0.321	0.679	0.528	0.308	0.165	0.368	0.632
ANN3	0.566	0.434	0.334	0.666	0.541	0.239	0.220	0.442	0.558
ANN4	0.548	0.452	0.100	0.900	0.419	0.255	0.326	0.517	0.483
ANN5	0.520	0.480	0.299	0.701	0.422	0.270	0.308	0.531	0.469
ANN6	0.537	0.463	0.221	0.779	0.617	0.184	0.199	0.500	0.500
ANN7	0.630	0.370	0.328	0.672	0.602	0.277	0.120	0.478	0.522
ANN8	0.831	0.169	0.594	0.406	0.390	0.278	0.332	0.286	0.714
ANN9	0.660	0.340	0.220	0.780	0.568	0.224	0.208	0.389	0.611
ANN10	0.645	0.355	0.272	0.728	0.402	0.303	0.295	0.503	0.497
Average relative importance	0.611	0.389	0.302	0.698	0.498	0.265	0.237	0.442	0.558
Normalized importance (%)	100.0	63.6	43.3	100.0	100.0	53.1	47.5	79.2	100.0

Notes: SEMM = Mobile money self-efficacy; TAMM = Mobile money technology anxiety; PEMM = Perceived ease-of-use mobile money; PUMM = Mobile money perceived usefulness; PIMM =Personal innovativeness in mobile money; ATMM = Attitude toward mobile money; IUMM = Mobile money usage intention.

Source: own elaboration

This research reveals the relevance of the two-stage approach integrating SEM and ANN techniques to enhance the assessment of technology adoption models for decisions makers. By comparing the results of the SEM and the ANN analyses, the major difference lies in the strength of the effect of the two constructs relating to innate personal ability and personality traits. The ANN analysis increases the relative importance of self-efficacy in the ease of using a mobile money transfer. Similarly, the relative importance of personal innovativeness has been improved regarding its effect on user attitude and intention to use mobile money with ANN analysis. The results reveal that ANNs are better than SEM in learning, predicting, and clarifying various factors influencing mobile money adoption. However, SEM supports the causal analysis (the reliability and validity of the measurements and path analysis), which is found to be limited in ANN application. Therefore, a multi-analysis technique such as the integrated approach (SEM-ANN) contributes more to sharpening the understanding of model variables' effect than using a sole technique.

From a different angle, the outcomes of this research have immense practical and managerial implications. This study can provide useful insights to the decision makers of telecommunication service providers, mobile money app developers, and mobile money service providers to enhance and maintain their customer base. First, the government of several emerging economies has been making efforts to achieve greater financial inclusion by using technology (Aggarwal et al., 2010). Recently, the African Development Bank (AfDB), in collaboration with the government of Togo, offered subsidies to farmers through e-wallets provided by mobile network operators Moov and Togocel in patronizing the digitization project of the agriculture transformation agenda (Aggarwal et al., 2010). Grounded on the World Bank/AfDB report, mobile financial services (MFS) significantly positively influence some

West African nations' macroeconomic development, and even the percentage of effect could reach a double-digit. Based on the proportion of GDP, among the largest beneficiaries are Togo (10.7%) and Cape Verde (9.4%) (Ratha et al., 2011). Islam et al. (2018) reported the significant benefits of mobile money on firm investment in three East Africa economies and encouraged the use of such services in other developing countries.

❖ Regarding the impact of customers' risk perceived in mobile money acceptance during the COVID-19 while using a multi-analytic methodology such as SEM-ANN, the result confirmed almost the hypotheses derived from the literature. Importantly, our results suggest that perceived privacy risk (PRR) stands out as the most critical antecedent of the perceived overall risk (POR), in which the latter negatively affects the behavioral intention (BI) to use mobile money services (MMS). This study remains the first to examine MMS acceptance during the COVID-19 crisis empirically. The results are based on survey data and assume a very simple model; however, they provide valuable insights for theory and practice understanding factors influencing mobile money adoption. To promote citizens' trust, service providers must provide instructions on using MMS safely and coping with privacy breaches and security problems if they arise. The SEM-ANN methodology will aid fulfill the current literature gap of MMS acceptance and provide practical guidance for evidence-based decision-making (cf. (Gbongli, 2022b)**)**

9 Concluding Scholarly Implications of Integrated Findings Remark

Over the past two decades, the range of digital financial services accessible through mobile phones has grown significantly. Whereas innovations play a critical role in making our life easier, their adoption by users is influenced by several factors. Notably, the recent rise of mobile phones in Africa has led to a heightened interest in mobile financial services (MFS), including mobile banking, mobile payment, and mobile money, which can be identified as the three domains of the MFS field (Shaikh et al., 2022). With the increasing use and demand for smartphones, research remains ongoing to assess customer, policy, management, and theoretical viewpoints in the MFS field (Chawla & Joshi, 2017). Most Previous efforts to synthesize knowledge in the MFS field have been sparse in scope and purpose.

This thesis aims to offer a systematic review of the literature on the MFS adoption and, to some extent, the adoption of mobile money services through the technology acceptance model (TAM). By leveraging AI strategies, including structural equation modeling (SEM) and artificial neural networks (ANN), this work provides a comprehensive understanding of the drivers of MFS adoption. These multi-analytical methodologies enable robust decision-making and prediction, crucial for enhancing financial inclusion in developing countries. We separately examined MFS and mobile money services using quantitative survey data to reveal adoption drivers through these advanced analytical techniques. The primary contributions of this work include integrating AI strategies to predict factors influencing consumer acceptance of MFS and categorizing different types of MFS based on user preference. The findings are presented and compared with existing literature, highlighting significant contributions to academic and practical fields while acknowledging limitations. This research offers valuable insights for financial institutions, service providers, policymakers, and scholars, ultimately promoting financial inclusion through the effective adoption of mobile financial services.

9.1 Summary of Findings

This dissertation predicts factors influencing consumer acceptance of mobile financial services (MFS) and categorizes MFS types based on user preference using multi-analytical methodologies. It includes five studies: three on MFS and two on mobile money services.

Table 8 below provides an overview of the key predictors of mobile financial services

(MFS), the most frequently used drivers based on the Technology Acceptance Model (TAM), and both significant and non-significant relationships reported in the remaining chapters. Chapters 5 and 6 utilized a Structural Equation Modeling (SEM) and Artificial Neural Network (ANN) methodology to examine MFS, resulting in two columns for each chapter that offer information on the critical factors and their respective importance levels.

The study combined some constructs such as (i) perceived usefulness (TAM), (ii) relative advantage (DOI), (iii) performance expectancy (UTAUT), extrinsic motivation, job fit, and outcome expectations into one construct: performance expectancy, as they were deemed equivalent by Venkatesh et al. (2003c). In the same vein, (i) compatibility (DOI) and (ii) facilitating conditions (UTAUT2) were both classified as facilitating conditions. Effort expectancy was used to capture the concepts of (i) perceived ease of use and (ii) complexity in the UTAUT. In chapter 4, the adoption of MFS is reflected as behavioral intention, general trust as trust, and aggregate perceived risk as risk.

Table 8 List of significant and non-significant relationships

Independent/ Input neuron	Dependent/ Output neuron	Chapter						
		$2\ MFS$	$3\ MFS$	$4\ MFS$	$5\ MM_{(SEM)}$	$5\ MM_{(ANN)}$	$6\ MM_{(SEM)}$	$6\ MM_{(ANN)}$
Performance Expectancy (PE)/ Perceived Usefulness (PU)	Behavioral Intention	*						
Attitude (AT)		*			*	$1_{(PI)}$		
Effort Expectancy (EE)/ Perceived Ease-of–Use (PEOU)		*						
Habit (HB)		*						
Subjective Norms (SN)		*	*					
Perceived security (PS)		*	*					
Facilitating Condition (FC)/Compatibility			*					
Trust (TR)/(General Trust)			*	*				
Self-Efficacy (SE)			*					
Perceived Mobility (PM)			*					
Perceived Risk (PR)/Aggregate or Overall perceived risk)			*	*			*	
Personal innovativeness (PI)					*	$2_{(PR)}$		
Dispositional Trust (DT)	General Trust			*				
Technology Trust (TT)				*				
Vendor Trust (VT)				*				
Perceived Privacy Risk (PRR)	Aggregate perceived risk			*			*	$1_{(TIR,MOR.SER)}$
Perceived security Risk (SER)				*			*	$4_{(PRR,TIR,MOR)}$
Perceived Time Risk (TIR)				n.s.			n.s.	$2_{(PRR,MOR,SER)}$
Perceived cost (PC)/ Perceived monetary risk (MOR)				*			*	$3_{(PRR,TIR,SER)}$
self-efficacy (SE)	PEOU				*	$1_{(TA)}$		
Technology anxiety (TA)	PEOU				*	$2_{(SE)}$		
self-efficacy (SE)	PU				*	$2_{(PEOU)}$		
Technology anxiety (TA)	PU				n.s.			
PEOU	PU				*	$1_{(SE)}$		
PEOU	AT				*	$1_{(PU,PI)}$		
PU	AT				*	$2_{(PEOU,PI)}$		
PI	AT				*	$3_{(PEOU,PU)}$		

Notes: MFS: Mobile financial services; MM_{SEM}: Mobile money study with Structural Equation modeling; MM_{ANN}: Mobile money study with Artificial Neural Network; n.s.= No statistically significant effect

Source: own research result

In **Table 8** for instance, the significant hypothesis in the second row of the 5MM $_{(SEM)}$ column suggests that attitude significantly influences predicting mobile money behavioral intention when using the SEM methodology in chapter 5. Regarding intention, (i) perceived risk was significant in three studies, while (ii) attitude was significant in two studies, with greater relative importance than personal innovativeness. Additionally, (iii) subjective norms, perceived security, and trust were significant in the two studies. Regarding perceived risk, (iv) perceived privacy risk was significant in two studies, with higher relative importance than time, monetary, and security risks. For hypotheses that are non-significant, the Table highlights the statistically non-significant impact of perceived time risk on the aggregate perceived risk for MFS adoption (chapter 4) and mobile money service adoption (chapter 6). Moreover, the impact of technology anxiety on mobile money's perceived usefulness (chapter 5) was also non-significant.

We started the second chapter with a systematic literature review (SLR) and weight analysis of the last decade's research on mobile financial services (MFS) acceptance, despite being the most recent study developed and published. We found six factors to be the best predictors of the behavioral intention to use MFS: (i) attitude, (ii) perceived ease of use, (iii) performance expectancy, (iv) habit, (v) social norms, and (vi) perceived usefulness. We constructed a Technological-Personal-Environmental (TPE) framework from the review to support future research in this field.

Chapter three provides a comprehensive review of TAM-based MFS studies. We tried to fill the gap by offering a literature review in the subject-specialist field while covering all relevant studies under it. We discovered that these studies' main variables predicting behavioral intention were (i) perceived security, (ii) compatibility, (iii) subjective norm, (iv) trust, (v) facilitating condition, (vi) self-efficacy, (vii) perceived mobility, and (viii) risk. Our paper highlights the importance of consumers' perceptions of MFS regarding service quality and how technology acceptance theories can improve our understanding of user intentions.

In chapter four, we analyzed the multidimensional effect of the trust and risk model on mobile financial services (MFS) and used the output of this analysis to classify MFS types based on the preferences of experts and experienced MFS users in Togo. We found that vendor trust, technology trust, and dispositional trust were significant antecedents of general trust, while perceived privacy risk was a significant driver of aggregate perceived risk. We also found that dispositional trust and general trust were critical drivers of MFS use behavior. Based on our analysis derived from the findings of TOPSIS, mobile money transfer was classified as the core application used in MFS, followed by mobile payment and mobile banking, which is consistent with AHP results on a similar topic.

The fifth chapter evaluated mobile money adoption in Togo by extending the technology acceptance model with self-efficacy, technology anxiety, and personal innovativeness. The study found that self-efficacy had the highest importance and a strong correlation with mobile money's perceived ease of use and usefulness. Users who believed in their ability to use mobile money transfers were more likely to find it useful. Perceived ease of use was the most significant factor in shaping attitude, followed by perceived usefulness and personal innovativeness. The study indicates that mobile money users in Togo value both ease of use and usefulness. With a higher relative importance score, personal innovativeness was also found to have a significant relationship with the intention to use mobile money. Individuals with higher levels of personal innovativeness were more likely to develop positive feelings toward using technology. The study highlights the importance of attitude in shaping behavioral intention.

The sixth chapter focuses on multidimensional risk perception, including perceived privacy risk, perceived time risk, perceived security risk, and perceived monetary risk in mobile money services in Togo. The study found that perceived privacy risk was the most significant predictor of the overall perceived risk, followed by perceived time, monetary, and security risks. This suggests that privacy risks should be carefully reflected when adopting mobile services in Togo.

9.2 Consistency and Compatibility of Findings Across Timing, Samples, Methodology

In order to confirm the efficacy of the approach taken in this dissertation and to distinguish it from other works, a comparison of the results obtained using various methods will be carried out. This will examine how different factors, such as timing, samples, and scientific methodologies, have influenced the outcomes. Through this analysis, the dissertation aims to highlight the unique contributions of its approach and offer insights into the factors that can impact research outcomes.

The comparison will be aided by **Table 8** (List of significant and non-significant relationships), **Table 9** (Summary of Data collected and methodology adopted), and **Table 10** (Comparison of MFS type between outputs of TOPSIS and AHP techniques). Such a practice ensures consistency and compatibility in the findings and supports the conclusion.

Consistency and compatibility regarding different timing: In chapters 4 and 6, the study examined the multifaceted perceived risk factors (as listed in **Table 8**) at different periods of data collection (March to May 2017 and September to November 2021, respectively, as shown in **Table 9**). By comparing two datasets (one in 2017 and the other in 2021 during this COVID-19 global crisis) with the same variables and applying the same SEM methodology, the study found that perceived privacy risk remains the most critical antecedent of perceived overall risk, which negatively affects the behavioral intention to use mobile financial services or mobile money service. The results were generally consistent, with a slight difference in the path coefficients. However, these findings partially align with earlier research on the COVID-19 pandemic's impact on mobile payment adoption, suggesting that perceived risk is moderated by perceived security (Belanche et al., 2022). Although the sample size and the data collection period differ between the study of chapters 4 and 6 (See **Table 9**), this particularity does not affect the comparison results.

Understanding users' behaviors is an efficient way to analyze new technology adoption and develop an appropriate strategy for optimizing users' experiences. We can conclude that perceived risk, particularly privacy concerns, prevailed irrespective of the forceful adoption of mobile money due to the COVID-19 pandemic. This implies that the situations may not change over time within the Togolese respondents. Therefore, this present research, which contributes to the perceived risk theory using perceived risk as a multi-dimensional framework within the scope of modern mobile financial service research, is appropriate. More research is required to encourage MFS companies to build trust-based strategies to improve service adoption.

Consistency and compatibility concerning the different samples and applied methodology: **Table 10** compares the MFS types obtained from two well-known MCDM techniques, TOPSIS and AHP. The rankings of alternatives obtained by both methods in the same dataset are similar, with mobile money being the most preferred MFS major category, followed by mobile payment and mobile banking. According to the study, the decisions made by different methods should have varied if there were discrepancies in the dataset. Chapters 5 and 6 utilized a hybrid SEM and ANN methodology (as shown in **Tables 8** and **9**). The findings from both methods are consistent, with trivial differences. Factors that revealed greater significance from the SEM technique also have the highest normalized importance with the ANN methodology. Given the

result of Chapter 5, the path coefficient between self-efficacy and perceived usefulness is 0.163 ($p < 0.01$), with the highest normalized importance. The major difference between the two methods lies in the strength of the effect of the two constructs relating to innate personal ability and personality traits. The ANN analysis increases the relative importance of self-efficacy in the ease of using mobile money transfer, and personal innovativeness is improved in terms of its effect on users' attitudes and intentions to use mobile money.

The method of multi-analytical data study, as suggested by Silberzahn et al. (2018), can be employed to assess the level of confidence that can be attributed to the conclusions drawn from the research. Overall, the SEM-ANN methodology used in Chapters 5 and 6 is consistent, with ANNs being better than SEM in learning, predicting, and clarifying various factors influencing mobile money adoption. However, SEM supports causal analysis, which is limited in ANN application. This finding is consistent with earlier research on mobile banking adoption (Sharma, 2019), suggesting that the integrated approach (SEM-ANN) contributes more to sharpening the understanding of the model variables' effect than using a single technique.

Table 9 Summary of Data collected and methodology adopted

Chapters	Data set timing	Sample	Methodology
Chapter 4	March-May, 2017.	538 MFS users with SEM, and 74 both MFS experienced users and experts for TOPSIS and AHP	SEM, AHP, TOPSIS
Chapter 5	Jan- Feb 2019	539 users of mobile-based money	SEM, ANN
Chapter 6	Sept- Nov 2021	275 respondents of mobile money services	SEM, ANN
Recall that Chapter 4 is the follow-up of the previous MFS adoption study with SEM-AHP methodology (Gbongli, 2017) on the same data set but adopting a different methodology with SEM-TOPSIS.			

SEM: Structural equation modeling, AHP: Analytic hierarchy process, TOPSIS: Technique for order of preference by similarity to an ideal solution, ANN: Artificial neural network.

Source: own research result

Table 10 Comparison of MFS type between outputs of TOPSIS and AHP techniques

Mobile financial services alternative	TOPSIS % distribution of coefficient	TOPSIS Rank	AHP % distribution of coefficient	AHP Rank
Mobile money	46.68%	1	60%	1
Mobile payment	38.24%	2	24.49%	2
Mobile banking	15.07%	3	15.26%	3

Source: own research result

9.3 Main Research Contributions and Recommendations

This study makes significant contributions to research and practice by advancing knowledge and offering direct implications for financial institutions, service providers, IT and marketing departments, users, and scholars. These contributions, based on identified research gaps and objectives, include leveraging AI strategies to provide a comprehensive understanding of the drivers of mobile financial services (MFS) adoption. By integrating structural equation modeling (SEM), artificial neural networks (ANN), and multicriteria decision-making techniques (MCDM), the study offers a robust framework for understanding user behavior and enhancing MFS adoption, thereby contributing to financial inclusion in developing countries.

9.3.1 Key Contributions

- **C1 – Systematic Literature Review:** Conducted the first systematic literature review (SLR) in mobile financial services (MFS) over the last ten years, incorporating a weight analysis and encompassing the COVID-19 pandemic period. This review introduced a framework categorizing common MFS constructs into Technological, Personal, and Environmental dimensions, providing a detailed understanding of the critical drivers,

models, and theories of MFS acceptance.

- **C2 – Technology Acceptance Model (TAM) Integration:** Utilized the technology acceptance model (TAM) to investigate the adoption of MFS through a sustained meta-analysis integrating the TAM framework and the PRISMA statement. This analysis contributes to a comprehensive understanding of the primary drivers behind MFS acceptance, advancing knowledge in this domain.
- **C3 – Trust and Risk Factors:** Identified trust and risk as primary factors influencing MFS adoption, introducing a novel benchmark methodology to assess their impact. The study confirmed the causal relationship between trust and risk, providing clarity on these complex concepts and highlighting the importance of trust-building strategies in low-trust societies.
- **C4 – Multi-Analytical SEM-ANN Approach:** Demonstrated the benefits of integrating structural equation modeling (SEM) with artificial neural network (ANN) analysis to investigate MFS adoption. This multi-analytical approach validates SEM results and identifies linear and complex non-linear relationships, increasing confidence and validity in the research outcomes.
- **C5 – Extended TAM Framework:** Proposed a novel research model combining the TAM framework with additional constructs such as self-efficacy, technology anxiety, and personal innovativeness. This multi-analytical SEM-ANN technique filled gaps in previous studies and provided a deeper understanding of individual attitudes and behavior towards mobile money in a developing country context.
- **C6 – Risk Perception During COVID-19:** Conducted the first systematic exploration of the relationship between risk perception and mobile money services (MMS) adoption in Togo during the COVID-19 pandemic using a multi-analytic methodology. The findings highlighted perceived privacy risk (PPR) as the most significant factor affecting overall perceived risk (POR), which negatively influences the intention to use MMS.
- **C7 – Practical Implications for Financial Inclusion:** The research offers valuable insights for practitioners to develop, enhance, and implement MFS that garner widespread consumer acceptance. Recommendations include prioritizing user-centered design, awareness campaigns, incentives, and ensuring data security and privacy to foster the adoption of mobile digital financial services and promote financial inclusion.

9.3.2 Selected New Scientific Findings

1. **Novel Framework for MFS Constructs:** Introduced a framework categorizing common MFS constructs into Technological, Personal, and Environmental dimensions.

2. **Validation of SEM-ANN Methodology:** Validated the SEM-ANN methodology as an effective approach for studying MFS adoption, demonstrating the synergy between traditional SEM and advanced AI techniques like ANN.

3. **Key Predictors of MFS Adoption:** Identified key predictors of MFS adoption, including perceived usefulness, ease of use, and trust, which are crucial for enhancing user acceptance.

4. **Impact of COVID-19 on MFS Acceptance:** Conducted a systematic literature review revealing the impact of the COVID-19 pandemic on MFS adoption and acceptance.

5. **Trust and Risk Benchmark Methodology:** Developed a novel benchmark methodology to assess the impact of trust and risk on MFS adoption, providing a new

perspective on these factors.

6. **AI-Driven Insights for Financial Inclusion:** Leveraged AI strategies, particularly the use of ANN, to provide deeper insights into customer behavior and enhance the understanding and prediction of MFS adoption.

9.4 Policy Analysis

The findings of this dissertation underscore the importance of perceived usefulness, perceived ease of use, and trust in the adoption of mobile financial services (MFS). Furthermore, self-efficacy and personal innovativeness significantly influence attitudes towards mobile money, highlighting the interplay between technological and personal factors in driving MFS adoption. This policy analysis section aims to translate these scientific insights into actionable recommendations for policymakers, financial institutions, and other stakeholders to enhance the adoption of MFS and promote financial inclusion.

9.4.1 Enhancing Technological Infrastructure

Recommendation:

- Invest in robust and reliable communication networks to support the widespread use of Internet-enabled phones, smartphones, and tablets, ensuring seamless access to mobile financial services.

Rationale:

- The accessibility and reliability of communication networks are foundational to the success of MFS. Enhanced infrastructure will reduce technical barriers and improve user experience, increasing perceived ease of use and usefulness.

9.4.2 Building Trust and Reducing Perceived Risk

Recommendation:

- Develop and implement comprehensive data privacy and security policies to protect users' information and build trust in mobile financial services.
- Conduct regular audits and transparency reports to demonstrate commitment to data security.

Rationale:

- Trust and perceived risk are critical factors influencing MFS adoption. Effective data privacy and security measures can mitigate perceived privacy risk, enhancing overall trust and encouraging adoption.

9.4.3 Promoting User Education and Digital Literacy

Recommendation:

- Launch educational campaigns to improve digital literacy, focusing on the benefits and safe use of mobile financial services.
- Provide resources and training programs to increase users' self-efficacy in navigating digital financial platforms.

Rationale:

- Increased digital literacy and self-efficacy can significantly enhance users' confidence in using MFS, addressing concerns related to technology anxiety and perceived complexity.

9.4.4 Leveraging AI and Multi-Analytical Approaches

Recommendation:

- Utilize AI-driven strategies, such as the SEM-ANN approach, to analyze user behavior and predict adoption patterns, enabling personalized and targeted financial services.
- Incorporate AI in developing user-centric applications that can adapt to individual

preferences and usage patterns.

Rationale:

- AI strategies provide deeper insights into customer behavior, allowing for the development of tailored services that meet specific user needs. This personalization can improve user satisfaction and adoption rates.

9.4.5 Encouraging Innovation and Personalization

Recommendation:

- Foster an environment that encourages personal innovativeness by supporting startups and financial technology (FinTech) initiatives that introduce innovative MFS solutions.
- Offer personalized financial products that cater to the diverse needs of different user segments, including underserved and unbanked populations.

Rationale:

- Innovation drives the evolution of MFS, and personalized products can address unique user requirements, enhancing perceived usefulness and overall adoption.

9.4.6 Facilitating Financial Inclusion During Crises

Recommendation:

- Implement emergency response strategies that leverage mobile financial services to provide uninterrupted financial access during crises such as the COVID-19 pandemic.
- Develop contingency plans that utilize digital financial platforms to distribute financial aid and support to affected populations swiftly.

Rationale:

- Crises can disrupt traditional financial services, but MFS can offer resilient and flexible solutions. Ensuring their availability during emergencies can maintain financial stability and inclusion.

By implementing these policy recommendations, stakeholders can enhance MFS adoption, tailor services to meet user needs, and expand financial inclusion efforts, particularly in underserved and unbanked communities. This integrated approach ensures that technological advancements translate into practical benefits, fostering a more inclusive and resilient financial ecosystem.

9.5 Research Limitations and Suggestions for Future Research

Despite the valuable contribution of this study to the mobile financial services domain, certain limitations exist, justifying further investigations and research. These limitations mainly pertain to factors beyond the researcher's control. It is recommended to address these limitations by replicating the study's theoretical models and methodology across different samples, countries, and cultural groups, using various technologies to validate the findings. Additionally, incorporating new studies as they are published can strengthen the systematic literature review and provide additional insights.

Regarding the weight analysis conducted in the systematic literature review, a notable limitation was the time frame in which the studies were developed, which concluded prior to the completion of the remaining studies included in the review. This limitation restricted the ability to test the model with the most commonly used constructs in the literature, highlighting the need for further investigation.

Furthermore, the review was limited to studies from the Scopus database, excluding conference publications, editorials, and book chapters. Expanding the scope to include a broader range of databases and studies may lead to variations in the significance of variables and relationships identified.

Lastly, the study solely examined the adoption of mobile financial services from a consumer

perspective. Future research could explore the adoption of mobile money services by different stakeholders, such as comparing the level of intention and acceptance among various financial institution market shares.

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Corresponding Publications

Papers of the Cumulative Dissertation

The following papers are part of the cumulative dissertation. The order of the list corresponds to the order in which the articles appear in the dissertation.

[1] **K. Gbongli,** "A Systematic Review and Weight Analysis of Mobile Financial Services Adoption Literature from 2011 to 2021," Theory, Methodol. Pract., vol. 18, no. 2, pp. 23–49, 2022, doi: 10.18096/TMP.2022.02.02.

[2] **K. Gbongli**, "Understanding Mobile Financial Services Adoption through a Systematic Review of the Technology Acceptance Model," Open J. Bus. Manag., vol. 10, no. 05, pp. 2389–2404, 2022, doi: 10.4236/ojbm.2022.105119.

[3] **K. Gbongli**, Y. Xu, K. M. Amedjonekou, and L. Kovács, "Evaluation and Classification of Mobile Financial Services Sustainability Using Structural Equation Modeling and Multiple Criteria Decision-Making Methods," Sustainability, vol. 12, no. 4, p. 1288, Feb. 2020, doi: 10.3390/su12041288.

[4] **K. Gbongli**, Y. Xu, and K. M. Amedjonekou, "Extended Technology Acceptance Model

to Predict Mobile-Based Money Acceptance and Sustainability: A Multi-Analytical Structural Equation Modeling and Neural Network Approach," Sustainability, vol. 11, no. 13, p. 3639, Jul. 2019, doi: 10.3390/su11133639.

[5] **K. Gbongli**, "Assessing perceived risk in mobile money adoption under COVID-19: a combined sem-artificial neural network techniques," Int. J. Res. -GRANTHAALAYAH, vol. 10, no. 1, pp. 69–95, Jan. 2022, doi: 10.29121/granthaalayah.v10.i1.2022.4434.

List of further Publication of the Author

Article papers

[1] Z. Shurong, K. Dumor, V. C. Lartey, O. M. Mutiiria, E. K. Amouzou, and **K. Gbongli**, "Assessing the macroeconomic effects of China–Eastern African BRI transport infrastructure on Eastern African countries," Int. J. Financ. Econ., Oct. 2022, doi: 10.1002/ijfe.2718.

[2] K. Dumor and **K. Gbongli**, "Trade impacts of the New Silk Road in Africa: Insight from Neural Networks Analysis," Theory, Methodol. Pract., vol. 2021, no. 02, pp. 13–26, 2021.

[3] O. E. Boadu, K. Kissi Mireku, and **K. Gbongli**, "Physical Optics and the Impedance Boundary Condition," Am. J. Eng. Res., vol. 6, no. 7, pp. 17–29, 2017.

[4] K. Gbongli, "A two-staged SEM-AHP technique for understanding and prioritizing mobile financial services perspectives adoption," Eur. J. Bus. Manag., vol. 9, no. 30, pp. 107–120, 2017.

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