AI AND GOVERNANCE QUALITY: TWIN PILLARS IN THE EVOLUTION OF FINANCIAL DEVELOPMENT

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A final year project submitted in partial fulfilment of the requirement for the degree of

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(2) No portion of this FYP has been submitted in support of any application for any other degree or qualification of this or any other university, or other institutes of learning.

(3) Equal contribution has been made by each group member in completing the FYP.

(4) The word count of this research report is _____22,532_____.

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DEDICATION

We would like to dedicate this project to all individuals who have played a role in its successful completion. Every form of contribution, whether direct or indirect, has been immensely valuable and deeply appreciated.

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PREFACE

This study is critically important for the fulfillment of our undergraduate program, the Bachelor of Business Administration (Honours) in Banking and Finance offered by Universiti Tunku Abdul Rahman (UTAR). The focus of this research is AI and Governance Quality: Twin Pillars in Financial Development. Accordingly, this study aims to examine how artificial intelligence (AI) and the quality of governance jointly influence the progress and stability of financial development, highlighting their interdependent roles in shaping a modern financial ecosystem.

With the rapid advancement of information and communication technologies, AI has become increasingly integrated into financial systems, transforming traditional operations and decision-making processes. At the same time, good governance—characterized by transparency, accountability, and strong institutional frameworks—remains essential to ensure that these technological innovations are implemented effectively and ethically. In this modern age, financial development is no longer driven by a single factor but rather by a combination of technological innovation and sound governance.

This comprehensive investigation into the dual impact of AI and governance quality is intended not only to enhance academic knowledge but also to offer practical insights for policymakers, regulators, and industry leaders. By understanding how these two pillars interact to influence financial development, the study aims to support the formulation of informed strategies that promote a robust, inclusive, and future-ready financial sector.

ABSTRACT

The growing importance of Artificial Intelligence (AI) as a transformative force in financial systems is gaining recognition, particularly in developing economies. However, the combined impact of AI adoption and governance quality on financial development remains insufficiently explored. This study examines the roles of AI integration and governance standards across 58 developing countries over the period of 1996 to 2021. The analysis reveals that: (1) increased adoption of AI technologies significantly supports the development of the financial sector, and (2) strong governance, particularly political stability, reinforces financial system security and fosters long-term financial growth. These effects are especially evident in countries facing higher levels of financial exclusion and where financial institutions demonstrate greater efficiency. The variables used to measure financial development, AI penetration, and governance quality include domestic credit to the private sector, digital infrastructure indicators, and political stability, respectively, sourced from the World Bank and other global databases. Employing the two-step system Generalized Method of Moments (GMM) estimator, the study ensures robustness against endogeneity and autocorrelation, while accounting for country-specific heterogeneity. The findings highlight key policy implications: (1) governments should focus on establishing politically stable and transparent institutions, and (2) strategic investment in AI technologies should be prioritized to enhance financial inclusion and accelerate economic development.

Keywords: Artificial Intelligence. Governance Quality, Financial Development, GMM, Financial Inclusion, Financial Performance, Macroeconomic Variable

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LIST OF ABBREVIATIONS

AI	Artificial Intelligence
AR(1)	Arellano-Bond Test (1)
AR(2)	Arellano-Bond Test (2)
ATM	Automated Teller Machines
CV	Control Variables
DEA	Data Envelopment Analysis
DIT	Diffusion of Innovation Theory
DV	Dependent Variables
FD	Financial Development
FDI	Foreign Direct Investment
FI	Financial Inclusion
FYP	Final Year Project
GFI	The World Bank: Global Financial Development
GMM	General Methods of Moments
GNI	Gross National Income
GDP	Gross Domestic Product
GQ	Governance Quality
HDI	Human Development Index
ICT	Information and Communication Technology
IMF	International Monetary Fund

IV	Independent Variable
MCV	Macroeconomic Variables
MSEs	Medium-Sized Enterprises
NIM	Net Interest Margin
OLS	Ordinary Least Square
ROA	Return on Assets
ROE	Return on Equity
SMEs	Small and Medium-Sized Enterprises
2SLS	2 Stage Least Square
UNDP	United Nations Development Programme
WDI	The World Bank: World Development Indicators
WGI	The World Bank: World Governance Indicator

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CHAPTER 1: INTRODUCTION

1.0 Introduction

Chapter One presents a detailed background on financial development, the growth of artificial intelligence, and governance quality, with research gaps identified. Next, research objectives, research questions, and hypotheses are constructed correspondingly. Moreover, the significance of the study is discussed comprehensively. Subsequently, the key points for each chapter in this study are summarised in the chapter layout. Finally, important points of Chapter One are summarised in the conclusion.

1.1 Research Background

1.1.1 Financial Development, Governance Quality, and Artificial Intelligence

Financial development serves a critical role in maintaining the stability and efficiency of financial systems, serving as the backbone for effective capital allocation, savings mobilisation, and financial inclusion (Bayar, 2023). The World Bank (2017) highlights the significance of a robust financial system in promoting these areas. A developed financial system, encompassing both financial institutions like commercial banks and financial markets such as stock and bond markets, is crucial for optimising capital allocation, attracting foreign capital inflows, and improving savings rates (Gorton & Winton, 2003; World Bank Group, 2017).

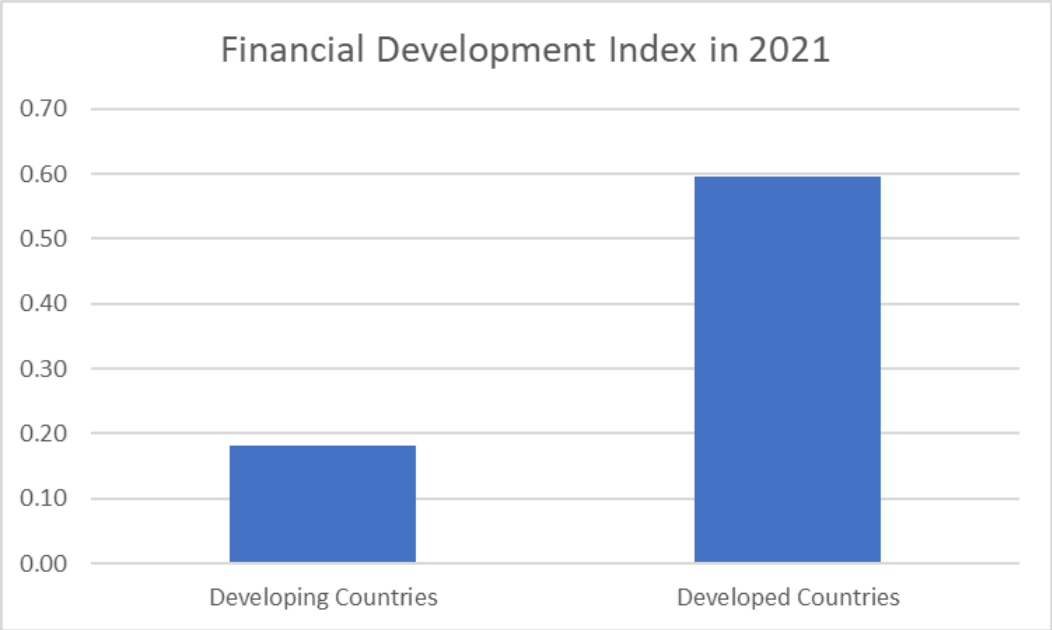

Figure 1.1.1 Financial Development Index in 2021. Adapted from (IMF, 2021)

Figure 1.1.1 presents a comparative analysis of financial development between developing and developed countries using the Financial Development Index. The graph illustrates that developed nations consistently score higher, indicating a more mature financial sector, broader access to financial services, and stronger regulatory frameworks.

This study focuses on developing countries, where financial systems face structural challenges. Existing literature suggests that while developing countries have made progress in economic and social indicators, their financial development still lags behind that of developed countries. According to Paprotny (2020), the gap between developing and developed countries in key development indicators has narrowed over time, but progress has been uneven. Within the developing world, some countries have made significant strides in closing gaps in economic and social development, while others continue to face challenges. These disparities highlight the persistent institutional, economic, and technological barriers that hinder financial development in many developing countries.

Countries are classified as developed or developing based on various economic, social, and technological indicators. Developed countries such as the United States, which had a GDP of $27.36 trillion in 2023, generally have a high per capita Gross Domestic Product (GDP) or Gross National Income (GNI) and tend to be in the top 25% of the Human Development Index (HDI), which scores countries on a scale from 0.000 (lowest development) to 1.000 (highest development) (World Bank, 2024). The HDI, tracked by the United Nations Development Programme (UNDP), incorporates GDP per capita, literacy rates, life expectancy, political stability, and access to essential services such as electricity. Countries with scores ranging from 0.800 to 1.000 are categorised as developed, whereas those with lower scores fall into the developing, least developed, or underdeveloped classifications (UNDP, 2013). Developing countries are further categorised into high, medium, or low HDI groups based on their scores, with the high group corresponding to HDI percentiles of 51-75 (UNDP, 2013). Additionally, the low- and lower-middle-income countries are also considered developing nations (World Bank, 2024).

The quality of governance has emerged as a crucial determinant of financial development. Effective governance ensures the stability, transparency, and efficiency of financial systems. As noted by Li and Filer (2007) and Abdelsalam et al. (2024), good governance fosters trust in financial institutions, which is essential for attracting investment and promoting financial inclusion. Bekana (2023) further emphasises that improvements in governance quality can significantly and positively impact the growth of financial sectors. Governance quality, characterised by strong regulatory frameworks and accountability, is not only about regulation but also about creating an environment conducive to innovation and growth (Vishwanath & Kaufmann, 2001).

During financial crises, the importance of governance becomes particularly evident. For example, the Global Financial Crisis draws a clear picture of

the importance of effective governance in supporting a robust financial system. Beck et al. (2014) discovered that an overexpansion of finance can hinder financial development once it surpasses a specific limit. Similarly, Arcand et al. (2012) discovered that once credit to the private sector approaches 100% of GDP, its influence on output begins to drop. These findings highlight the necessity of a balanced approach to financial development, where AI and governance work in tandem to ensure sustainable and inclusive growth. A study by Kaufmann et al. (2010) found that countries with stronger governance mostly result in more stable and efficient financial systems, further calling attention to the critical role of governance in financial development.

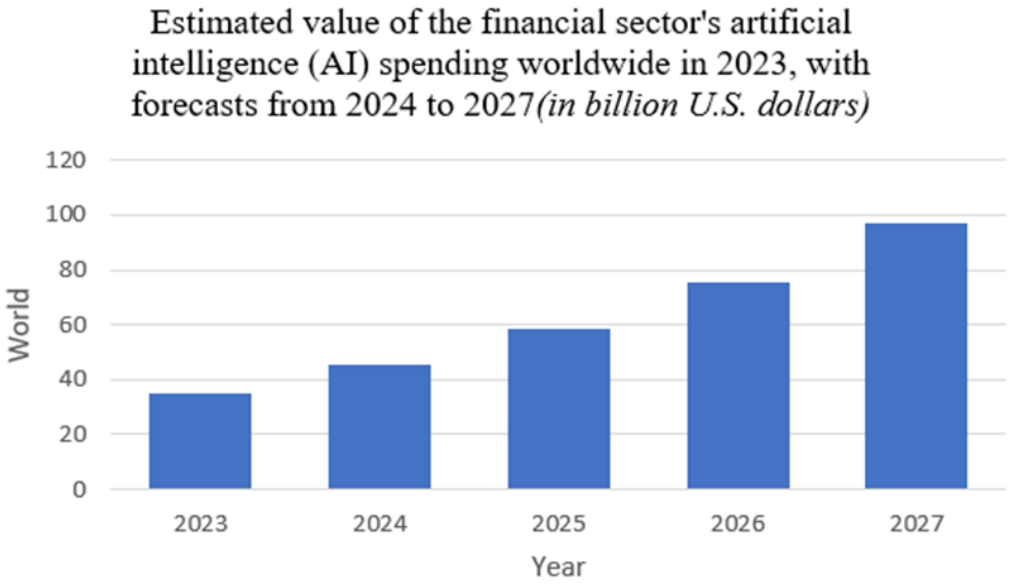

Figure 1.1.2 Estimated value of the financial sector's artificial intelligence (AI) spending worldwide in 2023, with forecasts from 2024 to 2027 (in billion U.S. dollars). Adapted from Statista (2024).

Over the last twenty years, artificial intelligence (AI) has advanced rapidly and is now applied across various industries and functions (Bahoo et al., 2024). AI encompasses computer systems that are built to carry out tasks that require human intelligence, such as learning, reasoning, problem-

solving, and interpreting language (The Investopedia Team & Scott, 2024). AI's integration into financial systems has enhanced efficiency, accuracy, and profitability through advanced data analytics, predictive modelling, and automation (Francis, 2018; Sarker, 2022). Moreover, Figure 1.1.2, adapted from Statista (2024), forecasts that AI spending worldwide will increase to US$97 billion in 2027, reflecting its growing significance in the financial sector. The widespread adoption of AI has been fuelled by advancements in machine learning, the increasing availability of big data, and the need for financial institutions to maintain a competitive edge in an ever-evolving marketplace (Dwivedi et al., 2023).

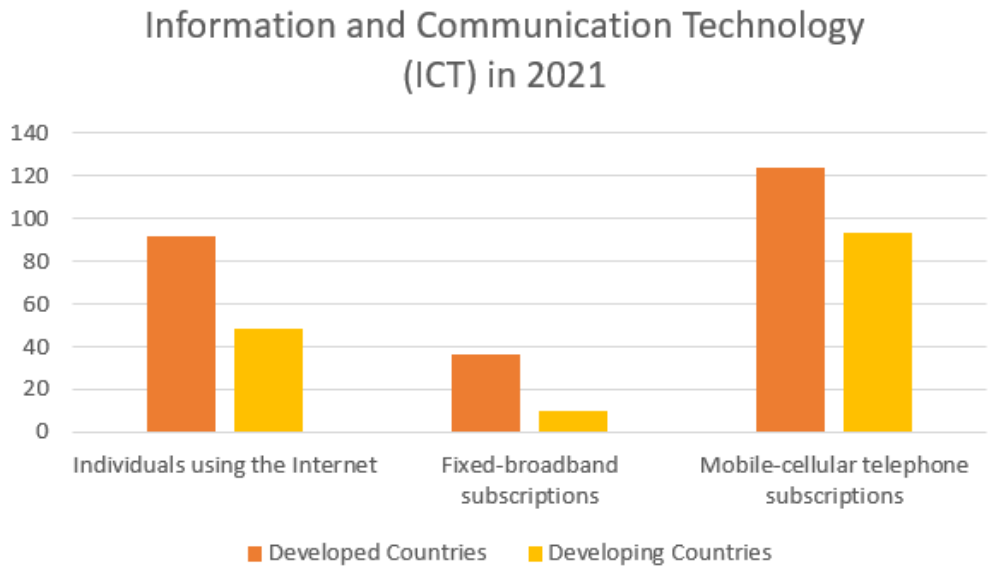

Figure 1.1.3 Information and Communication Technology (ICT) in 2021 (per 100 people). Adapted from (World Development Indicators | DataBank, 2021).

Information and Communication Technology (ICT) serves as the foundational infrastructure that supports both AI and governance quality. AI enhances ICT capabilities, which in turn support accessibility and efficiency (Makepe et al., 2012; Thakur, 2021). Since the 1990s, ICT has been an essential catalyst for growth, transforming economic, social, political, and cultural aspects of life (Vu, 2011; Pereira, 2014). It enhances process

efficiency, reduces costs, and improves productivity, particularly in trade activities, by minimising expenses and barriers related to moving goods through ports. For instance, cloud computing provides payment services that demand advanced computing power at a minimum cost (Gonzalez-Paramo, 2017). Indicators such as individuals using the internet (IUT), fixed broadband subscriptions (FBS), and mobile cellular subscriptions (MCS) per 100 inhabitants are proxies for ICT (Alshubiri et al., 2019).

In developed countries, ICT enhances communication and information exchange, allowing the efficient functioning of businesses and governments and expanding their reach to broader markets through e-commerce. This leads to increased productivity and financial development (OECD, 2005). Additionally, ICT supports advanced financial services, including digital banking and automated trading systems, which streamline operations and optimise financial management (Li et al., 2022). Furthermore, the diffusion of ICT within the financial sector leads to reduced costs, data-driven decision-making, and stronger supervision, thus supporting financial development via improved efficiency in financial institutions and reduced information asymmetry in transactions (Gonzalez-Paramo, 2017; Navaretti et al., 2018; Alshubiri et al., 2019).

In developing countries, ICT is equally transformative by facilitating financial inclusion through mobile banking, digital payments, and online financial services. These advancements connect underserved communication with vital financial resources, contributing to the growth of the financial sector (Hussain et al., 2023). Furthermore, ICT aids in education and skill development by providing access to online learning platforms, which are crucial for enhancing the employability and productivity of individuals in these regions (Pavel et al., 2015). However, ICT faced challenges in developing countries compared to developed countries due to constrained financial resources, limited internet, and inadequate mobile infrastructure (Kozma & Vota, 2013; Touray et al., 2013; Avgerou et al., 2016).

Overall, ICT serves as a catalyst for economic advancement, offering diverse benefits that adapt to the specific needs and capabilities of both developing and developed nations (Oloyede et al., 2023). AI's impact on financial development is profound. Its applications range from automating complex tasks to improving risk management and customer experiences. For instance, Haleem et al. (2022) note that AI-driven algorithms can process large datasets instantly, generating insights that improve financial decision-making and performance. Hence, as AI adoption accelerates, companies must navigate challenges such as integrating AI with existing systems, addressing ethical concerns, and ensuring data security.

Although the individual benefits of AI and governance quality in financial development are well-documented, there is a gap in perceiving their joint effect, particularly in developing countries. The integration of AI into financial systems requires robust governance to manage risks and ensure ethical usage. This study aims to address this gap through a thorough investigation of the synergistic impact of AI deployment and governance quality on financial development. This research will utilise GMM estimators to analyse this impact across developing countries, along with the control variables—financial inclusion, financial performance, and macroeconomic variables in the sampled countries.

1.2 Problem Statement

1.2.1 Governance Quality Affecting Financial Development

The association between financial development and governance quality is complex, with both theoretical and empirical studies presenting mixed findings. In some cases, weak governance systems may introduce inefficiencies within institutional frameworks, which can sometimes accelerate bureaucratic processes and seemingly drive economic outcomes.

However, these short-term benefits often come at a significant cost. While poor governance might initially appear to promote economic progress, it typically leads to long-term challenges such as increased inequality, diminished trust in institutions, and a less stable business environment, all of which hinder sustainable development. Khalid and Shafiullah (2020) emphasise the bidirectional relationship between governance and financial development, indicating that strong governance enhances financial systems, while financial development, in turn, reinforces better governance. Wen et al. (2022) further argue that governance quality plays a key role in attracting private and foreign direct investments (FDI), which are crucial for fostering economic growth. These points raise important questions about the sustainability of the financial growth being promoted.

Effective governance can have a positive and sustainable influence on financial development. Zhuang et al. (2010) argue that strong governance supports both economic growth and financial inclusion, especially in developing regions. Evidence shows that when governance mechanisms are effective, financial systems tend to be more resilient and contribute to broader economic prosperity (Khalid & Shafiullah, 2020; Iqbal et al., 2021). However, some democratic institutions, often considered markers of good governance, may sometimes redirect resources to address the needs of various social groups, which could limit their impact on financial development (Sirowy & Inkeles, 1990; Samarasinghe, 2018). Filfilan (2021) and Abaidoo and Agyapong (2022) examine how government effectiveness differs across economic contexts, noting that in welfare states or democratic regimes, governance can either support or impede financial development depending on institutional efficiency. Moreover, Atanga Ondoa and Seabrook (2020) highlight the importance of institutional characteristics in determining the effectiveness of governance in promoting financial development across different economies. These debates depict that the impact of governance quality on financial development is often context-dependent, shaped by unique institutional characteristics and socio-political environments (Mandon & Mathonnat, 2015).

1.2.2 AI Affecting Financial Development

The exponential growth of AI-driven technologies presents both transformative prospects and disruptive pitfalls, particularly in developing countries. AI is driving financial innovation by addressing infrastructure gaps and promoting financial inclusion (Bello, 2023). However, it also exposes vulnerabilities in governance and technical capacities. For example, in Kenya, AI-driven crop insurance programmes, designed to protect small-scale farmers from extreme weather, have struggled with poor data quality. These systems, which rely on satellite imagery to monitor rainfall and drought, often fail to account for localised weather conditions, leading to inaccurate assessments and incorrect payouts. As a result, many farmers have lost trust and abandoned the programmes, undermining financial stability in rural areas (Kagondu Njagi, 2019; Kshetri, 2020). Similarly, AI-based digital payment systems in India have encountered obstacles due to poor network coverage and data security concerns in rural regions, limiting their effectiveness (Fan & Qiang, 2024; Georgieva, 2024). In South Africa, the lack of skilled workers and inadequate infrastructure has further hindered the full potential of AI in financial services (UNCTAD, 2023). These examples underscore the need for careful planning and oversight in the deployment of AI technologies in developing economies.

Additionally, the application of AI in developing countries presents significant challenges that can impede financial development. The effectiveness of AI significantly depends on data quality, yet many developing nations face limitations in data collection and processing, which undermine the accuracy and reliability of AI models (Fan & Qiang, 2024; Georgieva, 2024). Furthermore, the rapid adoption of AI often surpasses the development of appropriate regulatory frameworks, raising concerns about algorithmic bias, data privacy, and systemic risks (Scherer, 2016; UNCTAD, 2023). The lack of robust infrastructure and skilled labour further widens the digital divide, limiting opportunities for financial innovation (Fan & Qiang, 2024). Without significant investments in infrastructure, education,

and governance reforms, AI's potential to drive sustainable financial development in these economies may remain unrealised (Mhlanga, 2021; UNCTAD, 2023; Georgieva, 2024).

1.2.3 Governance Quality and Artificial Intelligence Affecting Financial Development

According to the data presented in Figure 1.1.2 [Estimated value of the financial sector's artificial intelligence (AI) spending worldwide in 2023, with forecasts from 2024 to 2027 (in billion U.S. dollars), adapted from Statista (2024)], the rapid growth of AI investments in the financial sector highlights the potential for financial innovation and development. AI as a transformative technology holds the capacity to revolutionise government operations by improving service delivery, streamlining internal processes, reinforcing policy adherence, and detecting fraud (World Bank, 2021). However, these advancements also reveal substantial challenges, particularly in developing countries. This leads us to focus our research on the critical challenge of understanding how the interaction between AI and governance quality in developing nations impacts the successful deployment and effectiveness of AI-driven financial systems. As AI continues to transform financial systems worldwide, it is essential to understand the influence of governance quality on its deployment in these regions. This understanding is key to fully harnessing AI's potential while managing the associated risks (OECD, 2024).

As a disruptive technology, AI is reshaping the financial sector, driving financial development, while also posing governance challenges in developing countries. For example, AI-driven solutions have demonstrated potential in overcoming infrastructural challenges in developing economies and enhancing financial inclusion (Koester et al., 2023; Mucci & Stryker, 2023). According to a report by the International Monetary Fund (IMF), investment in AI by financial institutions is anticipated to exceed $97 billion

by 2027, growing at a compound annual rate of 29% (Kearns, 2023). In 2023 alone, AI spending in the financial industry is projected to reach $35 billion, with the banking sector contributing the largest share, approximately $21 billion (Kearns, 2023). Investment firms like Amundi SA are developing AI infrastructure for macroeconomic and market research and leveraging AI for personalised portfolio management, reflecting the technology's increasing role in financial services customisation (Kearns, 2023).

This study explores both the upside and downside of governance quality on financial development while also investigating the opportunities and challenges AI proposes within the financial sector (World Bank, 2017; Truby, 2020; Filfilan, 2021; Abaidoo & Agyapong, 2022). The subsequent analysis focuses on how the combination of governance quality and AI may influence financial development, assessing whether the interaction between governance quality and AI results in beneficial or adverse outcomes for financial development, along with the implications of this relationship.

The integration of governance quality with AI holds great promise for advancing financial development, especially in settings where governance frameworks are robust (World Bank, 2017). Effective governance practices, including transparency, accountability, and robust regulatory oversight, foster an environment conducive to AI-driven innovations within the financial sector. In countries where governance quality is high, AI contributes to enhanced financial system efficiency, improved access to financial services, and increased financial inclusion.

In regions where governance is strong, AI has been effectively utilised to streamline credit scoring, fraud detection, and risk management. This is especially beneficial in developing nations where traditional financial infrastructure is often lacking, allowing AI to fill gaps in service delivery (Koester et al., 2023; Mucci & Stryker, 2023). Koester et al. (2023) highlight how AI-driven solutions can overcome infrastructural challenges in developing economies by providing alternative channels for financial access

and service delivery. Mucci and Stryker (2023) further emphasise that AI serves to enhance financial inclusion in underserved communities, leveraging mobile technology and data analytics. AI-powered financial products enhance risk assessment accuracy, broadening access to credit for both individuals and businesses. This contributes to more inclusive financial markets and increased overall stability. M-Pesa's success in Kenya illustrates how AI-enabled mobile banking can dramatically improve financial inclusion, particularly among underbanked communities (Lott & Sinha, 2019).

Paytm's expansion in India encountered significant regulatory challenges as its AI-based operations expanded, contributing to market instability, illustrating the difficulties of deploying AI in a rapidly evolving regulatory landscape (Benjamin, 2023; Wachira & Njuguna, 2023). In contrast, M-Pesa in Kenya demonstrates how AI can effectively boost financial inclusion when supported by strong governance structures (Avickson & Ogunola, 2024). However, M-Pesa's challenges in regions such as Tanzania and South Africa highlight the need for localised governance adaptations when deploying AI solutions (Lott & Sinha, 2019; Zuiderwijk et al., 2021).

Similarly, Paytm's expansion in India highlights both the opportunities and challenges of deploying AI in financial markets with diverse regulatory conditions. While AI-facilitated operations enabled Paytm's growth, they also encountered regulatory obstacles, resulting in market volatility—a reminder of the risks associated with AI deployment in the absence of strong governance frameworks (Benjamin, 2023; Wachira & Njuguna, 2023).

In well-governed environments, strong regulatory oversight ensures that AI systems comply with ethical standards and data protection laws. Strong legal frameworks mitigate risks associated with algorithmic biases and the misuse of financial data. Consequently, AI's potential to enhance financial development can be fully realised while minimising risks related to data

privacy, security, and discrimination (Hou et al., 2022). Paytm in India, for instance, faced regulatory scrutiny when its AI-driven loan operations encountered challenges, underscoring the importance of robust governance in managing AI technologies within financial systems (Truby et al., 2020). This demonstrates that while AI is a powerful tool for financial innovation, its positive impact is contingent upon careful regulation and oversight.

It is worth mentioning that the connection between governance quality and AI is not always simple. In countries with weak governance, AI may struggle to generate positive financial outcomes and could even worsen existing problems (Truby, 2020). Poor governance, characterised by a lack of regulatory oversight, leaves AI systems vulnerable to manipulation, biases, and erosion of trust in financial institutions. In corrupt environments, AI algorithms can be exploited to serve specific interests, further marginalising disadvantaged populations (Nahar, 2024). As proof, bKash in Bangladesh encountered significant technical challenges in its AI-powered payment system due to weak infrastructure and governance, limiting its potential to enhance financial inclusion (Chowdhury, 2020; Yasaman Rohanifar et al., 2022; Olugboja, 2023).

Countries with weak governance often struggle to provide the infrastructure and technical skills needed for effective AI implementation, leading to less-than-optimal financial development outcomes. This can also worsen existing inequalities due to algorithmic bias or insufficient data privacy protections (Taeihagh, 2021; Huang et al., 2023; Zhu & Chu, 2023; Nahar, 2024). In Pakistan, the AI credit scoring system FinBox faced challenges due to incomplete and inaccurate data, leading to erroneous loan rejections (Morrison, 2021). Similarly, Nigeria's Paylater platform experienced high default rates because AI-driven credit assessments failed to accurately evaluate borrowers' repayment capabilities (Koranteng & You, 2024). These examples demonstrate how governance quality is a major determinant of AI effectiveness in financial systems, especially in regions with weak infrastructure and regulatory frameworks (Biallas & O'Neill, 2020).

Further research by Pan et al. (2024) indicated a nuanced relationship between AI adoption and regulatory intensity, suggesting an inverted U-shaped dynamic. This is particularly relevant in developing countries, where regulatory capacity may not keep pace with rapid technological advancements (World Bank, 2021; Nahar, 2024). While initial AI implementation enhances regulatory processes, excessive reliance on AI can result in diminishing returns. This suggests the need for strategic AI investments, with policymakers carefully weighing the advantages of AI against the risks of becoming overly reliant on the technology. This dynamic underscores the critical need to align AI adoption with strong governance quality to maximise its benefits.

Moreover, AI's reliance on data may exacerbate economic inequalities in countries with poor governance. Marginalised populations lacking access to technology and financial services may be further excluded from the benefits of AI-driven financial systems. In lack of proper regulatory frameworks, AI systems may reinforce existing biases, promoting unfair lending practices and deepening economic inequalities (Comunale & Manera, 2024; Georgieff, 2024; Özer et al., 2024).

The interaction between governance quality and AI introduces both opportunities and challenges for financial development (Truby, 2020). In environments with strong governance, AI can enhance financial inclusion, drive innovation, and improve system stability (Lott & Sinha, 2019; Hou et al., 2022). However, in countries with weak governance, AI may amplify financial instability, increase inequality, and erode trust in financial systems (Taeihagh, 2021; Benjamin, 2023; Wachira & Njuguna, 2023; Nahar, 2024). AI's reliance on large datasets and algorithmic decision-making can worsen biases and lead to exclusion in poorly regulated contexts (Özer et al., 2024). The mixed outcomes of AI's integration highlight the critical role of governance in determining AI's effectiveness in promoting financial development. Further investigation is needed to understand how governance

quality influences the success or failure of AI integration within financial systems (Comunale & Manera, 2024; Georgieff, 2024).

This research is dedicated to investigating the intricate association between governance quality and AI within the scope of financial development. It explores whether this relationship fosters financial progress or poses significant challenges. A key question persists: can the integration of AI and governance quality genuinely foster financial development, or might their interplay cause setbacks in the financial system? The subsequent chapters will present research findings, uncovering the profound impact of this interaction, and offer insights into potential future trends in financial development.

In conclusion, the interplay between AI and governance quality presents a critical challenge for financial development, particularly in developing countries. This research seeks to provide a deeper understanding of this complex relationship, addressing the question of whether this interaction can truly drive financial progress or if it will lead to adverse outcomes, ultimately contributing to informed policy decisions and sustainable financial development strategies.

1.3 Research Objectives

1.3.1 General Research Objectives

The general objective of this study is to investigate the impact of artificial intelligence and governance quality on financial development in 58 developing countries. Meanwhile, the nation-specific factors affecting the application of artificial intelligence and the level of governance quality are further assessed in this study.

1.3.2 Specific Objectives

The following specific objectives are constructed to achieve the proposed general objectives.

1. To examine whether a significant relationship between governance quality and financial development in 58 developing countries exists.

2. To examine whether a significant relationship between AI and financial development in 58 developing countries exists.

3. To examine whether a significant relationship between governance quality and AI and financial development in 58 developing countries exists.

1.4 Research Questions

To provide a concise direction in this study, the following research questions are developed.

1. Is there a significant relationship between governance quality and financial development in 58 developing countries between 1996 and 2021?

2. Is there a significant relationship between AI and financial development in 58 developing countries between 1996 and 2021?

3. Is there a significant relationship between governance quality and AI and financial development in 58 developing countries between 1996 and 2021?

1.5 Hypotheses of the Study

H_1: There is a significant relationship between governance quality and financial development in 58 developing countries between 1996 and 2021.

H_2: There is a significant relationship between AI and financial development in 58 developing countries between 1996 and 2021.

H_3: There is a significant relationship between governance quality and AI and financial development in 58 developing countries between 1996 and 2021.

1.6 Significance of Study

This research is devoted to contributing to the existing literature on financial development in developing countries by examining the often-overlooked role of governance quality. By incorporating governance quality into our econometric model, this research aims to present a more delicate overview of its influence on financial development, which prior research has overlooked. This study also uniquely integrates AI into the analysis, which could offer a more comprehensive study of how these two pillars jointly influence financial development.

Former studies have revealed that good governance not only promotes financial development by fostering stability, transparency, and efficiency within financial systems but also plays a crucial role in environmental protection. For instance, as Solaymani and Montes (2024) highlight, good governance significantly reduces CO_2 emissions, demonstrating the broader implications of governance quality beyond the financial sector. Additionally, Talmaciu (2014) emphasises that the interrelation between institutions, governance, and regional development policy is a critical determinant of financial development. This suggests that strong governance frameworks, coupled with effective policy, are essential for driving both sustainable financial growth and positive environmental outcomes.

In the context of reducing financial fraud, AI has proven to be a valuable tool. Yaiprasert and Hidayanto (2024) highlight that AI can simulate business threshold cost data to identify the optimal mitigation measures and enhance cost strategies, ultimately maximising profits. Additionally, AI enhances risk management by leveraging big data to predict and mitigate financial risks with greater accuracy (Cao et al., 2024). As Li et al. (2021) state, AI has proven effective in detecting fraud in financial institutions through repeated training and real-time identification. AI also optimises investment strategies by analysing market trends and executing trades at high speeds, potentially improving investment returns (Addy et al., 2024). These advancements highlight how AI can significantly improve financial market efficiency and enhance overall market stability.

CHAPTER 2: REVIEW OF LITERATURE

2.0 Introduction

Chapter Two presents a review of literature on the dependent variable (financial development) and the independent variables (ICT diffusion and governance quality). Next, based on extensive literature from trustworthy sources, the relationships between the dependent variable and the independent variables are summarised. Thirdly, a review of the literature on three control variables—(1) financial performance, (2) financial inclusion, and (3) macroeconomic variables—is provided. Fourth, a conceptual framework created especially for the study will be presented after a thorough explanation of the theoretical foundations. Finally, previous research and theories are used to build the hypotheses.

2.1 Review of Literature

2.1.1 Dependent Variable – Financial Development

Many support that financial development drives the global economy to improve and creates jobs (Easterly & Levine, 2001; Zaidi et al., 2019). A better financial system boosts finance for expensive projects and encourages growth as it facilitates asset movements from less productive businesses to higher productive ones, which boosts innovation in the generation of new ideas. As a consequence, the financial industry promotes growth in many different areas. Developed countries have been able to keep their per capita income increase going in aid of an abundance of capital and a robust banking system, resulting in financial deepening that helps economic growth by making capital work better. Also, economic growth happens when GDP per capita goes up (Easterly & Levine, 2003). New technologies are important for economic growth, especially in the areas of communication and

information (Hõbe & Alas, 2015; Brem et al., 2016; Mao et al., 2020; Umar et al., 2020). Opoku et al. (2019) say that financial development encourages trade in goods and services, creates information for investors, oversees corporate governance, and makes dealing and risk management easier. Following King and Levine's (1993) research, many real-world studies have shown that financial development stimulates economic activities, such as investment (Demirgüç-Kunt & Maksimovic, 1996; Rajan & Zingales, 1996; Ndikumana, 2000), employment, productivity, and long-term economic growth (Levine, 1997; Levine & Zervos, 1998; Beck et al., 2000b). The evidence proposed above supports that when the banking industry gets better, it helps the economy grow.

Financial development drives economic growth, according to earlier studies (Puatwoe & Piabuo, 2017; António & Carmen, 2018; Nguyen et al., 2022; Sulemana & Dramani, 2022; Mbulawa & Chingoiro, 2024). This relationship has been intensively investigated since the 1980s. The prevalent viewpoint holds that financial development promotes economic growth by encouraging domestic savings and investment through a liberalised banking sector (Bassanini et al., 2001; Svirydzenka, 2016). According to Sinha and Shastri (2023), the effective performance of the financial industry and its intermediaries best reflects financial growth. The function of the financial system is to provide investment information, allocate money, and monitor investments, which is critical to this efficiency (Scholtens, 2006; Dutta & Meierrieks, 2021).

As financial systems evolve, the expense of obtaining information diminishes, resulting in more effective resource allocation (Aglietta & Breton, 2001; Hermes & Lensink, 2003).

Financial development is affected by several socio-economic, cultural, and geographical aspects. Huang (2010) contends that variables like income levels, inflation rates, political stability, ethnic and religious diversity,

copyright protection, professional accounting standards, and maritime access significantly influence the scope and character of financial growth.

Financial development reduces poverty. Jeanneney and Kpodar (2011) analysed its effect on poverty in developing countries from 1966 to 2000. Financial development aids the impoverished by enabling them to obtain liquid assets and achieve elevated savings rates. Nonetheless, they observed that financial crises, which disproportionately impact the impoverished, might incur substantial costs.

The interrelation between financial development and income inequality has been examined. Kim and Lin (2011) analysed the influence of financial growth on income inequality in developed and developing nations from 1960 to 2005. Their findings indicated that financial development mitigates income disparity, but only upon attaining a specific threshold. Prior to reaching this level, financial progress may intensify inequality.

Outreville (1999) examined 58 developing nations and discovered the positive association of financial development and human capital development and its negative association with political instability. Consequently, developing countries that fail to meet these parameters will fall behind in financial development compared to other nations.

2.1.2 Independent Variable (1) – Governance Quality

Several findings indicate that financial development is highly hinged on the governance quality of countries (Rasheed et al., 2016; Sayılır et al., 2018; Abubakar et al., 2020; Atanga Ondoa & Seabrook, 2020; Khan et al., 2022). Atanga Ondoa and Seabrook (2020) revealed the positive impacts of governance quality indicators such as regulatory quality, political stability and absence of violence in the long run. Khan et al. (2022) came out with similar results with a sample of 189 countries, confirming the significance

of institutional quality in financial development with regard to regulatory quality, political stability, and corruption control. Efforts dedicated to improving governance quality, upholding the rule of law, and combating corruption were able to help a nation achieve elevated financial development (Sayılır et al., 2018).

Improvements in governance quality through refining the legal and institutional framework, enforcing standards, empowering supervisory institutions, and creating an efficient regulatory environment that promotes financial inclusion push forward financial development. Simultaneously, maintaining a stable regime ensures the well-being of social, economic, and political aspects, providing security for savings and dividends that will contribute significantly to financial deepening in the long run (Abubakar et al., 2020). A study conducted by Bekana (2023) on African countries suggests that governance quality has a significant and positive influence on financial development, taking into account the cross-country differences. It is justified that poor governance quality hinders financial development, owing to weak protection of private property rights that discourages savings and investments due to distrust in financial institutions. This result resonates with Ayadi et al. (2015), Cherif & Dreger (2016), and Ofori et al. (2021).

Abaidoo and Agyapong (2022) used the limited information maximum likelihood (LIML) method to analyse 29 sub-region countries of Sub-Saharan Africa from 2001 to 2018. These economies were characterised by poor institutional structures with great disparity in the quality of institutional structures among the various countries. The result shows that governance quality is a profound variable in facilitating financial development in the observed areas. Thus, improvements in institutional quality represent an enhancement in policies, governance, regulatory structures, freedom of speech and property rights, statutory framework, and oversight operations that are believed to contribute positively to financial vibrancy and growth. It added that effective corruption control and stability in the political environment are non-negligible in enhancing financial development. They

verified that a macroeconomic environment with sound governance, rule of law, robust regulatory systems, and voice and accountability benefits financial development, highlighting that the effect is not restricted to economies that are completely exempted from conflicts.

In the past, the banking sector as well as the stock market were indicators of financial development (Law & Azman-Saini, 2012; Ellahi, 2021). The outcomes show that the measures of institutions and government play a big role in both areas. Rasheed et al. (2016) agree that the standard of institutions is statistically linked to the financial development of the banking sector. It is notable that the growth of the stock market doesn't follow a straight line (Law & Azman-Saini, 2012). The U-shaped link suggests that regulation has a positive effect on stock market growth if it is only above a certain level, especially in developed countries rather than developing countries. It matched studies that were done afterwards by Hechmy (2016), who came to the conclusion that countries with low levels of institutional growth (below the threshold level) might not gain from the good quality of institutions. This shows that financial development can go to a higher level if institutions and governments are helped to grow (Ali et al., 2020).

To investigate governance quality concerning its effect on financial development, empirical studies with data obtained from diverse samples integrating multiple economies of a variety of countries or areas, encompassing discrete time intervals in terms of length and regions in time, focusing on different indicators and aspects of financial development using a series of methodologies, were conducted. This leads to the diversity of results and conclusions with respect to the nexus between governance quality and financial development.

2.1.3 Independent Variable (2) – ICT Diffusion

Artificial intelligence (AI) has evolved into a phrase used to describe the future and all of its components. AI has not only supplanted traditional computing approaches but has also altered the way businesses operate (Darrell & John, 2009). All aspects have transformed, encompassing the digitisation of banking. Technology is progressively being incorporated into several facets of networking and computing (Mbangula, 2022). AI is anticipated to become progressively vital in assisting digitised assets, especially physical infrastructure. Progressive ICT managers and engineers perceive AI as an integral element of systems, networking, apps, communication, and contemporary commerce and content, rather than merely software and algorithms that facilitate intelligent services and products (Anderson & Stoneman, 2008).

AI is increasingly favoured by researchers and policymakers because of its transformative nature and significant developmental potential (Agrawal et al. 2019). AI may be utilised for any cognitive work executed by computers or technology (Russell & Norvig, 2010). AI plays a significant role in financial development. Researchers emphasised AI's capacity to serve as the forthcoming General-Purpose Technology (GPT) and its ability to revolutionise the economy and finance by infiltrating and transforming many industries (Agrawal et al., 2019; Brynjolfsson et al., 2019; Cockburn et al., 2019).

Regionally, the extensive integration of AI presents new opportunities for expanding the technological portfolio and establishing novel commercial avenues, essential for structural and financial development (Trajtenberg, 2019).

An incredible advancement in ICT is influencing every area of the financial sector. It has significantly transformed the methodologies employed by banks and financial institutions in managing and processing information. In

2014, the worldwide banking sector's ICT expenditures surpassed US$197 billion, comprising a higher percentage of ICT investment than any other sector since 1994 (Chien et al., 2020). Simultaneously, the rapidity and characteristics of financial development are evolving alongside the proliferation of ICT. Enhancements in ICT within the business industry provide distinctive commercial opportunities for current and potential businesses by facilitating novel value creation and the delivery of products and services (Cai et al., 2021).

According to Allen (2002) and Domowitz (2002), financial technology can mitigate information asymmetry between customers and producers while also decreasing data administration expenses. Purcell and Toland (2003) assert that ICT substantially improves the management of credit information data records and the availability of debtor and organisational suggestions. Shamim (2007) and Majeed and Ayub (2018) illustrate that ICT might facilitate financial development by reducing operational and informational expenses.

Majeed and Malik (2016) assert that ICT usage in the public sector favourably impacts the financial industry by reducing market unfairness and transaction fees while improving information on markets. Furthermore, it enhances the optimisation of resource distribution in financial institutions by redistributing resources from surplus to deficit units via information transmission. Furthermore, utilising cross-sectional data from 147 economies, they found that ICT in the public sector moderates the impact of financial development on cross-country growth inequalities.

Asongu and Acha-Anyi (2017) revealed that the diffusion of ICT alleviates the detrimental effects of market power on loan pricing and size, utilising GMM and quantile regression with data from 163 banks in African countries. Moreover, ICT improves financial accessibility by reducing its impact on market power. In contrast, Peruta (2016) discovered that the introduction of mobile money had minimal impact on financial accessibility. Gosavi (2018)

evidenced that data from African enterprises in 2013 shows mobile money improves productivity and enables access to credit for businesses.
Asongu and Acha-Anyi (2017) delved into the relationship between ICT and financial development in 52 African countries using quantile regression analysis, accounting for varying degrees of financial development. They demonstrated that a rise in mobile phones favourably impacts formal financial growth. Their findings indicate that ICT and financial institutions mutually reinforce one another to promote financial development.

Nguyen et al. (2020) deployed data from 1997 to 2018 and used the GMM technique to present global evidence about the relationship between ICT and financial development. A strong and positive correlation exists between mobile usage and all indicators of financial progress. Ejemeyovwi (2021) examined a cohort of 54 Africans from 2000 to 2017 to assess the impact of ICT and innovation on financial development and got a result that ICT can positively impact financial development.

Purcell and Toland (2003) contend that ICT is essential for the safeguarding of credit information data records and the delivery of debtor and institutional references. ICT may promote financial development by decreasing operational and information costs, as demonstrated by Shamim (2007) and Majeed and Ayub (2018). The empirical results of the study by Pradhan et al. (2016) confirmed the existence of causal linkages between ICT and financial development in Asian economies. Majeed and Malik (2016) claim that the financial sector might gain from the integration of ICT in the public sector by reducing transaction costs, market distortions, and information expenses, while concurrently enhancing market information.

By facilitating the transmission of information, ICT also aids in the financial industry's optimisation of resource allocation by shifting resources from surplus to deficit sectors. This study will use ICT as a proxy for AI. In addition, this research obtained the use of fixed broadband subscriptions (per 100 people) to represent the ICT diffusion.

2.1.4 Control Variable (1) – Financial Performance

Banks boost financial development by utilising and allocating funds to investment projects that have the highest potential long-term benefits. It is also widely recognised that improved financial performance and economic stability stem from a well-structured banking system, characterised by strong oversight, sound governance, and prudent risk management practices. On the other hand, Caprio and Levine (2007) point out that encouraging appropriate banking procedures has been difficult. Defending the individual interests of creditors, investors, and depositors is the primary objective of sensible bank regulation. The second objective is to uphold the integrity and reputation of the financial services that the markets provide in order to safeguard the public interest (Gully, 2015).

The financial performance of a nation's banks significantly influences its overall financial development. Therefore, the net interest margin—the net return on bank assets—will be used to assess the performance of commercial banks. Interest-earning assets are divided by the ratio of interest revenue to interest expenses to compute it. Enad and Gerinda (2022) underline that economic ratios might be used by investors to understand bank performance. They added that when assessing bank performance, ratio comparisons can produce statistics that are more impartial.

Financial development is the process of improving the complexity and accessibility of financial services within an economy. It involves improving the financial infrastructure as well as the growth and diversification of financial markets, goods, and organisations. A study by Yusuf and Olaniran-Akinyele (2019) used return on equity and assets as a proxy for bank performance. Previous literature claims that financial success is a prerequisite for financial development (Berger et al., 2004; Hasan et al., 2009). The significant resources that banking companies invest in guaranteeing financial inclusion and sharing this information with different stakeholders, such as government regulators, have a direct bearing on the

nation's influence in financial development (European Commission, 2001, 2008; Eccles & Serafeim, 2013).

According to Levine (2005), the financial development of its primary tasks is positively impacted by financial performance. Financial markets also carry out these vital tasks, in addition to banks and other financial institutions.

Several recent studies explored the linkage between financial development and financial performance (De la Torre et al., 2010; Mehrotra & Yetman, 2015; García & Jose, 2016; Neaime & Gaysset, 2018). Furthermore, the connection between financial development and performance was examined by Beck et al. (2009) and Mago and Chitokwindo (2014). There is also evidence depicting the relationship between financial growth and performance in emerging nations (Zulfiqar et al., 2016; Ahluwalia & Bhatti, 2017). Uma et al. (2013) made an effort to investigate the significance of financial performance in rural banks and offered proof that a favourable correlation exists between that and financial development.

Financial performance is significantly influenced by banking performance, according to Ravikumar (2012), while financial exclusion in the official financial system is widespread. Research by Le et al. (2019) found that financial performance drives financial development, particularly in the context of Asia. A high positive correlation is found between financial performance methods and financial development, according to research conducted by Mutinda et al. (2018) on the relationship between financial performance and financial development by capturing annual data from 2009 to 2014. Similarly, Shihadeh et al. (2018) examined the relationship between financial performance and financial development in Jordan and found a positive correlation result.

According to Shihadeh and Liu's (2019) analysis, financial performance metrics can assist banks in lowering risks and increasing profits. Al-

Chahadah et al. (2020) investigated the connection between financial performance and financial development using basic regression analysis on Jordanian banks. Their findings indicated its statistically significant influence on the advancement of the country. Financial performance has a favourable influence on Palestinian financial development, suggested by Shihadeh's (2021) analysis of the relationship between financial inclusion and bank performance in Palestine between 2005 and 2015.

The correlation between capital spending and local government financial performance significantly influences sustainable financial development in Banten. Financial development for local governments encompasses several factors, such as fiscal responsibility, efficient use of funds, and revenue production (Thalib & Ekaningtias, 2019). Effective financial management supports optimised resource allocation, builds investor confidence, and drives financial progress (Astuti & Mispiyanti, 2019).

The budgetary performance of local governments and the rate of economic growth in an area are closely linked. Strong financial outcomes provide a solid foundation for sustained economic growth. Financial performance factors that affect economic growth include things like independence, efficacy, efficiency, fiscal decentralisation, compatibility, and reliance. Anticipations of future economic expansion frequently influence financial performance (Levine, 1997). According to Calderón and Liu (2003), finance is a significant factor and an active contributor to economic growth. According to Greenwood and Jovanovic (1990), Wu et al. (2010), and Liu (2018), finance has an impact on economic growth. Local governments can increase infrastructure, boost investment and growth in important economic sectors, and allocate resources more effectively with the support of fiscal management. Economic growth will also be facilitated by sound financial development (Cheng & Degryse, 2010).

2.1.5 Control Variable (2) – Financial Inclusion

Over the past several years, researchers and policymakers have raised interest in exploring how financial inclusion can nurture financial development in economies. Financial inclusion emerged to be a great focus, as evidence from historical studies dedicated to scrutinising the association of financial inclusion in association with financial development has proposed a tested hypothesis. It is broadly recognised that financial inclusion has gained political priority in the policy structure, given the value of an inclusive financial system (Hlophe, 2018).

Financial inclusion is a defined term for "the ease of accessibility and availability of formal finance, such as bank deposits, credits, insurance, etc., for all participants in an economy" (Kim, 2018). It can also be defined as the process by which the formal financial system is easily accessible, widely available, and highly usable by all users (Sarma & Pais, 2010). When financial services become progressively prevalent among individual and enterprise users, the financial industry expands, and the central bank can better oversee the sector's progress toward financial stability (Morgan & Pontines, 2014; Hlophe, 2018).

A recent study by Lenka (2022) suggests that financial inclusion is an integral dimension of financial development. Targeted research on a sample in India has confirmed a positive and unidirectional causality: greater financial inclusion can improve financial development. The empirical result from research by Ali et al. (2020) supports that increased access to financial services through successful banking penetration, such as the increased provision of financial services and availability of ATMs and bank branches, fosters financial development. This outcome coincides with Rasheed et al. (2016), whose empirical result shows that financial inclusion is a significantly positive indicator of the financial development of the banking sector.

Musembi and Chun (2020) proxied financial inclusion with mobile money services and found that it had a statistically significant and positive relationship with regard to financial development, specifically in the long run, concerning a sample in Kenya. This result implies that the adoption of e-wallets, which enhanced financial access, had a further advanced impact on spurring financial development. It is found attributable to an increase in mobile savings and access to credit facilities in the mobile money ecosystem, stimulating economic activities, typically small to medium-sized corporations. An advancement in technology is conducive to a more effective payment system, making it easy for trade payments, leading to increased aggregate spending. Eventually, financial inclusion with a larger deposit base and increased mobile saving portfolios generates a multiplying effect on financial development (Hariharan & Marktanner, 2012).

2.1.6 Control Variable (3) – Macroeconomic Variables

Chinn (2006) advocates that greater trade openness can promote the development of the stock market, especially when legal development reaches a certain threshold level. It is believed that financial development and trade openness are important for stock market development and capital account liberalisation, respectively. Also, Baltaji (2009) indicates that greater trade openness benefits financial development. Evidence provided by Luintel and Khan (1999) as well as Boyd et al. (2001) indicates that GDP per capita significantly and positively impacts financial development. Ang and McKibbin (2007), Kim and Lin (2010), and Bittencourt (2011) also provided supporting evidence.

According to Yu and Gan (2010), Dogga et al. (2017), and Tsaurai (2018), GDP per capita is a significant and favourable factor that influences financial development in developing nations. According to Bhattacharya et al. (2018), remittances are money transferred between nations through financial institutions, allowing recipients to seek or acquire alternative

financial services and goods. Herger et al. (2008) claim that by offering alternatives for funding investments and easing liquidity constraints, remittances contribute to the prosperity of nations with undeveloped banking sectors. Remittances boost the amount of credit and deposits in emerging economies, which significantly and favourably affect the growth of the banking sector in these nations (Raza et al., 2017). Nazir et al. (2018) obtained results that are aligned with the nations and point to the necessity of better institutional frameworks in order to boost remittance inflows, thus enhancing financial development. According to Luciano & Regis (2007), a positive, significant, and reciprocal causal relationship exists between trade openness and financial development.

2.2 Theoretical Framework

This section provides a comprehensive discussion of key theories developed by previous scholars that support the relationship between financial development and its drivers, fintech penetration and governance quality. The theories examined include (1) institutional theory and (2) diffusion of innovation theory (DIT).

2.2.1 Institutional theory

Institutional theory discusses how social norms, values, laws, and regulations influence organisational behaviours, particularly inside financial institutions (Selznick, 1948; North, 1989). Organisations conform to society standards to get approval, secure resources, and deliver services. Scott (2005) elaborates on this by classifying institutions into three pillars: regulative (rules), normative (values), and cognitive (beliefs). The quality of institutions, defined by robust legal frameworks and governance, is vital for the stability and success of financial institutions (Glaeser et al., 2004). Efficient institutions enhance financial sector advancement by encouraging

openness, accountability, and innovation (Lindstedt & Naurin, 2010). Technological advancements are propelling institutional transformation and altering conventional financial frameworks (Greenwood & Hinings, 2013).

A previous publication by North (1981) puts a definition to concluding institutions as the "rules of the game in a society, or more formally, humanly devised constraints that shape human intervention". Institutions with power over the allocation of capital are a predominant determinant in financial sector development, determining the capacity for growth. Frunză (2011) further explains the formal and informal rules represented by institutions as a major driver in moulding economic and social activities and forming a mechanism that optimises the use of national resources while applying and monitoring the implementation of those rules. A framework proposed by Acemoglu et al. (2005) implies that dominance over economic resources empowers institutions to influence resource allocation and eventually shapes the course of the economic growth roadmap. Theoretically, institutions that impose policies and regulations may or may not cause immediate or progressive effects on economic activities to the extent that financial development can be influenced in various ways, to certain degrees.

2.2.2 Diffusion of innovation theory (DIT)

The diffusion of innovation theory (DIT) proposes that the introduction and dissemination of new technologies, such as accessibility to technology, follow a predictable pattern defined by the process of innovation decision-making (Wen et al., 2023). As ICT access becomes increasingly commonplace and integrated into financial institutions, it enables the diffusion of financial services, stimulates financial innovation in products, and improves market efficiency, all of which contribute to overall market financial development (Kongkuah, 2023). Furthermore, the resources-based view argues that ICT access is a critical resource that allows financial institutions to improve their efficiency, expand their audience, and innovate

with respect to their services, therefore encouraging greater financial inclusion and stimulating financial development (Kongkuah et al., 2021).

According to Raheem et al. (2020), more access to these technologies led to greater financial services usage, higher savings, and easier use of credit, all of which helped countries that were developing grow and reduce poverty. Technology knowledge was included as an endogenous component of financial development in Romer's (1986) growth model. The supply-side hypothesis, often known as the ICT diffusion theory, contends that the spread of ICT has a one-way effect on financial development (Pradhan et al., 2018). According to this reasoning, more investment in ICT infrastructure and improved utilisation of that infrastructure lead to higher job prospects and enhanced company productivity, both of which have a beneficial impact on financial development. Ergo, the growth of ICT infrastructure creates new digital activities that improve the nation's financial development (Hamed, n.d.).

DIT is also a theoretical framework for investigating the acceptance and spread of AI technological innovation in the banking industry, as well as the following influence on financial development (Rogers, Singhal, & Quinlan, 2014). It advocates that innovation acceptance follows a predictable path, beginning with early adopters and then extending to the mainstream market. It examines how AI technology affects banks in various nations and the ramifications for financial performance, as it contributes to the study by describing AI technology adoption as a process impacted by variables like technological complexity, organisational preparedness, and market demand (Truby, 2020).

Understanding these adoption processes is critical for determining how rapidly AI technologies might contribute to increasing financial performance indicators, hence promoting financial development (Shiyyab et al., 2023). However, DIT may face difficulties embracing AI technology, despite their potential benefits. This might happen if cultural or legal issues

impede the proliferation of AI advances, limiting their influence on financial performance outcomes and impeding financial development (Gyau, 2024).

By harnessing the capabilities of AI, financial institutions may develop innovative solutions that address the specific needs and preferences of clients, improve risk management strategies, and optimise operational processes (Adam, 2024). AI has been applied in several functional domains within banking, encompassing customer service, customer relationship management, fraud detection, credit and risk assessment, marketing, payment processing, back-end operations, and data acquisition. From the consumer's viewpoint, the most prevalent applications encompass chatbots, robo-advisers, mobile banking, and customer engagement (Belanche et al., 2019; Trivedi, 2019; Elrefai et al., 2021; Wicaksono & Zahra, 2022).

AI has been utilised in credit decision-making within the banking sector, employing machine learning algorithms to evaluate customer eligibility for credit products, thereby enhancing accuracy, efficiency, profitability, and cost-effectiveness (Trivedi, 2019; Gramespacher & Posth, 2021; Hwang & Kim, 2021; Tiwari & Saxena, 2021; Ali et al., 2022; Estran et al., 2022; Mogaji & Nguyen, 2022). Regulators emphasise the necessity of tackling transparency, interpretability, and bias concerns in AI credit models (Fourie & Bennett, 2019; Königstorfer & Thalmann, 2021; Estran et al., 2022). AI accelerates fraud detection and optimises back-end operations, payment services, and data collection (Carminati et al., 2018; Abu Daqar et al., 2020; Chitimira & Ncube, 2021; Haddad, 2021).

2.2.3 Theoretical Framework for DIT Theory and Institutional Theory

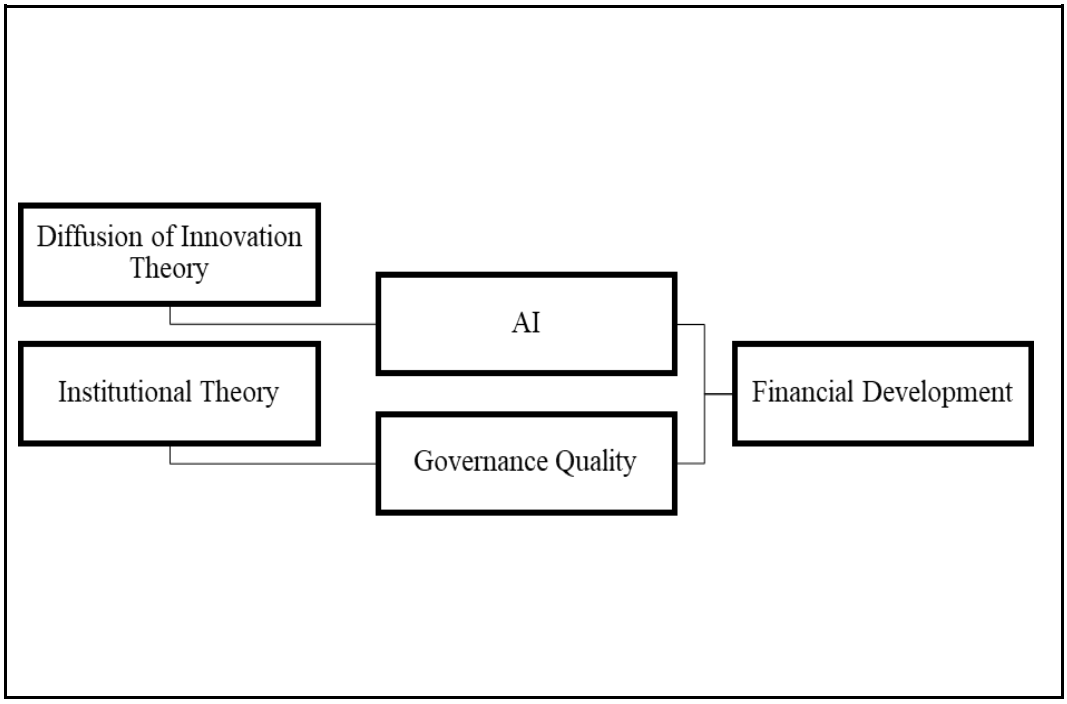

Figure 2.1. Theoretical Framework

2.3 Conceptual Framework

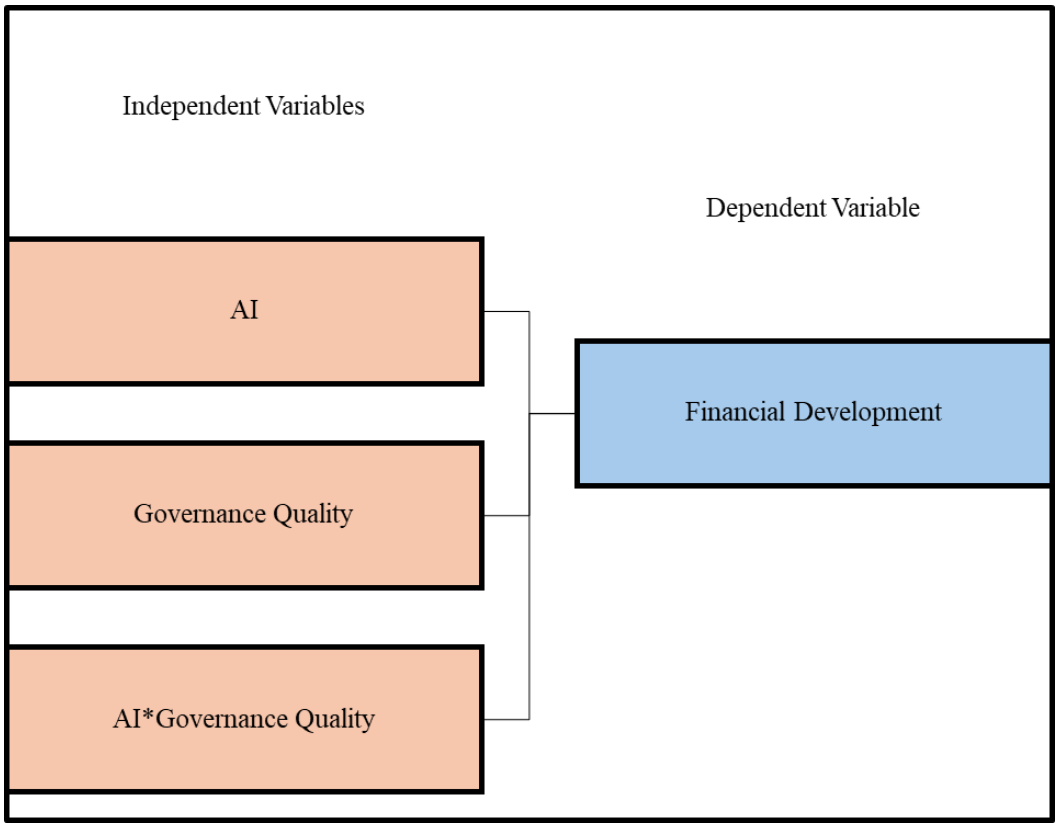

Figure 2.2. Conceptual Framework

2.4 Hypothesis Development

2.4.1 Governance quality and financial development

Governance quality is statistically significant in affecting financial development. Higher governance quality indicates a sound structure of policies and regulations, enabling business development and foreign trade and contributing to GDP growth (Lopes, Packham & Walther, 2023). Better regulatory and governance quality can lead to economic prosperity, cultivating an invulnerable financial system to shocks, hence promoting financial stability (Malik et al., 2022). A well-established governance

structure aids in the prevention of corruption and inhibition of monopolies, stimulating economic growth, market transparency, social well-being, robust financial systems, and environmental preservation by means of regulations (Mujtaba et al., 2018). Several studies suggest that good governance quality gives rise to investors' and depositors' confidence to participate in the financial market, promoting financial development (Ayadi et al., 2015; Cherif & Dreger, 2016; Abubakar et al., 2020; Bekana, 2023). Though the degree of influence may vary among economies and sectors of financial markets, it persists as significant. The above statements construct a foundation for the hypothesis stated below.

H_1: There is a significant relationship between governance quality and financial development in 58 developing countries

2.4.2 ICT Diffusion and Financial Development

On a panel set of 102 nations from 1996 to 2005, Vu (2011) examined the premise that ICT penetration affects financial development. Internet penetration, mobile phone penetration, and PC penetration are the ICT diffusion indices used. The standard cross-country regression approach and the new Generalised Method of Moments (GMM) for dynamic panel data analysis show that ICT drives financial development growth. He recommends e-government and e-commerce since internet adoption has a minimal effect compared to mobile phones and PCs. However, recent empirical research suggests that ICT acquisition has mixed effects on financial development. Some research (Freeman & Soete, 1985, 1994, 1997; Aghion & Howitt, 1998) suggests that ICT might hurt developing country employment and labour markets. This literature claims that fast ICT adoption eliminates unskilled employment but excludes those low-income individuals since they are poorly equipped and qualified, increasing poverty and economic inequality and significant to affect financial development (Allen et al., 2014; Alter & Yontcheva, 2015; Adeola & Evans, 2017). It has

gained increased emphasis owing to its potential transformative power in fostering development. Inclusive financial systems allow individuals and firms better access to resources to aid their financial needs (World Bank, 2013). Financial inclusion stimulates the participation of economic agents as providers and users of capital, which is associated with economic growth (Oanh, 2024). Financial inclusion is directly dedicated to higher economic growth, increasing the output level with greater access provided to financial services, and ultimately accelerating financial development (Kamalu et al., 2019). Positive financial inclusion facilitates diversity in banks' portfolios, thereby lowering risk levels and stabilising banks' deposit bases and mitigating liquidity risks, and improves the dissemination of monetary policy, eventually creating a financially stable environment (Morgan & Pontines, 2014). Thus, it is rationally concluded that financial inclusion is significantly positive in relation to financial development.

H_2: There is a significant relationship between artificial intelligence and financial development in 58 developing countries

2.4.3 Governance Quality and Artificial Intelligence and Financial Development

Artificial intelligence is transforming human relationships and corporate operations, emerging as an essential instrument for everyday assistance in social and commercial endeavours, and making substantial contributions to financial advancement (Heylighen, 2017; Aghion et al., 2018; Lu, 2021). Nonetheless, concerns remain about AI's influence on human development owing to possible biases, employment displacement, and exacerbating digital disparities (Maiti & Awasthi, 2020). Governments are essential in alleviating these adverse effects by implementing legislation, increasing transparency, and funding educational initiatives to enhance AI's positive influence on well-being (Davis, 2017; Sharma et al., 2020). Effective governance facilitates the generation of employment possibilities,

diminishes poverty, and enhances living standards for better financial development of nations (Eichhorst et al., 2009; Kwon & Kim, 2014).

Saba and Pretorius (2024) assert that governments ought to dedicate resources to AI initiatives that might beneficially impact financial development, positing that well-defined regulatory frameworks encourage innovation, advance AI research, and reconcile safety with ethical issues. Effective governance and investment in AI substantially enhance financial development by augmenting transparency, accountability, and efficiency in AI investments. As AI governance is still developing, the dangers linked to AI necessitate the establishment of new regulatory and governance frameworks to match its fast proliferation (Guihot, Matthew, & Suzor, 2017; Taeihagh, Ramesh, & Howlett, 2021). Emerging governance frameworks, such as adaptive and hybrid governance and self-regulatory efforts, are essential in this context (Leiser & Murray, 2016; Guihot et al., 2017; Linkov et al., 2018; IEEE, 2019; Tan & Taeihagh, 2021b). Understanding and mitigating AI risks is crucial for harnessing its advantages, including enhanced efficiency in goods and financial services (Agarwal, Gurjar, Agarwal, & Birla, 2015; Lim & Taeihagh, 2018; Yigitcanlar et al., 2018). As AI systems become increasingly complicated, there is a necessity for targeted governance procedures pertaining to AI-related domains, as well as a comprehensive global AI governance framework to sustain better financial development (Butcher & Beridze, 2019).

H_3: There is a significant relationship between artificial intelligence and governance quality on financial development in 58 developing countries

2.4.4 Financial Performance (CV) and Financial Development

In the studies by Hillman and Keim (2001) and Choi and Wang (2009), it was found that financial performance plays a significant role in contributing to financial development. Additionally, Kessy (2008) analysed the relationship between the efficiency of the financial institution's financial performance and financial development by using the GMM method in examining three East African countries (Tanzania, Kenya & Uganda) from 1944 to 2005. The data envelopment analysis method (DEA) was used in assessing the efficiency of banks. DEA was prevalently used not only for banks (Vegesna & Dash, 2014) but in many other contexts, e.g., education (Goncharuk, 2016; Ramzi & Ayadi, 2016; Yahia & Essid, 2019), healthcare (Lo Storto & Goncharuk, 2017), and industry (Goncharuk & SellersRubio, 2018). Kessy (2008), using DEA, concluded that the well-being of financial performance correlates positively with financial development and that greater credit provided by commercial banks to the private sector will lead to financial development of the nation, which confirms the hypothesis of the study that a bank's financial performance is necessary for financial development.

2.4.5 Financial Inclusion (CV) and Financial Development

Financial inclusion is statistically significant to affect financial development. Financial inclusion has gained increased emphasis owing to its potential transformative power in fostering development. Inclusive financial systems allow individuals and firms better access to resources to aid their financial needs (World Bank, 2013). Financial inclusion stimulates the participation of economic agents as providers and users of capital, which is associated with economic growth (Oanh, 2024). Financial inclusion is directly related to higher growth in the economy, increasing the output level with greater

access provided concerning financial services, and ultimately accelerating financial development (Kamalu, Wan Ibrahim, Ahmad, & Mustapha, 2019). Positive financial inclusion facilitates the diversification of bank assets, thereby reducing risk levels; increases the stability of banks' deposit base, reducing liquidity risks; and improves the transmission of monetary policy, eventually creating a financially stable environment (Morgan & Pontines, 2014). Thus, it is hypothesized in this study that financial inclusion has a significant relationship with regard to financial development.

2.4.6 Macroeconomic Variables (CV) and Financial Development

Both GDP per capita and trade openness have been shown to have a positive influence on financial development (King & Levine, 1993; Arestis & Demetriades, 1997; Christopoulos & Tsionas, 2004; Hassan et al., 2011; Nasir et al., 2014). Research supporting the demand-following hypothesis indicates that GDP growth precedes financial development (Zang & Kim, 2007; Gozgor, 2015; Peia & Roszbach, 2015). Baltagi et al. (2009) and Law and Habibullah (2009) found that GDP drives financial development, while Cherif and Dreger (2016) found differences in developing countries. The empirical findings may differ since the research cannot account for GDP disparities among nations. Thus, whether GDP or income affects financial development uniformly across nations with different income levels is unknown.

In the initial stages, GDP growth can drive the demand for financial products and services, but this effect may diminish as growth continues. Huang and Lin (2009) state that developing countries have more investment prospects and financial service demand than developed countries. It is possible that beyond a certain threshold, additional increases in GDP yield only marginal benefits.

The trade openness–finance hypothesis states that trade openness boosts economic growth by increasing credit demand and financial development (Kim et al., 2010). Trade openness enhances financial intermediation by improving access to goods and services and increasing transaction volume and logistical activities. Chinn and Ito (2006) propose that trade and financial openness should go together to boost financial development. However, trade openness can disrupt financially underdeveloped markets and nations lacking well-implemented policies and strong economic growth.

CHAPTER 3: RESEARCH METHODOLOGY

3.0 Introduction

Chapter Three presents a complete research approach. Starting with discussing the research design and data-gathering method, the study framework and econometrics are then presented after detailing the data sources for each variable model. Finally, the generalised method of moments (GMM) has been adopted as the estimating approach used in this study, which will be discussed.

3.1 Research Design

A research design represents the blueprint of the research process by displaying how a study will move from the research purpose/questions to the outcomes (Abutabenjeh & Jaradat, 2018). This study examines the effect of governance quality and artificial intelligence on financial development in 58 developing countries between 1996 and 2021. The categorisation of countries for this study is according to the classification of the World Bank Atlas methodology. Countries with a per capita GNI of $1,135 or less are classified as low-income, and others with a per capita GNI of $1,136 to $4,465 are categorised as lower-middle-income countries (World Bank, 2024). Using secondary data can reap the benefit of the convenience and economy of being relatively accessible to datasets from nationally representative samples, covering a wide range of topics over a long period (Kiecolt & Nathan, 1985; Boslaugh, 2007; Vartanian, 2011). Lastly, the generalised methods of moments (GMM) model is used in analysing the dynamic relationship between financial development, artificial intelligence (ICT Diffusion), and governance quality, together with the control variables – financial inclusion, financial performance, and macroeconomic variables in the sampled countries.

3.2 Source of Data

In this study, a balanced panel of data comprising 58 countries is developed. The data sources are from World Development Indicators (WDI), World Governance Indicators (WGI) and the International Monetary Fund (IMF).

Variables	Variables description and measurement	Author	Data Sources
Financial Development (DV)	Financial Development Index	Alshubiri, Jamil, & Elheddad (2019), Amir & Gokmenoglu (2020), Akinlo (2023)	International Monetary Fund (IMF)
Governance Quality (IV)	Government Effectiveness	Alam, Kiterage, & Bizuayehu (2017), Singh & Pradhan, (2022)	The World Bank: World Governance Indicators (WGI)
ICT Diffusion (IV)	Fixed broadband subscriptions (per 100 people)	Alshubiri, Jamil, & Elheddad (2019), Akinlo (2023)	The World Bank: World Development Indicators (WDI)
Macroeconomic Variable (CV)	GDP per Capita growth annual % Trade (% of GDP)	Chinn & Ito (2006), Girma & Shortland (2008), Law & Habibullah (2009), Huang (2010a)	The World Bank: World Development Indicators (WDI)

Financial Inclusion (CV)	Automated teller machines per 100,000 adults Commercial bank branches per 100,000 adults	Kim, Yu, & Hassan (2018)	The World Bank: World Development Indicators (WDI)
Financial Performance (CV)	Bank Return on equity (ROE)	Koester et al. (2023), Asgari & Izawa (2023)	The World Bank: Global Financial Development (GFI)

Table 3.2.1: Data Sources and Variable Definitions

3.2.1 Financial Development

According to Easterly (2001) and Zaidi et al. (2019), an explanation is made that economic growth and the creation of job possibilities are attributed to good financial development. The International Monetary Fund (IMF) developed a financial development index that takes into consideration the depth, access, and efficiency of both financial markets and financial institutions (Amir & Gokmenoglu, 2020). This index was used to quantify financial development (FD). To put it simply, it is a measurement of the results that the financial institutions of the countries have achieved. The information was obtained from the Financial Development Index published by the International Monetary Fund from 1996 to 2021, yearly.

3.2.2 Governance Quality

Among the six indicators of governance quality (GQ), government effectiveness is adopted as the proxy used in this study. Government

effectiveness is determined by people's perception of the quality of state services, the quality of the public sector and the degree to which it is independent from political pressures, the quality of policy formulation and implementation, and the trustworthiness of its dedication to such policies. A greater value indicates better government effectiveness (WGI, 2024). Contributions made by Alam et al. (2017) and Singh and Pradhan (2020) shed light on the positive influence that the efficiency and quality of governance have on the aspects of financial development and overall performance.

3.2.3 Artificial Intelligence (AI)

AI is proxied by ICT, and ICT is proxied by fixed broadband in this study. ICT encompasses IT equipment, communications equipment, and software. These components have been increasingly integrated into all kinds of products and services. Generally, ICT represents technologies that facilitate, create, store, send, transmit, receive, and manipulate information, which impacts the financial development and technology of different industries and thus alters the economic activities (Schumpeter, 1942; Nelson, 1959; Griliches, 1991; Brynjolfsson & McAfee, 2014). According to Alshubiri et al. (2019), they have used three variables, including the individuals using the Internet (% of population), mobile cellular subscriptions (per 100 people), and fixed broadband subscriptions (per 100 people), to represent ICT diffusion. Empirical evidence indicates that ICT diffusion positively contributes, albeit to varying degrees, to financial development (Oliner & Sichel, 2000; Jalava & Pohjola, 2002). In this study, fixed broadband subscriptions (per 100 people) will be the applied proxy.

3.2.4 Macroeconomic Variable

In line with the studies by Chinn and Ito (2006), Girma and Shortland (2008), Law and Habibullah (2009), and Huang (2010a), this research includes GDP per capita and trade openness as control variables. To acknowledge the macroeconomic conditions in financial development, trade openness is recognised as one of the pivotal determinants of financial development in developed and developing economies (Law, 2007; Kim et al., 2010; Zhang et al., 2015; Ashraf, 2018).

3.2.5 Financial Inclusion

As explained by Rajan and Zingales (2003), the advancement of financial inclusion will both directly and indirectly contribute to a nation's financial development. In a similar vein, Chibba (2009) emphasises the fact that financial inclusion (FI) contributes to the management of poverty and to the enhancement of inclusive financial development. According to Aduda and Kalunda (2012) and Ravikumar (2012), the phrase "financial inclusion" refers to the process of integrating all elements of society into the overarching framework of the recognised financial system. According to Ali, Nazir, Hashmi, and Ullah (2022), they discovered that financial inclusion has a considerable favourable impact on financial development based on automated teller machines per 100,000 adults, commercial bank branches per 100,000 adults, and depositors with commercial banks per 1,000 individuals. This study employs automated teller machines per 100,000 adults and commercial bank branches per 100,000 adults as proxies for financial inclusion.

3.2.6 Financial Performance

Unlike traditional financial development measures, the Global Financial Development Index integrates contemporary determinants of financial access distinguished by ATMs and financial branches per 100,000 adults and financial efficiency distinguished by common financial performance ratios, such as net interest margin (NIM), lending deposit spread, return on assets (ROA), and return on equity (ROE) (Asgari & Izawa, 2023). According to Ongore and Kusa (2013), strong financial performance by commercial banks positively impacts financial development. When banks perform well, they become more attractive to investors, which in turn can stimulate further financial development. This study applied bank return on equity (%, after tax) as a proxy for financial performance.

3.3 Research Framework

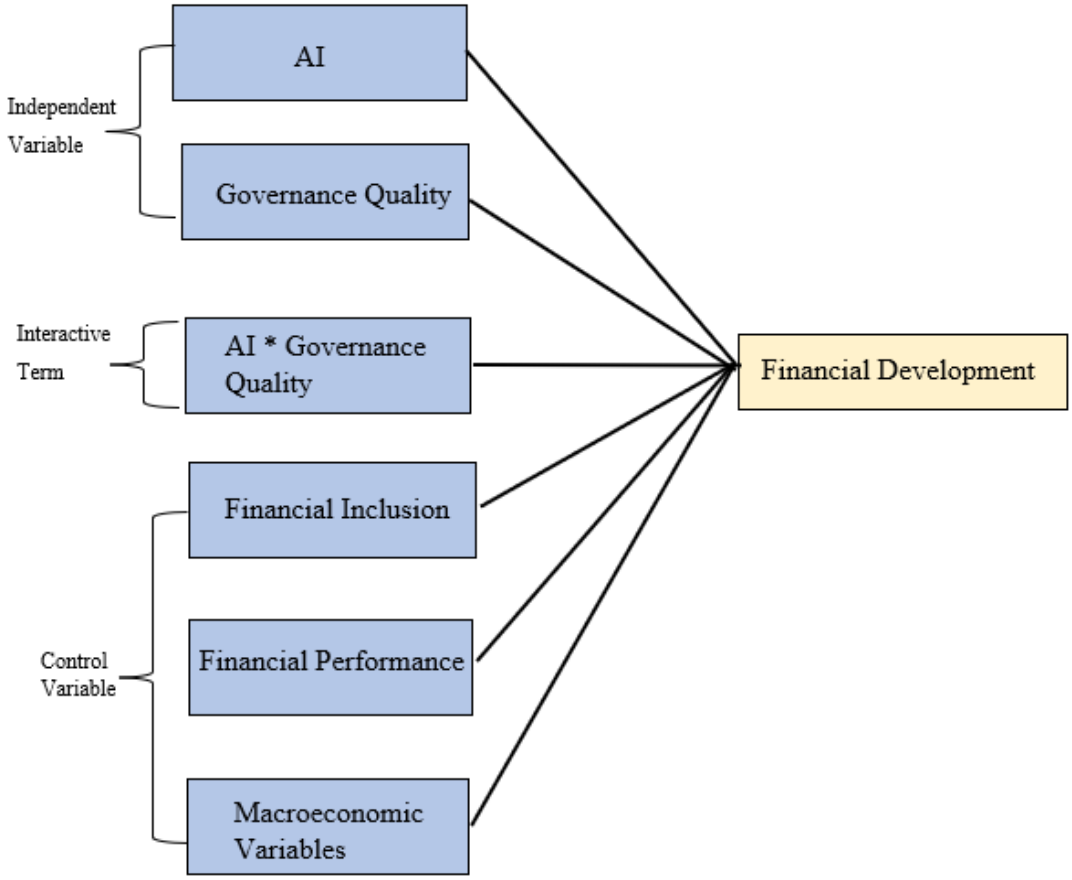

Figure 3.1 Research Framework

3.4 Econometric Model

$$FD_{it} = \beta_0 + \beta_1 GQ_{it} + \beta_2 AI_{it} + \beta_3 (GQ*AI)_{it} + \beta_4 CVs_{it} + \beta_5 FD_{it-1} + \varepsilon_{it}$$

Where:

Financial Development (FD) = Financial development index

Governance Quality (GQ) = Government effectiveness

Artificial Intelligence (AI) = Fixed broadband subscriptions (per 100 people)

Control variables (CVs) = (1) Macroeconomic Variables;

(2) Financial Inclusion;

(3) Financial Performance

i = 58 countries from developing countries

t = 1996, 1997, 1998, 1999, 2000, 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019, 2020, 2021 (26 years)

3.5 Data Processing

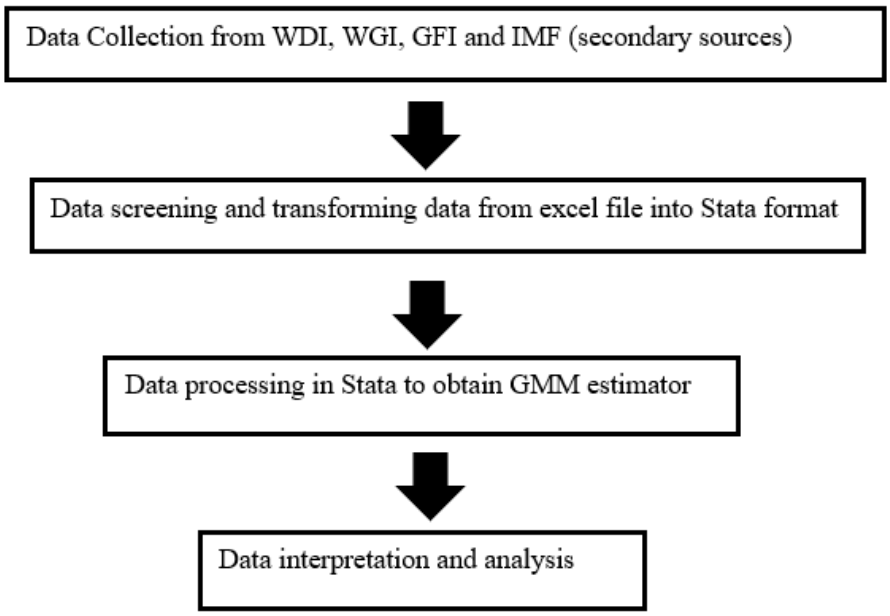

Figure 3.2 Data Processing.

3.6 Generalised Methods of Moments (GMM)

In this report, we utilise the generalised method of moments (GMM) as our primary methodology, given its suitability for dynamic panel data analysis. GMM is particularly effective in addressing the issue of endogeneity, which occurs when explanatory variables are in correlation with the error term in a model. This methodology also mitigates omitted variable bias by controlling for unobserved panel heterogeneity, ensuring that our results are more reliable. Additionally, GMM helps to correct measurement errors within the data.

There are two primary variations of GMM: Difference GMM and System GMM. Difference GMM, introduced by Arellano and Bond (1991), addresses endogeneity by transforming all regressors through differencing, effectively removing fixed effects. However, this approach has a limitation, especially when dealing with unbalanced panel data. The differencing process, which subtracts the previous observation from the current one, can amplify gaps in the data, potentially weakening the results.

System GMM, proposed by Arellano and Bond (1991) and further developed by Blundell and Bond (1998), enhances the efficiency of the estimator by introducing additional instruments. Unlike Difference GMM, System GMM builds a system of two equations: the original and a transformed version. It uses orthogonal deviations, subtracting the average of all future observations of the variable rather than the previous one, which reduces data loss and makes it more robust, even in the presence of gaps in the panel data.

Given these advantages, we have chosen GMM for this analysis to ensure accurate and efficient estimation, especially in the presence of endogeneity and unbalanced panel data.

3.6.1 One-Step and Two-Step GMM

First step:

The weighting matrix, $A = (Z'\Omega Z) -1$ is substituted with a sub-optimal weighting matrix, $A = (Z'\mathrm{H}Z) -1$, where H is an "estimate" of Ω based on a minimally arbitrary assumption about the errors, such as homoscedasticity. This yields the function, $\beta' 1 = (X'Z(Z'\mathrm{H}Z) -1Z'X) -1X'Z(Z'\mathrm{H}Z) -1Z'Y$.

Second step:

By using the β 1 (one-step GMM), the optimal weighting matrix setting $A = (Z'\Omega\ \beta\ 1\ Z)\ -1$ is reconstructed. The function is then constructed by replacing the optimal weighting matrix, $\beta\ 2 = (X'Z(Z'\Omega\ \beta\ 1\ Z)\ -1Z'X)\ -1X'Z(Z'\Omega\ \beta\ 1\ Z)\ -1Z'Y$.

3.6.2 Difference and System GMM

The Arellano-Bond estimator by Arellano and Bond (1991) and the Arellano-Bover/Blundell-Bond estimator by Arellano and Bover (1995) and Blundell and Bond (1998) are gaining popularity in use for research purposes as dynamic panel estimators. The estimators provide a solution to tackle problems such as fixed effects and endogeneity of regressors simultaneously, avoiding bias in dynamic panel models. However, they are distinctly instrumented. Both estimators were designed to address the following circumstances (Roodman, 2009):

(1) Short panel data, N > T
(2) Autoregressive dependent variable, $y_{it} = f(y_{it-1})$
(3) Endogenous regressors: $Cov(x, \varepsilon \neq 0)$
(4) Individual fixed effects
(5) Heteroskedasticity
(6) Autocorrelation among individuals but not across individuals

$$y_{it} = \alpha y_{i,t-1} + x'_{it}\beta + \varepsilon_{it} \quad (1)$$
$$\varepsilon_{it} = \mu_i + v_{it}$$
$$E[\mu_i] = E[v_{it}] = E[\mu_i v_{it}] = 0$$

where i represents observational units and t represents time. y represents the regressand and $y_{i,t-1}$ is the lagged value of y. x is a vector of regressors,

possibly including lagged values. The disturbance term consists of two orthogonal components: the fixed effects, μ_i, and idiosyncratic shocks, v_{it}. Subtracting $y_{i,t-1}$ from both sides of (1) forms an equivalent equation for difference,

$$\Delta y_{it} = (\alpha - 1)y_{i,t-1} + x'_{it}\beta + \varepsilon_{it} \quad (2)$$

This model suits the case for both estimations using linear GMM. Arellano-Bond estimation, also known as Difference GMM, proceeds after removing the fixed effects through first-differencing the data (Roodman, 2009). Arellano-Bover/Blundell-Bond estimation, then augments Difference GMM via an introduction of instrumental variables, which are uncorrelated with the fixed effects. This allows for more instruments and improves efficiency. Combining the two equations—the initial and transformed—forms System GMM (Roodman, 2009).

Applying first-difference transformation to (1) gives,

$$\Delta y_{it} = \alpha \Delta y_{i,t-1} + \Delta x'_{it}\beta + \Delta v_{it} \quad (3)$$

In (3), the fixed effects are eliminated, but the lagged dependent variable, $y_{i,t-1}$ remains potentially endogenous since $y_{i,t-1}$ from $\Delta y_{i,t-1} = y_{i,t-1} - y_{i,t-2}$ is correlated with $v_{i,t-1}$ from $\Delta v_{it} = v_{i,t-1} - v_{i,t-2}$. In like manner, any predetermined variables in x becomes likely endogenous instead of not strictly exogenous due to their potential correlation with $v_{i,t-1}$. The previous observation is subtracted from the contemporaneous variable in this transformation. One weakness proposed is that it widens the gaps in unbalanced panel data. An absence in one y_{it} is followed by an absence of the corresponding Δy_{it} and $\Delta y_{i,t+1}$ in the transformed data. One may formulate datasets that completely vanished after the first transformation (Roodman, 2009), this calls for the second transformation, known as "forward orthogonal deviations" or "orthogonal deviations" (Arellano &

Bover, 1995). The second transformation subtracts the mean of all future available observations from the contemporaneous variable, allowing computations for all observations despite the gaps except for the last, minimizing data loss. Lagged observations become valid instruments without entering the formula (Roodman, 2009).

While the first transformation eliminates fixed effects from the regressors, the second transformation alters the instruments to be exogenous to the fixed effects. An additional assumption regards the modifications in instrumental variables, w_{it}, are uncorrelated with fixed effects, μ_i: $E(\Delta w_{it}\mu_i) = 0$. Thus, $E(w_{it}\mu_i)$ is time-invariant. With this assumption hold, $\Delta w_{i,t-1}$ becomes a valid instrument for the variables in levels (Roodman, 2009):

$$E(\Delta w_{i,t-1}\varepsilon_{it}) = E(\Delta w_{i,t-1}\mu_i) + E(w_{i,t-1}v_{it}) - E(w_{i,t-2}v_{it})$$
$$= 0 + 0 - 0$$

In short, where Arellano–Bond (Difference GMM) instruments differences with levels, Blundell–Bond (System GMM) instruments levels with differences.
In this study, both approaches will be used, complemented with a series of comparisons and robustness checks in the generation of results.

3.6.3 Diagnostic test

The econometric model's suitability for use with the Generalised Method of Moments (GMM) model depends on meeting certain requirements. Error terms in a GMM model that exhibit autocorrelation defy the assumption that the errors are identically and independently distributed. This may result in biased standard errors, imprecise statistical results, and ineffective parameter estimations. As a result, consideration of this issue is essential for guaranteeing the accuracy of the outcomes (Biørn, 2014).

The crucial diagnostic in dynamic panel data estimation is the AR test for residual autocorrelation. Due to its formulation, the residuals of the differenced equation are expected to display serial correlation; nevertheless, if the assumption of serial independence in the original errors is justified, the differenced residuals should have notable AR(2) characteristics. A large AR(2) statistic indicates that the second lags of endogenous variables are unsuitable instruments for their present values (Baum, 2013).

Arellano and Bond formulate a test for an occurrence that can invalidate certain lags as instruments, which is an autocorrelation in the unique disturbance term, v_{it}. Of course, the full disturbance, ε_{it}, is presumed to be autocorrelated because it contains fixed effects, and the estimators are designed to eliminate this source of trouble. But if the v_{it} are themselves serially correlated of order 1, then, for instance, $y_{i,t-2}$ is endogenous to the $v_{i,t-1}$ in the error term in differences, $\Delta\varepsilon_{it} = v_{it} - v_{i,t-1}$, making it a potentially invalid instrument after all. The Arellano-Bond test for autocorrelation is valid for any GMM regression on panel data, including OLS and 2SLS, given that none of the regressors is "post-determined", depending on future disturbances (Roodman, 2009).

The hypothesis statements for the Arellano-Bond test are presented:

H_0: There is no serial correlation
H_1: There is a serial correlation

The hypothesis statements for the AR (1) are presented:

H_0: There is no first-order serial correlation in the differenced error term
H_1: There is first-order serial correlation in the differenced error term

The hypothesis statements for the AR (2) are presented:

H_0: There is no second-order serial correlation in the differenced error term

H_1: There is second-order serial correlation in the differenced error term

This research is expected to reject the null hypothesis in AR(1) and not reject the null hypothesis in AR(2)

3.7 Conclusion

Chapter Three gives a comprehensive overview of the study's methodology. It employs secondary data gathered from the Worldwide Governance Indicators (WGI), World Development Indicators (WDI), and the International Monetary Fund (IMF). After data collection, data screening and processing are conducted. The data-generating procedure is then executed using Stata software. Following a detailed analysis of various estimation techniques, a two-step system generalized method of moments (GMM) is utilised to address autocorrelation issues and the characteristics of a small T and large N dataset, ensuring robust results.

CHAPTER 4: DATA ANALYSIS

4.0 Introduction

Chapter Four investigates the impact of artificial intelligence and governance quality on financial development in 58 developing countries from 1996 to 2021. A thorough examination of the gathered data is performed using descriptive statistics, hypothesis testing, and diagnostic evaluations. Generalised method of moments (GMM) estimates are employed to mitigate possible endogeneity and unobserved heterogeneity in the dataset, incorporating both independent and control variables. Diagnostic checks are then performed through Arellano-Bond serial correlation tests to ensure model validity, particularly in confirming the absence of second-order autocorrelation.

Additionally, this chapter provides detailed interpretations of the empirical results generated using Stata software. A robustness check is also conducted, incorporating sensitivity analyses and alternative model specifications to verify the reliability and consistency of the findings. Key insights derived from the data will be further explored in the context of relevant literature and their broader implications for the study's objectives.

4.1 Descriptive Statistics

Variables	Obs	Mean	Std. Dev.	Min	Max
y1	1612	.1529775	.1011176	0	.5837564
x1	1597	27.55636	17.33796	-.8411018	75.40984

x9	1040	1.7119	5.75232	0	97.2663
x10	1570	2.08821	5.030821	-48.39246	90.75806
x12	908	12.60638	16.34982	0	106.88
x16	1066	15.20536	10.99565	-116.1993	74.27419

Table 4.1.1: Summarized Statistics of the Main Variables

Note: y1 indicates financial development index, a proxy for financial development; x1 indicates government effectiveness, a proxy for governance quality; x9 indicates fixed broadband subscriptions (per 100 people), a proxy for AI; x10 indicates GDP per capita growth (annual %), a proxy for macroeconomic variables; x12 indicates automated teller machines (ATMs) (per 100,000 adults), a proxy for financial inclusion; x16 indicates bank return on equity (%, after tax), a proxy for financial performance.

Table 4.1.1 demonstrates a summary of statistics of the dependent variables, independent variables, and control variables. The proxy of financial development has 1,612 observations, with a mean of 0.153 and a standard deviation of 0.101. The values range from 0 to 0.584, indicating a moderate level of variation. The relatively low standard deviation suggests that most values are closely clustered around the mean. Among the independent variables, government effectiveness (x1) has the highest mean of 27.56 and a standard deviation of 17.34, demonstrating significant variation. On the other hand, fixed broadband subscriptions (per 100 people) (x9) has a much lower mean of 1.71 and a standard deviation of 5.75, with values ranging widely from 0 to 97.27. Both GDP per capita growth (annual %) (x10) and automated teller machines (ATMs) (per 100,000 adults) (x12) also show considerable variation, with mean values of 2.03 and 12.61, respectively, and relatively high standard deviations. For bank return on equity (%, after tax) (x16), the mean is 15.21 with a standard deviation of 10.99. However, the presence of extreme values ranging from -116.20 to 74.27 suggests possible outliers or country-specific differences. This study will use ICT as a proxy for AI. In addition, this research obtained the use of fixed broadband subscriptions (per 100 people) to

represent the ICT diffusion. Overall, the dataset shows considerable variability, particularly among the independent variables, which may be influenced by economic conditions, country characteristics or differences in measurement scales.

	y1	x1	x9	x10	x12	x16
y1	1					
x1	0.594	1				
x9	0.443	0.247	1			
x10	0.0669	0.192	-0.0975	1		
x12	0.439	0.277	0.696	-0.105	1	
x16	-0.259	-0.112	-0.251	0.179	-0.329	1

Table 4.1.2: Correlation Matrix of the Main Variables

Note: y1 indicates the financial development index, a proxy for financial development; x1 indicates government effectiveness, a proxy for governance quality; x9 indicates fixed broadband subscriptions (per 100 people), a proxy for AI; x10 indicates GDP per capita growth (annual %), a proxy for macroeconomic variables; x12 indicates automated teller machines (ATMs) (per 100,000 adults), a proxy for financial inclusion; x16 indicates bank return on equity (%, after tax), a proxy for financial performance.

Table 4.1.2 denotes the pairwise correlation between proxies of the main variables, reflecting the expected relationships based on the theoretical framework and econometric models. The correlation coefficients indicate how the dependent variable (y1) interacts with the independent and control variables. The positive correlations between y1 and variables like x1, x9, and x12 align with the proposed hypotheses, suggesting their potential influence. Meanwhile, x16 exhibits a negative correlation with several variables, indicating possible inverse relationships. These correlations provide preliminary insights into variable linkages, supporting the model's theoretical foundation.

4.2 Results from Dynamic Panel GMM Estimation

	(1)	(2)	(3)	(4)	(5)	**(6)**
	one step difference	two step difference	two step robust difference	one step system	two step system	**two step robust system**
	ly1	ly1	ly1	ly1	ly1	**ly1**
L.ly1	0.235***	0.198***	0.198*	0.622***	0.603***	**0.603***
	(6.91)	(6.43)	(1.82)	(17.72)	(37.18)	**(6.79)**
lx1	0.0147***	0.0145***	0.0145	0.0275***	0.0266***	**0.0266***
	(3.36)	(7.66)	(1.52)	(8.94)	(23.26)	**(2.72)**
lx9	0.0336***	0.0327***	0.0327	0.0507***	0.0516***	**0.0516***
	(3.16)	(9.55)	(1.28)	(4.51)	(24.00)	**(2.60)**
lx1lx9	-0.00868***	-0.00821***	-0.00821	-0.0117***	-0.0117***	**-0.0117**
	(-3.27)	(-9.15)	(-1.43)	(-4.11)	(-20.50)	**(-2.36)**
lx10	-0.0224*	-0.0221***	-0.0221**	0.0435***	0.0406***	**0.0406***
	(-1.93)	(-17.94)	(-1.99)	(3.02)	(11.72)	**(1.90)**
lx12	0.0103***	0.0109***	0.0109*	0.0105***	0.00916***	**0.00916**
	(4.20)	(16.03)	(1.95)	(4.55)	(8.47)	**(2.19)**
lx16	0.0190	0.0176***	0.0176	0.133***	0.129***	**0.129***
	(1.09)	(6.33)	(0.60)	(6.05)	(10.87)	**(2.90)**
_cons				-0.876***	-0.836***	**-0.836***
				(-8.86)	(-16.19)	**(-3.86)**
N	619	619	619	690	690	**690**
ar1	0.000	0.029	0.138	0.000	0.000	**0.001**

	[-6.84]	[-2.18]	[-1.48]	[-10.91]	[-3.66]	**[-3.45]**
ar2	0.650	0.590	0.611	0.616	0.567	**0.573**
	[0.45]	[0.54]	[0.51]	[0.50]	[0.57]	**[0.56]**

Table 4.2.1: Results from Dynamic Panel GMM Estimation

t statistics in parentheses ()
* p < 10 percent, ** p < 5 percent, *** p < 1 percent
ar test results presented with p-value
Z-score in square brackets []
l represents natural logarithm, ln

Note: y1 indicates the financial development index, a proxy for financial development; L.y1 indicates the lagged financial development index, a proxy for lagged financial development; x1 indicates government effectiveness, a proxy for governance quality; x9 indicates fixed broadband subscriptions (per 100 people, a proxy for AI; x1x9 indicates the interaction term between x1 and x9; x10 indicates GDP per capita growth (annual %), a proxy for macroeconomic variables; x12 indicates automated teller machines (ATMs) (per 100,000 adults), a proxy for financial inclusion; x16 indicates bank return on equity (%, after tax), a proxy for financial performance.

Table 4.2.1 presents the generated results from the dynamic panel generalised method of moments (GMM) estimations, carried out using Stata software. The analysis employs both difference and system GMM methods. These estimators, first introduced by Holtz-Eakin et al. (1988) and refined by Arellano and Bond (1991), provide a more sophisticated means of addressing biases in panel data estimations. Specifically, system GMM, introduced by Arellano and Bover (1995) and improved by Blundell and Bond (1998), includes additional moment conditions, making it more reliable in handling persistent series.

Blundell and Bond (1998) noted that when a series exhibits high persistence, difference GMM may introduce bias. This occurs because the lagged levels of the series are only weakly correlated with the first differences, diminishing the

explanatory power of the model. System GMM mitigates this problem by using lagged first differences as instruments in the level equations, thereby improving the model's ability to account for variations in the dependent variable. This study focuses on the results derived from the system GMM estimation. Following the recommendations of Roodman (2009a), we selected the two-step system GMM model because it is more asymptotically efficient and robust, balancing efficiency and bias by using the robust option for standard errors. Roodman (2009b) highlighted the problem of instrument proliferation, which can result in overfitting and biased standard errors. To prevent this, the collapse option was applied to reduce the complexity of the instrument set.

According to Roodman (2009b), the models in Table 4.2.1 can be divided into two main groups: Models 1–3 represent difference GMM estimations, and Models 4–6 represent system GMM estimations. Model 1 employs one-step difference GMM, Model 2 utilises two-step difference GMM, and Model 3 applies two-step robust difference GMM. In contrast, Model 4 uses one-step system GMM, Model 5 applies two-step system GMM, and Model 6 employs two-step robust system GMM. The system GMM models provide a more comprehensive solution than difference GMM because they are better able to mitigate biases effectively. Therefore, system GMM was selected for this analysis, particularly focusing on Model 6, which uses two-step robust system GMM—the most efficient and reliable estimation method in this context.

This research now interprets the results from Model 6, considered the best fit due to its robustness. The dependent variable in this model is financial development, measured by the financial development index (y1). This index provides a relative ranking of countries based on the depth (size and liquidity), access (the ability of individuals and companies to obtain financial services), and efficiency (the capacity of institutions to offer low-cost financial services with sustainable revenues and the level of capital market activity) of their financial institutions and markets. It is a composite measure that aggregates the financial institutions index and the financial market index.

First of all, based on the results in Table 4.2.1, the coefficient for the lagged value of the financial development index (L.y1) is 0.603 and is highly significant at a significance level of 1 percent, indicating a positive and persistent effect of financial development in previous periods on current financial development. As per 1 percent increase in the lagged financial development index, the current financial development index increases by an average of 0.603 percent, ceteris paribus. This finding indicates that financial development tends to follow a path-dependent trajectory, supporting the notion that financial systems evolve gradually and often display inertia over time.

Secondly, governance quality is represented by government effectiveness (x1), which reflects the public's perception of the quality of public services, the competence and independence of the civil service, the quality of policy formulation and implementation, and the credibility of the government's commitment to these policies. This measure captures a broad assessment of how effectively the government functions and its ability to uphold high standards in governance (World Bank, 2024). It has a positive and significant relationship with financial development (y1) at 1 percent significance level. This outcome highlights the pivotal role that governance quality plays in supporting the growth of a strong financial sector. This means that governance quality is a driver of financial development. This outcome is aligned with the results of Alam, Kiterage, and Bizuayehu (2017) and Singh and Pradhan (2022), as the authors advocate that good governance quality is critical to financial development in improving market efficiency and attracting external resources. Furthermore, the quality of governance has hugely impacted the allocation of foreign aid by different organisations across countries, hence influencing a country's financial development.

Moving on to the next, AI is represented by the number of fixed broadband subscriptions (x9). The internet plays a crucial role in advancing financial development by enabling seamless information exchange between financial institutions and their clients. It provides users with quick and simple access to a variety of financial goods and services, including banking, investing, and lending alternatives (Akinlo, 2023). Fixed broadband subscriptions are defined as fixed

connections that offer high-speed internet access (via a TCP/IP connection) with downstream speeds of 256 kbit/s or greater. Table 4.2.1 shows that AI (x9), measured by fixed broadband subscriptions, has a positive and statistically significant relationship with financial development (y1) at 1 percent significance level. The spread of ICT technologies is pivotal in fostering financial development by expanding access to financial services and improving market efficiency through enhanced communication tools. This outcome is aligned with the results of Alshubiri, Jamil, and Elheddad (2019) and Akinlo (2023), which mentioned that ICT is an essential indication of financial development because it can lower the costs of banking services, enabling institutions like commercial banks and microfinance institutions to increase their business activities (Dewan & Ramaprasad, 2014). In addition, ICT enhances the operational flexibility of banks and strengthens financial risk disclosures, thereby ensuring safer practices within the banking sector (Waverman, Meloria, & Melvyn, 2005). Lastly, ICT allows for more efficient assessments of creditworthiness, which helps facilitate deposits (Pradhan, Mallik, & Bagchi, 2018).

Subsequently, the interaction term between governance quality (proxied by government effectiveness) and AI (proxied by fixed broadband subscriptions (per 100 people)) (x1x9) shows a negative and statistically significant relationship with financial development (y1) at 5 percent significance level. This finding indicates that the interaction between ICT diffusion and government effectiveness negatively impacts financial development, as their combined influence results in a reduction of the overall financial development index, likely due to overlapping functions in facilitating financial activities and governance.

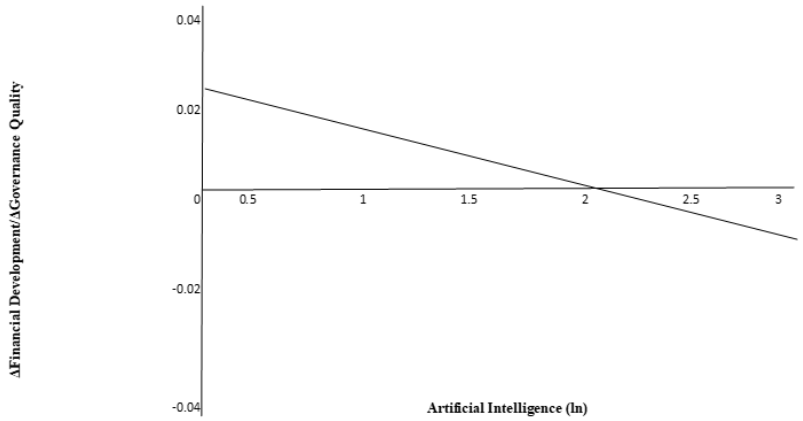

Figure 4.1.1: The partial effect of Artificial Intelligence (AI) on Financial Development.

Kotera (2012) posits that the negative coefficient of the interacting term might be explained by mathematical differentiation. By analysing the partial derivative, we may evaluate the partial impact of the interaction term.

The partial effect of governance quality on financial development is favourable when the adoption of AI is below 2.2735 but becomes negative if the adoption of AI exceeds this threshold (refer to Figure 4.1.1). Multiple justifications were presented:

The quality of governance may facilitate the establishment and maintenance of robust property rights, an effective legal framework, and a sound and efficient financial system for financial development. Favara (2003) posits that institutions constitute a network of official and informal laws designed to establish order in economic and social spheres while providing a framework for the implementation and oversight of these norms to optimise the utilisation of national resources. Consequently, institutions are crucial in formulating policies that facilitate institutional changes and promote the establishment of growth-orientated financial systems (Blackburn & Forgues-Puccio, 2010; Casson et al., 2010; Angelopoulos et al., 2011). In accordance with the previous literature (Law & Azaman-Saini, 2012;

Ijaz & Idrees, 2016), government effectiveness is one of the significant causes of disparities in financial development among nations. Government effectiveness entails minimising firm operational costs, therefore fostering investment activities (Bekana, 2023). La Porta et al. (1997, 1998) elucidated the phenomenon of investor protection and said that worldwide discrepancies in financial efficacy might be attributed to variances in legislative laws and the quality of enforcement. They determined that effective laws and vigorous enforcement by the legal system incentivise investors to finance enterprises, leading to a more robust and advanced financial industry. Consequently, these advanced financial markets exhibit accelerated financial development (Lee, 2012; Chow et al., 2017; Yang, 2019). Based on the studies of Klomp and de Haan (2014), Bonnal and Yaya (2015), and Kutan et al. (2017), the prospective outcome of financial development is fundamentally associated with regulations, legislation, and the quality of financial oversight. The quality of governance remained more effective and had a lasting influence on low-income economies. Simultaneously, effective governance guarantees the proper distribution of resources, alongside the mitigation of corruption and the maintenance of political stability, which collectively foster sustained financial development (Iqbal, 2021).

Knowing that a favourable governance quality is complementary to financial development, the incorporation of AI in this context complicates that relationship. Figure 4.1.1 pictures out that financial development can be hindered as AI becomes more prevalent. The penetration of the Internet and information technology has brought an evolution in the financial field to explore innovative digital methodologies aside from the conventional statistical approaches of conduct in the financial market. Since AI is integrated with finance, it is majorly used in various contexts, including investment planning, algorithmic trading, fraud detection, and loan and insurance underwriting (Xie, 2019). In respect of the growing availability of digital data, increased data storage accompanied with enlarged computer processing capacity to operate at a lowered cost, and automatic data analysis through algorithmic calculations, AI has served an incremental crucial part of the finance sector and the overall economy, with greater analytical capacity to better serve the financial market players (Fernández, 2019). With the use of AI tools,

financial data can be interpreted and managed with improved efficiency and efficacy, generating meticulous results in support of financial conduct. AI is capable of processing vast amounts of data beyond human capacity, generating valuable insights that support future predictions and enable informed financial decision-making (Aderibigbe et al., 2023). These advancements have the potential to transform the financial industry by fostering innovation and overcoming the limitations of traditional financial practices (Zakaria et al., 2023).

Despite the advantages of AI mentioned before, the underlying complexity and uncertainty regarding AI are believed to have been the factors that caused a downturn in financial development. The extensive use of AI raises concerns regarding a demand for oversight to safeguard transparency, fairness, and accountability (Cath, 2018). While AI has significantly benefitted the finance sector, it also exposes this data-reliant industry to potential risks stemming from AI failures. AI systems often lack transparency and legitimacy due to their capacity for autonomous learning and evolving beyond the scope initially envisioned by their developers. The disparity between existing legal standards and the nature of AI raises questions about accountability, particularly regarding algorithmic decision-making (Feldman & Stein, 2022). The black-box property of AI, with its inherent unpredictability and complexity, presents significant challenges for regulators in crafting policies that adequately assign responsibility for unforeseen consequences (Gasser & Almeida, 2017; Perry & Uuk, 2019; Taeihagh et al., 2021). Other than that, the use of AI vicariously fosters the creation of more sophisticated and intelligent cyber threats, which compounds the difficulty in cyber defence. This results in possible cyberattacks that can disrupt the banking system, causing a downfall in the international market operations (Попело et al., 2024).

The advancement in AI also comes in tandem with the likelihood of AI misuse in aid of achieving a specific outcome, which can be in the form of human manipulation or coercive abuse. This urges regulators to gain attention on the construction of a sufficiently fitting legal framework in the context of monitoring the financial markets where autonomous learning algorithms transact with each other, and the definition to determine the legitimacy of market trading operations is

blurred (Carroll et al., 2023). Additionally, regulators face difficulties in managing disruptive innovations, largely because regulations are inherently reactive, often developed in response to existing challenges and facts (Kaal & Vermeulen, 2017; De Almeida et al., 2021). The vigorous evolution of AI fosters innovation in financial products and services, makes them increasingly intricate to understand (Truby et al., 2020), and compounds the obstacle for regulators to keep the regulations in pace (Buckley et al., 2021). Emerging economies often lack the infrastructure, legal frameworks, and expertise required to effectively regulate AI technologies (Sharma et al., 2022).

AI possesses the risk of worsening the undesirable injustices, exaggerating prejudices, and intensifying the social and economic inequalities without proper justifications in its utilisation (Aderibigbe, Ohenhen, Nwaobia, Gidiagba, & Ani, 2023). The rapid pace of AI development, combined with insufficient knowledge of emerging technologies, exacerbates information asymmetry and leaves regulators struggling to keep up, hindering their ability to address current legal gaps (Clair & DNV, 2019; Taeihagh et al., 2021). The adoption of AI requires governance oversight. Inadequate regulatory oversight in AI implementation can pose economic risks, as public and regulatory fears over potential harm may stifle innovation in what could otherwise be a highly beneficial field (Truby et al., 2020). Regulators with good intentions can unintentionally cause repercussions that deter emerging economies from the assimilation of AI (Buckley et al., 2021). In summary, good governance quality and advanced AI technology alone can create an advantageous edge for improved financial development to take place. Nonetheless, as AI is increasingly interconnected with the financial system, the risks associated with AI can be magnified in the absence of adequate regulatory supervision to gatekeep AI from unfavourable advancements and dishonest usages. Hence, a precondition that both aspects are reciprocally beneficial is necessary to prevent a backfire on financial development.

Evaluating the average value from 1996 to 2021, 12 countries exceeded the threshold. Ranked from the least to the most deviation from the threshold, these countries are Algeria, Bolivia, Egypt (Arab Republic), Iran (Islamic Republic),

Lebanon, Mongolia, South Sudan, Sri Lanka, Tunisia, Ukraine, Uzbekistan, and Vietnam.

In terms of a series of control variables, starting with GDP per capita growth (x10), representing macroeconomic variables, it is positively and statistically significant in association with financial development (y1), with a coefficient of 0.0406 at a 10 percent significance level. This indicates that a 1 percent rise in GDP per capita corresponds to an average 0.0406 percent increase in the financial development index, holding all other factors constant. Nonetheless, the relatively modest significance implies that although macroeconomic growth positively influences financial development, its effect may be less pronounced or direct when compared to factors such as governance quality or ICT diffusion. This suggests that economic growth, on its own, may be insufficient to drive substantial improvements in the financial sector without simultaneous advancements in institutional or technological frameworks. Previous studies have used GDP per capita as a proxy for macroeconomic variables to identify the impact on financial development (Chinn & Ito, 2006; Girma & Shortland, 2008; Law & Habibullah, 2009; Huang, 2010a). Our result coincides with the outcome of Gwachha (2022) in that GDP enhances financial development. This is because a high GDP reflects that the citizen may have excess savings and will have a high tendency to save their money in financial institutions or make investments, hence inducing the progress of financial development.

Other than that, the number of ATMs per 100,000 adults (x12), a proxy for financial inclusion, shows a positive and statistically significant effect on financial development (y1), with a coefficient of 0.00916 at 5 percent significance level. This means that if everything else stays the same, the financial development index rises by an average of 0.00916 percent for every 1 percent increase in the financial inclusion index, which is measured by ATM access. This shows how important financial infrastructure is for making more people able to use fundamental banking services and helping the financial sector grow. This result backs up what Kim et al. (2018) found, which is that if there is a low level of financial inclusion, a lot of people may have money problems because they can't get bank deposits, loans,

insurance, and other related services. Because of this, more people having access to financial services is likely to lead to better financial development.

Finally, financial performance (x16), which is measured by the return on equity (ROE) of banks, is statistically significant and has a positive relationship with financial development (y1), with a coefficient of 0.129 at the 1% significance level. This means that the financial growth measure goes up by an average of 0.129 percent for every 1 percent rise in ROE, ceteris paribus. A banking industry that makes more money not only shows that the economy is healthier and more stable, but it also gives people more money to borrow and spend, which helps the economy grow to boost financial development. Koester et al. (2023) and Asgari and Izawa (2023) back up our findings stating that better financial performance will make it cheaper to lend money and make it easier for customers to get new financial goods and services. This will help financial companies do better business, which will finally lead to more financial development.

To summarise the above result from Model 6, the two-step robust system GMM, strong evidence is available to conclude that government effectiveness, ICT diffusion, financial inclusion, and banking performance all play crucial roles in promoting financial development. The collaborative outcome between government effectiveness and ICT diffusion turns out to have a counter-effect despite them separately being complementary to financial development. While the contribution of macroeconomic growth is noteworthy, albeit to a lesser extent, the enduring nature of financial development underscores the path-dependent trajectory of the sector's evolution.

4.3 Diagnostic Tests

This diagnostic test serves the purpose of testing for one of the initial assumptions of the GMM model: autocorrelation among individuals but not across individuals. AR(1) tests for first-order serial correlation in the differenced error term. Negative serial correlation is expected due to the mathematical process of differencing.

Rejecting the null hypothesis of AR(1) infers that there is autocorrelation among individuals, which satisfies the initial assumption of the model. On the other hand, AR(2) tests for second-order serial correlation in the differenced error term, which represents first-order serial correlation of the error term in levels. Therefore, the rule of thumb was to not reject the null hypothesis in AR(2). Henceforth, the lagged dependent variable can be used as a valid instrument, and the model is well-specified (Roodman, 2009).

Referring to Table 4.2.1, AR(1) is rejected in most models at a significance level of 5 percent, defying the null hypothesis of not having a first-order serial correlation in the differenced error term. However, it is not rejected in model (3). This AR(1) outcome that is non-satisfactory in model (3) suggests that the difference GMM models are not suitable for this study. Moving on to the second indicator, the null hypothesis of AR(2) is not rejected in all models, confirming the absence of second-order serial correlation in the differenced error, hence no autocorrelation in levels. Notably, both tests revealed satisfactory results for model (6), the two-step robust system GMM model. In conclusion, both diagnostic tests were passed in terms of model (6), suggesting that the model was well-specified without the autocorrelation problem, leading it to be a good fit for this study.

4.4 Robustness Check

	(7)	(8)	(9)	(10)	(11)	**(12)**
	one step difference	two step difference	two step robust difference	one step system	two step system	**two step robust system**
	ly1	ly1	ly1	ly1	ly1	**ly1**
L.ly1	0.189***	0.180***	0.180***	0.472***	0.512***	**0.512*** **
	(5.15)	(21.36)	(2.63)	(14.34)	(18.86)	**(5.37)**
lx1	0.00688	0.00733***	0.00733	0.0345***	0.0285***	**0.0285*** **

	(1.63)	(7.35)	(0.82)	(11.06)	(10.48)	**(3.89)**
lx9	0.0205**	0.0217***	0.0217	0.0695***	0.0602***	**0.0602*** **
	(2.36)	(14.29)	(1.63)	(8.19)	(14.90)	**(4.36)**
lx1lx9	-0.00458**	-0.00479***	-0.00479	-0.0161***	-0.0133***	**-0.0133*** **
	(-2.04)	(-11.24)	(-1.05)	(-6.96)	(-13.07)	**(-3.81)**
lx11	0.00185	0.000772	0.000772	0.0286***	0.0215***	**0.0215***
	(0.28)	(1.02)	(0.10)	(6.23)	(6.77)	**(1.66)**
lx13	0.0193***	0.0190***	0.0190***	0.0131***	0.0120***	**0.0120*** **
	(5.63)	(16.83)	(2.71)	(7.11)	(13.56)	**(2.84)**
lx16	-0.00561	0.000521	0.000521	0.0193	0.0471***	**0.0471***
	(-0.31)	(0.12)	(0.02)	(0.98)	(4.59)	**(1.68)**
_cons				-0.272***	-0.364***	**-0.364*** **
				(-3.09)	(-9.11)	**(-2.62)**
N	679	679	679	744	744	**744**
ar1	0.000	0.011	0.053	0.000	0.000	**0.001**
	[-9.49]	[-2.55]	[-1.94]	[-8.73]	[-3.80]	**[-3.32]**
ar2	0.634	0.606	0.625	0.825	0.750	**0.753**
	[-0.48]	[-0.52]	[-0.49]	[0.22]	[0.32]	**[0.32]**

Table 4.4.1: Results from Dynamic Panel GMM Estimation for Robustness Checking

t statistics in parentheses ()

* p < 10 percent, ** p < 5 percent, *** p < 1 percent

ar test results presented with p-value

Z-score in square brackets []

l represents natural logarithm, ln

Note: y1 indicates the financial development index, a proxy for financial development; L.y1 indicates the lagged financial development index, a proxy for lagged financial development; x1 indicates government effectiveness, a proxy for governance quality; x9 indicates fixed broadband subscriptions (per 100 people), a proxy for AI; x1x9 indicates the interaction term between x1 and x9; x11 indicates trade (% of GDP), a proxy for macroeconomic variables; x13 indicates commercial bank branches (per 100,000 adults), a proxy for financial inclusion; x16 indicates bank return on equity (%, after tax), a proxy for financial performance.

A robustness check is a common practice for researchers in conducting empirical work to examine how the "core" regression coefficients estimate changes when an alteration of the regression specification has taken place, especially when one or more regressors have been added or removed (Lu & White, 2014). Researchers can look into the stability of the initial estimates for feasible modifications in the model specification (Neumayer & Plümper, 2017). In this paper, changes are made with respect to the proxies for two of the control variables to investigate the robustness of the test result: (i) GDP per capita growth (annual %) (x10) is replaced by trade (% of GDP) (x11) as the proxy for macroeconomic variables. It has been tested that trade (% of GDP) can positively and significantly affect financial development (Zainudin & Nordin, 2017). (ii) Automated teller machines (ATMs) (per 100,000 adults) (x12) is replaced by commercial bank branches (per 100,000 adults) (x13) as the proxy for financial inclusion. Research conducted indicates that commercial bank branches (per 100,000 adults) acting as a financial inclusion index contribute positive and significant effects on financial development (Rasheed et al., 2016). The result of the modified regression model is shown in Table 4.4.1.

Table 4.4.1 shows a positive and significant relationship between trade (% of GDP) (x11) and the Financial Development Index (y1), identical to the result of the initial proxy for macroeconomic variables shown in Table 4.2.1. When trade (% of GDP) increases by 1 percent, the financial development index increases by an average of 0.0215 percent, ceteris paribus. Besides that, commercial bank branches (per 100,000 adults) (x13) resulted in a positive and significant relationship with the financial development index (y1), similar to the result of the initial proxy for

financial inclusion shown in Table 4.2.1. When commercial bank branches (per 100,000 adults) increase by 1 percent, the financial development index increases by an average of 0.0120 percent, ceteris paribus.

The result in Table 4.4.1 corresponds with Table 4.2.1 for the remaining unchanged variables. The positive impact of the lagged financial development index (L.y1) is verified, noting that the effect of the previous state of financial development can be brought forward to the current state. The outcome also reveals the positive and significant relationship between government effectiveness (x1) and the financial development index (y1), which appears to be consistent with the result shown in Table 4.2.1. The relationship between fixed broadband subscriptions (per 100 people) (x9) and the financial development index (y1) also remained positive and significant. Other than that, the interaction term representing the collaborative effect of government effectiveness and ICT diffusion (x1x9) persists, having a negative and significant relationship with y1. Lastly, bank return on equity (%, after tax) (x16) maintained a positive and significant relationship with the financial development index (y1). When the bank return on equity (%, after tax) increases by 1 percent, the financial development index increases by an average of 0.0471 percent.

Observing the outcome in Table 4.4.1 in comparison with Table 4.2.1, we can conclude that the findings are robust and reliable despite modifications in model specification. Primarily, the initial proxies for the main variables were input for model estimation, which generated a result for 58 developing countries, excluding the Central African Republic, Comoros, Congo Republic, and Sierra Leone, with a total of 690 observations from 1996 to 2021 taken into account. Consequently, when a change in proxies for the main variables took place—(i) the substitution of trade (% of GDP) (x11) for GDP per capita growth (annual %) (x10) as the proxy for macroeconomic variables; (ii) the substitution of commercial bank branches (per 100,000 adults) (x13) for automated teller machines (ATMs) (per 100,000 adults) (x12) as the proxy for financial inclusion—the result remained consistent with identical signs for the coefficient of both the substituted proxies to the initial proxies. The modified model exhibits a result for 54 developing countries, excluding the

Central African Republic, Comoros, Congo Republic, Liberia, Malawi, Myanmar, Nigeria, and Sierra Leone, with a total of 744 observations from 1996 to 2021. The modified model also passed the diagnostic tests. Therefore, it is justifiable to conclude that the results generated are consistent and mutually supporting.

4.5 Conclusion

Chapter Four presents the results of the dynamic panel GMM estimations. Table 4.1.1 displays the summarised descriptive statistics of the main variables, while Table 4.1.2 shows the correlation between the main variables involved. Next, Table 4.2.1 displays the results of the empirical models, outlining that all the independent and control variables included in this study are statistically significant in explaining the dependent variable in association with comprehensive interpretations. A diagnostic test was then performed to test the presence of autocorrelation, proving the absence of the problem addressed. Lastly, alternative proxies were substituted into the initial model for robustness checking to ensure consistency in the result; the outcomes were as anticipated. It is notable that the interaction term, which represents the collective effect between governance quality and AI, is statistically significant in influencing financial development, but it exhibits a negative effect. Further discussion and implications were to be made in the subsequent chapter: Chapter Five.

CHAPTER 5: DISCUSSION AND CONCLUSION

5.0 Introduction

Chapter Five presents the discussion and conclusion of the study. It started with a summary of the statistical analysis, highlighting key findings derived from the data. This is followed by an in-depth discussion of the results in relation to the research objectives and existing literature. The chapter then explores the implications of the study, addressing its theoretical and practical contributions. Additionally, the study's limitations are acknowledged, followed by recommendations for future research to improve and expand upon the findings. Finally, it concludes with a summary of the overall research and its broader impact.

5.1 Summary of Statistical Analysis

Variables	Proxies	Coefficient	P-value	Results
Independent Variables				
Governance Quality (GQ)	Government Effectiveness	0.0266	0.007	Significantly positive
Artificial Intelligence (AI)	Fixed broadband subscriptions (per 100 people)	0.0516	0.009	Significantly positive
Interactive Term				

Governance Quality (GQ) * Artificial Intelligence (AI)	Government Effectiveness * Fixed broadband subscriptions (per 100 people)	-0.0117	0.018	Significantly negative
Control Variables				
Macroeconomic Variables	GDP per capita growth (annual %)	0.0406	0.057	Significantly positive
Financial Inclusion	Automated teller machines (ATMs) (per 100,000 adults)	0.00916	0.028	Significantly positive
Financial Performance	Bank return on equity (%, after tax)	0.129	0.004	Significantly positive

Table 5.1.1: Summary of the Statistical Findings

Table 5.1.1 included two independent variables namely: (1) Artificial Intelligence (AI); and (2) Governance Quality (GQ), the interactive term namely: (3) Governance Quality (GQ) * Artificial Intelligence (AI), and the three control variables namely: (4) macroeconomic variables; (5) financial inclusion; (6) financial performance employed in the model demonstrated a strong significant relationship with financial development. Hence, all the independent variables and control variables selected are strong indicators of financial development.

5.2 Discussion on Findings

5.2.1 Artificial Intelligence and Financial Development

As shown in Table 5.1.1, AI exhibits a statistically significant positive correlation with financial development in the countries analysed. This coincides with the result of Shiyyab et al. (2023), who studied 15 Jordanian banks between 2014 and 2021. The study indicated that AI has the potential to significantly boost financial growth by improving the efficiency of banking operations. Ris et al. (2020) and Umamaheswari and Valarmathi (2023) showed that the use of AI technologies, such as machine learning algorithms, improves bank performance, which in turn contributes to enhanced financial development. Chhaidar et al. (2023) emphasised AI's positive contribution to financial growth by examining 23 European banks from 2010 to 2019, uncovering a significant relationship between AI and financial advancement. Hsu et al. (2014) explored the connection between artificial intelligence and financial growth in 32 industrialised and developing countries, finding a bidirectional positive relationship between these two factors. Moreover, Tee et al. (2014) found that AI is favourable in driving financial development in seven East Asian countries between 1998 and 2009.

In conclusion, AI promotes financial advancement via enhanced risk management capabilities. It can analyse large volumes of financial data and identify unforeseen risks and fraudulent activities (Zhou et al., 2023; Giudici et al., 2024). Thus, it can be argued that AI has the potential to greatly impact financial development in emerging economies.

5.2.2 Governance Quality and Financial Development

Secondly, the results indicate that governance quality significantly influences financial development through a positive correlation. These results are consistent with Alawi et al. (2022), who analysed the effect of governance quality on financial development across 17 developing countries using data from 1990 to 2020, demonstrating a significant enhancement in financial development.

Moreover, Roe and Siegel (2007), Huang (2010), and Le et al. (2015) contended that governance quality substantially affects financial market performance. Ineffective governments struggle to implement policies that promote business activity, financial flows, and the efficient operation of financial markets. Additionally, political uncertainty is expected to result in risky macroeconomic policies, which can hinder the development of financial infrastructure (Roe & Siegel, 2007). Huang (2010) suggests that enhancing governance quality could foster financial development.

Several recent studies offer quantitative evidence supporting the link between governance quality and financial development (Rodrik et al., 2002; Klomp & de Haan, 2014; Bonnal & Yaya, 2015; Le et al., 2016). Levine (1997) posits how governance is crucial for the efficient operation of financial markets.

Arestis and Demetriades (1997), along with Demetriades and Andrianova (2004), argued that the success of financial development largely depends on governance quality, particularly in relation to financial regulation and the enforcement of the rule of law. Thus, previous research strongly supports our study, indicating that governance quality may greatly influence the financial prosperity of poor countries.

5.2.3 Financial Inclusion and Financial Development

The results in Table 5.1.1 indicate that the control variable of financial inclusion has a significant and positive effect on financial development, consistent with Adnan's (2011) research, which asserts that financial inclusion is vital for financial development as it improves access to financial services, a critical advancement towards financial development.

Numerous research has linked elevated financial inclusion to advanced financial development inside a country (Allen et al., 2014; Alter & Yontcheva, 2015; Adeola & Evans, 2017). Lenka (2021) examined the relationship between financial inclusion and financial development in India from 1980 to 2017, concluding that financial inclusion is a crucial factor of financial sector advancement in a developing nation. Financial inclusion is posited to directly enhance a nation's financial development (Allen et al. 2016) by facilitating the efficient use of productive resources to reduce capital costs (Sarma & Pais 2011).

Financial inclusion could lower the number of people living in poverty and make it easier for them to get the money they need to improve their lives, especially poor people who save and borrow money informally (Elgharib, 2024). Financial inclusion also leads to more spending, which boosts economic growth and helps financial development. People also save more, and small businesses can grow and make investments (Beck et al., 2007; Banerjee et al., 2015; Mlachila et al., 2016; Allen et al., 2016; Ouma et al., 2017; Siddik, 2017; Park & Mercado, 2018; Suresh & Dutta, 2018). Furthermore, it has been demonstrated that financial inclusion makes monetary policy more effective at controlling inflation by affecting a larger portion of the population (Jungo et al., 2021). This has a big impact on financial development by granting credit to a large group of people who previously couldn't do business with banks.

Rasheed et al. (2016) utilised the generalised method of moments (GMM) to analyse a panel of 97 countries from 2004 to 2012, employing the number of commercial bank branches and ATMs per 100,000 adults as proxies for financial inclusion. They concluded that financial inclusion is a significant factor of financial development, with a positive and significant impact on it. Therefore, we contend that the influence of financial development will be amplified by increased financial inclusion.

5.2.4 Financial Performance and Financial Development

The findings of this study indicate that financial performance significantly and positively impacts financial development, in accordance with prior studies. Levine (2005) asserts that the efficacy of financial institutions profoundly influences financial development. The effectiveness of banking is essential for the progress of financial activities. Many banks in both developing and developed countries initiate programs involving their banking sectors to improve financial inclusion (World Bank, 2014). This study corresponds with numerous previous investigations (Uadiale & Fagbemi, 2012; Torugsa et al., 2012; Iqbal et al., 2012; Cavaco & Crifo, 2014; Zhou et al., 2015; Nobanee & Ellili, 2016; Le et al., 2019; Ramzan et al., 2021) concerning financial performance indicators in the banking sector of developing nations, specifically bank return on assets (%, after tax), bank return on equity (%, after tax), and bank net interest margin. Furthermore, strong financial performance is seen as less susceptible to banking crises (Olgu et al., 2014). Hillman and Keim (2001) and Choi and Wang (2009) investigated the relationship between banking sector efficiency and financial development, suggesting that enhanced efficiency allows banks to lower lending costs, expand branch networks, and offer more types of financial goods and services to more customers. These findings align with our results shown in Table 5.1.1.

5.2.5 Macroeconomics Variables and Financial Development

The macroeconomic variables of (1) GDP per capita and (2) trade openness have been shown to impact financial development significantly and positively. Multiple empirical studies support this claim (King & Levine, 1993; Arestis & Demetriades, 1997; Christopoulos & Tsionas, 2004; Hassan et al., 2011; Nasir et al., 2014). Secondly, a number of studies demonstrate that GDP per capita may stimulate financial development (Robinson, 1952; Odhiambo, 2009). Gwachha (2022) asserts that a rise in GDP per capita is associated with an increased demand for financial services, as consumers want to invest or safeguard their assets in banks, hence promoting growth in the banking industry. Yu and Gan (2010), Dogga et al. (2017), and Tsaurai (2018) similarly concluded that GDP per capita is a significant and favourable catalyst for financial development in developing countries. Empirical research, including works by Luciano and Regis (2007), Karimu and Marbuah (2017), Aluko and Ajayi (2018), Zhang and Zhu (2020), and Ashraf et al. (2021), demonstrates that an increase in GDP per capita is associated with a heightened demand for financial services, as individuals endeavour to invest or save their assets in banks, consequently promoting growth in the banking sector. However, Fu et al. (2020) and Khalfaoui (2015) found that trade openness has a significant negative effect on financial development, which contradicts our findings.

Diverse countries have varying economic development attributable to variables including the nation's legal framework (Shleifer & Vishny, 1998) and trade liberalisation (Rajan & Zingales, 2003). Trade openness is believed to be able to influence financial development, as free trade generates uncertainty and income variability among workers, hence increasing the need for insurance and other financial services, which subsequently increases the financial system (Newbery and Stiglitz, 1984). Furthermore, trade liberalisation across nations would heighten the need for foreign currency as they manufacture more financially dependent

commodities. Thus, open trade will augment the demand for foreign investment, resulting in financial development (Murthy et al., 2014).

5.2.6 Governance Quality and AI on Financial Development

As AI becomes more widespread and surpasses the threshold of 2.2735, it may start to impede financial development if governance quality does not evolve in parallel. While AI brings innovation and improves efficiency in the financial sector, the associated risks, such as decreased transparency, increased cyber threats, and potential misuse, are likely to grow in a lack of adequate regulatory oversight. If governance quality does not sufficiently adapt to manage the rising influence of AI, the negative aspects of AI could continue to expand, ultimately causing a setback in financial progress. Without an effective legal framework to constrain the use of AI, the sceptical perception of the public against the threat that AI may pose may increase, suspicious financial activities that exploit the loopholes in the law may be allowed, and there may be a heightened risk of insecure cybersecurity cases (Yeoh, 2019; Taeihagh, 2021; O'Shaughnessy et al., 2023). Despite that, overregulation impedes the innovation of financial products and services and restrains competition in the financial sector, which is the opposite yet unfavourable scenario (Kuziemski & Misuraca, 2020). Hence, governance quality and AI must develop at a similar pace to prevent a decline in financial development. Good governance quality to close the enforcement gap, underscoring the derivation of a suitable and effective regulatory framework that complements the adoption of AI while ensuring transparency and accountability in the implementation of regulations to secure public trust, is called for to harness the benefits of AI (De Almeida et al., 2021; Caroll et al., 2023).

5.3 Implications of the Study

5.3.1 Strengthen Governance Quality

The rapid advancement of AI and its widespread application across various industries and social contexts necessitates the development of an appropriate governance framework to prevent disruptive misuse, ensure robust enforcement, eliminate bias and privacy breaches, and cultivate trust while preserving the technologies' potential for development and capacity to benefit the public good (Clair & DNV, 2019).

The findings suggested a positive relationship between governance quality and financial development. As a result, Levine's (1997) study suggests that the quality of governance must be emphasised in order to speed financial development. Strong legal, political, and governance frameworks are required for liberalisation because they enable the adoption and implementation of laws, rules, and regulations. Thus, effective governance promotes the implementation of policies aimed at strengthening institutions that promote growth-orientated financial systems (Blackburn & Forgues-Puccio, 2010; Casson et al., 2010; Angelopoulos et al., 2011). An advanced financial system increases intermediation efficiency by reducing information asymmetries, transaction costs, and monitoring expenses, consequently encouraging investment, mobilising capital, supervising management, and simplifying risk trading, hedging, and diversification. These functions improve resource allocation, increase the accumulation of physical and human capital, and accelerate technical advancement, all of which drive economic growth (Bagehot, 1873; Levine, 1997; Creane et al., 2004; Demetriades & Fielding, 2012; Schumpeter & Swedberg, 2021).

According to Altunbaş and Thornton (2012), the financial institution loan distribution to the private sector can help to reduce corruption. The quality of governance, notably in terms of corruption control, considerably

enhances bank cost efficiency (Lensink & Meesters, 2014; Chan et al., 2015; Agostino et al., 2023). Furthermore, the quality of governance improves the impact of financial liberalisation on stock market efficiency in developing countries (Naghavi & Lau, 2016). Egbendewe and Oloufade (2020) investigated the impact of governance quality on the competitiveness of the banking sector in developing countries, finding that corruption control, government efficacy, and the rule of law significantly improve the profitability and efficiency of the banking industry.

Governance frameworks are viewed as critical to the productive and smooth operation of financial markets and institutions, as well as effective resource allocation. A strong institutional framework that protects property rights, enforces contracts, and upholds the rule of law is essential for market efficiency and improved economic performance (Acemoglu et al., 2001; Yıldırım & Gökalp, 2016). An efficient institutional structure increases the productiveness of foreign banks by lowering information costs (Mian, 2006). Financial efficiency is crucial for financial development, allowing for the most cost-effective resource allocation (Čihák et al., 2012; Olgu, 2014; Aizenman et al., 2015; Svirydzenka, 2016; Yu & Huang, 2017). It also reduces the negative effects of financial crises on firms that rely on external funding and strengthens the financial system (Olgu, 2014; Diallo, 2018). Institutional quality improves financial system efficiency by encouraging competition within the financial sector (Staikouras et al., 2008; Lensink et al., 2008; Andries, 2011; Johnson, 2011), reducing information asymmetries, and lowering transaction costs (North, 1994; Levine, 2005; Hooper et al., 2009; Groenewegen et al., 2010; Filippidis & Katrakilidis, 2014).

Robust institutions increase competitiveness in the local financial industry, attracting foreign investment and perhaps improving banking system efficiency (Staikouras et al., 2008; Lensink et al., 2008). Regulatory quality enhances market competitiveness while ensuring efficiency and stability (Andries, 2011; Johnson, 2011). A minimum level of institutional quality is required for banking industry changes and efficiency gains (Delis, 2012).

Improving the institutional and governance frameworks may encourage foreign investment through mergers and acquisitions, resulting in improved financial management capabilities and system efficacy (Staikouras et al., 2008). Improved institutional quality boosts competitiveness, driving financial institutions and markets to improve their innovation and efficiency (Khan et al., 2022). Furthermore, a solid institutional structure reduces systemic risk, ensuring the stability and resilience of the financial sector. As a result, superior economic and political institutions improve bank stability by minimising information asymmetry and adverse selection, promoting a more efficient financial system (Azmi et al., 2024).

Andrianova et al. (2011) emphasised the importance of the government as a political institution that creates large trade monopolies, hence encouraging the growth of global financial systems. Mardan (2017) investigates the constraints on external fundraising, such as tax regulations and interest exemptions, which impede the optimal use of investment opportunities, resulting in financial distress; these stringent rules are more prevalent in less financially developed economies than in their financially developed counterparts. Financial sector inclusion is hampered by weak institutional frameworks, corruption, political instability, unaccountable leadership, low bureaucratic standards, and inefficient law enforcement (Zeqiraj et al., 2022). The fair legal framework, political stability, corruption mitigation, and accountability are indices of institutional quality and their potential to impact financial system operations (Hooper et al., 2009). Increased openness reduces transaction costs by removing information asymmetry, while bribery and corruption harm financial sectors (Jain et al., 2017).

5.3.2 Invest in Digital Capital

In lack of the necessary digital infrastructures and knowledge, developing countries are at risk of falling behind the advanced digital agenda (Wu & Lin, 2025). Given that AI can boost financial development, developing

countries are at a shortage of AI professionals, which slowed down the implementation of AI technologies and the lack of expertise in the maintenance of AI systems to embrace this ongoing digital transformation (Dwivedi et al., 2021; Aderibigbe et al., 2023; Joel et al., 2024). Hence, it appears urgently necessary to address the skill gaps and shortage of a skilled workforce to prioritise the capacity of AI. A survey result by Sidhu et al. (2024) showed a clear picture of the skill gaps in emerging economies. A major proportion of 25% of respondents claimed to be very unfamiliar with AI, while 24% of respondents were not sure of the AI adoption within their organisations, which suggests that there might be an information asymmetry among the organisations. A study by Díaz-Arancibia et al. (2024) identified that the main technological barrier for small and medium-sized enterprises (SMEs) in developing countries is knowledge and skill gaps, suggesting that the absence of ICT proficiency requires all-encompassing educational programmes to guarantee the digital competency of medium-sized enterprises (MSEs). Despite an acknowledgement of the critical gaps in which a demand for skilled talents was raised, there remained a short supply of AI professionals, stressing the need for an intervention of skill development programmes to reskill and upskill the current workforce (Sidhu et al., 2024; Olaniyi et al., 2024). Government authorities, educational institutions, and industry pioneers should reconstruct the existing academic and training scheme to comprehensively demonstrate digital technology fundamentals and practical skills that are aligned with the fast-paced digital transitions (Olaniyi et al., 2024). Aside from formal educational programmes like vocational and educational courses, informal programmes such as skill seminars and on-the-job training can also speed up the acquisition of relevant skills (Ma et al., 2024).

Besides narrowing the knowledge and skills gap, it is equally vital to build up digital infrastructures that complement the implementation of new technologies. Digital technologies that drive digital evolution to contribute towards quality development require a backup by strong digital infrastructures to offer enhanced accessibility and connectivity (Bhowmick

& Seetharaman, 2024). It is found that digital infrastructures essentially promote internet penetration and cut down information acquisition costs, which eventually puts a thrust to economic growth and organisational innovation (Gu et al., 2024). Strong and robust digital infrastructures are fundamental to ensure a smooth transition from the existing technological landscape to embracing innovative technological breakthroughs and putting them into practical use, raising organisational agility to encounter upcoming obstacles in the constantly changing business environment by transforming business models, primary procedures and functions (Bhowmick & Seetharaman, 2024).

One critical condition to retain the expertise for a sustainable AI-immersed environment is to forge AI talents to stay in their home countries in aid of serving their local economies. Despite the strong efforts dedicated to training human capital, it is simply as if flogging a dead horse if "brain drain" occurs. The concept of globalisation has made brain drain a common phenomenon in the context of developing countries (Dupont et al., 2025). They are constantly losing highly skilled talents to developed countries with a more stable political and economic environment, better living standards, and perceived more opportunities for success (Farooq, 2025), which may ultimately affect economic development, as innovation is stalled (Khan, 2024). Countries are advised to invest more in education and research by providing incentives such as scholarships and grants to boost competitiveness and to recruit and retain talent domestically and internationally (Shneiderman, 2020). Aside from financial aid, countries can collaborate at academic, industrial, and institutional levels to establish innovation hubs and technology clusters, having brainstorming sessions that facilitate the exchange of knowledge and expertise to broaden horizons and expand knowledge bases (Jarrahi et al., 2023; Yassine & Jacobs, 2024), to transmit from brain drain to brain gain. For the local policymakers, it is advised to devise adaptive employment policies that are flexible yet versatile to be applied to the dynamic technology landscape that fosters lifelong learning, set up safety nets to protect the welfare of dislocated

workers, and provide incentives to empower industries that are vulnerable to automation in diversifying and innovating in job creation (Olaniyi et al., 2024).

5.3.3 Align Governance Quality with AI

AI played a role in opening the financial field to unsought opportunities, but challenges also come along (Xie, 2019). To harness the advantageous edge attributable to the deployment of AI, a narrowly defined regulatory framework should be a priority. Efficient rules and regulations serve as the fundamental requirement to address AI-driven concerns such as algorithmic accountability, user consent, and data privacy and security (Aderibigbe et al., 2023). In order for regulators to construct a comprehensive regulatory framework while avoiding an underfitting or overfitting scenario (Truby et al., 2020), regulators should gain adequate knowledge to understand the nature of AI to bridge the gap in governing AI-driven activities (Taeihagh, 2021).

Governance quality plays a crucial role in ensuring that AI-driven financial systems operate in a fair, transparent, and efficient manner. A well-structured regulatory framework can foster trust in AI-powered financial services by enforcing algorithmic transparency and explainability (Fink et al., 2020). This is particularly important in areas such as credit scoring, algorithmic trading, and fraud detection, where opaque AI decision-making processes may lead to unintended biases or systemic risks (Daníelsson et al., 2022). Without strong governance mechanisms, AI's potential to enhance financial decision-making could be overshadowed by ethical concerns and security vulnerabilities. To address this, regulators must strike a balance between enabling AI-driven innovation and safeguarding consumer rights through stringent data protection laws and ethical AI practices (Anil & Babatope, 2024).

Additionally, governance frameworks play a vital role in mitigating data privacy and cybersecurity risks, which are heightened by AI's reliance on the vast amounts of personal and financial data. Effective data governance structures not only ensure compliance with stringent data protection laws but also enhance cybersecurity resilience by enforcing data classification, access controls and real-time monitoring (Weber et al., 2009; Khatri & Brown, 2010). Furthermore, organisations with robust data governance frameworks are better equipped to recover from AI-driven cyber threats, minimising operational disruptions and financial losses (Da Veiga & Eloff, 2007). Regulatory lag in AI governance must be carefully managed. The fast-paced evolution of AI technologies frequently surpasses the progress of regulatory frameworks, leading to gaps in oversight (Guihot et al., 2017). Therefore, aligning governance quality with AI regulation is imperative for policymakers and financial institutions to develop an adaptive, forward-looking regulatory landscape. This approach balances technology innovation with risk management, ultimately fostering a stable, secure, and inclusive financial ecosystem.

5.4 Limitations of Study

Observing the panel dataset obtained, it appears to have missing figures for some indicators. General reasonings may be due to such indicators being generated by periodical surveys or they were only available after being launched or introduced. Moreover, it is believed to have been a problem due to a deficiency in the statistical capacity of the developing countries included. They may not have possessed the ability to collect useful data or derive informational statistics given the time period observed in this study.

5.5 Recommendations for Future Research

This section provides recommendations for future scholars interested in studying the relationship between governance quality, AI, and financial development. As AI continues to advance and more comprehensive data becomes available, researchers are encouraged to utilise the latest datasets. Data-collecting authorities are also advised to consistently collect more data to refine the existing datasets to complement future studies.

5.6 Conclusion

The ultimate objective of this empirical study is to investigate the association between governance quality and AI on financial development, resulting in both indicators being statistically significant determinants of financial development, individually and jointly. Secondary research is employed, compiling data extracted from the World Bank and implementing GMM methods for estimation using the Stata software. 6 GMM models were run through, while the result from a two-step robust system GMM was deemed most efficient and robust; hence, it serves as the best-suited model for this study.

This study hopes to shed light on the current situation in which AI technologies are gaining unprecedented attention in the financial sector, thus requiring regulators to keep pace with their vigorous evolution. Given the result, governance quality and AI independently promote the financial development of a nation, yet their joint effect appears to harm it. From existing literature, it is rationally concluded that the adoption of AI should be complemented with well-structured regulatory frameworks to maximise its potential benefits to a maximum. Comprehensive discussions have been made on the findings. Despite the above conclusions, it is worth noting that there is a limitation in this study, which is data unavailability. Hence, fellow researchers are advised to obtain the latest data possible for future investigation on similar topics.

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APPENDICES

Appendix 1.1: List of Developing Countries

Algeria	Iran, Islamic Rep
Angola	Jordan
Bangladesh	Kenya
Benin	Kyrgyz Republic
Bhutan	Lebanon
Bolivia	Lesotho
Burkina Faso	Liberia
Burundi	Madagascar
Cambodia	Malawi
Cameroon	Mali
Chad	Mauritania
Congo, Dem Rep	Mongolia
Cote d'Ivoire	Morocco
Djibouti	Mozambique
Egypt, Arab Rep	Myanmar
Eswatini	Nepal
Gambia, The	Nicaragua
Ghana	Niger
Guinea	Nigeria
Haiti	Pakistan
Honduras	Philippines
India	Rwanda

Senegal	Tunisia
South Sudan	Uganda
Sri Lanka	Uzbekistan
Sudan	Vietnam
Tajikistan	Yemen, Rep
Tanzania	Zambia
Togo	Zimbabw

Appendix 4.1.1: Summarized Statistics of the Main Variables

```
. tsset code time
       panel variable:  code (strongly balanced)
        time variable:  time, 1996 to 2021
                delta:  1 unit

. sum y1 x1 x9 x10 x12 x16
```

Variable	Obs	Mean	Std. Dev.	Min	Max
y1	1,612	.1529775	.1011176	0	.5837564
x1	1,597	27.55636	17.33796	-.8411018	75.40984
x9	1,040	1.7119	5.75232	0	97.2663
x10	1,570	2.08821	5.030821	-48.39246	90.75806
x12	908	12.60638	16.34982	0	106.88
x16	1,066	15.20536	10.99565	-116.1993	74.27419

```
. generate ly1=ln(y1+1)

. generate lx1=ln(x1+1)
(15 missing values generated)

. generate lx9=ln(x9+1)
(572 missing values generated)

. generate lx10=ln(x10+49)
(42 missing values generated)

. generate lx12=ln(x12+1)
(704 missing values generated)

. generate lx16=ln(x16+117)
(546 missing values generated)

. generate lx1lx9=lx1*lx9
(575 missing values generated)
```

Appendix 4.1.2: Correlation Matrix of the Main Variables

```
. estpost correlate y1 x1 x9 x10 x12 x16, matrix listwise
```

	e(b)	e(rho)	e(p)	e(count)
y1				
y1	1	1		690
x1	.5936469	.5936469	6.22e-67	690
x9	.4432486	.4432486	1.43e-34	690
x10	.0669398	.0669398	.0788926	690
x12	.4390228	.4390228	7.09e-34	690
x16	-.2591087	-.2591087	4.77e-12	690
x1				
x1	1	1		690
x9	.2468019	.2468019	4.93e-11	690
x10	.1915432	.1915432	3.99e-07	690
x12	.2765986	.2765986	1.39e-13	690
x16	-.1122475	-.1122475	.0031522	690
x9				
x9	1	1		690
x10	-.0975041	-.0975041	.0103866	690
x12	.6957173	.6957173	6.1e-101	690
x16	-.2506994	-.2506994	2.38e-11	690
x10				
x10	1	1		690
x12	-.1051191	-.1051191	.0057114	690
x16	.1794471	.1794471	2.10e-06	690
x12				
x12	1	1		690
x16	-.3293821	-.3293821	6.36e-19	690
x16				
x16	1	1		690

Appendix 4.2.1 Results from Dynamic Panel GMM Estimation

```
. xtabond2 ly1 l.ly1 lx1 lx9 lx1lx9 lx10 lx12 lx16, gmm(ly1,lag(1 15)collapse) gmm(lx1,lag(20 9)collapse) gmm(lx9,lag(9 18)collapse) gmm(lx1lx9,lag(1 14
> )collapse) gmm(lx10,lag(2 15)collapse) gmm(lx12,lag(2 12)collapse) gmm(lx16,lag(10 16)collapse) iv(time) two robust
Favoring space over speed. To switch, type or click on mata: mata set matafavor speed, perm.
Warning: Number of instruments may be large relative to number of observations.
Warning: Two-step estimated covariance matrix of moments is singular.
  Using a generalized inverse to calculate optimal weighting matrix for two-step estimation.
  Difference-in-Sargan/Hansen statistics may be negative.
  DFm
  7

Dynamic panel-data estimation, two-step system GMM

Group variable: code                            Number of obs      =       690
Time variable : time                            Number of groups   =        58
Number of instruments = 92                      Obs per group: min =         1
Wald chi2(7)  =   2777.94                                      avg =     11.90
Prob > chi2   =      0.000                                     max =        18

                             Corrected
         ly1 |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         ly1 |
          L1.|     .60284   .0887617     6.79   0.000     .4288701    .7768098
             |
         lx1 |    .026565   .0097829     2.72   0.007     .0073909    .0457391
         lx9 |    .051627   .0198678     2.60   0.009     .0126868    .0905672
       lx1lx9|  -.0116547   .0049329    -2.36   0.018    -.0213229   -.0019865
        lx10 |   .0405698   .0212966     1.90   0.057    -.0011708    .0823104
        lx12 |   .0091576   .0041787     2.19   0.028     .0009676    .0173477
        lx16 |   .1288939   .0444923     2.90   0.004     .0416905    .2160972
       _cons |  -.8359857   .2165041    -3.86   0.000    -1.260326   -.4116455
------------------------------------------------------------------------------
Instruments for first differences equation
  Standard
    D.time
  GMM-type (missing=0, separate instruments for each period unless collapsed)
    L(10/16).lx16 collapsed
    L(2/12).lx12 collapsed
    L(2/15).lx10 collapsed
    L(1/14).lx1lx9 collapsed
    L(9/18).lx9 collapsed
    L(9/20).lx1 collapsed
    L(1/15).ly1 collapsed
Instruments for levels equation
  Standard
    time
    _cons
  GMM-type (missing=0, separate instruments for each period unless collapsed)
    DL9.lx16 collapsed
    DL.lx12 collapsed
    DL.lx10 collapsed
    D.lx1lx9 collapsed
    DL8.lx9 collapsed
    DL8.lx1 collapsed
    D.ly1 collapsed
------------------------------------------------------------------------------
Arellano-Bond test for AR(1) in first differences: z =  -3.45  Pr > z =  0.001
Arellano-Bond test for AR(2) in first differences: z =   0.56  Pr > z =  0.573
------------------------------------------------------------------------------
Sargan test of overid. restrictions: chi2(84)   = 371.25  Prob > chi2 =  0.000
  (Not robust, but not weakened by many instruments.)
Hansen test of overid. restrictions: chi2(84)   =  47.16  Prob > chi2 =  1.000
  (Robust, but weakened by many instruments.)

Difference-in-Hansen tests of exogeneity of instrument subsets:
  GMM instruments for levels
    Hansen test excluding group:     chi2(77)   =  46.74  Prob > chi2 =  0.997
    Difference (null H = exogenous): chi2(7)    =   0.41  Prob > chi2 =  1.000
  gmm(ly1, collapse lag(1 15))
    Hansen test excluding group:     chi2(68)   =  47.16  Prob > chi2 =  0.975
    Difference (null H = exogenous): chi2(16)   =   0.00  Prob > chi2 =  1.000
  gmm(lx1, collapse lag(9 20))
    Hansen test excluding group:     chi2(71)   =  51.26  Prob > chi2 =  0.963
    Difference (null H = exogenous): chi2(13)   =  -4.10  Prob > chi2 =  1.000
```

```
gmm(lx9, collapse lag(9 18))
  Hansen test excluding group:     chi2(73)    =  45.94  Prob > chi2 =  0.994
  Difference (null H = exogenous): chi2(11)    =   1.22  Prob > chi2 =  1.000
gmm(lx1lx9, collapse lag(1 14))
  Hansen test excluding group:     chi2(69)    =  50.24  Prob > chi2 =  0.957
  Difference (null H = exogenous): chi2(15)    =  -3.08  Prob > chi2 =  1.000
gmm(lx10, collapse lag(2 15))
  Hansen test excluding group:     chi2(69)    =  49.64  Prob > chi2 =  0.962
  Difference (null H = exogenous): chi2(15)    =  -2.49  Prob > chi2 =  1.000
gmm(lx12, collapse lag(2 12))
  Hansen test excluding group:     chi2(72)    =  45.36  Prob > chi2 =  0.994
  Difference (null H = exogenous): chi2(12)    =   1.79  Prob > chi2 =  1.000
gmm(lx16, collapse lag(10 16))
  Hansen test excluding group:     chi2(76)    =  52.02  Prob > chi2 =  0.984
  Difference (null H = exogenous): chi2(8)     =  -4.86  Prob > chi2 =  1.000
iv(time)
  Hansen test excluding group:     chi2(83)    =  47.15  Prob > chi2 =  0.999
  Difference (null H = exogenous): chi2(1)     =   0.01  Prob > chi2 =  0.918
```

Appendix 4.4.1 Results from Dynamic Panel GMM Estimation for Robustness Checking

```
. xtabond2 ly1 l.ly1 lx1 lx9 lx1lx9 lx11 lx13 lx16, gmm(ly1,lag(1 2)collapse) gmm(lx1,lag(20 9)collapse) gmm(lx9,lag(9 18)collapse) gmm(lx1lx9,lag(5 15)
> collapse) gmm(lx11,lag(2 15)collapse) gmm(lx13,lag(7 12)collapse) gmm(lx16,lag(13 19)collapse) iv(time) two robust
Favoring space over speed. To switch, type or click on mata: mata set matafavor speed, perm.
Warning: Number of instruments may be large relative to number of observations.
Warning: Two-step estimated covariance matrix of moments is singular.
  Using a generalized inverse to calculate optimal weighting matrix for two-step estimation.
  Difference-in-Sargan/Hansen statistics may be negative.
  DFm
  7

Dynamic panel-data estimation, two-step system GMM

Group variable: code                        Number of obs      =       744
Time variable : time                        Number of groups   =        54
Number of instruments = 71                  Obs per group: min =         1
Wald chi2(7)  =   2049.98                                  avg =     13.78
Prob > chi2   =      0.000                                 max =        18
```

ly1	Coef.	Corrected Std. Err.	z	P>|z|	[95% Conf.	Interval]
ly1						
L1.	.5124046	.0954982	5.37	0.000	.3252315	.6995777
lx1	.0285248	.0073267	3.89	0.000	.0141647	.0428849
lx9	.0602224	.0138022	4.36	0.000	.0331705	.0872743
lx1lx9	-.0133131	.0034972	-3.81	0.000	-.0201674	-.0064588
lx11	.0215439	.0129974	1.66	0.097	-.0039306	.0470184
lx13	.0119765	.0042145	2.84	0.004	.0037163	.0202366
lx16	.0470717	.0279388	1.68	0.092	-.0076874	.1018309
_cons	-.3635152	.1389643	-2.62	0.009	-.6358802	-.0911503

```
Instruments for first differences equation
  Standard
    D.time
  GMM-type (missing=0, separate instruments for each period unless collapsed)
    L(13/19).lx16 collapsed
```

```
    L(7/12).lx13 collapsed
    L(2/15).lx11 collapsed
    L(5/15).lx11x9 collapsed
    L(9/18).lx9 collapsed
    L(9/20).lx1 collapsed
    L(1/2).ly1 collapsed
Instruments for levels equation
  Standard
    time
    _cons
  GMM-type (missing=0, separate instruments for each period unless collapsed)
    DL12.lx16 collapsed
    DL6.lx13 collapsed
    DL.lx11 collapsed
    DL4.lx11x9 collapsed
    DL8.lx9 collapsed
    DL8.lx1 collapsed
    D.ly1 collapsed
------------------------------------------------------------------------------
Arellano-Bond test for AR(1) in first differences: z =  -3.32  Pr > z =  0.001
Arellano-Bond test for AR(2) in first differences: z =   0.32  Pr > z =  0.753
------------------------------------------------------------------------------
Sargan test of overid. restrictions: chi2(63)    = 382.32  Prob > chi2 =  0.000
  (Not robust, but not weakened by many instruments.)
Hansen test of overid. restrictions: chi2(63)    =  41.16  Prob > chi2 =  0.985
  (Robust, but weakened by many instruments.)

Difference-in-Hansen tests of exogeneity of instrument subsets:
  GMM instruments for levels
    Hansen test excluding group:     chi2(56)    =  47.53  Prob > chi2 =  0.782
    Difference (null H = exogenous): chi2(7)     =  -6.37  Prob > chi2 =  1.000
  gmm(ly1, collapse lag(1 2))
    Hansen test excluding group:     chi2(60)    =  41.16  Prob > chi2 =  0.970
    Difference (null H = exogenous): chi2(3)     =   0.00  Prob > chi2 =  1.000
  gmm(lx1, collapse lag(9 20))
    Hansen test excluding group:     chi2(50)    =  46.86  Prob > chi2 =  0.600
    Difference (null H = exogenous): chi2(13)    =  -5.70  Prob > chi2 =  1.000


  gmm(lx9, collapse lag(9 18))
    Hansen test excluding group:     chi2(52)    =  44.63  Prob > chi2 =  0.756
    Difference (null H = exogenous): chi2(11)    =  -3.48  Prob > chi2 =  1.000
  gmm(lx11x9, collapse lag(5 15))
    Hansen test excluding group:     chi2(51)    =  48.27  Prob > chi2 =  0.583
    Difference (null H = exogenous): chi2(12)    =  -7.11  Prob > chi2 =  1.000
  gmm(lx11, collapse lag(2 15))
    Hansen test excluding group:     chi2(48)    =  46.58  Prob > chi2 =  0.531
    Difference (null H = exogenous): chi2(15)    =  -5.42  Prob > chi2 =  1.000
  gmm(lx13, collapse lag(7 12))
    Hansen test excluding group:     chi2(56)    =  47.43  Prob > chi2 =  0.786
    Difference (null H = exogenous): chi2(7)     =  -6.27  Prob > chi2 =  1.000
  gmm(lx16, collapse lag(13 19))
    Hansen test excluding group:     chi2(55)    =  50.77  Prob > chi2 =  0.637
    Difference (null H = exogenous): chi2(8)     =  -9.61  Prob > chi2 =  1.000
  iv(time)
    Hansen test excluding group:     chi2(62)    =  41.16  Prob > chi2 =  0.981
    Difference (null H = exogenous): chi2(1)     =   0.00  Prob > chi2 =  0.968
```