# Impact of digital financial innovation on financial system development in Common Market for Eastern and Southern Africa (COMESA) countries

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## Abstract

**Purpose** – This paper aims to assess the impact of digital financial innovation on financial system development in Common Market for eastern and Southern Africa (COMESA). This paper evaluates the dynamic relationship between digital financial innovation measures and financial system development using time series data from COMESA countries for the period 1997–2019.

**Design/methodology/approach** – A dynamic autoregressive distributed lag model (ARDL) was adopted and the mean group (MG), pooled mean group (PMG) and dynamic fixed effect (DFE) of the model were estimated to evaluate the short- and long-run impact. In addition, the dynamic generalized method of moments (DGMM) was adopted for a robustness check. The Hausman test results show PMG to be the most consistent and efficient estimator, while the coefficient of lagged dependent variable of different GMM is less than the fixed effect coefficient, and, as such, suggests system GMM is the most suitable estimator. Data for the study were sourced from World Bank Development Indicator (WDI, 2020), World Governance Indicator (WGI, 2020) and World Bank Global Financial Development Database (GFD, 2020).

**Findings** – The result shows that digital financial innovation significantly impacts financial system development in the long run. As such, the evidence revealed that automated teller machines (ATMs), point of sale (POS), mobile payments (MP) and mobile banking are significant and contribute positively to financial system development in the long run, while mobile money (MM) and Internet banking (INB) are insignificant but exhibit positive and inverse relationship with financial development respectively. Further investigation revealed that institutional quality and a stable macroeconomic environment including their interactive term are significantly imperative in predicting financial system development in the COMESA region.

**Practical implications** – Researchers recommend a cohesive and conscious policy that would checkmate the divergence in the short run and suggest a common regional innovative financial strategy that could be pursued to incentivize technology transfer needed to promote financial system development in the long run. More so,



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plausible product and process innovations may be adapted to complement innovative institutions in the different components of the COMESA financial system.
**Social implications** – Digital financial innovation services if well managed increase the inherent benefits in financial system development.
**Originality/value** – To the best of the authors' knowledge, this paper presents new background information on digital financial innovation that may stimulate the development of the financial system, particularly in the COMESA region. It also exposes the relevance of digital financial innovation, institutional quality and stable macroeconomic environment as well as their interactive effect on COMESA financial system development.

**Keywords** Digital financial innovation, Financial system development
**Paper type** Research paper

## 1. Introduction

There is a need for a developed and healthy financial system in developing countries, most especially, in regions of Africa (Nguena, 2019). The major concerns of the region's financial development are the depth and inclusion characteristics of the financial system, explaining significantly the little support of the economies' supply side (Nguena and Tsafack-Nanfosso, 2014; Meisel and Mvogo, 2007; Ndebbio, 2004). According to Faure (2013), a financial system refers to institutional arrangements that cover credit creation and borrowing of money by non-financial institutions, firms and individuals, and financial intermediation, which eases funds transfer and makes funds available to the deficit units; and establishment of markets in shares and debt securities to allocate money and price efficiently. A developed financial system holds the capability to absorb disturbances and reduce macroeconomic inequality, depending on the level of achievement of some of its functions, such as risk diversification, lowering financial constraints and information asymmetries (Bernanke *et al.*, 1999). However, it is not clear how a developed financial system is hinged on the innovation level of the financial system.

Technological innovation is the significant dynamism behind present-day financial innovation (Achieng *et al.*, 2015). Over the past two decades, financial technology has revolutionized the financial sector as information and communication technology (ICT) platforms have enabled the use of different digitalized financial services from automated teller machines (ATMs), mobile payments systems, online banking and blockchain technologies (Lashitew *et al.*, 2019; Batiz-Lazo, 2018; Scott *et al.*, 2017; Konheim, 2016; Frame and White, 2012; Hall and Kahn, 2003). There are considerable moves in recent times to recognize the place of financial innovation after the 2008 financial crisis (Engelen *et al.*, 2010; Greenwood and Scharfstein, 2013; Khraisha and Arthur, 2018). Scholars have emphasized the major cause of the 2008 financial crisis as financial innovations' abuse and misuse including its dark sides (Henderson and Pearson, 2011; Diaz-Rainey and Ibikunle, 2012; Boz and Mendoza, 2014; Hausman and Johnston, 2014). However, literature has also revealed the wide economic benefits of financial innovations with an interface between technological innovation and financial innovation (Finnerty, 2001; Błach, 2011; Shiller, 2013). Technological innovations such as digital finance have enhanced the payment systems' unifications globally, then again, it has in Africa, re-defined the type of financial products and services accessible in the financial system (Nguena, 2012, 2015, 2019; Johnson and Upadhyaya, 2015; Ondiege, 2010; Jonathan and Camilo, 2008). Digital financial services as a financial innovation have changed the financial system, and have principally simplified the approaches and procedures of financial service delivery. The relationship between digital financial services as an off-shoot of financial innovation and financial development has witnessed different views in theory and empirical studies.

According to Ozili (2018), the importance of digital finance is drawing the consideration of practitioners, academia and policymakers due to various concerns if addressed that will allow digital finance to serve every unit of the economy better. Financial services provided via the Internet, personal computers, mobile phones or card-linked digital payment systems could be termed digital finance (Manyika *et al.*, 2016; Ozili, 2018). Although there is no one definition for digital finance, it encompasses every service, product infrastructure and technology that allows the various units in an economy to save, access credit facilities and make payments without the need to visit bank branches (Gomber *et al.*, 2017; Ozili, 2018). Three strategic mechanisms exist for any digital financial service – a platform for digital transactions, retail agents and customers (CGAP, 2015). Using digital financial services requires that the user of the digital financial services owns a bank account for cash payments or to receive payments with the help of digital platforms.

Further, the diffusion of digital networks, associated with digital financial services, has direct and indirect effects. Digital financial services can increase efficiency and productivity in the financial sector due to positive network externalities (Scott *et al.*, 2017; Hall and Kahn, 2003). Digital finance comes with benefits such as larger financial inclusion and deeper financial development, increases economic growth, economic stability, banking performance, aggregate government performance, and better monetary and financial regulation (Nguena, 2019; Ozili, 2018; Scott *et al.*, 2017; Manyika *et al.*, 2016; Gutierrez and Singh, 2013). Also, in improving financial inclusiveness through digital finance (Batiz-Lazo, 2018), savings are mobilized and investments are allocated efficiently. These could promote convergence across different Common Market for Eastern and Southern Africa (COMESA) member countries and other emerging economies where developing countries "leapfrog" to the desired modern economic systems through financial development (Lashitew *et al.*, 2019).

The COMESA is made up of 21 countries coming together as economic and trading units for the achievement of a common goal-economic prosperity through trade barriers resolution. The members comprise countries from the Eastern and Southern regions of Africa. The organization was created in 1994 to enhance regional integration for the economic prosperity of the member states, especially, to resolve each country's trade barriers. Within the trading units, the effort has also been channelled into improving the financial sectors of the member countries to help them realize a common monetary area (COMESA, 2018). Such a common monetary area will add to the economic development of the member states. For further development of the financial sector in the economic and trading unit, a regional payment and settlement system (REPSS) has been developed to facilitate cross-border settlement between central banks. The vision of REPSS is to diminish banking charges across foreign banks and therefore reduce the cost of intra-regional trade.

Considering the above discussion, existing literature focused on a specific country in analyzing the impact of digital financial services on financial development; there are limited findings on regional blocks. Therefore, the growing investment in technology based on digital financial services and financial development in emerging regional blocks need to be examined. This article extends the existing literature on digital financial service and financial development by analyzing the impact of digital financial innovation on financial system development both in the short run and the long run in COMESA member states. Considering the relevance of quality institutions and a stable macroeconomic environment in investors' property protection and confidence; transaction costs reduction and guards against default in investment rules as noted by Williamson (1985), North (1990) and Manasseh *et al.* (2017) in their respective studies, additional knowledge to existing literature was the extended investigation on the interactive effect of institutional quality index (INQI) and digital financial innovation index; and macroeconomic environment and digital financial innovation index on financial system development respectively which other studies such as Lashitew *et al.* (2019), Nguena (2019), Ozili (2018), Scott *et al.* (2017)

and Manyika *et al.* (2016) do not account for. To capture short- and long-run impacts, we employ a dynamic autoregressive distributed lag model (ARDL) approach for the estimation. In this model, we estimated the mean group (MG), pool mean group (PMG) and dynamic fixed effect (DFE). The Hausman results suggest PMG as the most efficient and consistent estimation technique to ascertain the long-run relationships between digital financial services and financial development.

In addition, the estimated ARDL results were robustly checked using the dynamic generalized method of moments (DGMM), which could help in addressing the likely endogeneity problem inherent in panel data. The study estimated the model with a panel data set over 23 years (1997–2020) for 20 countries. A key finding from the study is that most measures of digital financial innovation significantly influence financial system development positively in the long run, with rather few not significant. The rest of the paper is structured thus: Section two deepens the discussion of the dynamics of digital financial innovation, while section three presents the review of the literature. Section four captures the model and data description, and section five is for empirical findings and discussion. The conclusions of the paper are contained in section six.

## 2. Dynamics of digital financial innovation

Digital finance explains the influence of novel technological development on the financial system. This technology comprises varities of new products, applications, processes and business techniques efficient enough to transform the traditional way of financial services providers to enhance profits (*Miller, 1986*; *Alvarez and Francesco, 2009*). Similarly, financial innovation is perceived as an act of inventing new financial products, services or processes such as derivatives, private equity, securitization, hedge funds and Islamic bond or Sukuk, which come through advances in financial instruments or tools. It also includes the creation of financial technology, institutions and markets or payment systems (Mminele, 2008; *Lerner and Tufano, 2011*). Financial technological innovation may not be new, but in recent years, the drive to invest in new technologies has considerably increased, and the speed of innovation in the financial system is tremendous, and its effect has been felt around the globe. This innovation ranges from Internet banking (INB), Internet payment, mobile payment, mobile banking and mobile money (MM) among others. The invention of digital technology has changed the activities of the financial services industry. This change has improved peoples' saving, borrowing, investment and payment habits, and, as such, this has helped in enhancing welfare, reduce the cost of capital without a proportional increase in systemic risk, and improve access to capital and increased liquidity, among others (Mminele, 2008; *Miller, 1986*).

Many economies – developing, emerging and developed – rely heavily on innovative financial technologies to boost their businesses, customers and their economic activities through the inherent benefits of innovative finance and technology which enhances the ability to invent new markets, guide existing innovative ideas and set a standard for newer techniques of running a business. Thus, many economies have transformed from traditional and manual to digital systems to compete with the global markets, and, as such, African economies are active players in innovative financial technologies. Hence, this was proven by the COMESA Connect initiative that was held in Kigali in June 2018. This initiative constitutes deliberate efforts towards taping into today's digital solutions, which are needed to respond to industries and the need for the markets in the region. This is aimed at providing synergy for businesses and digital services providers to provide solutions that will encourage the creation of a smarter, sustainable, innovative, efficient and profitable business environment in Africa. Consequently, COMESA Connect brought IT companies, telecommunication companies, banks and distributors together and leverage the opportunity for all to partner in a supply chain network that provides solutions to various customer bases. This initiative benefited COMESA member countries and contributed to their ranking in the Global Competitiveness Index (GCI) score which is measured on a scale of 0–100. Thus, according to the 2019 World Economic Forum, COMESA's average GCI score was 49.0, and six member states were ranked among the top 100 globally. These six member countries include Mauritius (GCI 64.3; ranked 52), Seychelles (GCI 59.6, ranked 76), Tunisia (GCI 56.4, ranked 87), Egypt (GCI 54.5, ranked 93), Kenya (GCI 54.1. Ranked 95) and Rwanda (GCI 52.8, ranked 100). This implies that COMESA member countries on average are highly competitive in the global frontier.

## 3. Literature review

In a seminal paper, King and Levine (1993), anchoring on the Schumpeterian thesis, alluded that finance is crucial for innovation as well as economic growth and development. The channels acknowledged by King and Levine (1993) are the roles financial intermediaries play in accumulating savings for investment, which improves capital allocation, therefore supporting innovation in the economy. Aside from the "finance–innovation–economic growth/development" nexus theorized by Schumpeter, relatively little has been discussed on how finance could gain from technological change. Reasonably, most literature emphasis on finance as it is related to growth has been on financial sector development – savings link, financial development-investment link and financial development-capital allocation link. It is well known that technological changes are noteworthy in the drive behind financial innovation observed today (Achieng *et al.*, 2015).

Financial innovation is the creation of new versions of the components of the financial system, vis-a-vis, financial instruments, financial institutions, financial regulations and financial markets (Van Horne, 1985). However, the development of a financial system entails enhancements in the core functions of the financial systems which include diversification of risk, pooling of savings, investment monitoring, facilitation of exchange of goods and services, and allocation of capital to investments (Levine, 2005; Bernanke *et al.*, 1999). The greatest benefits of innovation are not from the invention of the idea but the benefits from widespread adoption (Kanga *et al.*, 2022). Invariably, Rogers's (2003) innovation diffusion theory (IDT) has been used to study technology adoption. The theory is anchored on four elements – innovation, time, communication channels and social systems. How an individual adopts technology depends on his/her observations concerning comparative advantage, complexity, compatibility, trialability and social norms. Most times, rapid diffusion in financial innovation occurs with securities class innovation (Cavanna, 1992). Also, another theory for the study of technological innovation especially in finance is the constraint-induced financial innovation theory developed by Silber (1983). The theory points out that the purpose of profit maximization of a financial institution is the key reason for financial innovation. There are some restrictions including external handicaps, such as policy and internal handicaps, organizational management and leadership style in the process of pursuing profit maximization in an organization (Cherotich *et al.*, 2015). These restrictions and limitations not only guarantee the stability of management, but also reduce the efficiency of a financial institution, and so financial institutions strive toward casting them off through financial innovation (Silber, 1983).

Empirically, a study conducted by Beck *et al.* (2016) found that financial innovation has a positive influence on the banking industry. Azimova and Mollaahmetoglu (2017), using panel data analysis that covered 20 countries from the period 2005 to 2014, examined the influence of financial innovation and services on gross savings and domestic savings. The study reveals that the level of financial access and financial innovations exert an influence on gross savings and total domestic savings. On their part, Amore *et al.* (2013) found a significant relationship between finance and technological innovation, implying that financial innovation determines the level of financial development. On the other hand, Allen and Carletti (2006) discovered that financial innovations like securitization, which can transfer credit risk, can obstruct the thorough screening of money borrowers, thus creating a fertile ground for financial loopholes.

Duygun *et al.* (2013) carried out a study that investigated commercial banks in the United Kingdom for the period covering 2001–2012. The result of their study shows that financial innovation contributes to banks' productivity and general efficiency if they utilize the benefits that come from their functions. In a panel data study that captured 40 Organisation for Economic Co-operation and Development (OECD) and non-OECD countries for the period spanning 1989–2011, Lee *et al.* (2020) discovered that bank supervision and regulations, financial reforms and political governance lowers how financial innovation influences bank growth. Aayale (2017) explored the effect of financial innovation on the economic performance of BRICS and G6 nations using panel data with fixed effects from 1991 to 2014. The study's findings revealed that financial innovation has a positive effect on the financial performance of these countries. Qamruzzaman and Wei (2019) examined the nexus between financial inclusion and financial innovation while incorporating financial development and remittance inflows in the case of six South Asian countries. Findings from panel ARDL confirmed the positive association between financial innovation and financial inclusion, which was observed both in the long run and short run.

Wang *et al.* (2022) examined the impacts of financial innovation on banks' profitability in Africa. The study employed the dynamic panel data method and GMM estimations via a panel data regression model. They found that bank ATM cards affect banks' financial performances, but POS terminals and INB did not. In Kenya, Cherotich *et al.* (2015) investigated how financial innovations influence the financial performance of commercial banks. They discovered that financial innovations positively influence financial performance. Mugane and Ondigo (2016) examined the relationship between financial innovations and the financial performance of commercial banks in Kenya. They found a negative relationship between product innovations and return on assets which contradicts Cherotich *et al.* (2015). However, the relationship between service innovation as well as organizational innovation and return on asset was positive and significant. While in Kenya, Nzioka and Kamakia (2017) found a positive relationship between financial innovation and bank's financial performance. Tahir *et al.* (2018) revealed a positive and significant impact of transactions on the Web/Internet on the efficiency ratio. Nevertheless, ATMs, Mobile Banking (MOB) and point of sale (POS) were non-significant.

In conclusion, evidence from the review of empirical literature has shown a body of knowledge on the relationship between digital financial innovation and its impact on other economic parameters such as GDP, bank profitability, financial development, savings and others. Though the findings on the impact of financial innovation on financial system development strongly indicate a positive relationship but are limited in scope, especially in COMESA, however, it is pertinent to note that in the COMESA region, there are few or no such studies on the impact of digital financial innovation on financial system development, accounting for the influence of institutional quality and macroeconomic environment on financial system development in the region. Many studies that attempted to explain the relationship were country-specific studies as earlier discussed. Few cross-country studies on financial innovation impact were particularly interested in either the banking system, stock market and economic growth (see Wang *et al.*, 2022; Aayale, 2017), while other studies are on financial inclusion, financial innovation, incorporating financial development and remittance inflows concentrated in South Asian and European countries (see Qamruzzaman and Wei, 2019; Beck *et al.*, 2016).

## 4. Empirical model and data description

Following Pesaran *et al.* (1999, 2001), the panel ARDL approach which is considered as the baseline model is adopted for the study. Evaluating the suitability of ARDL scholars like Odhiambo (2009) and Al-Malkawi *et al.* (2012) perceived the ARDL technique to be more technical and most consistent in estimating the long-run effect compared with Johansen and Juselius (1990), Gregory and Hansen (1996), Engle and Granger (1987) and Johansen (1988). The reliability of ARDL was also supported by Choong *et al.* (2005) and Rahman and Salahuddin (2012) who adopted it in their various studies. Thus, the ARDL approach is viable in simultaneously estimating the long-run and short-run parameters of the model, as well as assesses the effect of changes in digital financial innovation measures on financial system development in COMESA. As such, this study used annual time series data for the period 1997–2019 owing to its availability. Data on digital financial innovation and financial system development measures were generated from World Development Indicator (WDI, 2020), World Governance Indicator (WGI, 2020) and World Bank Global Financial Development Database (GFD, 2020). Following the assumptions of ARDL, we checked if the time series data are non-stationary and possess a unit root (see Table 1). Also, we performed the descriptive statistics and correlation matrix to provide basic information on the variables for the study..

From Table 1, the min and max values are 7.911 and −3.841, respectively. Thus, these are the least and the highest values of the variable's coefficients. The Jarque–Bera probability values are significant with no evidence of serial correlation in the series. In addition, the correlation matrix shows the degree of association between a few measures of digital financial innovation and financial system development. The coefficients of the variables show a weak correlation except for a few variables whose values are larger than 0.7 such as INB, INQI, MM and mobile banking (MB). This outcome increases the suspicion that these variables may drift together in the long run.

### *4.1 Baseline model – ARDL (p, q, q, . . ., q)*

Using the ARDL as a baseline approach is technical in addressing issues of a small sample size of data, and it performs better by producing more robust results compared to other techniques (Pesaran *et al.*, 2001). Though ARDL may be weak in accounting for endogeneity problems in high-frequency and panel data. Hence, the adoption of the DGMM which in this study serves as a robustness check model tackles the endogeneity problem. As such, as a baseline model, ARDL is the most efficient technique in estimating the impact of digital financial innovation and establishing the long-run effect on financial system development, and the output can be used for policy forecasting that could promote the performance of the financial system in COMESA because ARDL yields consistent estimates of the long-run coefficients that are asymptotically normal (Manasseh *et al.*, 2017). The baseline approach also enhances the chances to discover the correct dynamic structure of the model which promotes efficient estimation of long-run parameters perceived as difficult under other cointegration procedures (Pesaran *et al.*, 2001). Thus, the generalized ARDL (p, q, q, . . ., q) baseline model is specified as shown below.

$$InY_{i.t} = \sum_{j=1}^{p} \gamma_{i,j} InY_{i,t-j} + \sum_{j=0}^{q} \vartheta_{i,j} X_{i,t-j} + \sum_{j=0}^{q} \delta_{i,j} Cont_{i,t-j} + \theta_i + \varepsilon_{i,t} \quad (1)$$

**Table 1.**
Descriptive statistics and correlation matrix

| Variable | *FD* | *ATM* | *POS* | *MP* | *MM* | *MB* | *INB* | *MEV* | *ROL* | *REQ* | *GEF* | *INQI* | *DFII* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mean | *0.213* | *0.113* | *0.930* | *0.342* | *0.273* | *0.072* | *5.245* | *0.735* | *0.272* | *0.927* | *0.279* | *0.475* | *0.577* |
| Median | 0.391 | 0.294 | 0.903 | −0.172 | 0.661 | 0.053 | 3.415 | 0.352 | 0.078 | 0.874 | 0.691 | 0.417 | 0.682 |
| Max | 1.589 | 0.660 | 7.911 | 0.264 | 0.557 | 0.711 | 1.611 | 0.320 | 0.143 | 0.174 | 0.923 | 0.723 | 0.238 |
| Min | 0.227 | −0.063 | −0.153 | −3.841 | 0.040 | 0.019 | 1.300 | 0.239 | 0.541 | 0.489 | 0.115 | 0.266 | 0.322 |
| Std. Dev. | 0.443 | 0.268 | 3.081 | 0.326 | 0.886 | 0.153 | 2.513 | 0.582 | 0.539 | 0.525 | 0.645 | 0.305 | 0.441 |
| Skewness | 0.690 | 1.716 | 1.721 | 0.257 | 0.385 | 2.213 | 2.642 | 0.442 | 0.241 | 0.344 | 0.919 | 0.226 | 0.369 |
| Kurtosis | 2.410 | 7.015 | 5.171 | 2.053 | 3.040 | 10.72 | 9.015 | 2.091 | 3.145 | 1.863 | 2.110 | 3.008 | 2.450 |
| JB | 3.131 | 40.66 | 17.21 | 5.121 | 2.014 | 80.93 | 39.06 | 21.33 | 5.379 | 4.518 | 7.193 | 3.912 | 2.065 |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| *Correlation matrix* | | | | | | | | | | | | | |
| *FD* | 1 | | | | | | | | | | | | |
| *ATM* | −0.211 | 1 | | | | | | | | | | | |
| *POS* | 0.128 | −0.632 | 1 | | | | | | | | | | |
| *MP* | −0.212 | −0.673 | −0.511 | 1 | | | | | | | | | |
| *MM* | −0.631 | 0.443 | 0.813 | −0.562 | 1 | | | | | | | | |
| *MB* | −0.597 | −0.710 | −0.651 | 0.655 | −0.838 | 1 | | | | | | | |
| *INB* | 0.831 | 0.615 | 0.477 | −0.533 | 0.413 | −0.912 | 1 | | | | | | |
| *MEV* | 0.724 | 0.576 | 0.514 | −0.633 | 0.502 | −0.741 | 0.730 | 1 | | | | | |
| *ROL* | 0.351 | 0.211 | 0.371 | −0.392 | 0.285 | −0.414 | 0.557 | 0.340 | 1 | | | | |
| *REQ* | 0.554 | 0.417 | 0.332 | −0.223 | 0.331 | −0.288 | 0.516 | 0.210 | 0.521 | 1 | | | |
| *GEF* | 0.622 | 0.597 | 0.507 | −0.392 | 0.411 | −0.201 | 0.635 | 0.359 | 0.561 | 0.475 | 1 | | |
| *INQI* | 0.371 | 0.816 | 0.667 | −0.793 | 0.617 | −0.545 | 0.655 | 0.518 | 0.365 | 0.227 | −0.337 | 1 | |
| *DFII* | 0.550 | 0.698 | 0.775 | −0.497 | 0.516 | −0.344 | 0.500 | 0.301 | 0.681 | 0.271 | −0.222 | 0.590 | 1 |

**Source(s):** Author’s conception: JB stand for Jarque–Bera where $Y_{i.t}$ is the dependent variable which is the financial system development measured with financial deepening and proxied with the ratio of broad money supply (M2/GDP). $X_{i,t}$ is the $K \times 1$ vector of independent variables (measures of digital financial innovation) that are allowed to be purely $I(0)\ or\ I(1)$. Thus, $\gamma_{i,j}$ is the coefficient of the lagged dependent variable sometimes referred to as scalers, while $\vartheta_{i,j}$ is the $K \times 1$ coefficient of the independent variables or coefficient vector. $CONT_{i,t}$ is the vector of the control variables, while $\delta_{tj}$ is the related coefficients of the control variables. $\theta_i$ is the unit-specific fixed effect. $i = 1, \ldots, N$; $t = 1, 2, \ldots, T$; $p.q$ are the optimal lag order. $\varepsilon_{i,t}$ is the error term. In addition, all the measures of digital financial innovation such as ATM, POS, mobile payments (MP), MM, Mobile Banking (MB) and INB are in the natural log.

This study also controls for the influence of institutional quality by investigating the impact of the macroeconomic volatility (MEV) on financial system development, as well as accounts for the influence of institutional quality by examining the impact of rule of law (ROL), regulatory quality (REQ) and government effectiveness (GEF), and $\varepsilon_{i,t}$ is the error term. Understanding the *a-priori* expectations of the parameters in eqn. 1 is important at this stage. It is anticipated that $\vartheta > 0$ which states that an increase in digital financial innovation leads to an improvement in financial system development, while MEV is expected to be negatively related to financial system development. Thus, following the re-parameterized ARDL (p, q) of Pesaran *et al.* (1999) and Pesaran *et al.* (2001), a conditional ARDL (p, q, q, . . ., q) error correction term (ECT) is expressed as:

$$\Delta Y_{i.t} = \Phi_i[Y_{i,t-1} - \lambda_i X_{i,t}] + \sum_{j=1}^{p-1} \beta_{i,j} \Delta Y_{i,t-j} + \sum_{j=0}^{q-1} \Pi_{i,j} \Delta X_{i,t-j} + \theta_i + \varepsilon_{i,t} \quad (2)$$

where $\Phi_i = -(1 - \gamma_i)$, group-specific speed of adjustment coefficient (expected that $\Phi_i < 0$). $\lambda_i =$ Vector of long-run relationships. $ECT = [Y_{i,t-1} - \lambda_i X_{i,t}]$ is the error correction term. $\beta_{i,j}\ and\ \Pi_{i,j}$ are the short-run dynamic coefficients. The long-run coefficient $\lambda_i$ is defined to be the same across countries. If $\lambda_i$ is significantly negative, then there exists a long-run relationship between the dependent and independent variables while all the dynamics and the error correction terms are free to vary (Asteriou, 2009).

The estimated MG, PMG and DFE maximum likelihood approach in the estimation, considering both the dynamic adjustment process and the long-run equilibrium (Demetriades and Law, 2006). On the other hand, to choose any of the three estimators (MG, PMG and DFE) for consistency, the Hausman test is used. The first assumption for the panel ARDL is that there are cross-sectional dependence (CSD) problems in the panel. For the cross-sectional independence test, we use Pesaran, Frees and Friedman's CSD tests. We discovered that all the panels are not cross-correlated. Therefore, we used the Levin–Lin–Chu (LLC) panel unit root test that assumes a greater number of periods than panels without including cross-dependence means. Panel ARDL can be applied even when variables have different orders of integration, but must not be greater than I(1). The order of integration of the variables shows that FD, ATM, MP, MM, MB, INB, MEV, ROL, REQ and GEF are all I(0), while POS is I(1) at a 5% level of significance. So, the data are suitable for panel ARDL. Also, to check if the variables have a long-run relationship, we used Pedroni's and Kao's test to test for the cointegration of the panels. These two tests show that the variables have a long-run relationship. Finally, Pesaran *et al.* (1999) assert that the ARDL model, especially PMG and MG, provide consistent coefficients despite the possible presence of endogeneity since it includes lags of dependent and independent variables, p and q, respectively.

*4.2 Robustness model – Generalized method of moments (GMM)*

Re-investigating the baseline (ARDL) results, we introduced and adopted the dynamic GMM model developed by Arellano and Bover (1995) and Blundell and Bond (1998). This model is considered to be more robust in addressing endogeneity bias, reverse causality and the omitted variables issues. In the baseline (ARDL) model, financial deepening proxied with the ratio of broad money ($M_2/GDP$) was used as a measure of financial system development. Hence, adopting dynamic GMM as a robust model, the ratio of credit to the private sector ($CPS/GDP$) was used as an alternative measure of financial system development. According to Beck *et al.* (2000), $M_2$ *to GDP* ($M_2/GDP$) and $CPS/GDP$ measures the depth of the financial system. The rationale for the choice of the two proxies was to ascertain if truly digital financial innovation measures are significant predictors of financial system development in COMESA. Given the above discussion, the study specifies a dynamic model as:

$$InY_{i,t} = \beta_0 + \beta_1 InY_{t-1} + \beta_2 InX_{it} + \rho_t + \varnothing_i + \varepsilon_{it} \quad (3)$$

where $Y_{i,t}$ denotes financial development proxied with the ratio of credit to the private sector ($CPS/GDP$), and $Y_{t-1}$ is the first-year lag of $Y_{it}$. In addition, $X_{it}$ is a set of digital financial development measures which includes ATM, POS, MP, MM, MB and INB which are in their natural log. Hence, $\rho_t$ is the time specific effect, while $\varnothing_i$ is the unobserved country-specific effect. $\varepsilon_{it}$ represents the error term, while $i$ indicates the cross-sectional index. Thus, $t$ is the time index.

In addition, to understand the influence of institutional quality and macroeconomic environment as well as the indexes of digital financial innovation and institutional quality on financial system development in COMESA, eqn.(3) is further expressed as;

$$InY_{i,t} = \beta_0 + \beta_1 InY_{t-1} + \beta_2 InX_{it} + \beta_3 InQ_{it} + \beta_4 InEnv_{i,t} + \beta_5 InM_{i,t} + \rho_t + \varnothing_i + \varepsilon_{it} \quad (4)$$

where $Q_{it}$ represents institutional quality measures such as role law, regulatory quality and GEF, while $Env_{i,t}$ captures the impact of macroeconomic environment looking at the effect of MEV on financial system development in COMESA. As such, $M_{it}$ captures the influence of the indexes of digital financial innovation and institutional quality on financial system development. Thus, the indexes were generated using the principal component analysis (PCA). In like manner, understanding the interactive ($Interact_{i,t}$) effect of institutional quality, macroeconomic environment on digital financial innovation and their impact on financial system development in COMESA, eqn.(4) is expressed as;

$$\begin{aligned} InY_{i,t} = \beta_0 + \beta_1 InY_{t-1} + \beta_2 InX_{it} + \beta_3 InQ_{it} + \beta_4 InEnv_{i,t} + \beta_5 InM_{i,t} \\ + \beta_5 InInteract_{i,t} + \rho_t + \varnothing_i + \varepsilon_{it} \end{aligned} \quad (5)$$

## 5. Empirical findings and discussion

Before the ARDL (p, q) estimation, the variables were subjected to unit roots tests, and these tests include Levin *et al.* (2002), Im *et al.* (2003), ADF-Fisher chi-square initiated by Maddala and Wu (1999), and PP-Fisher chi-square as defined by Choi (2001). The results of the unit root test (see Table 2) depicted that none of the variables is integrated of $1 \sim (2)$. This implies that all the variables for the study are integrated of $1 \sim (0)$ or $1 \sim (1)$. From the results, the null hypothesis ($H_0$) of unit roots is rejected. Hence, we conclude that the series is stationary and have no unit roots. Following the outcome of the unit root tests, the choice of the ARDL approach as a baseline model is confirmed appropriate for the estimation. In addition, the ARDL estimated results (see Table 4) were robustly checked with the adoption of dynamic GMM whose results are presented in Table 5.

**Table 2.** Estimated unit root test results

| Variable | Levin, Lin and Chu | Im, Pesaran and Shin W-stat | ADF-Fisher chi-square | PP-Fisher chi-square | Integration order |
|---|---|---|---|---|---|
| *FD* | −5.665*** | −7.212*** | 20.79*** | 80.39*** | $I \sim (0)$ |
| *ATM* | −7.462*** | −5.958*** | 41.23*** | 11.74*** | $I \sim (0)$ |
| *POS* | −8.367*** | −6.784*** | 80.26*** | 76.31*** | $I \sim (1)$ |
| *MP* | −3.724*** | −8.862*** | 61.29*** | 91.28*** | $I \sim (1)$ |
| *MM* | −4.575 | −9.199*** | 68.95*** | 49.36*** | $I \sim (1)$ |
| *MB* | −5.369*** | −7.109*** | 90.39*** | 93.83*** | $I \sim (0)$ |
| *INB* | −6.663*** | −6.287*** | 72.86*** | 113.034*** | $I \sim (0)$ |
| *MEV* | −5.377*** | −4.947*** | 30.72*** | 35.86*** | $I \sim (0)$ |
| *ROL* | 0.682 | −3.841*** | 41.89*** | 27.93*** | $I \sim (0)$ |
| *REQ* | −5.916*** | −8.878*** | 97.39*** | 75.83*** | $I \sim (1)$ |
| *GEF* | −7.663*** | −6.792*** | 60.86*** | 99.34*** | $I \sim (0)$ |
| *INQI* | −6.705*** | −4.439*** | 20.72*** | 35.87*** | $I \sim (0)$ |
| *DFII* | 0.685 | −3.417*** | 37.90*** | 31.65*** | $I \sim (1)$ |

**Source(s):** Conceptualization. ***, ** and * significant at the 1, 5 and 10% levels, respectively

After ascertaining that our choice variables have no unit roots, we further investigate the existence of cointegration among the variables by adopting Pedroni (2004) and Kao and Chiang (1999) cointegration tests (see Table 3). This is to ensure that the assumptions of ARDL are satisfied and also to understand if there exists a long-run relationship between digital financial innovation and financial system development measures in the series.

Table 3 shows the presence of cointegration existing in the series. The results show that probability values of not less than 5 out of 7 tests conducted are less than a 5% level of significance. Thus, to confirm the results of Pedroni (2004) cointegration tests, we employed Kao and Chiang (1999) tests for robustness checks on our earlier findings. Amidst, the ADF statistics of the Kao tests for all the models were found to be less than a 5% level of significance. Hence, Kao and Chiang (1999) cointegration results confirmed that sincerely there exists a long-run relationship between digital financial innovation and financial system development measures.

### *5.1 Estimated baseline ARDL results*

This section presents and discusses the estimated results on the impact of digital financial innovation on financial system development in COMESA. Evaluating the dynamic panel ARDL techniques following Sakanko *et al.* (2019), estimators such as MG, PMG and DFE were estimated (see Table 4). Other post-estimation tests such as Breusch–Godfrey serial correlation and heteroscedasticity tests were carried out, and the evidence shows that variables are serially uncorrelated and homoscedastic.

We start by showing the MG, PMG and DFE results for the convergence coefficients (ECT), and the long-run and short-run coefficients of Equations (1) and (2) are presented in Table 4. The Hausman test to select the most consistent and efficient estimator between the three estimators, comparing the *p*-value (p) with the 5% level of significance reveals that the DFE performed better than the MG. It means that assuming common factors across sections rather than assuming differing parameters across cross-sections is a better approach. This could be reasonable given that the countries selected are in the same economic market. However, the Hausman test also revealed that PMG is better than MG and DFE. The PMG result shows that assuming differing common factors in the short run and the same common factor in the long run is a more feasible assumption that viewing the cross-sectional parameters as differing both in the short run and long run or common within the cross-

**Table 3.** Summary of results of cointegration tests

| Models | Panel-v | Panel-rho | Panel-PP | Panel-ADF | Group-rho | Group-PP | Group-ADF | Kao test |
|---|---|---|---|---|---|---|---|---|
| 1 | −4.764*** | 5.196*** | 0.374 | 2.083 | 5.861*** | −3.855*** | −3.937*** | −9.384*** |
| | (0.000) | (0.000) | (0.987) | (0.745) | (0.000) | (0.000) | (0.003) | (0.000) |
| 2 | −0.811 | 1.757 | −7.675*** | −10.15*** | 4.692*** | −13.07*** | −7.982*** | −4.694*** |
| | (0.982) | (0.860) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| 3 | −6.517*** | 8.678*** | 1.496 | 11.82*** | 7.382*** | 1.547 | 14.075*** | 6.219*** |
| | (0.000) | (0.000) | (0.967) | (0.000) | (0.000) | (1.004) | (0.000) | (0.001) |
| 4 | −2.751 | 3.866 | −5.916*** | −7.478*** | 4.316*** | −9.535*** | −5.293*** | 7.079*** |
| | (0.929) | (2.897) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.004) |
| 5 | −1.841 | 8.514*** | 3.793*** | 2.187*** | 10.00*** | 4.487*** | 5.359*** | −3.095*** |
| | (0.793) | (0.000) | (0.002) | (0.005) | (0.000) | (0.001) | (0.000) | (0.007) |
| 6 | −0.113 | 3.156 | −6.138*** | −3.854*** | 9.110*** | −2.363** | −0.027 | −13.01*** |
| | (0.381) | (3.019) | (0.001) | (0.002) | (0.000) | (0.014) | (0.321) | (0.000) |

**Source(s):** Conceptualization. ***, ** and * significant at the 1, 5 and 10% levels, respectively

**Table 4.** Baseline model estimated results, ARDL

| Long-run | MG | PMG | DFE | Short-run | MG | PMG | DFE |
|---|---|---|---|---|---|---|---|
| *InFD*(−1) | 0.473*** | 0.216** | −0.197*** | $ECT_{t-1}$ | −0.381** | −0.741*** | −0.667*** |
| | (0.011) | (0.007) | (0.033) | | (0.221) | (0.082) | (0.015) |
| *InATM* | 0.344** | 0.523*** | −0.141*** | Δ*ATM* | 0.261* | 0.613*** | 0.283 |
| | (0.110) | (0.042) | (0.012) | | (0.137) | (0.054) | (0.118) |
| *InPOS* | −0.750 | 0.427*** | 0.035 | Δ*POS* | −0.420** | 0.198*** | −0.593*** |
| | (2.140) | (0.015) | (0.192) | | (0.117) | (0.028) | (0.021) |
| *InMP* | −0.629** | 0.546*** | 0.466** | Δ*MP* | −0.437 | 0.612** | −0.532** |
| | (0.341) | (0.037) | (0.132) | | (0.324) | (0.224) | (0.114) |
| *InMM* | −1.358 | 0.719 | 2.081*** | Δ*MM* | 0.872*** | 0.037 | 0.501*** |
| | (1.125) | (0.572) | (0.011) | | (0.043) | (0.051) | (0.005) |
| *InMB* | 0.184** | 0.499*** | −0.579*** | Δ*MB* | 0.616 | 0.116*** | 0.326 |
| | (0.094) | (0.010) | (0.044) | | (0.886) | (0.022) | (0.241) |
| *InINB* | 0.377*** | −0.228 | 0.331*** | Δ*INB* | 0.039 | 0.717*** | −0.227*** |
| | (0.026) | (0.166) | (0.025) | | (0.091) | (0.066) | (0.033) |
| *InMEV* | −0.784*** | −0.775*** | 0.236 | Δ*MEV* | −0.619 | −0.731** | 0.500*** |
| | (0.026) | (0.018) | (0.115) | | (1.491) | (0.330) | (0.030) |
| *InROL* | 0.726*** | 0.307*** | −0.117 | Δ*ROL* | −7.68 | 0.417* | 0.302*** |
| | (0.168) | (0.005) | (0.131) | | (5.95) | (0.131) | (0.010) |
| *InREQ* | −0.917 | 0.418*** | 0.379*** | Δ*REQ* | −0.558*** | −0.720 | −0.215 |
| | (0.621) | (0.085) | (0.025) | | (0.025) | (1.211) | (1.007) |
| *InGEF* | 0.912** | 0.144*** | 0.214 | Δ*GEF* | 0.329*** | 0.661*** | −0.404*** |
| | (0.240) | (0.012) | (0.153) | | (0.041) | (0.003) | (0.001) |
| *In*(*INQI* * *DFII*) | 0.216** | 0.206*** | 0.105** | *C* | 10.051*** | 2.637*** | 11.450*** |
| | (0.040) | (0.024) | (0.030) | | (2.095) | (0.099) | (0.029) |
| *In*(*MEV* * *DFII*) | 0.075 | −0.316*** | −0.374*** | | | | |
| | (0.062) | (0.003) | (0.013) | | | | |
| Hausman | MG vs PMG | PMG vs DFE | MG vs DFE | | | | |
| | p.0.038 < 5% | p.0.957 > 5% | p.0.164 > 5% | | | | |
| R-Squared | 0.470 | 0.689 | 0.524 | | | | |
| Serial corr. | 8.066 | 3.514 | 6.519 | | | | |
| | (0.257) | (0.171) | (1.131) | | | | |
| Het test | 0.738 | 0.441 | 0.204 | | | | |
| | (0.671) | (0.751) | (0.197) | | | | |

**Note(s):** All equations include a constant country-specific term. SEs are in parentheses. For DFE estimates, the SEs are heteroskedastic consistent. Dependent variable: Financial Deepening (InFD) is proxied with M2/GDP. MG vs PMG (if *p*-value <5%, we use MG), PMG vs DFE (if *p*-value >5%, we use PMG) and MG vs DFE (if *p*-value >5%, we use DFE). ***, ** and * significant at the 1, 5 and 10% levels, respectively

**Table 5.** Robustness check-dynamic GMM estimated results

| Independent Variable↓ | Dept var: Ratio of credit to the private sector (CPS) 1 DGMM | 1 SGMM | 2 DGMM | 2 SGMM | 3 DGMM | 3 SGMM | 4 DGMM | 4 SGMM |
|---|---|---|---|---|---|---|---|---|
| *CPS*(−1) | 0.513*** (0.001) | 0.307** (0.117) | 0.497 (0.360) | −0.602** (0.003) | −0.451*** (0.012) | 0.711*** (0.003) | −0.572* (0.123) | 0.654** (0.002) |
| *lnATM* | 0.197*** (0.010) | 0.219*** (0.000) | 0.681* (0.07) | 1.027*** (0.000) | 0.551** (0.002) | 0.376*** (0.001) | | |
| *lnPOS* | 0.336 (0.276) | 0.109*** (0.000) | 0.472*** (0.000) | 0.557* (0.091) | −0.279 (0.143) | 0.784*** (0.000) | | |
| *lnMP* | −0.817** (0.0520 | −0.540 (0.401) | 0.179 (0.141) | 0.156*** (0.020) | 0.397 (0.202) | 0.733*** (0.000) | | |
| *lnMM* | −2.103 (0.971) | −0.441 (0.302) | −0.826*** (0.000) | −0.794** (0.041) | 1.118*** (0.000) | 2.626 (0.841) | | |
| *lnMB* | −0.609** (0.025) | 0.636*** (0.001) | 0.137*** (0.000) | 0.618* (0.110) | 0.807*** (0.000) | 0.594*** (0.002) | | |
| *lnINB* | −0.394*** (0.002) | −0.772*** (0.017) | 0.371*** (0.000) | 0.744*** (0.000) | −1.158*** (0.012) | 1.446** (0.022) | | |
| *lnROL* | 0.590*** (0.000) | 0.433** (0.000) | 0.464** (0.040) | 0.249*** (0.000) | 0.416*** (0.000) | 0.619** (0.021) | | |
| *lnREQ* | 0.968** (0.000) | 1.720** (0.012) | 0.691*** (0.001) | 1.021* (0.131) | 0.937* (0.009) | −0.894*** (0.000) | | |
| *lnGEF* | 1.433*** (0.001) | 0.285*** (0.000) | 0.405** [0.054) | 0.670** (0.021) | 0.818*** (0.000) | 1.173** (0.035) | | |
| *lnDFII* | | | | | | | 0.658*** (0.012) | 0.874*** (0.000) |
| *lnINQI* | | | | | | | 0.722*** (0.000) | 0.886*** (0.001) |
| *lnMEV* | | | | | | | 2.313 (0.751) | −1.277*** (0.011) |
| *ln*(*INQI* * *DFII*) | | | | | | | 1.027*** (0.014) | 0.549*** (0.000) |
| *ln*(*MEV* * *DFII*) | | | | | | | −0.528*** (0.001) | −0.418* (0.061) |
| *ln*(*ROL* * *ATM*) | −0.092*** (0.001) | 0.804** (0.031) | | | | | | |
| *ln*(*REQ* * *POS*) | | | 0.388*** (0.000) | 1.208*** (0.000) | | | | |
| *ln*(*GEF* * *MP*) | | | | | −1.304*** (0.016) | 0.871*** (0.003) | | |
| *ln*(*ROL* * *MM*) | −0.718*** (0.011) | 0.543*** (0.069) | | | | | | |
| *ln*(*REQ* * *MB*) | | | −0.195*** (0.003) | 0.476*** (0.061) | | | | |
| *ln*(*GEF* * *INB*) | | | | | −0.159*** (0.013) | 0.871*** (0.009) | | |
| *PMG* | 0.542 | | 0.469 | | 0.237 | | 0.497 | |
| *Fixed Effects* | 0.874 | | 0.941 | | 0.714 | | 0.695 | |
| AR(1) | (0.032) | (0.010) | (0.047) | (0.029) | (0.036) | (0.045) | (0.035) | (0.061) |
| AR(2) | (0.610) | (0.485) | (0.541) | (0.632) | (0.534) | (0.391) | (0.711) | (0.604) |
| Hansen | 0.481 | 0.349 | 0.476 | 0.298 | 0.326 | 0.613 | 0.358 | 0.515 |
| Wald | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

**Source(s):** Author's conception. (.); *p*-values; ***, ** and * represents 1, 5 and 10% level of significance. DGMM; Difference GMM and SGMM; System GMM sections in the short and long run. This assumption is more realistic given that achieving a particular policy framework requires a long period whereas different approaches are applied by different countries in the short run.

The PMG calculations were achieved using the Newton–Raphson algorithm with a fixed lag length for all variables. The assumption of common long-run coefficients has yielded a faster speed of convergence and higher standard errors, and the assumption could not be rejected at the usual significance level (5% significance level). The dynamic divergence in the short run is corrected 74% of the time. The PMG result reveals among our measures of digital financial innovation that ATM, POS, MP and MB are significant and contribute positively to financial system development in the long run, and, as such, supported the evidence provided by Tahir *et al.* (2018), Nzioka and Kamakia (2017), Wang *et al.* (2022), Qamruzzaman and Wei (2019), Lee *et al.* (2020) and Aayale (2017) who at the different time studied the relevance of various financial innovation or technology measures in predicting financial system performance. In like manner, further evidence from our findings suggests that a percentage increase in ATM, POS, MP and MB results in a 52%, 43%, 55% and 50% increase in financial system development in COMESA in the long run, respectively, which contradicted the findings of Mugane and Ondigo (2016) which argued that financial innovation does not significantly contribute to the financial performance of commercial banks in Kenya. Moreso, Mugane and Ondigo (2016) findings may be consistent with our findings on the relationship between MM and INB which is insignificantly related to financial system development in the long run. This outcome may be attributed to increasing cybercrime in the region. However, any policy option that can ensure efficient cyber security in COMESA, may lead to improvement in the use of MM and INB in economic transactions. Consequently, considering the findings of this study, it is pertinent to posit that the initiation and implementation of cohesive policies that could promote the confidence of the users of financial innovation/technology and services are capable of deepening the development of the COMESA financial system because it may enhance the significant reduction in transaction cost in the region.

In addition, attention to the important section of the results, as presented in Table 4, show the estimated results of the short-run dynamics coefficient of the lagged error correction term ($ECT_{t-1}$). Following the apriori expectation, we observed a significant negative coefficient expected when there is an existing adjustment to equilibrium in the long run due to the short-run shocks or dynamics. The absolute value of the coefficient of $ECT_{t-1}$ (−0.741) revealed the speed at which the variables adjust to shocks and return to equilibrium in the long annually. Hence, these results were found to be consistent across the baseline models (MG, PMG, DFE). However, the PMG model is considered the most consistent and efficient estimator suitable for the study given the Hausman test results. Further investigation also revealed that digital financial innovation measures such as ATM, POS, MP, MB and INB exhibit a significant and positive relationship with financial system development in the short run. As such, it is evident that digital financial innovation is a significant determinant of financial system development in COMESA both in the short and long run. Thus, this finding confirms the recent and recorded development in the COMESA financial system.

Also, further inquiry on the interactive effect of institutional quality and digital financial innovation indexes ($INQI * DFII$) shows that viable institution promotes investors' confidence, and, as such, lead to increasing demand for digital financial innovation services, which in turn stimulate financial activities while increasing the interactive effect of MEV and digital financial innovation ($MEV * DFII$) result to a decline in the development of the financial system due to the possible fall in the economic agents' demand for digital financial services in the region (see Table 4). This revealed the importance of able institutions in promoting a stable environment needed to boost investors' confidence as supported by our results on the relationship between other measures of institutional quality and financial system development. Thus, the results show that institutional quality measures such as quality REQ, ROL and GEF are important and significantly related to financial system development both in the short and long run. As such, the inability of COMESA authorities to ensure transparent and quality REQ, ROL and GEF in executing law and order in the region would deter the development of the financial system. However, this finding supported Williamson (1985), North (1990) and Manasseh *et al.*'s (2017) studies which established the relevance of viable and quality institutions in promoting economic activities. Hence, the viable institution could complement and promote the level of investors' confidence that may be affected by the negative and interactive influence of the volatile macroeconomic environment (MEV), which was found to be inversely related to financial system development (see Table 4).

*5.2 Robustness check results*

The evidence from the estimated baseline model (ARDL) revealed that digital financial innovation significantly predicts financial system development in the short and long run (see Table 4). We also observed that institutional quality and macroeconomic environment are key determinants of financial system development in the COMESA region, ceteris paribus as earlier pointed out by Manasseh *et al.* (2017) and North (1990), who reiterate the imperative nature of the viable institution in every economy. Considering the relevance of these findings in policy forecasting, we felt the need to robustly check the estimated dynamic ARDL model (baseline) reported in Table 4. To perform this check, we employed the DGMM estimation technique proposed by Arellano and Bond (1991) and extended by Arellano and Bover (1995), while the initial proxy for financial system development (M2/GDP) was replaced with the ratio of credit to the private sector (CPS). The main purpose is to ascertain if a truly long-run and significant relationship exists between digital financial innovation and financial system development in COMESA. In this dynamic GMM, we estimated both the difference GMM and system GMM. The decision on the most consistent and efficient model is taken by comparing the coefficients of one year lag of the dependent variable (CPS (−1)) of the DGMM result with that of the fixed effect result. If the coefficient of CPS (−1) is closer or less than the fixed effect coefficient, it is said to be downward biased. Thus, in that regard, system GMM becomes the most suitable for the estimation (see Table 5).

The estimated DGMM results (Table 5) were found to be consistent with the ARDL results reported earlier in Table 4. The evidence (see column 1) shows that indicators such as ATM, POS, MB and INB is significant and positively related to the financial system development in the long run, while MP and MM are insignificantly related to the digital financial system. Similarly, the results presented in columns 2 and 3 also supported the evidence which suggests that digital financial innovation (DFI) is a key determinant of financial system development which is consistent with the estimated ARDL results. In addition, the influence of the digital financial innovation index (DFII), generated with the PCA was further examined and the results are consistent (see Table 5, column 4) with the evidence from the impact of the decomposed measures of digital financial innovation on financial system development. In like manner, the index of institutional quality (INQI) was also generated using PCA. The result also supported our earlier findings which revealed that institutional quality is significant and positively related to financial system development. This truly shows the relevance of a viable regulatory environment in promoting financial system activities in COMESA. Hence, the relevance of the macroeconomic environment is paramount in promoting financial activities. This is supported by our findings which show that MEV is negative and significantly related to financial system development.

Taking into account the importance and role of institutional quality in every economy, we further extended the inquiry by examining the interactive impact of the index of institutional quality (INQI) and digital financial innovation (DFII) on financial system development. We also examined the interactive impact of the decomposed measures of institutional quality and digital financial innovation on financial system development respectively. From the results (see Table 5, column 4), we noticed that the interaction of *INQI* and *DFII* leads to a direct and significant relationship with financial system development, indicating that the impact of digital financial innovation would be felt when the viable institution is assured. Hence, this finding is consistent with the evidence on the interactive impact of the decomposed measures of institutional quality and digital financial innovation on financial system development. The result revealed the magnitude of the effect of improved REQ, ROL and GEF in promoting digital financial services and its impact on financial system development. Furthermore, similar evidence was observed in the interactive effect of *MEV* and *DFII* on financial system development, and, as such, support the importance of a stable macroeconomic environment in stimulating digital financial activities in COMESA.

Given the results presented in Tables 4 and 5, respectively, we inferred that digital financial innovation significantly promotes the development of the financial system in COMESA. Also, to ensure sustainable development in the region's financial system, coherent, viable and efficient policies that can stimulate viable institutions and a stable macroeconomic environment should be considered essential. The findings of this study could be beneficial to policymakers, financial practitioners, investors, researchers and in particular the COMESA government. This is because the models for the study were thoroughly screened following the assumptions of the GMM model adopted in the study. As such, there was no indication of a serial correlation problem through columns 1–4. The AR (2) value also shows that models 1–4 are free from serial correlation, while the Hansen test confirmed the validity of the instruments employed in the study. Hence, the Wald test result also confirmed that the explanatory variables in the model impacted jointly and significantly on financial system development in COMESA at a 1% level of significance (see Table 5).

## 6. Conclusion and policy implication

This article has explored the impact of digital financial innovation on financial system development on a panel of 20 COMESA member countries over the period of 1997–2019. The unique feature of this study is on the application of the panel ARDL estimation procedure (baseline model) and the dynamic GMM (robust model), as well as the limited empirical evidence on the subject in COMESA. In addition to the knowledge gap is our ability to account for the impact of the decomposed measures of digital financial innovation and its index, decomposed institutional quality measures and its index, macroeconomic environment as well as their respective interactive effect on financial system development in COMESA. These two techniques are appropriate for panel datasets with a period large enough and greater than or equal to the cross-section dimensions and with the analysis of identical long-run and common speed of adjustment to the long run. Hence, the findings from the estimated techniques show that a homogenous long-run association exists amongst most of the COMESA countries in the short and long run. But, more is the fact that most measures of digital financial innovations are positive and significantly related to financial system development. This finding supports the evidence from Duygun *et al.* (2013), Tahir *et al.* (2018), Nzioka and Kamakia (2017), Wang *et al.* (2022), Qamruzzaman and Wei (2019) and Lee *et al.* (2020) studies. However, some of the measures found negative in the long run could be caused by factors such as the lack of literacy programs inherent in developing countries that will guarantee that people apply comprehensive financial decisions and choose financial products which benefit their needs as well as how to use associated channels. Also, the overwhelming influence of financial innovation in the short run may have led to the underestimation of the risk inherent in the use in the long run. This supports the empirical findings of Allen and Carletti (2006).

Other factors that may have significantly affected how some of these measures of financial innovation influence financial system development are consumer protection and confidence, REQ, ROL and GEF and macroeconomic environment as well as other financial infrastructures not serving as a gateway to other financial products such as insurance. Therefore, attention should be given to the long-run impact of some of the measures of digital financial innovation, institutional quality measures and the macroeconomic environment by providing conscious policies that will checkmate the divergence in the short run. That is, a common policy on regional innovative financial strategy should be pursued to provide incentives for technology transfer to promote financial system development in the member states, and plausible product and process innovations should always be in place to complement the inherent benefits of the quality institution in the different components of the COMESA financial system.

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