International Journal of Advanced Business Studies
Volume 4. Issue 6. (2025)
ISSN: 2940-2735

Full length article

Analysis of Technological Innovation on Financial Sector Performance in South Africa

Mpakane Mahlako Seroka [1], Mubanga Mpundu [2*]

1 University of the Western Cape, EMS. Economics department,
Robert Sobukwe Road, Belville, Cape Town, South Africa.
Email: 4070289@myuwc.ac.za

2 University of the Western Cape, EMS. Economics department,
Robert Sobukwe Road, Belville, Cape Town, South Africa.
ORCID: https://orcid.org/0000-0002-4009-9151

*Corresponding e-mail: mmpundu@uwc.ac.za

Article Info

Received: 16.09.2025

Accepted: 20.10.2025

Available online: 30.11.2025

Keywords:

Technological Innovation, Financial sector, Information communication technology, private sector, economic growth

DOI:

https://doi.org/10.59857/mw6jyp93

ABSTRACT

This study examines how technological innovation has shaped economic growth and financial sector performance in South Africa between 1999 and 2023. While many studies treat innovation and finance as separate areas, this research brings them together in a country-specific context. Financial sector performance is measured through domestic credit to the private sector (DCPS), with exchange rate (EXR), broad money supply (M3), inflation (INF), gross fixed capital formation (GFCF), and information and communication technology (ICT) service exports as the main explanatory variables. Time series techniques. including unit root and cointegration tests, the Vector Error Correction Model (VECM), variance decomposition, and Generalised Impulse Response Functions (GIRF) are applied to capture both short- and long-run relationships. In the short run, exchange-rate depreciation, rising inflation, and ICT service exports reduce DCPS, while M3 and GFCF show no significant impact. In the long run, however, ICT service exports emerge as a positive driver, highlighting the role of digital innovation in deepening credit markets. The error-correction results show a slow but steady adjustment toward equilibrium, pointing to structural challenges within the financial system. The study used quarterly data sourced from different databases with differing measurement frequencies, the data was therefore turned into logs during analysis stage to make it more unified for ease of analysis and application. Overall, the findings indicate that technological innovation is an important but uneven driver of South Africa's growth. Policy efforts should link innovation to credit access, design public investment to support rather than crowd out private borrowing and better align digital and financial sector strategies.

1. Introduction

Technological innovation drives economic growth and is key to strengthening the financial sector's performance. Improvements in technology enhance productivity by optimising processes and resources, fostering capital accumulation and sustained economic growth (Challoumis, 2024). For instance, Challoumis (2024) further claims that manufacturing and digital infrastructure innovations help lower operational expenses and improve competitiveness. Meanwhile, financial technology (Fintech) developments such as AI-driven tools, blockchain, and mobile payments increase financial inclusion and lower transaction costs; for example, while blockchain increases transaction openness, peer-to-peer lending systems open up access to credit (Feyen, Frost, Gambacorta, Natarajan & Saal, 2021). Feyen et al. (2021) further explain that although digital innovation increases efficiency and competitiveness, it compromises market consolidation. Regulatory systems have to maintain a balance between creativity and protection against monopolistic behaviour.

According to the European Central Bank (2017), innovation results in an increase in output, allowing companies to simplify procedures, minimise redundancy, and use advanced technologies such as automation and AI. This aligns with the concept of increasing returns to scale, where companies can produce a larger output with the same amount of input. As explained by Johnson & Wales University (2024), distributed ledger technology and robotic process automation (RPA) enhance service delivery, reduce expenses and streamlining operations. Both PwC (2021) and Johnson & Wales University (2024) agree that process innovations, such as AI-powered fraud detection systems and electronic funds transfers, further enhance the speed and reliability of financial transactions, thereby promoting overall economic efficiency.

Even though it is not a perfect metric, the decline in private research and development (R&D) spending, which by some estimates is nearly 40% lower than in 2009, suggests a growing innovation gap compared with a few peers (World Bank, 2017). Consequently, South Africa is falling behind competitors in emerging markets as well as leaders in global technology and expertise. Because of its current infrastructure and human resources, South Africa has untapped potential for innovation that could help eliminate poverty and create jobs by commercialising better goods and services. As Africa gets ready for a future of rapid technological development and the digital revolution, South Africa could take the lead. Even though research and development spending has decreased, South Africa can still benefit from technological innovation, particularly in 4IR technology, to boost economic growth and financial sector performance as long as the country shrinks the innovation gap by strengthening institutional frameworks and making strategic investments in infrastructure and human capital.
The economic and financial sector environment of South Africa has immense potential but also ongoing issues, including inequality, unemployment, and constrained financial inclusion. The Gini index shows South Africa is among the most unequal countries in the world. According to the IMF (2020), the various indications of this inequality is through the skewed income distribution where the poorest 40% of the population retains 7% of income, and the wealthiest 20% holds more than 68%; unequal access to opportunities; and regional disparities where for example Gauteng, the largest economic province, with an income per capita about double that of the predominantly rural provinces such as Limpopo and Eastern Cape. Therefore, being near the economic hubs raises income and employment opportunities. Unemployment levels in South Africa remain a challenge, Statistics South Africa (2025) stated an unemployment rate of 31,9% in the 4th quarter of 2024, therefore highlighting issues such as labour market inefficiencies and poor-quality education. In recent years, economic growth has been slow; the gross domestic product (GDP) only increased by 0.6% in 2024, and the projected 2025 growth is 1.7% (South African Reserve Bank, 2025).

One of the most sophisticated financial systems in Africa is in South Africa. The International Trade Administration (2023) reveals that South Africa generates almost 40% of all fintech income on the African continent, hence underlining its leading role in the regional financial technology environment. However, despite this sophistication, there are challenges. FSCA (2022), at the time of the 2021 FinScope South Africa Consumer Survey, almost 6% of the adult population (roughly 2.4 million people) were unbanked. This emphasises how many people still do not have access to formal financial services. FSCA (2022) further explains that usage stays low even among those with bank accounts because of steep service fees and products not suited for low-income households. The results draw focus to a glaring disparity between the nation's developed financial system and its capacity to properly service all demographic groups. Therefore, bridging this gap requires not just extending access but also ensuring that financial products are inexpensive, accessible, and responsive to the requirements of low-income consumers.

This paper takes an integrated, country-specific approach by analysing combined relationship of technological innovation, economic growth, or financial development within the South African context, with financial sector performance measured by domestic credit to the private sector as a percentage of GDP.

2. LITERATURE REVIEW

Technological innovation has quickly modified sectors and economies throughout the world, acting as a stimulus for both economic growth and sectoral transformation. Advancements in digital technology have the potential to move industries such as financial services from the periphery to the middle of global economic activity, profoundly changing how organisations operate and compete. A study conducted in China by Zhang (2024) found that economic growth is faster in locations with higher patent production and R&D spending than in those without. On the other hand, while the European Union (EU) and the United States (US) are both major investors in innovation, Runiewicz-Wardyn (2009) concludes that the US is the clear leader in technological innovation because it contributes to a higher R&D investment, which leads to faster industrial upgrades and economic expansion.

In recent years, there has been a surge of new technologies globally, and the Fintech sector is no stranger to this trend. Technologies such as Blockchain, cloud computing, data analytics, and AI were used to study their possible impact on the development of the Fintech sector in the United States and the global economy as stated by Oyewole & Adegbite (2023), These developments improve financial inclusion, efficiency, and accessibility, but they also raise fears about cybersecurity and regulatory issues.

During a study session at the African Economic Conference 2023, researchers discussed the diverse technological capacities of African countries, viewing them as an asset rather than a challenge (United Nations Economic Commission for Africa, 2023). The World Bank (2024) reported noteworthy progress in Africa's digital transformation, noting that over 160 million Africans gained broadband internet access between 2019 and 2022, with a 115% increase in internet users from 2016 to 2021. Additionally, 191 million individuals made or received digital payments between 2014 and 2021, highlighting advances in financial inclusion, while countries like Mauritania and Uganda saw advancements in fibre optic infrastructure. Despite these positive developments, challenges such as high mobile data costs, low digital literacy, and regulatory hurdles persist. Kasongo and Makamu (2024) established a substantial positive relationship between economic growth and innovation in 32

African nations, while a study by Mesagan, Vo, and Emmanuel (2023) found that innovation has a positive influence on long-term economic growth across 46 countries. Together, these findings highlight the substantial potential of innovation to transform Africa's economic landscape, underscoring the need for deliberate efforts to bridge the digital divide and achieve inclusive, sustainable growth. With projects like the Southern African Development Community (SADC) Financial Inclusion Strategy aiming to integrate fintech into banking institutions and expand access to financial services, SADC has been aggressively pursuing initiatives to promote financial inclusion through digital solutions (South African Development Community, 2024).

The Southern African region is witnessing a rapid transformation as governments and innovators alike use digital technology to advance economic modernisation and social development. With nations like Lesotho investing in digital connections to support economic modernisation, broadband infrastructure development has accelerated (FinMark Trust, 2020). Furthermore, R&D funding is increasingly recognised as vital for promoting innovation, as policy frameworks emphasise the need for higher education and human capital development to sustain technological advances (Southern African Development Community, 2022). As member countries cooperate to improve mobile money rules, digital payment systems, and cross-border fintech solutions, SADC's collaborative initiatives are also enhancing technological advancement (Southern African Development Community, 2024). These developments demonstrate the region's commitment to leveraging technology for sustainability and enhancing financial sector efficiency.

Theoretical Literature

Schumpeterian Growth Model

In 1990, Philippe Aghion and Peter Howitt developed a model based on Joseph A. Schumpeter's concept of creative destruction, first introduced in 1942. They argue that, unlike Paul Romer's endogenous growth model from 1990, which focuses on horizontal innovation, the Schumpeterian Growth Model emphasises the process by which old technology is replaced by new innovations. Gene M. Grossman and Elhanan Helpman expanded the Schumpeterian Growth Model in 1994 by incorporating aspects of international trade and sectoral research and development (R&D) competition, demonstrating how openness to trade impacts innovation-driven growth.

Aghion, Akcigit and Howitt (2015) state that the Schumpeterian growth model is founded on three fundamental concepts. First, long-run growth is the product of innovations. Second, innovations are the product of entrepreneurial investments driven by the possibility of monopoly rents. Lastly, new innovations replace outdated technologies. This means that creative destruction is a necessary part of growth. Creative destruction is the practice of continuously developing new products and processes to replace obsolete ones (Caballero, 2008). Below, the three concepts will be expanded:

Long-run growth is fundamentally driven by innovation. Aghion and Howitt (1992) define innovation as the creation of modern technologies, processes, and products to increase productivity and economic output. This definition is supported by studies conducted by Mohamed, Liu, and Nie (2022), Adak (2015), Kasongo & Makamu (2024), and Benazzouz & Sadok (2024) all of which have found a significant long-term positive relationship between innovation and economic growth.

Technology Acceptance Model

The Technology Acceptance Model (TAM) was introduced by Fred D. Davis (1985). The model is based on the **Theory of Reasoned Action (TRA) by Ajzen & Fishbein (1980).** TRA focuses on general human decision-making while TAM specifically explains technology adoption. TAM is more focused and applicable in predicting how individuals adopt and use information systems. Bagozzi, Davis, and Warshaw (1992) criticised and broadened TAM by including motivation-based models and TRA into user acceptance studies. Focusing just on perceptions, they contended, TAM oversimplifies the adoption process and fails to include social influence and emotional elements adequately.

According to Davis (1985) The main mechanisms are: Perceived Usefulness (PU) - The extent to which a person believes that using a particular technology will improve their performance; Perceived Ease of Use (PEOU) - The degree to which a person believes that using the technology will be free of effort; lastly (3) Behavioural Intention (BI) - The likelihood that an individual will adopt and use the technology based on their perceptions.
To quantify the variables within the Technology Acceptance Model (TAM), the following equation expresses how different factors that contribute to an individual's Behavioural Intention (BI) to adopt technology:

$$BI = \propto PU + \beta PEOU + \gamma SN + \delta FC$$

Where:

- BI - Behavioural Intention, representing the likelihood of an individual adopting and using the technology.
- PU - Perceived Usefulness, referring to the extent to which a user believes that using the technology will enhance their performance.
- $PEOU$ - Perceived Ease of Use, indicating how effortless or intuitive a user perceives the technology to be.
- SN - Social Norms, capturing the influence of social and environmental factors on the adoption decision.
- FC - Facilitating Conditions, reflecting external conditions that support or hinder the adoption of technology, such as infrastructure or organizational policies.

$\propto, \beta, \gamma$ and δ - Coefficients representing the weight or influence of each factor on Behavioural Intention, which can be determined through empirical research and statistical modelling.

Endogenous Growth Theory

The process of endogenous technological progress is fuelled by deliberate investment choices made by participants who prioritise profit, such as researchers and entrepreneurs (Romer, 1989). Paul Romer first introduced the endogenous growth theory in his 1986 paper. In 1988, Robert Lucas focused on the role of human capital and the consequent spillover effect on the economic growth of a country. As explained before Philippe Aghion and Peter Howitt (1992) introduced a model that explains creative destruction, which is when innovations replace old technology. Gene Grossman and Elhanan Helpman in 1991 merged research and development into growth models, and lastly, Paul Krugman emphasised the increasing returns and economic geography.

The key mechanisms are: Human Capital, which is an extensive collection of knowledge and skills that people gain through education and experience and that increases productivity (Romer,1989); Research and development, the utilisation of resources to generate new information, create better goods, or find economical manufacturing techniques (Black, Hashimzade, and Myles,2012); Innovation, which is the economic application of a new idea according to Black et al. (2012); Increasing returns to scale, increasing all inputs will result in the outputs increasing in the same proportion Black et al. (2012). Spillover effects, innovations and improvements in a certain industry will, in effect, spill over into other industries and will therefore improve the economic productivity (Hayes, 2022).

To model endogenous growth, consider the AK Model, which assumes constant returns to capital:
$Y = AK$
Where:

- Y - Output (GDP)
- A - Productivity factor (technological progress)
- K - Capital stock (Including human capital)

Fintech and blockchain technology have made South Africa's financial industry far more efficient and open to everyone. Blockchain applications, especially in banking and investing, have made transactions easier, cheaper, and safer, which has built confidence among users (Maboe, 2018). Furthermore, according to Che Hashim, Yusoff, and Mohd Jawi (2023), human capital development is essential to maintaining technological innovation since education and skill development provide people the expertise to propel fintech innovations. The South African government's policy and regulatory framework has also had an impact on technology adoption, with efforts like the National Data and Cloud Policy aimed at improving digital infrastructure and governance.

Empirical Literature
Broughel and Thierer (2019) examine how technological innovation is a key factor in driving economic growth and human advancement. The authors examine available research to determine the influence of innovation on economic development. Their study demonstrates how risk-taking, entrepreneurship, and innovation, even without consent, all contribute to the economy's long-term growth. The paper examines historical patterns and their implications for policy. The authors emphasise that regulatory hurdles can hinder technological progress and propose policy frameworks that foster innovation while mitigating short-term disruptions.

Hausmann, Yildirim, Chacua, Hartog, and Matha (2024) conducted this empirical study to examine global trends in innovation patterns using an economic complexity method. The researchers examine scientific papers, patents, and international trade statistics to determine how a country's technological knowledge influences its ability to expand and compete. They use economic complexity indexes to figure out how innovation affects future revenue, patenting, and publication growth. The analysis uses data from 2020, including OpenAlex for scientific papers, WIPO for patents, and the United Nations COMTRADE dataset for trade. The findings suggest that economic complexity has a significant impact on innovation trajectories, with a country's strengths influencing its future diversification prospects. The writers suggest that measures that encourage more sophisticated and varied innovation would help the economy develop.

Liu and Xia (2018) carried out an empirical study to look at how R&D expenditure, innovation, and economic growth in China are all connected and change over time. Using a Vector Autoregression (VAR) model, an impulse response function, and a variance decomposition function, the researchers look at data from 1995 to 2016 to see how stable these correlations are over time. Their research shows that R&D spending and technological innovation help the economy thrive, however conversion efficiency is still poor and R&D spending that is only for short-term profits is common. The process of integrating scientific and technical breakthroughs into the market is very sluggish, which limits the full economic impact of innovation. The report suggests that to help the economy expand in a way that lasts, more money should be put into research and development (R&D), funds should be made more efficient, rewards for scientific innovation should be increased, and the marketisation of innovative accomplishments should be encouraged.

Manasseh, Nwakoby, Okanya, Nwonye, Odidi, Thaddeus, Ede, and Nzidee (2023) looked into how digital financial innovation affects the growth of the financial system in the Common Market for Eastern and Southern Africa (COMESA) countries. Their study looked at how ATMs, point-of-sale systems, mobile payments, and mobile banking help the financial sector thrive. They looked at time-series data from 1997 to 2019 using a dynamic autoregressive distributed lag (ARDL) model and a dynamic generalised method of moments (DGMM) model to make sure their results were dependable. The results showed that digital financial innovation helps the long-term growth of the financial system, although mobile money and online banking had mixed benefits. The recommendations stressed the need of having consistent regional policies and technology transfer plans to make the most of financial innovation. The research, which came out in 2023, gives us information about how fintech is helping to grow the economies of COMESA countries.

Milanzi, Mongale, & Muchara (2024) looked into how innovation investments aided South Africa's economic growth. The authors used the Granger causality technique and a newer Autoregressive Distributed Lag (ARDL) bounds testing approach to examine annual time series data from the South African Reserve Bank; the data used is from 1990 to 2022. Their results indicated that investments in research and development (R&D) and information and communication technologies (ICT) favour economic development, highlighting the significance of innovation-driven growth. The study suggests significant investments in higher education and human capital to support South Africa's innovation ecosystem and its economic stability.

Mugabe (2022) studied how fintech affected South Africa's banking industry's performance. The study used the Autoregressive Distributed Lag (ARDL) model and the Granger Causality test to examine data from 2000 to 2018 to see if fintech firms have an impact on banking performance indicators comprising return on equity (ROE), return on assets (ROA), net interest margin (NIM), and yield on earning assets. The findings showed that the existence of fintech has significant effects on long-term banking performance; ROE showed a negative correlation, whereas other metrics showed positive benefits. The report suggests that NIM reductions be closely monitored to avoid dangerous lending practices and that banks embrace fintech innovations to boost efficiency and competitiveness.

Melamane (2023) focused on how the banking sector in South Africa was affected by the digital transformation. The study examined resource-based perspectives and competitive strategies using a qualitative research methodology to evaluate the impact of digital technology on banking operations. The results show that while digital transformation improves competitive advantage, efficiency, and customer experience, it also comes with concerns, including cybersecurity and regulatory compliance. To optimise the advantages of digital transformation in South Africa's banking industry, the report suggests bolstering digital infrastructure, enhancing cybersecurity protocols, and encouraging innovation-friendly regulations.

Research Gap

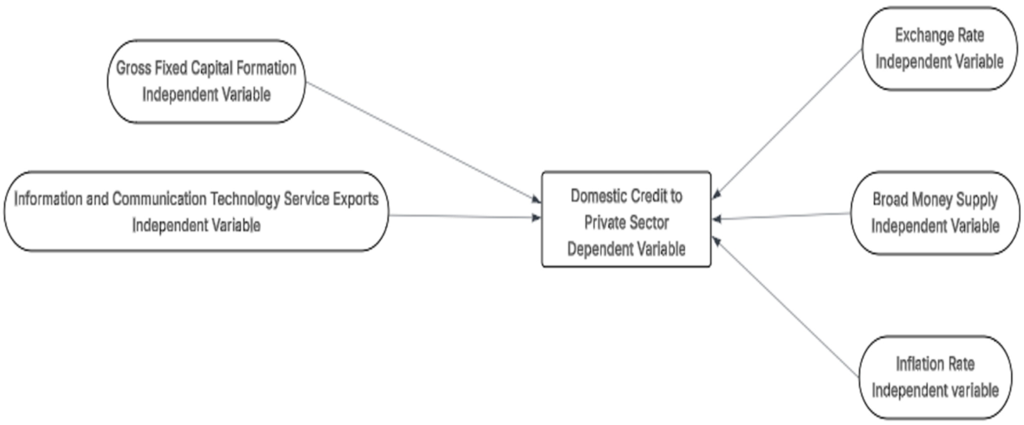
Although studies have investigated the role of technological innovation in economic growth and financial performance globally and Africa, little research has been conducted on the concurrent role of technological innovation in both economic growth and financial sector performance in the South African context. In South Africa specifically, empirical work has often employed diverse innovation measures such as R&D expenditure, patents, or broadband penetration, and has used varying financial indicators, making direct comparisons and integrated policy insights difficult. There is a clear absence of research that uses ICT service exports as the sole variable for technological innovation, examines domestic credit to the private sector (DCPS % of GDP) as the primary measure of financial sector depth, and simultaneously incorporates key macroeconomic determinants such as exchange rate, broad money supply, inflation, and gross fixed capital formation in a country specific analysis.

Furthermore, this paper aims to provide policymakers and key stakeholders with the necessary information to drive growth and enhance financial performance through innovation.

2.4 Conceptual Framework

Figure 1 presents the conceptual framework for this study, positioning domestic credit to the private sector (DCPS % of GDP) as the dependent variable. The five independent variables, exchange rate, broad money supply, inflation rate, gross fixed capital formation, and ICT service exports are shown as key macroeconomic and technological drivers influencing DCPS, which in turn is examined for its relationship with economic growth in South Africa.

Figure 1: Conceptual Framework



Source: (Mpakane and Mpundu,2025)

3. METHODOLOGY

In the model specification section, the variables required to create a regression model are briefly discussed. According to The World Bank (n.d), Domestic Credit to the Private Sector (DCPS) includes financial claims from banks, leasing companies, and insurance companies, among other financial institutions, that create a demand for repayment. This metric, expressed as a percentage of GDP, illustrates the scope and reach of financial intermediation throughout the economy. Therefore, using the above parameters as a starting point, the paper uses DCPS as a proxy for financial sector performance.

This paper presents the empirical analysis and interpretation of results in line with the objectives of the study. EViews 14 was employed as the econometric software for all estimations, and a 5% significance level was adopted throughout. The analysis follows the procedures outlined in the previous chapter, with outcomes presented in tables and figures, and values rounded to four decimal places.

Additionally, this model includes macroeconomic variables such as the exchange rate, broad money supply, inflation and gross fixed capital formation to reflect the broader policy and institutional factors that shape how financial intermediation operates. The exchange rate affects foreign investment, trade competitiveness, and the cost of external debt, which are factors that directly impact the stability and liquidity of financial institutions. On the other hand, Broad money supply shows how much money is circulating in the economy, which affects interest rates and the banking sector's capacity. Inflation is an indicator of price stability; it can influence real interest rates, affect how people and businesses borrow. Gross fixed capital formation (GFCF) reflects long-term investments in things like infrastructure and equipment, pointing to future economic growth and demand for financing.

The relationship between the dependent and independent variables is represented by the following functional equation:

$$DCPS = f(EXR, M3, INF, GFCF, ICT)$$

Therefore, the study's regression equation becomes:

$$DCPS_t = \beta + \beta_1 EXR_t + \beta_2 M3_t + \beta_3 INF_t + \beta_4 GFCF_t + \beta_5 ICT + \epsilon_t$$

The equation will be transformed into log form in order to improve its interpretability and adaptability:

$$lnDCPS_t = \beta + \beta_1 lnEXR_t + \beta_2 lnM3_t + \beta_3 lnINF_t + \beta_4 lnGFCF_t + \beta_5 lnICT + \epsilon_t$$

Dependent Variable:

- Domestic Credit to Private Sector (DCPS)

Independent variables:

- Exchange Rate (EXR)
- Broad Money Supply (M3)
- Inflation Rate (INF)
- Information and Communication Technology Service Exports(ICT)
- Gross Fixed Capital Formation (GFCF)
- β – Constant term
- ϵ- Error Term

Table 1: Variables in regression model

Variable	Unit of measurement	Source
Domestic Credit to the Private Sector	Quarterly data of Domestic Credit to the Private Sector measured in millions	World Bank

Exchange Rate	Quarterly data Exchange Rate in currency unit	IMF
Broad Money Supply	Quarterly data of Broad Money Supply in currency unit	SARB
Information and Communication Technology Service Exports	Quarterly data of Information and Communication Technology Service Exports in millions	World Bank
Gross Fixed Capital Formation	Quarterly data of Gross Fixed Capital Formation in millions	SARB
Inflation	Quarterly data of inflation in millions	SARB, STATS SA

Source: Authors (2025)

Unit Root

Unit root testing lets you figure out if a variable has to be differenced to become stationary. Differencing is necessary until a stable pattern appears in a series that has one or more unit roots. This is also important when using models like the Vector Error Correction Model (VECM), which implies that variables be cointegrated and integrated of the same order.

There are two unit root tests that are commonly used when conducting an empirical analysis, namely the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests.

The ADF accounts for serial correlation by adding lagged differenced terms. Its general form is:

$$\Delta Y_t = \alpha + B_t + \delta Y_{t-1} + \sum_{i=1}^{n} \vartheta_i \Delta Y_{t-i} + \varepsilon_t$$

Where ΔY_t is the first difference, t is the period and ε_t is the white noise.

The PP Test is different since it changes the test statistic to consider heteroskedasticity and autocorrelation without introducing lag factors directly. The main benefit is that it works well when the error terms are unstable or have a lot of structure. Its general form is:

$$\Delta Y_t = B_0 X_t + \propto Y_{t-1} + \mu_t$$

Where adjusts for potential issues in μ_t which then makes it more reliable in small samples or in high-noise environments.

Cointegration

Unlike the Engle-Granger approach, the Johansen test for cointegration allows for different cointegrating relationships; nonetheless, this test is sensitive to asymptotic characteristics, namely large samples. If the sample size is too small, the findings are not trustworthy, then one should employ Auto Regressive Distributed Lags (ARDL).

Error Correction Model (ECM)

The ECM is great for showing both short-term changes and long-term changes between factors. The error correction term in an ECM is a measure of how much the past period's disequilibrium affects the corrections made in the present. As a result, both short-term volatility and the rate at which the variables return to equilibrium may be captured by the model.

Post tests will serial correlation, stability test, Normality, Causality and Variance decomposition.

4. RESULTS AND DICUSSION

Table 2 displays the results of a unit root analysis, a statistical method for testing the non-stationarity and presence of a unit root in time-series datasets. A unit root indicates that the variable is unstable over the long run, susceptible to random shocks, and has a tendency to revert to its mean. The Augmented Dickey-Fuller test and the Phillips-Perron test are used to see if the variables have a unit root. When the variable's stationarity can be established and the probability value is less than the significance threshold (5%) the null hypothesis is rejected.

Table 2: Results of ADF and PP @Level

Variable	Model Specification	ADF test	PP Test	Conclusion
	LEVEL			
lnDCPS	Intercept	1.0000	1.0000	Non-stationary
	Trend and intercept	1.0000	1.0000	Non-stationary
	None	1.0000	1.0000	Non-stationary
lnEXR	Intercept	0.4299	0.4597	Non-stationary
	Trend and intercept	0.7581	0.7812	Non-stationary
	None	0.2931	0.2748	Non-stationary
lnM3	Intercept	1.0000	1.0000	Non-stationary
	Trend and intercept	0.9952	0.9952	Non-stationary
	None	1.0000	1.0000	Non-stationary
lnINF	Intercept	0.0899	0.2576	Non-stationary
	Trend and intercept	0.0042	0.1134	Stationary
	None	0.2617	0.3732	Non-stationary
lnICT	Intercept	0.9969	0.9870	Non-stationary
	Trend and intercept	0.9861	0.9475	Non-stationary
	None	0.9743	0.9904	Non-stationary
LGFCF	Intercept	0.3783	0.3769	Non-stationary
	Trend and intercept	0.9597	0.9597	Non-stationary
	None	0.8961	0.8947	Non-stationary

Table 3: Results of ADF and PP @1st difference

Variable	Model Specification	ADF test	PP Test	Conclusion
	1st difference			
lnDCPS	Intercept	0.0538	0.0000	Stationary
	Trend and intercept	0.0000	0.0000	Stationary
	None	0.0953	0.0000	Stationary
lnEXR	Intercept	0.0000	0.0000	Stationary
	Trend and intercept	0.0000	0.0000	Stationary
	None	0.0000	0.0000	Stationary
lnM3	Intercept	0.0000	0.0000	Stationary
	Trend and intercept	0.0000	0.0000	Stationary
	None	0.0377	0.0000	Stationary
lnINF	Intercept	0.0318	0.0001	Stationary
	Trend and intercept	0.1226	0.0009	Stationary
	None	0.0026	0.0000	Stationary
lnICT	Intercept	0.3556	0.0028	Stationary
	Trend and intercept	0.3165	0.0102	Stationary
	None	0.1656	0.0004	Stationary
LGFCF	Intercept	0.0000	0.0000	Stationary
	Trend and intercept	0.0000	0.0000	Stationary
	None	0.0000	0.0000	Stationary

None of the six series have consistent evidence of stationarity at levels when tested using either the ADF or Phillips–Perron tests. lnDCPS, lnEXR, lnM3, lnICT, and lnGFCF all have p-values that are higher than 0.05 for the "none," "intercept," and "trend and intercept" criteria. Therefore, there are unit roots.

When you first-difference all six variables, they all become stationary. Across all parameters, both the ADF and PP tests have p-values less than 0.05, with several at 0.0000. This validates that each series is integrated of order one, I(1). Now that all the variables are confirmed to be stationary at first difference, it is appropriate to proceed with Johansen cointegration tests.

Johansen Cointegration

Table 4: Cointegration Analysis with Trace Values

Hypothesized no. of CE(s)	Eigenvalue	Trace statistic	0,05 Critical Value	Probability **
None*	0.316020	109.2624	95.75366	0.0042
At most 1*	0.250672	73.55871	69.81889	0.0244
At most 2	0.199882	46.43229	47.85613	0.0676
At most 3	0.170129	25.47071	29.79707	0.1453
At most 4	0.061974	7.941161	15.49471	0.4717
At most 5	0.020294	1.927302	3.841465	0.1651

The trace test Indicates 2 cointegrating equations at the 0.05 level
*Denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Table 5: Unrestricted Cointegration Rank Test (Maximum Eigen Values)

Hypothesized no. of CE(s)	Eigenvalue	Max- Eigen Statistic	0,05 Critical Value	Probability **
None	0.3160	35.7037	40.0776	0.1434
At most 1	0.2507	27.1264	33.8769	0.2567
At most 2	0.1999	20.9616	27.5843	0.2786
At most 3	0.1701	17.5296	21.1316	0.1485
At most 4	0.0620	6.0139	14.2646	0.6114
At most 5	0.0203	1.9273	3.8415	0.1651

Max-eigenvalue test indicates no cointegration at the 0.05 level
* Denotes rejection of the hypothesis at the 0.05 level
** MacKinnon-Haug-Michelis (1999) p-values

The Johansen trace and maximum-eigenvalue tests are shown in Tables 4 and Table 5. They give a mixed picture of how the variables are related in the long run. The trace test rejects the null hypothesis of no cointegration (trace = 109.2624 > critical value of 95.75366; p = 0.0042) and the hypothesis of at most one cointegrating equation (trace = 73.55871 > critical value of 69.81889; p = 0.0244). However, it does not reject the hypothesis of at most two cointegrating equations (trace = 46.43229 < critical value of 47.85613; p = 0.0676), providing evidence of two long-run relationships at the 5% level.

The maximum-eigenvalue test, on the other hand, is more careful. It does not reject the null hypothesis of no cointegration (max-eigen = 35.7037 < critical value of 40.0776; p = 0.1434), nor does it reject higher rank hypotheses, indicating no cointegration at the 5% significance level. It is not uncommon for the two tests to differ like this, especially in moderate sized samples. The trace test is better at finding numerous cointegrating relationships, whereas the max-eigenvalue test is more conservative. Therefore, this study relies on the trace test results and proceeds on the basis that two cointegrating equations exist.

Vector Error Correction

Table 6: Results of the VECM for Domestic Credit to Private Sector in the long run

Variable	Cointegrating Equation	Standard Error	T-Stat	Constant
lnDCPS(-1)	1.0000			-4.8782
lnEXR(-1)	0.1663	0.0621	2.6793	
lnGFCF(-1)	0.2590	0.0480	5.3998	
lnICT(-1)	0.0572	0.0317	1.8078	
lnInf(-1)	0.2302	0.0390	5.9064	
lnM3(-1)	-0.9993	0.0588	-17.0031	

The long-run relationship for domestic credit to the private sector indicates that the constant term is 4.8782. This intercept suggests that when all explanatory variables are unchanged, Domestic Credit to Private Sector remains at 4.8782.

There is a positive and significant (based on the t-stat, if greater than 2, than it is significant, if not, it is insignificant) relationship between exchange-rate and private-sector credit. A one-unit rise in lnEXR(−1) leads to a 16.63% decrease in lnDCPS, this suggests several things such as that when the south African currency remains weak against other currencies for an extended period of time it can make it harder for banks and lenders to borrow credit to the private sector; If firms or banks have borrowed in US dollars, euros, or other stronger currencies, a weaker rand means they need more rands to repay the same amount of foreign debt. Therefore, this increases repayment burdens and can crowd out new borrowing in the domestic credit market.

Table 7: Results of the VECM for Domestic Credit to Private Sector in the short run

Error Correction	Cointeq1	T-stat	Standard Error
D(lnDCPS)	-0.0310	-0.8346	0.0371
D(lnEXR)	-0.3582	-4.1840	0.0856
D(lnGFCF)	-0.0958	-0.9893	0.0969
D(lnICT)	-0.2947	-2.2554	0.1307
D(lnInf)	-0.3485	-3.0634	0.1138
D(lnM3)	-0.0040	-0.1264	0.0314

The short-run error-correction term is −0.0310, it is negative however insignificant ($t < 2$). this implies a slow and weak adjustment of only about 3.1% of any disequilibrium corrects each quarter. In the short run, exchange-rate depreciation has a significantly negative impact on credit: D(lnEXR) carries a coefficient of −0.3582, therefore a one-unit currency depreciation reduces credit by 35.82%. Changes in gross fixed capital formation show a small negative but insignificant effect of 9.58%, indicating investment shocks do not translate into credit changes in the short run. D(lnICT) significantly decreases credit in the short term. A one-unit rise lowers

D(lnDCPS) by 29.47%, suggesting technological innovations may temporarily replace the need to borrow. Short-run inflation D(lnInf) also negatively affects credit: a one-unit increase reduces D(lnDCPS) by 34.85%, reflecting a decrease in borrowing under inflation. Finally, changes in broad money D(lnM3) have an insignificant short-run impact of 0.4% on credit, the coefficient is tiny and statistically insignificant.

Table 8: Results of the Serial Correlation

Lags	LM-stat	Probability	Conclusion
1	27.9602	0.8286	No serial correlation
2	26.0939	0.8879	No serial correlation

H_0: is that there is no serial correlation at lags 1 to h
H_1 : that there is serial correlation of the order

Table 8 demonstrates the results of the serial correlation test. According to the classic linear regression assumptions, there should not be serial correlation in the residuals. The null hypothesis of no serial correlation is accepted because all the probability values are higher than the 5% significance level.

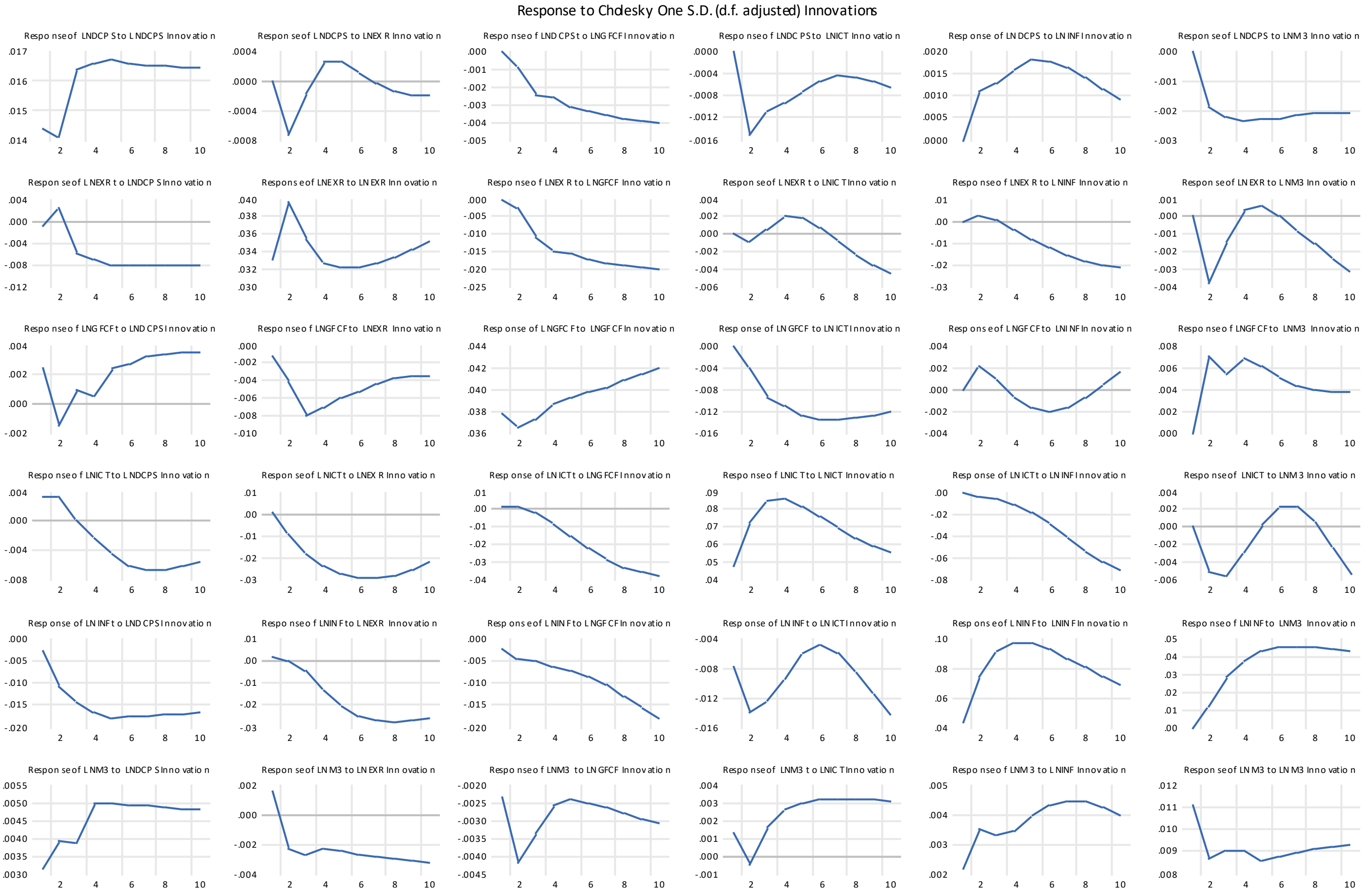
Table 8: Results of variance decomposition

Variance period	S.E.	lnDCPS	lnEXR	lnGFCF	lnICT	lnINF	lnM3
1	0.014397	100.0000	0.000000	0.000000	0.000000	0.000000	0.000000
2	0.020383	97.95065	0.133373	0.233145	0.559353	0.281143	0.842341
3	0.026411	96.76351	0.083779	1.035058	0.502389	0.402548	1.212711
4	0.031430	96.12363	0.066135	1.399655	0.447068	0.533984	1.429528
5	0.035860	95.52167	0.056121	1.861010	0.383895	0.657169	1.520133
6	0.039772	95.06276	0.046034	2.262773	0.331814	0.733294	1.563322
7	0.043308	94.72859	0.038902	2.618085	0.290504	0.761077	1.562846
8	0.046566	94.46823	0.034568	2.931077	0.261289	0.750951	1.553880
9	0.049604	94.24946	0.032026	3.215906	0.242334	0.715967	1.544306
10	0.052469	94.05369	0.030111	3.476944	0.232427	0.668101	1.538731

In the first period 100% of the variation due to shock on DCPS is attributed to DCPS itself while all the other variables contribute 0%. In the fifth period DCPS own shock contributes 95.52167%, while exchange rate (0.04603%) GFCF (2.262773%), ICT(1.861010%), inflation(0.657169%) and money supply(1.520133%). However, in the tenth period DCPS own shock contributes 94.05369%, while exchange rate(0.030111%) GFCF(3.476944%), ICT(0.232427%), inflation(0.668101%) and money supply(1.538731%). Gross Fixed Capital Formation is the largest extern driver, rising to 3.476944%.

Figure 2: Results of the Impulse Response Function

Each variable's shock administered and its impact on the VECM system are displayed in the GIRF. The short term for this research is one to three quarters, the medium term is three to seven quarters, and the long term is eight to ten quarters.



Private-sector credit largely drives itself, with its own shocks lingering for almost ten quarters before settling down. Outside factors do matter, but to a lesser extent: gross fixed capital formation and the money supply have the clearest and longest-lasting positive impacts. In contrast, shifts in the exchange rate and ICT barely register, and inflation only gives credit a small, short-term bump. The graphs exhibit credit being shaped mostly by its own momentum, while investment and monetary conditions add a steady but secondary influence.

5. CONCLUSION

The choice of macroeconomic and innovation variables was guided by established theory and evidence, particularly the Schumpeterian Growth Model and Endogenous Growth Theory, which link innovation to growth and connect finance with economic performance. Using the VECM, Johansen cointegration tests, variance decomposition, and the Generalised Impulse Response Function (GIRF), the study draws the following conclusions:

- The Johansen trace test confirmed two cointegrating equations, indicating that ICT service exports, macroeconomic variables, and DCPS move together over time. Broad money supply (M3) showed a strong positive long-run effect on DCPS, emphasizing the importance of monetary depth in supporting credit expansion. In contrast, exchange rate depreciation, higher inflation, increased GFCF, and growth in ICT service exports were each associated with long-run decreases in DCPS, therefore while these factors may stimulate other areas of the economy, they do not necessarily deepen private-sector credit in the long run.
- The short-run error-correction term was negative but not statistically significant, suggesting a slow adjustment rate of about 3.1% per quarter back to equilibrium. In the short run, exchange-rate depreciation, higher inflation, and growth in ICT service exports all showed significant negative effects on DCPS, while changes in money supply (M3) and investment (GFCF) were not significant. This suggests that periods of

macroeconomic instability and sudden technology shifts can temporarily limit the flow of credit in the financial sector.

Granger causality tests revealed a one-way causal relationship from exchange rate to DCPS, as well as from exchange rate to M3. No bidirectional relationships were detected for ICT service exports and other macroeconomic variables with DCPS. Therefore, credit markets in South Africa respond asymmetrically to innovation and macroeconomic shifts.

- DCPS variations were driven by its own shocks for the most part, with GFCF and M3 as the most influential external drivers over the period. This highlights the relative self-sustaining momentum of private-sector credit, moderated by investment activity and liquidity conditions.

In conclusion, the empirical evidence enables rejection of the null hypotheses for certain relationships, particularly the long-run relationship between broad money supply and DCPS, while supporting the view that the growth impact of technological innovation on financial sector depth is complex, indirect, and sensitive to macroeconomic conditions.

Comparison to previous literature reviewed

Long-run relationships

- Money supply and financial deepening: The finding that the broad money supply (M3) has a strong, positive long-run effect on domestic credit to the private sector (DCPS) is consistent with much of the literature on financial depth. Economic theory suggests that an expansion of a country's money supply increases the pool of funds available for banks to lend, thereby stimulating credit expansion. The study provides further empirical confirmation of this long-standing relationship.
- ICT and financial deepening: The finding that ICT service exports are associated with long-run *decreases* in DCPS appears to contrast with literature that emphasizes the positive role of ICT in financial development. While the statement notes that ICT may stimulate other areas of the economy, it does not necessarily deepen private-sector credit. Previous studies, like one on Asian developing economies, have found that ICT can hinder economic growth on its own but has a positive impact when combined with financial development. This difference could be explained by the specifics of South Africa's economic structure, the nature of its ICT exports, or the methodology used. Another possibility is that, while ICT improves credit access through reduced information asymmetry, it may not translate into overall credit market deepening in the long run.
- Other macroeconomic variables: The study's finding that exchange rate depreciation, inflation, and gross fixed capital formation (GFCF) are associated with long-run decreases in DCPS aligns with literature suggesting that macroeconomic instability can dampen financial sector development. For example, high inflation erodes purchasing power and discourages saving, while exchange rate volatility increases risk, both of which can lead to a contraction in credit markets. Some studies on sub-Saharan Africa similarly note the negative impact of inflation on credit growth.

Short-run dynamics

- **Speed of adjustment:** The VECM's error-correction term, which suggests a slow adjustment back to equilibrium (3.1% per quarter), is a specific empirical result that enriches the existing literature. It indicates a degree of stickiness or inertia in the system, implying that shocks can have persistent effects.

- **Impact of instability:** The finding that short-run exchange rate depreciation and higher inflation have significant negative effects on DCPS aligns with standard macroeconomic theory and empirical findings, which show that financial stability is sensitive to macroeconomic shocks.
- **Innovation and investment:** The study's result that short-run changes in money supply and GFCF were not significant differs from some literature, especially in the case of GFCF. While investment is typically linked to credit, the short-run results suggest that its immediate effects on credit markets in South Africa may be less direct or subject to other factors.

South African Context

- Money supply and exchange rate causality: The one-way causal relationship from the exchange rate to DCPS and to M3 highlights the importance of exchange rate fluctuations as a potential driver of both credit and monetary policy in South Africa. Some literature on other regions, such as Pakistan, has also found a causal relationship between credit to the private sector and monetary policy.
- Drivers of variation: The conclusion that DCPS variations are mostly driven by its own shocks, with GFCF and M3 as the most influential external drivers, provides context for the specific South African credit market. It suggests that internal market dynamics are critical, but that investment and liquidity conditions play the most significant external role. This complements studies that highlight financial market specifics in developing nations.

RECOMMENDATIONS

Growth in ICT service exports on its own does not guarantee more private-sector credit. Policymakers should encourage financial institutions to create credit products designed for ICT-focused businesses, especially SMEs, so that innovation can translate into tangible benefits for the financial sector. The negative relationship between GFCF and DCPS suggests that public investment may be displacing domestic to private sector borrowing. To avoid this, public investment programmes should be designed to complement private-sector innovation, for instance, by promoting public–private partnerships. To fully unlock the growth potential of innovation, technology and industrial policies should be closely tied to financial sector strategies. This would help ensure that progress in the digital economy is supported by credit markets that can respond effectively.

REFERENCES

Adak, M. (2015). Technological Progress, Innovation and Economic Growth; the Case of Turkey. Procedia - Social and Behavioral Sciences, 195, 776–782. https://doi.org/10.1016/j.sbspro.2015.06.478

Aghion, P., & Howitt, P. (1990). A model of growth through creative destruction (NBER Working Paper No. 3223). National Bureau of Economic Research. https://www.nber.org/system/files/working_papers/w3223/w3223.pdf

Aghion, P., & Howitt, P. (1992). A model of growth through creative destruction. Econometrica, 60(2), 323–351. https://doi.org/10.2307/2951599

Aghion, P., Akcigit, U., & Howitt, P. (2015). The Schumpeterian growth paradigm. Annual Review of Economics, 7, 557–575. https://doi.org/10.1146/annurev-economics-080614-115412

Ajzen, I., & Fishbein, M. (1980). Understanding attitudes and predicting social behavior. Englewood Cliffs, NJ: Prentice-Hall. https://www.scienceopen.com/book?vid=c20c4174-d8dc-428d-b352-280b05eacdf7

Bagozzi, R., Davis, F., & Warshaw, P. (1992). Development and test of a theory of technological learning and usage. Human Relations, 45(7), 659–686. https://www.researchgate.net/publication/43117394_Development_and_Test_of_a_Theory_of_Technological_Learning_and_Usage

Benazzouz, S., & Sadok, H. (2024). Analysis of the relationship between innovation, digitalization, and economic growth in North African countries. In M. A. Bach Tobji et al. (Eds.), Digital economy: Emerging

technologies and business innovation. ICDEc 2024 (Lecture Notes in Business Information Processing, Vol. 531). Springer. https://doi.org/10.1007/978-3-031-76368-7_13
Black, J., Hashimzade, N., & Myles, G. (2021). Oxford dictionary of economics (4th ed.). Oxford University Press. https://www.oxfordreference.com/display/10.1093/acref/9780199696321.001.0001/acref-9780199696321
Broughel, J., & Thierer, A. (2019). Technological innovation and economic growth: A brief report on the evidence. Mercatus Research, Mercatus Center at George Mason University. https://www.mercatus.org/publications/entrepreneurship/technological-innovation-and-economic-growth
Caballero, R. J. (2008). Creative destruction. In S. N. Durlauf & L. E. Blume (Eds.), The New Palgrave Dictionary of Economics (2nd ed.). Palgrave Macmillan. https://economics.mit.edu/sites/default/files/publications/creative%20destruction.pdf
Challoumis, C. (2024). The role of technological innovation in shaping capital accumulation and economic growth. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=4924780
Che Hashim, H. I., Yusoff, M. E., & Mohd Jawi, J. R. (2023). The role of human capital on driving fintech force. International Journal of Academic Research in Business & Social Sciences, 13(12). https://hrmars.com/papers_submitted/19876/the-role-of-human-capital-on-driving-fintech-force.pdf
Davis, F. D. (1985). A technology acceptance model for empirically testing new end-user information systems: Theory and results (Ph.D. thesis). Massachusetts Institute of Technology, Sloan School of Management. https://dspace.mit.edu/handle/1721.1/15192
European Central Bank. (2020). How does innovation lead to growth? https://www.ecb.europa.eu/ecb-and-you/explainers/tell-me-more/html/growth.en.html
Feyen, E., Frost, J., Gambacorta, L., Natarajan, H., & Saal, M. (2021). Fintech and the digital transformation of financial services: Implications for market structure and public policy (BIS Papers No. 117). Bank for International Settlements. https://www.bis.org/publ/bppdf/bispap117.pdf
Financial Sector Conduct Authority (FSCA). (2022). FinScope SA Consumer 2021 Survey Results Prepared for FSCA. https://www.fsca.co.za/Documents/FinScope%20SA%20Consumer%202021%20Survey%20%20Results%20Prepared%20for%20FSCA.pdf
FinMark Trust. (2020, June). Innovation ecosystem scoping in the SADC region [Blog post]. FinMark Trust. https://finmark.org.za/knowledge-hub/blog/innovation-ecosystem-scoping-in-the-sadc-region?entity=blog
Grossman, G. M., & Helpman, E. (1991). Trade, knowledge spillovers, and growth. European Economic Review, 35(2–3), 517–526. https://doi.org/10.1016/0014-2921(91)90153-A
Grossman, G. M., & Helpman, E. (1994). Endogenous innovation in the theory of growth. The Journal of Economic Perspectives, 8(1), 23–44. https://www.aeaweb.org/articles?id=10.1257/jep.8.1.23
Hausmann, R., Yildirim, M. A., Chacua, C., Hartog, M., & Matha, S. G. (2024). Global trends in innovation patterns: A complexity approach (Economic Research Working Paper No. 80/2024). https://www.wipo.int/edocs/pubdocs/en/wipo-pub-econstat-wp-80-en-global-trends-in-innovation-patterns-a-complexity-approach.pdf
Hayes, A. (2022). Endogenous growth. Investopedia. https://www.investopedia.com/terms/e/endogenous-growth.asp
International Monetary Fund. (2020). Six charts explain South Africa's inequality. https://www.imf.org/en/News/Articles/2020/01/29/na012820six-charts-on-south-africas-persistent-and-multi-faceted-inequality
International Trade Administration. (2023). South Africa fintech opportunities. https://www.trade.gov/market-intelligence/south-africa-fintech-opportunities
Johnson & Wales University. (2024). The role of financial innovation in solving global challenges. https://online.jwu.edu/blog/the-role-of-financial-innovation-in-solving-global-challenges/
Kasongo, A., & Makamu, T. (2024). Innovation and economic growth: An empirical analysis for African countries. African Journal of Science, Technology, Innovation and Development. https://doi.org/10.1080/20421338.2024.2382612

Liu, Y., & Xia, X. (2018). Research on the dynamic interrelationship among R&D investment, technological innovation, and economic growth in China. Sustainability, 10(11), Article 4260. https://doi.org/10.3390/su10114260
Lucas, R. E. (1988). On the mechanics of economic development. Journal of Monetary Economics, 22(1), 3–42. https://doi.org/10.1016/0304-3932(88)90168-7
Maboe, L. (2018). The adoption of blockchain technology in South Africa's financial sector. Journal of Payments Strategy & Systems, 12(2), 146–156. https://www.researchgate.net/publication/357878893_Blockchain_Technology_Adoption_in_the_South_African_Financial_Service_Sector_Perceived_Advantages_Challenges_and_Potential_Use_Cases
Manasseh, C. O., Nwakoby, N. P., Okanya, O. I., Nwonye, N. I., Odidi, G., Thaddeus, A., Ede, C., & Nzidee, A. (2023). Digital financial innovation and financial system growth in COMESA countries. Journal of Financial Innovation and Development, 4(1), 55–72. https://www.researchgate.net/publication/370066972_Impact_of_digital_financial_innovation_on_financial_system_development_in_Common_Market_for_Eastern_and_Southern_Africa_COMESA_countries
Melamane, S. (2023). Assessing the impact of digital transformation on business performance in South Africa's banking industry (Master's research article, University of the Witwatersrand). https://wiredspace.wits.ac.za/server/api/core/bitstreams/46887ca9-f813-4bc9-82d5-f78a9fdcbb7b/content
Mesagan, E. P., Vo, X. V., & Emmanuel, P. M. (2023). The technological role in the growth-enhancing financial development: Evidence from African nations. Economic Change and Restructuring, 56, 657–680. https://doi.org/10.1007/s10644-022-09442-z
Milanzi, N., Mongale, I., & Muchara, B. (2024). Innovation investments and economic growth in South Africa: An ARDL approach. South African Journal of Economic Studies, 92(3), 201–220.
Mohamed, A., Liu, Y., & Nie, H. (2022). Innovation and long-term growth: Evidence from panel data. Journal of Applied Economics, 25(2), 145–160. https://www.researchgate.net/publication/359374142_Causality_between_Technological_Innovation_and_Economic_Growth_Evidence_from_the_Economies_of_Developing_Countries
Mugabe, L. M. (2022). The effect of fintech on banking performance in South Africa (Master's thesis, University of Cape Town, Graduate School of Business). http://hdl.handle.net/11427/39072
Oyewole, A., & Adegbite, M. (2023). The impact of Artificial Intelligence, Blockchain, Cloud Computing and Data Analytics on the future of the FinTech Industry in the US [Working Paper]. SSRN. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=4487815
PwC. (2021). Global FinTech Report 2021. PricewaterhouseCoopers. https://www.pwc.com/fintech-report-2021
Romer, P. M. (1989). Endogenous technological change. Journal of Political Economy, 98(5, Part 2), S71–S102. https://doi.org/10.1086/261725
Runiewicz-Wardyn, M. (2009). Evaluating and comparing the innovative performance of the United States and the European Union (Center for European Studies Working Paper Series No. 172). https://ces.fas.harvard.edu/uploads/files/Working-Papers-Archives/CES_172.pdf
Schumpeter, J. A. (1942). Capitalism, socialism and democracy (1st ed.). New York, NY: Harper & Brothers. (Introduction of the "creative destruction" concept in economics.). https://papers.ssrn.com/sol3/papers.cfm?abstract_id=1496200
Southern African Development Community. (2022). Skills audit for three priority value chains: Demand and supply analysis. https://www.sadc.int/sites/default/files/2022-07/Skills_Audit_for_3_Priority_Value_Chains.pdf
Southern African Development Community. (2024). SADC adopts technology to drive financial inclusion initiatives within the region. https://www.sadc.int/latest-news/sadc-adopts-technology-drive-financial-inclusion-initiatives-within-region
South African Reserve Bank. (2025). Statement of the Monetary Policy Committee: March 2025. https://www.resbank.co.za/en/home/publications/publication-detail-pages/statements/monetary-policy-statements/2025/march [Accessed: 18 April 2025].
Statistics South Africa. (2025). The struggle for more work hours: Time-related underemployment in South Africa. https://www.statssa.gov.za/?p=18028

United Nations Economic Commission for Africa. (2023). Innovation, technology and industrialisation in Africa. https://www.uneca.org/stories/innovation%2C-technology-and-industrialisation-in-africa

World Bank. (n.d.). Domestic credit to private sector (% of GDP) (FS.AST.PRVT.GD.ZS). World Development Indicators. https://databank.worldbank.org/metadataglossary/world-development-indicators/series/FS.AST.PRVT.GD.ZS

World Bank. (2017). South Africa Economic Update: Innovation for Productivity and Inclusiveness. Washington, DC: The World Bank. https://documents.worldbank.org/en/publication/documents-reports/documentdetail/779551505322376708/south-africa-economic-update-innovation-for-productivity-and-inclusiveness

World Bank. (2024, January 18). Digital transformation drives development in AFE, AFW Africa. https://www.worldbank.org/en/results/2024/01/18/digital-transformation-drives-development-in-afe-afw-africa

Zhang, H. (2024). The impact of technological innovation on economic growth: A study based on relevant cases. Proceedings of the 3rd International Conference on Financial Technology and Business Analysis. https://doi.org/10.54254/2754-1169/139/2024.19289