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Cashless Economy and GDP Growth in Tanzania: Implications for Macroeconomic Performance

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KEYWORDS

GDP growth, Currency in Circulation, ARDL model, Error correction, Foreign direct investment

ABSTRACT

This study investigates the long-run and short-run determinants of GDP growth using the Autoregressive Distributed Lag (ARDL) modelling framework over the period 1990-2022. The analysis focuses on currency in circulation as a share of GDP and foreign direct investment (FDI). Currency in circulation relative to GDP is employed as an indirect proxy for reliance on physical cash and, by implication, the degree of cash dependence in the economy. The ARDL bounds testing approach confirms the existence of a stable long-run cointegrating relationship between the variables, with the F-statistic exceeding the upper critical bound at the 1 percent significant level. The estimated error correction term is negative and statistically significant, indicating that approximately 67 percent of short-run disequilibrium is corrected within one year. Long-run results show that higher currency in circulation relative to GDP has negative effect on economic growth, while FDI has a positive and statistically significant impact. In the short run, FDI exhibits a negative effect, reflecting transitional adjustment costs.

1.0 Introduction

1.1 Background of the Study

The transition from physical currency to digital payment systems has become a prominent feature of financial development across both advanced and emerging economies. Technological

advancements, particularly in mobile telecommunications, have facilitated the proliferation of electronic payment platforms, including mobile money, online banking, and cash-based systems. Proponents argue that such systems reduce transaction costs, enhance financial inclusion, and improve the traceability of economic transactions, with potential implications for macroeconomic stability and growth (Tee and Ong, 2016). In developing economies, however, the realization of these benefits is conditioned by institutional, infrastructural, and socio-economic factors that may either facilitate or constrain the effective adoption of digital finance.

On the context of Tanzania, mobile money adoption has expanded rapidly since the mid-2000s, extending financial services to previously unbanked populations. Nevertheless, the macroeconomics consequences of this shift away from physical currency remain empirically underexplored. While a substantial body of microeconomic evidence demonstrates that mobile money improves household risk management and savings behaviour (Jack and Suri, 2011), there is a dearth of macro-econometric evidence on whether the aggregate transition away from physical currency influences real GDP dynamics in Tanzania. Specifically, no existing study has estimated the short-run and long-run effects of digital payment substation on output in Tanzania using time-series methods. This paper addresses that gap by employing an ARDL bound testing approach to quarterly data from 1990 to 2022, using currency in circulation (CiC) relative to GDP as an inverse proxy for digital finance adoption, where a methodological choice validated in prior literature (Nandru et al., 2021; Mbiti and Weil, 2015).

The regulatory environment governing digital payments in Tanzania has evolved considerably over time. Contrary to claims that the 1991 Banking and Financial Institutions Act constitutes the primary bottleneck, subsequent legislation, and most notably the 2015 National Payment Systems Act (NPSA) explicitly governs electronic money and mobile payment systems. The NPSA provides a legal framework for payment system oversight, licensing of payment services providers, and consumer protection provisions. However, contemporary regulatory gaps persist in areas such as cross-platform interoperability, agent liquidity management, and data privacy enforcement. These gaps, rather than the Banking and Financial Institutions Act alone, represent the binding constraints to a fully integrated digital payment ecosystem.

Infrastructural deficits further complicate the transition. Despite relatively high mobile cellular subscription rates in East Africa, Tanzania ranks low on the Network Readiness Index, driven by

limited internet access in rural areas where much of the population resides (Lazović & Duričković 2014). This digital divide constrains the geographic reach of cashless transactions. Moreover, low levels of financial and digital literacy inhibit effective use of available platforms, with concerns over fraud and data security further dampening adoption (Frimpong et al., 2022). From a macroeconomic perspective, the relationship between cashless economy initiatives and GDP growth is theoretically ambiguous. A well-regulated digital financial system may increase transaction velocity, reduce revenue leakages, and improve monetary policy transmission. Conversely, poor managed transitions may exacerbate inequality, introduce cyber vulnerabilities, and undermine financial stability and this remains an empirical question.

Therefore, this study examines the relationship between the substation of physical currency as an inverse proxy for digital financial adoption and GDP growth in Tanzania. By integrating qualitative institutional analysis with time series econometric evidence, the paper contributes a macro-level perspective to a literature predominantly focused on microeconomic outcomes. The findings aim to inform policy decisions regarding digital financial regulation, infrastructure investment, and financial literacy programs in low-income economies.

1.2 Statement of the Problem

While substantial microeconomic evidence demonstrates that mobile money adoption in Tanzania improves household risk-sharing, savings behaviour, and remittance efficiency (Jack and Suri, 2011), the macroeconomic consequences of a system-wide transition away from physical currency remain largely unquantified. Existing studies on cashless economies in Sub-Saharan Africa have primarily employed qualitative or cross-sectional survey methods, leaving a critical empirical gap: no time series econometric evidence currently exists on whether the aggregate substitution of digital payments for physical currency has influenced real GDP dynamics in Tanzania.

Specifically, it remains unknown whether declines in currency in circulation (CiC) relative to GDP a plausible inverse proxy for digital payment adoption, exhibit statistically significant short-run and long-run relationships with output growth, controlling for conventional determinants such as capital, labour, and monetary aggregates. Furthermore, prior research has not disentangled the potentially offsetting effects of digital finance: increased transaction velocity and financial deepening versus regulatory gaps, infrastructural deficits, and low digital literacy that may dampen macroeconomic transmission. The core empirical question is whether the shift toward cashless

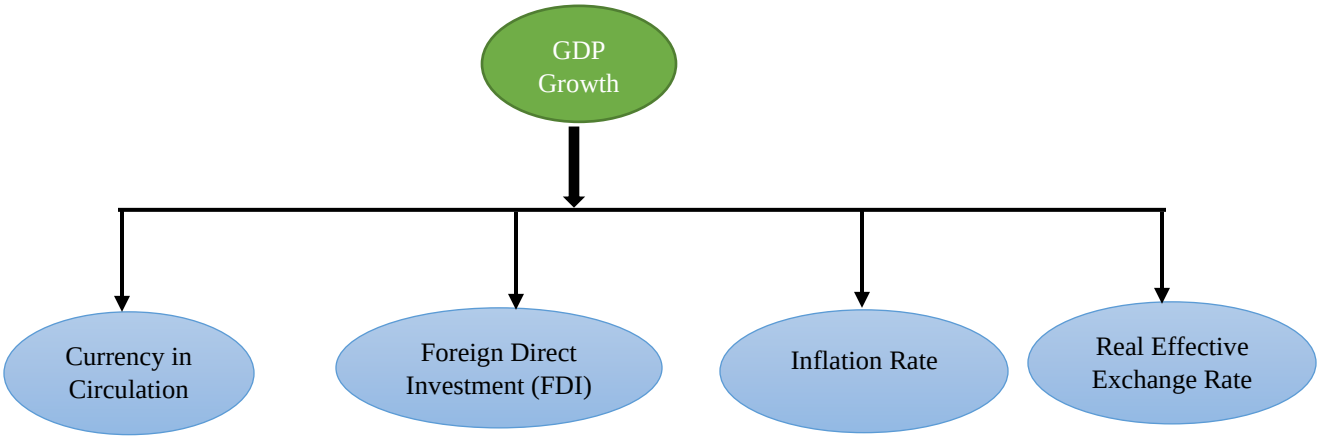
transactions, proxied by the trend in CiC, has contributed to GDP growth once institutional and infrastructural constraints are accounted for. Answering this question is necessary to move beyond micro-level narratives and provide macro-econometric evidence for policymakers weighing investments in digital financial regulation and infrastructure.

2.0 Literature Review

2.1 Conceptual Framework

The diagram below shoes a conceptual framework where four independent variables are hypothesized to influence GDP growth, the dependent variable. The conceptual framework illustrates how four macroeconomic variables which are currency in circulation, foreign direct investment, inflation rate, and real effective exchange rate influences GDP growth. It suggests that increased currency in circulation can stimulate economic activity by boosting spending and investment, through its effectiveness depends on factors like transaction costs and money velocity. On the other hand, foreign direct investment is expected to drive growth by bringing in capital, technology, and employment opportunities. Also, inflation rate has a conditional effect, where moderate levels may signal economic expansion but high inflation can erode purchasing power and slow growth. Additionally, the real effective exchange rate affects growth primarily through trade competitiveness, as depreciation tends to boost exports and appreciation dampens them.

Figure 1: Conceptual Framework of GDP Growth and Macroeconomic Variables



2.2 Theoretical Literature Review

The study on the Cashless economy and GDP growth is guided by the number of theories which are the Quantity Theory of Money, Keynesian Theory, Monetarist Theory, and Endogenous Growth Theory. The Quantity Theory of Money, developed by Irving Fisher, states that the amount of money circulating in the economy has a direct influence on economic activities, price levels and output growth. According to the theory, an increase in money supply raises spending and investment, which can stimulate production and increase GDP growth. Also, the Keynesian Theory, introduced by John Maynard Keynes, argues that money circulation affects aggregate demand through interest rates, consumption, and investment. When currency in circulation increases, borrowing and spending become easier, leading to higher investment, employment, and production, which positively influence GDP growth.

Additionally, the Monetarist Theory, associated with Milton Friedman, emphasizes that money supply plays a crucial role in determining economic stability and growth. The theory suggests that controlled and stable growth in currency in circulation supports sustainable economic expansion, while excessive money supply growth may result in inflation and macroeconomic instability. Furthermore, the Endogenous Growth Theory developed by Paul Romer, explains that economic growth is generated internally through investment, innovation, human capital development, and technological progress. The theory stipulates that an efficient financial and monetary system enhances productivity by facilitating investment and entrepreneurship. Increased currency in circulation can therefore support economic growth by improving access to capital and encouraging productive activities within the economy. Overall, these theories provide a comprehensive framework for explaining how currency in circulation influences investment, consumption, production, and ultimately GDP growth.

The study also grounded in the Baumol-Tobin Model developed by Baumol (1952) and later extended by Tobin (1956). The model explains the demand for cash balances using an inventory theoretical approach, where economic agents hold currency primarily to facilitate transactions while minimizing the opportunity cost of holding non-interest-bearing money. According to the model, the amount of currency held by individuals and firms depends on transaction needs, income levels, and interest rates. Therefore, currency in circulation is theoretically justified as an important

explanatory variable because it reflects transaction demand and liquidity preferences within the economy.

2.3 Empirical Literature Review

The shift towards cashless economies has garnered considerable attention in academic and policy circles, with researchers examining its potential impacts on various aspects of economic activity and societal well-being. Numerous studies have explored the relationship between cashless payment systems and economic growth, financial inclusion, and poverty reduction. Furthermore, the adoption of cashless payment technologies is influenced by a complex interplay of factors, including technological infrastructure, regulatory frameworks, consumer behavior, and cultural norms. Despite continuous progress, some critical issues need to be addressed to achieve a more harmonious, inclusive and sustainable cashless society (Khando et al., 2022). Understanding these factors and their interactions is crucial for designing effective policies and interventions to promote the responsible and inclusive adoption of cashless payment systems (Siano et al. 2020). The digital divide between urban and rural areas, which limit access to technology and financial services for certain segments of the population, has been shown to exacerbate existing inequalities.

The importance of digital financial literacy as a prerequisite for financial inclusion, highlighting the need to equip individuals with the necessary skills and knowledge to navigate the digital financial landscape effectively has been underscored (Azeez & Akhtar, 2021). The literature on digital financial literacy emphasizes the importance of adaptive capability, suggesting that individuals need to not only understand digital financial concepts but also be able to apply them in real-world situations (Luo & Zeng, 2020). This includes the ability to assess the risks and benefits of different digital financial products and services, protect themselves from fraud and cybercrime, and make informed financial decisions (Azeez & Akhtar, 2021; Yadav & Banerji, 2024). The traditional "more technology-more inclusion" approach does not always work, and financial inclusion policies shall be amended to include the propositions on digital literacy and access to cash as well (Dostov et al., 2019).

The empirical studies find a robust positive association between digital/ cashless payment adoption and GDP growth, largely because electronic payment trails encourage formalization (firms move

out of the informal sector), increase taxable activity and raise measured economic activity. Aguilar et al. (2024) show that an increase in electronic payment transactions correlates with higher measured GDP growth, primarily because digital trails reduce informality and increase tax revenues. The effects, while moderate in scale, is consistent across both advanced and emerging economies, suggesting that payment modernization complements traditional growth drivers.

Research focused on Sub-Saharan Africa and similar markets shows that mobile-money platforms increase economic activity by lowering transaction costs, enabling remittances and savings, and improving access to credit and markets; studies using night-lights and other proxies report higher local economic activity where mobile money spreads (Fabregas and Yokossi, 2022). These effects can translate into nontrivial GDP gains in countries where cash use had previously been dominant. Ahmad et al. (2020) similarly suggests that mobile money adoption in five African markets led to measurable GDP gains, indicating that the shift from cash to digital finance plays a macroeconomic role beyond financial inclusion.

Wong et al. (2020) finds that Country-level and payment-type studies (OECD/G7 samples) reveal heterogeneity: debit card and card-based transactions often show the clearest positive link with GDP in high-income countries, while some e-money, reflecting differences in institutional strength, consumer trust, and infrastructure. Conversely, evidence from developing economies indicates that rapid but poorly regulated adoption may produce weaker or even ambiguous growth effects (Zaman et al., 2022). This implies the macroeconomic payoff depends on infrastructure, regulation, and the mix of cashless instruments.

Micro-level quasi-experimental and district-level analysis document that greater digital payment intensity raises household earnings (especially for self-employed) and business revenues, which aggregate up to measurable GDP increases. Dubey and Purnanandam (2023), using data from India, show that districts with higher digital transaction intensity experienced faster income growth, particularly among self-employed workers and small businesses. This supports the idea that the macroeconomic benefits of cashless systems are mediated through productivity improvements at the household and enterprise levels.

While digitalization offers growth opportunities, research highlights risks that may temper or reverse gains. Behavioural factors such as financial literacy, digital trust, and user readiness influence adoption. Moreover, cyber vulnerabilities and payment system outages can threaten

financial stability, with potential GDP implications. Aljaradat & Shukla (2025) emphasizes that poorly managed transitions may lead to exclusion of vulnerable populations, while recent financial press reports stress the importance of regulatory frameworks to sustain the macroeconomic dividends of a cashless economy.

According to Anuforo et al. (2024) evidence from Nigeria's cashless policy reforms illustrates how transitioning to a digital payment system can influence macroeconomic stability and growth. Studies show that the policy, introduced to curb excess cash circulation, improved payment efficiency and financial intermediation, which positively impacted GDP growth in the medium term. However, researchers also caution that inadequate infrastructure, rural urban divides, and low financial literacy limited the full growth potential. This case highlights that while cashless reforms can enhance macroeconomic performance, complementary policies are essential to maximize GDP outcomes.

Tran & Wang (2023) conducted an empirical study exploring the relationship between cashless payments and economic growth, focusing on G20 nations. Using panel data, the authors examined how the diffusion and adoption of cashless payment systems affect private consumption and trade. The analysis demonstrated that greater reliance on digital and cashless payment mechanisms significantly stimulates private consumption, with an estimated increase of about 0.7%. This heightened consumer activity, in turn translates into measurable contributions to overall economic performance, adding approximately 0.17% to GDP growth. These findings underscore the importance of cashless payments as a driver of economic expansion, particularly in advanced and emerging economies where consumption plays a central role in sustaining growth momentum. Complementing this, Wong et al. (2020) examined the impact of cashless payment instruments on GDP growth within OECD countries. The study compared the influence of debit cards, credit cards, e-money and cheque on economic performance, the results revealed that debit cards usage exerts a strong positive effect on GDP growth, suggesting that this payment method plays a particularly effective role in stimulating economic activity. Conversely, the contributions of credit cards, e-money, and cheque payments were less consistent and less clearly linked to growth. Generally, these studies highlight that while cashless payments broadly promote economic development, the type of instrument matters, with debit cards emerging as the most reliable driver of growth, while other forms of cashless payments exhibit more variable impacts.

Said (2018) carried out a study examining the relationship between foreign direct investment (FDI), financial development and economic growth, with a particular focus on the long-term dynamics among these variables. The research applied Johansen's cointegration techniques to test whether stable equilibrium relationships existed over time. The findings indicated that FDI and gross domestic product (GDP) growth are cointegrated, implying the existence of a long-run equilibrium association between the two. This suggests that changes in FDI inflows significantly influence GDP performance, while economic growth also has the potential to attract additional foreign investment. This results further highlight the importance of promoting policies that enhance financial sector development, as it acts as a critical channel through which FDI contributes to sustainable growth. Opoku et al. (2019) conducted a study to investigate the impact of foreign direct investment (FDI) on economic growth in Africa, applying the system generalized method of moments (GMM) approach. This econometric technique was employed to address potential endogeneity and ensure more reliable results. The findings revealed that FDI has a positive and unconditional effect on stimulating economic growth across African economies. However, when sectoral conditions and interactions were incorporated into the analysis, the growth-enhancing role of FDI appeared to be less straightforward and somewhat misleading.

3.0 Methodology

3.0 Introduction

This section discussed the methodology for data collection, preprocessing, model selection, estimation, evaluation and forecasting. The objective of this analysis is to examine the relationship between the development of a cashless economy and GDP in Tanzania, and assess its broader implications for macroeconomic performance.

3.1 Data Collection

Data for the GDP growth and the independent variables collected from reliable sources such as the World Bank, International Monetary Fund (IMF), Bank of Tanzania (BoT), and other relevant agencies. The data will cover a period from 1990 to 2022 with annual observations.

3.2 Multicollinearity test

A multicollinearity test conducted by using the Variance Inflation Factor (VIF) to detect if there is an inter-correlation among the independent variables. Oke et. al., (2019), multicollinearity is a phenomenon that occurs when two or more predictor variables in a regression model are highly correlated with each other. This can cause problems in the estimation of regression coefficients and can lead to unstable and unrealistic results. Fox (2019) and Belsley et al (1982) revealed that VIF measures the degree to which the variance of an estimated regression coefficient is increased due to multicollinearity, where VIF values greater than 5 or 10 are often used as a cutoff to indicate the presence of multicollinearity.

3.3 Lag Length Selection

Considering the effect of lag length in time series data analysis, the number of lags to include in the model was determined using Akaike Information Criteria (AIC) among other different criteria. This approach uses statistical measures such as the Akaike Information Criterion (AIC), Bayesian Information Criterion (BIC), and Schwarz Information Criterion (SIC) to compare the fit of different lag lengths. The lag lengths that yield the lowest value of the information criterion are typically selected as the optimal lag length (Burnhan & Anderson, 2004; Claeskens & Hjort, 2008).

3.4 Unit Root Test

The study employed standard unit root tests such as the Augmented Dickey-Fuller (ADF) test. The test assesses null hypothesis that a series contains a unit root against the alternative of stationarity. The outcomes of the unit root test indicates the order of integrations of the variables, whether I(0) at level or I(1) after first differencing. This step guide in the choice of appropriate econometric modelling, such as the Autoregressive Distributed Lag (ARDL) model or cointegration techniques, ensuring the validity and robustness of the analysis.

The ADF will be estimated as the following equation:

$$\Delta Y_t = \beta + \delta Y_{t-1} + \sum_{i=1}^{m} \alpha_i \Delta Y_{t-i} + \varepsilon_t$$

Where; Δ is the difference operator, ε_t is a pure white noise error term, and m is the maximum number of lags.

If the results obtained from ADF indicate that the data is stationary, it means that the time series variables are not affected by the trends, seasonal effects, or other non – stationary characteristics.

3.5 Model Estimation

This study applied a time series approach using annual data for Tanzania covering the period 1990 to 2022. The use of time series methods is suitable since the objective is to examine the dynamic relationships among macroeconomic variables over time. The analysis began with preliminary data processing, including consistency checks and transformations where appropriate, to ensure accuracy and reliability. Also, descriptive statistics employed to provide an overview of the trends and patterns of the series during the study period. Given that time series data are often characterized by non-stationarity, the next step involves testing for unit roots to determine the order of integration of each variable. The Autoregressive Distributed Lag (ARDL) error correction framework is employed to examine both the short-run dynamics and long-run relationship between GDP growth and its determinants which are currency in circulation, inflation rate, foreign direct investment (FDI), and the real effective exchange rate (REER). Following Pesaran et al., (2001), the ARDL model is specified as:

$$\Delta GDPGrowth_t = \alpha_0 + \sum_{i=1}^{p-1} \phi_i \Delta GDPGrowth_{t-i} + \sum_{j=0}^{q_1-1} \beta_j \Delta CIC_{t-j} + \sum_{k=0}^{q_2-1} \lambda_k \Delta INF_{t-k} + \sum_{l=0}^{q_3-1} \delta_l \Delta FDI_{t-l} + \sum_{m=0}^{q_4-1} \theta_m \Delta REER_{t-m} + \gamma ECT_{t-1} + \varepsilon_t$$

Where ECT_{t-1} is the error correction term derived from the long-run equilibrium relationship. The coefficient γ is expected to be negative and statistically significant, indicating the speed at which GDP growth adjusts back to long-run equilibrium following short-run shocks. The ARDL-ECM approach is appropriate regardless of whether variables are integrated of order I(0) or I(1), provided none is I(2), making it suitable for macroeconomic time-series analysis (Pesaran et al., 2001; Nkoro & Uko, 2016). Moreover, the inclusion of currency in circulation as an independent variable is supported by the Baumol-Tobin inventory theoretic model of money demand, which emphasizes the role of cash balances in facilitating transactions and influencing economic behaviour.

Table 1. Variable Descriptions

Variable	Description
GDPGrowth	*Gross Domestic Product Growth Rate* Measures the percentage change in the value of all goods and services produced within a country's borders over a specific period, usually a quarter or a year.
CIC	*Currency in Circulation* Currency in circulation as a share of GDP is an inverse proxy for digital finance adoption/ cashless economy
INF	*Inflation Rate* This is annual inflation rate impact the cost of living and purchasing power
FDI	*Foreign Direct Investment* An investment made by a firm or individual from one country into business interests located in another country
REER	*Real Effective Exchange Rate* Weighted index that measures a country's currency value relative to a basket of foreign currencies

4.0 Presentation of Results and Discussion

4.1 Descriptive Analysis

The descriptive statistics indicate notable variation across the variables over the 33 observations. GDP growth averages about 5.16 percent, suggesting moderate economic expansion, with values ranging from a low of 0.58 percent to a high of 7.67 percent, reflecting periods of both weak and strong growth. Currency in circulation relative to GDP has a very small mean, as expected, but shows some variability, indicating changes in liquidity conditions over time. Inflation averages 11.59 percent with a relatively high standard deviation, implying substantial price instability and

episodes of both low and high inflation. Additionally, Foreign direct investment (EDI) exhibits considerable dispersion, with large differences between minimum and maximum values, highlighting volatile capital inflows. The real effective exchange rate (REER) has a mean close to 99, with moderate variability, suggesting relatively stable but fluctuating external competitiveness over the period.

Table 2: Descriptive Statistics Analysis

Variable	Observations	Mean	Std. dev.	Min	Max
GDPGrowth	33	5.158573	1.972121	0.5843	7.6722
CIC	33	0.000047	0.0000205	0.00098	0.0078
INF	33	11.58615	9.457319	3.2903	35.8268
FDI	33	19.36663	2.903231	9.21034	21.45912
REER	33	98.66515	9.313346	80.87	118.52

4.2 Determination of Optimal Number of Lags

The lag order selection results based on the Akaike Information Criterion (AIC) suggest the optimal lags for each variable in the model. For GDP Growth, the minimum AIC value is observed at lag 2, indicating that a 2-lag specification is appropriate. Currency in circulation has a lower AIC occurs at lag 1, showing that the first lag is the most suitable. Additionally, inflation rate, the best fit is also found at lag 3, where the AIC reaches its lowest point. On the other hand, the minimum AIC value for foreign direct investment (FDI) occurs at 2, suggesting a 2-lag specification is optimal. Finally, for real effective exchange rate (REER), the lowest AIC is obtained at lag 0, which means no lag is required. Generally, the results imply that different variables require different optimal lag lengths, and these selections ensure efficiency and accuracy in subsequent time series modeling.

Table 3: Optimal Number of Lags

Variable	Lag	LL	LR	df	p	FPE	AIC
GDPGrowth	0	-54.2461				2.64382	3.81007
	1	-45.8139	16.864*	1	0.000	1.58384	3.29751
	2	-44.6422	2.3433	1	0.126	1.56602*	3.28567*
	3	-44.5706	0.14333	1	0.705	1.67127	3.34969
	4	-43.1912	2.7587	1	0.097	1.6309	3.32353
	0	277.161				3.10e-10	-19.0456

CIC	1	317.304	80.286	1	0.000	2.1e-11*	-21.7451*
	2	317.429	0.24953	1	0.617	2.20e-11	-21.6848
	3	317.89	0.92077	1	0.337	2.30e-11	-21.6476
	4	319.838	3.8968*	1	0.048	2.20e-11	-21.713
INF	0	-98.7654				56.97	6.88037
	1	-76.8668	43.797*	1	0.000	13.4831	5.43909
	2	-76.3347	1.0642	1	0.302	13.9325	5.47136
	3	-74.6355	3.3985	1	0.065	13.2902*	5.42314*
	4	-74.2276	0.81584	1	0.366	13.8678	5.46397
FDI	0	-625.254				3.30e+17	43.1899
	1	-611.864	26.779	1	0.000	1.40e+17	42.3355
	2	-608.734	6.2591*	1	0.012	1.2e+17*	42.1886*
	3	-608.681	0.10769	1	0.743	1.30e+17	42.2538
	4	-607.838	1.6853	1	0.194	1.30e+17	42.2647
REER	0	-104.986				87.4891*	7.30936*
	1	-104.985	0.00129	1	0.971	93.7496	7.37829
	2	-104.969	0.03179	1	0.858	100.386	7.44615
	3	-104.164	1.6104	1	0.204	101.848	7.45959
	4	-104.114	0.10031	1	0.751	108.929	7.52509

4.3 Unit Root Test with Optimal Number of Lags

The results of the Augmented Dickey-Fuller (ADF) unit root test conducted before differencing reveal mixed stationarity properties across the variables. With the null hypothesis which states that the series has unit root which means that the variable follows a stochastic trend, and its mean, variance, or autocovariance depends on time. While alternative hypothesis is the series does not have a unit root. Thus, two variables (currency in circulation, and inflation rate) exhibits p-value which is greater than 0.05 significant level, on which we fail to reject the null hypothesis of a unit root, implying non-stationarity. In contrast, the real effective exchange rate (REER), GDP growth and FDI is stationary at all predictable levels, associated with a p-value less than 0.01 which is well below the 1% critical value. This finding required to perform first differencing for non-stationary variables and check if stationarity obtained.

Table 4. Unit Root Test Before Differencing

Variable	No. of Obs	No. of Lags	Test Statistics	Dickey-Fuller Critical value

				1%	5%	10%	P-value
GDPGrowth	30	2	-4.043	-3.716	-2.986	-2.624	0.0012
CIC	31	1	-1.423	-3.709	-2.983	-2.623	0.5714
INF	29	3	-1.950	-3.723	-2.989	-2.625	0.3091
FDI	30	2	-3.512	-3.716	-2.986	-2.624	0.0077
REER	32	0	-5.204	-3.702	-2.980	-2.622	0.0000

4.4 First Difference Optimal Lag Selection

The initial results necessitated carrying out a second optimal lag selection after differencing variables which are not stationary at level. The first difference is a common technique used to transform a time series to make it stationary. Additionally, stationarity is a crucial assumption for many time series models as it ensures that the statistical properties of the series do not change over time. The first difference of a time series is calculated by taking the difference between consecutive observations. To ensure model complexity is reduced and improve forecast accuracy while addressing for multicollinearity and autocorrelation, we had to opt for optimal lag selection for each differenced variable used in the analysis. Akaike Information Criteria (AIC) is opted as it strikes a balance between model goodness of fit and model complexity. Moreover, it penalizes models with more parameters while favouring simpler models that explain the data well without drifting. Table 5 below provides a summary of first difference optimal lag selection for the two variables which were not stationary before.

Table 5: First Difference Optimal Lag Selection

Variable	Lag	LL	LR	df	p	FPE	AIC
CIC	0	177.303				2.0e-07*	-12.5931*
	1	177.345	0.08355	1	0.773	2.1e-07	-12.5246
	2	177.939	1.1881	1	0.276	2.2e-07	-12.4956
	3	179.586	3.2933	1	0.070	2.1e-07	-12.5418
	4	179.743	0.31447	1	0.575	2.2e-11	-12.4816
INF	0	-72.8873				11.471*	5.27767*
	1	-72.887	0.0007	1	0.979	12.3226	5.34907
	2	-72.0025	1.769	1	0.184	12.4319	5.35732
	3	-70.6974	2.6101	1	0.106	12.1779	5.33.553
	4	-70.686	0.02283	1	0.880	13.0938	5.40614

4.5 First Difference Unit Root Test

The initial results necessitated carrying out a second unit root test, which was performed after applying first differencing. Through employing the Dickey Fuller test, the result show that the two variables which before revealed non-stationary current are stationary. The p -value for all variables are less than 1% significant level which confirming strong evidence of being stationary. This means that the null hypothesis of a unit root is rejected for all variables after differencing indicating that they are integrated of order one, I(1), and suitable for further time series modeling such as ARDL or cointegration analysis.

Table 6. Unit Root After Differencing

Variable	No. of Obs	No. of Lags	Test Statistics	Dickey-Fuller Critical value			
				1%	5%	10%	P-value
CIC	31	0	-4.869	-3.709	-2.983	-2.623	0.0000
INF	31	0	-4.998	-3.709	-2.983	-2.623	0.0000

4.6 Optimal Lag Selection

The lag order selection results based on the Akaike Information Criterion (AIC) suggest the optimal lags for each variable in the model. For GDP Growth, the minimum AIC value is observed at lag 2, indicating that a 2-lag specification is appropriate. Currency in circulation has a lower AIC occurs at lag 0, showing that is more suitable when we apply no lag. Additionally, inflation rate, the best fit is also found at lag 0, where the AIC reaches its lowest point. On the other hand, the minimum AIC value for foreign direct investment (FDI) occurs at 2, suggesting a 2-lag specification is optimal. Finally, for real effective exchange rate (REER), the lowest AIC is obtained at lag 0, which means no lag is required. Generally, the results imply that different variables require different optimal lag lengths, and these selections ensure efficiency and accuracy in subsequent time series modeling.

4.7 Model Estimation

4.7.1 Discussion of the Long-Run and Short-Run Relationship Results of Cashless Economy and GDP Growth in Tanzania

The study uses ARDL model analysis which applied data from 1990 to 2022 with total of 33 observations. The R-square (0.6291) indicates that about 62.91% of the variation in GDP growth is explained by the included variables in the model. Additionally, the adjusted R-squared (0.5363) is also relatively high, suggesting good model fit even after accounting for degrees of freedom. The coefficient of the lagged GDP growth under the adjustment term is estimated at 0.6684 with a p-value less than 0.001 this represents the Error Correction Term (ECT), which is both negative and statistically significant, therefore confirming the existence of a stable long-run relationship in the model. The negative and significant coefficient indicates that deviations from the long-run equilibrium are corrected overtime. The result show that about 67% of the disequilibrium is adjusted within one year, suggesting that GDP growth responds relatively quickly to shocks and returns to its long-run equilibrium path. This strong speed of adjustment highlights the robustness of the system in restoring balance after shirt-term fluctuations. The long-run coefficients indicate the sustained impact of explanatory variables on GDP growth. The results show that currency in circulation relative to GDP which is reverse proxy for the cashless economy is negative (-132.2) and statistically significant at the 10% level (P value = 0.096). This suggests that higher dependence on cash transactions adversely affects economic growth in the long run. Since a lower currency in circulation share of GDP reflects greater adoption of cashless payments systems, the result implies that the expansion of the cashless economy contributes positively to economic growth. Although the relationship is only weakly significant statistically, the negative sign is consistent with the theoretical expectation that reduced reliance on physical cash supports economic modernization and growth. This result is different from that of Noman et al, (2023) where the findings show that in the long run, cashless bank payments such as card and e-money, credit transfer, cheque are strongly positively related to real GDP in G7 countries.

Moreover, foreign direct investment (FDI) demonstrates a positive and significant effect on GDP growth, with a coefficient of 0.3561 (p – value = 0.020). This indicate that FDI inflows play an important role in fostering long-term economic expansion through capital accumulation, technology transfer, employment creation, and productivity enhancement. This result aligns with the study by Aouar & Tahraoui (2023) which analyses the impact of foreign direct investment (FDI) on economic growth in the Arab Maghreb Union, whereby the result indicating that FDI has a significant positive impact and confirms that FDI is an important factor in promoting economic growth. However, in the short run, the differenced FDI variable has a negative and significant coefficient (-0.1669, p = 0.003), suggesting that foreign investments may initially impose adjustment costs or create short-term economic disruptions before their long-run growth benefits materialize. This is consistent by the study of Chizema (2025), which show that FDI significantly promote growth.

Table 7: Long-Run and Short-Run Relationship Results

GDPGrowth	Coefficient	Std. err.	t	P>t	[95% conf.	interval]
ADJ						
GDPGrowth						
L1.	-0.66839	0.161512	-4.14	0.000	-1.00174	-0.33505
LR						
CiCGDP	-132.188	76.34655	-1.73	0.096	-289.760	25.38342
InfRate	-0.00478	0.016127	-0.3	0.769	-0.03807	0.028503
FDI	0.356051	0.142353	2.5	0.020	0.062249	0.649853
REER	0.001775	0.010101	0.18	0.862	-0.01907	0.022623
SR						
FDI						
D1.	-0.16685	0.050068	-3.33	0.003	-0.27019	-0.06352
_cons	-3.31778	1.959362	-1.69	0.103	-7.3617	0.726144

4.7.2 Cointegration Test (ARDL Bounds Test)

The ARDL bound test examines whether a long-run relationship exists among the variables. The null hypothesis is no levels relationship. The reported F-statistics is 5.834, which is well above the upper bound I(1) critical values at all conventional significance levels (even the 1% upper bound of 5.06). This leads to a clear rejection of the null hypothesis based on the F-test, indicating strong

evidence of cointegration among the variables. The t-statistics on the lagged dependent variable is -4.138, this value is more negative than the I(1) critical value at the 10% level (-3.99 is stricter), but it is more negative than the I(0) bound and lies close to the rejection region, providing supportive, though comparatively weaker evidence of a long-run relationship. Generally, considering the decisive F-statistic and supportive t-statistic, the results confirm the existence of a stable long-run equilibrium relationship among the variables in the ARDL model.

Table 8. Pesaran/Shin/Smith (2001) ARDL Bounds Test

H_0: no levels relationship F = 5.834

t = -4.138

Critical Values (0.1-0.01), F-statistic, Case 3

	[I_0] L_1	[I_1] L_1	[I_0] L_05	[I_1] L_05	[I_0] L_025	[I_1] L_025	[I_0] L_01	[I_1] L_01
k_4	2.45	3.52	2.86	4.01	3.25	4.49	3.74	5.06

accept if F < critical value for I(0) regressors
reject if F > critical value for I(1) regressors

Critical Values (0.1-0.01), t-statistic, Case 3

	[I_0] L_1	[I_1] L_1	[I_0] L_05	[I_1] L_05	[I_0] L_025	[I_1] L_025	[I_0] L_01	[I_1] L_01
k_4	-2.57	-3.66	-2.86	-3.99	-3.13	-4.26	-3.43	-4.60

accept if t > critical value for I(0) regressors
reject if t < critical value for I(1) regressors
Critical values from Pesaran/Shin/Smith (2001)

4.7.3 Test for Serial Correlation: Breusch–Godfrey LM Test Results

The study conducted Breusch-Godfrey LM test to examine whether the regression residuals suffer from serial correlation, which would violate the classical OLS assumption of error independence. The null hypothesis of the Breusch-Godfrey test states that there is no serial correlation in the residuals up to the specific lag, while the alternative hypothesis indicates the presence of serial correlation. Since the p-value is greater than the conventional 5% significance level, we fail to reject the null hypothesis of no serial correlation. This implies that the residuals do not exhibit statistically significant first-order autocorrelation. This result means that the model appears to be

well specified with respect to serial independence, and the estimated coefficients and standard errors considered to be reliable. Moreover, the results support the adequacy of the model's dynamic structure and validate the assumption of uncorrelated disturbances.

Table 9: Breusch–Godfrey LM test for autocorrelation

lags(p)	chi2	df	Prob>chi2
1	2.564	1	0.1306

H_0: no serial correlation

4.7.4 Test for Heteroskedasticity: Breusch–Pagan/Cook–Weisberg Test Results

The heteroskedasticity test was attempted to assess whether the variance of the regression residuals is constant, an important assumption of the classical regression model. The study uses Breusch-Pagan/ Cook-Weisberg test to assess this assumption. The null hypothesis of the test states that the error terms have constant variance, while the alternative hypothesis suggests the presence of heteroskedasticity. The test makes use of GDP growth variable as fitted values for explanatory variable for the variance. From the result obtained, p-value exceeds the conventional 5% significance level, we fail to reject the null hypothesis of constant variance. This indicates that there is no statistically significant evidence of heteroskedasticity in the model residuals. Therefore, the assumption of homoskedasticity appears to hold, implying that the estimated coefficients are efficient and the standard errors are reliable for inference.

Breusch–Pagan/Cook–Weisberg test for heteroskedasticity

Assumption: Normal error terms

Variable: Fitted values of GDPGrowth

H_0: Constant variance

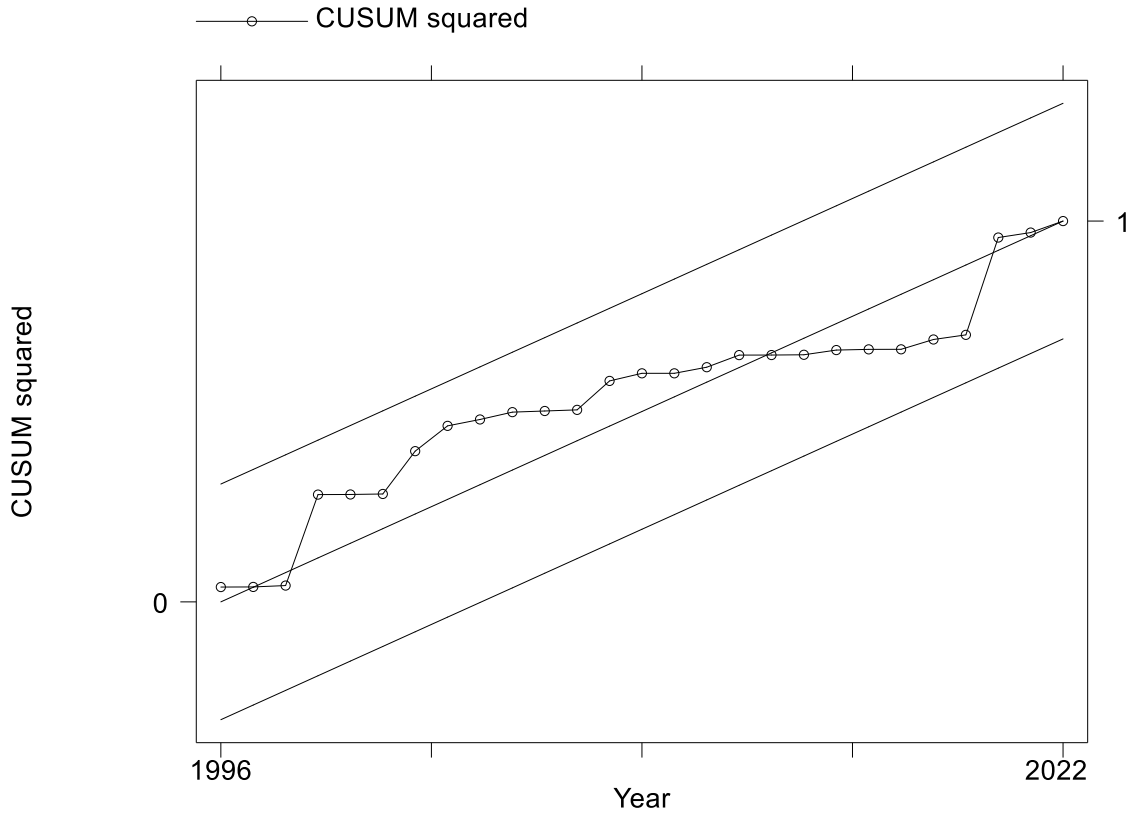
chi2(1) = 6.20

Prob > chi2 = 0.1128

4.7.5 Stability Test of the ARDL Model: CUSUM of Squares (CUSUMSQ) Test

The stability of the estimated ARDL coefficients was estimated using CUSUM of square test. The results from graph below indicate that the CUSUMSQ statistic lies within the 5% significance bounds throughout the sample period, implying the absence of structural breaks and confirming the stability of the model.

Figure 2. CUSUM of Squares Test



4.7.6 Bai and Perron Structural Breaks Test

This is a statistical method used to detect structural breaks in a regression model over time. The null hypothesis (H_0) for this test is no structural break means there is a stable relationship overtime, while alternative hypothesis (H_1) is one structural break exists. The results of Bai & Perron

structural break test show strongly reject the null hypothesis of parameter stability, with a supF statistic of 8.75 exceeding the critical values at the 1%, 5% and 10% significant levels. The results indicate a statistically significant structural break in 1998, suggesting that the relationship between GDP growth and FDI, inflation, real effective exchange rate and currency in circulation underwent a fundamental change during this period. This implies that the macroeconomic system shifted into a new regime, and therefore the estimated ARDL coefficients should be interpreted as average long-run effects across structural distinct periods.

Table 10: Test for Multiple Breaks at Unknown Break dates
(Bai & Perron. 1998. Econometrica)
H_0: no break(s) vs. H1: 1 break(s)

	Bai & Perron Critical Values			
	Test Statistic	1% Critical Value	5% Critical Value	10% Critical Value
supF	8.75	7.17	5.28	4.48

Estimated break points: 1998
Trimming: 0.25

5.0 Conclusion

The study reveals that the transition toward a cashless economy in Tanzania significantly influences GDP growth through its interaction with key macroeconomic variables. Empirical results show that currency in circulation as a share of GDP negatively affects long-run economic growth in Tanzania, implying that excessive reliance on physical cash weakens macroeconomic performance. Foreign direct investment, however, contributes positively to sustained growth through capital accumulation and productivity enhancement. The findings suggest that persistent expansion of currency circulation relative to GDP may reduce monetary efficiency and weaken formal financial intermediation. Consequently, the Bank of Tanzania should strengthen monetary policy measures aimed at reducing excessive cash circulation through active open market operations, reserve requirement adjustments, and expansion of formal electronic settlement systems to maintain a sustainable currency in circulation to GDP ratio consistent with long-run growth objectives.

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