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*Original Article*

# Investigating the Long-run Relationship between Public Debt and Economic Growth: Evidence from Mali

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**Abstract:** This study examines long-run relationship between the public debt and economic growth in Mali over the period 1980–2024 using the Autoregressive Distributed Lag (ARDL) bounds testing approach. After confirming mixed integration orders among the variables, we apply the ARDL model to capture the long-run dynamics. Our results show that population growth is the only variable with a statistically significant and positive long-run impact on economic growth. In contrast, the debt-to-GDP ratio, investment, trade openness, inflation, and human capital do not exhibit significant effects in the long run. These findings suggest that while demographic expansion supports growth, public debt has not played a decisive role in shaping Mali's economic performance. We conclude that effective debt management, quality investment, and human capital development are essential to unlock Mali's long-term growth potential. Our study contributes to the limited empirical literature on debt-growth dynamics in low-income and fragile economies.

**Keywords:** Public Debt; Economic Growth; Mali; Autoregressive Distributed Lag (ARDL) Approach

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## 1. Introduction

The intersection of public debt and economic expansion remains a pivotal issue in macroeconomic policy, particularly for developing nations like Mali, which face persistent fiscal imbalances and escalating debt levels. While moderate public borrowing can finance critical infrastructure and social investments, excessive debt accumulation may hinder long-term growth by crowding out private investment, elevating borrowing costs, and constraining fiscal flexibility (African Development Bank, 2024). Recent empirical studies underscore that the relationship between debt and growth is highly context-dependent, influenced by institutional quality, debt composition, and prevailing economic conditions (Dahal et al., 2024; Hoong et al., 2024). Given Mali's fragile economic environment that characterized by political instability, security challenges, and susceptibility to external shocks, a nuanced understanding of how public debt impacts growth is indispensable for formulating sustainable fiscal policies.

Mali's economic trajectory from 1980 to 2024 reflects a complex interplay of structural constraints, external shocks, and policy interventions. The country's GDP growth and debt dynamics have been shaped by its reliance on agriculture, gold exports, and external aid, alongside political instability and climate vulnerabilities. This section provides a detailed analysis of Mali's economic performance and fiscal sustainability over this period, drawing on official reports and

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scholarly research. Since the 1980s, Malian economy has also registered growth of 3.2% per annum average, which was agriculture-dominated that accounted for 45% of GDP and employed most of the people (Guindo et al., 2024). Productivity, however, was slowed by periodic droughts, inefficient state-owned firms, and inadequate infrastructure. The government embarked on a spending spree to finance government projects, and foreign debt increased from 42% of GDP in 1980 to 89% in 1990. Structural Adjustment Programs (SAPs) by the IMF and World Bank during the late 1980s were meant to stabilize the economy by controlling budget and privatizing but whose social costs fanned wide-scale discontent (African Development Bank, 2024).

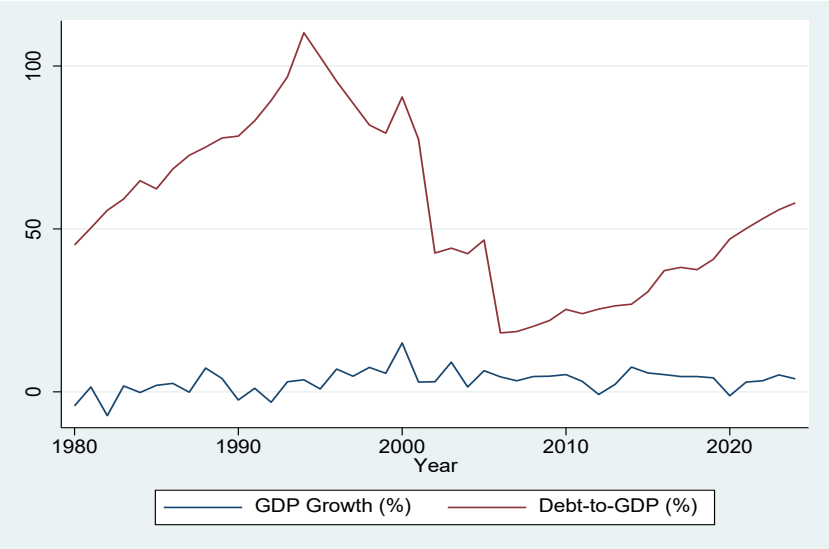



**Figure 1.** GDP Growth rate and Debt- to GDP (%) in Mali period 1980-2024.

The 1990s witnessed sluggish economic growth at a rate of 4.1% average GDP due to export of gold and cultivation of cotton. The Mali debt came to an all-time high at 110% of GDP in the mid-1990s and resulted in HIPC Initiative eligibility in 2000. HIPC and MDRI external debt relief in 2006 reduced the Mali debt to 27% of GDP by 2010, freeing fiscal space for spending on social and infrastructure (African Development Bank, 2023). The early 2000s marked Mali's strongest economic performance, with GDP growth peaking at 5–6%, fueled by gold mining expansion and agricultural modernization. However, the 2012 coup d'état and Tuareg rebellion disrupted economic activity, slashing growth to 0.5% and increasing security-related borrowing, which pushed the Debt-to-GDP ratio back to 40% by 2015 (World Bank, 2020). Post-2012, Mali's economy gradually recovered, averaging 4–5% growth, supported by gold exports (20% of GDP) and donor aid. However, terrorism, climate shocks, and the COVID-19 pandemic exacerbated fiscal pressures. Public debt rose to 52.6% of GDP in 2024, with risks amplified by Mali's withdrawal from ECOWAS and geopolitical tensions. The World Bank projects moderate growth of 4.7% in 2025, driven by nascent lithium production, but warns of persistent debt sustainability challenges (African Development Bank, 2023).

Recent research on African economies suggests that excessive debt has the potential to severely slow growth after it hits unsustainable levels. A study of 35 African economies by Ndoricimpa (2020) revealed that debt begins to impact growth negatively when it hits above 60% of GDP, particularly in low-income countries with low capacity in managing debt. Similarly, the African Development Bank (AfDB, 2023) concluded that in fragile states like Mali, expenditure financed with debt infrequently converts into productive investment due to governance deficiencies, corruption, and inefficient public spending. Conversely, there are studies arguing that as long as borrowed money is invested in high-return sectors—e.g., human development and infrastructure—debt can remain growth-stimulating even at high levels (World Bank, 2023). It underscores the central role that efficiency plays in the use of debt and institutions as drivers of fiscal performance.

Mali's recent macroeconomic trajectory illustrates these complexities. Public debt surged from 32.1% of GDP in 2015 to 53.4% in 2023, driven by escalating security expenditures, COVID-19 response measures, and large-scale infrastructure projects (BCEAO, 2024). While the country maintained an average GDP growth rate of 4.6% between 2015 and 2023, the sustainability of this growth is increasingly precarious. Debt servicing costs alone absorbed 25% of government revenue in 2023, diverting resources from essential public services and development initiatives (AfDB, 2024). Compounding these challenges, Mali's exposure to climate-related shocks and geopolitical instability further exacerbates fiscal vulnerabilities, necessitating a rigorous assessment of the debt-growth linkage (Pavia et al., 2025). There was a lack of paper discussed the Mali's debt long-run relationship with the growth. Therefore, this study is purposed to examine the relationship between government debt and Mali's economic growth. It is expected to contribute to the research gap well as a reference for the government fiscal policies.

## 2. Literature Review

### 2.1. Underlying Theory

Various influential economic schools of thought present varying perspectives on the relationship between debt and economic growth, including the classical/neo-classical, Keynesian, and Ricardian schools. Each of these theories presents varying insights into the short- and long-run implications of government borrowing for economic performance. Classical and neo-classical economists, according to Barsky et al. (1986), posit that while an increase in government debt has the potential to increase short-run economic expansion by making funds available for public expenditure, in the long term its effect is zero or even adverse as per the theory of crowding-out. Excess government consumption, in this view, will pump up the economy, reducing private investment. Government budget deficits funded by debt can boost the consumption of individuals in the short term; however, the resulting debt burden requires greater future taxation, creating a fiscal burden on future generations. Higher consumption also lowers the country's savings, increasing interest rates and discouraging private investment even more. Neo-classical economists also extend that foreign debt financing makes this crowding-out process worse in the end and reduces long-run prospects for growth.

On the other hand, Keynesian economics, as derived by Eisner (1989), emphasizes the short-run stimulus benefit of debt-financed government spending. Keynesians believe that government spending, and to a larger extent when debt-financed, can accelerate economic growth as it raises aggregate demand, increases income levels, and improves public well-being. Keynesian fiscal policy expansion stimulates consumption, further increasing national income and stimulating economic growth. In contrast with the neo-classical school, Keynesians believe that during times of economic slack, intervention by the government through financing with debt can actually fight against recessions without necessarily unleashing undesirable long-run effects. Contrary to the classical and Keynesian schools of economics, the Ricardian equivalence theorem, according to Mankiw (2009), holds that government expenditures funded by debt do not influence aggregate demand. This theorem assumes the presence of rational, forward-looking individuals expecting future tax increases to offset existing deficits. Therefore, households save more rather than consume to offset future fiscal burdens and therefore negate any stimulus effect of government borrowing. In such a model, the fiscal policy is rendered ineffective in changing economic results, as private conduct takes precedence of public sector actions.

### 2.2. Public Debt and Economic Growth

The nexus between debt and growth has been extensively studied in different economic setups with mixed findings spurred by methodology and contextual country specifics. Pegkas (2018, 2019) examines Greece's debt-growth nexus with the use of autoregressive distributed lag (ARDL) and threshold models, which establishes a long-run adverse impact, particularly from post-2000. The study identifies evidence of breaks and nonlinearity, where debt is devastating after threshold levels of 23.5% and 109.4% of GDP. Surprisingly, while extremely high debt levels (above 109.4%) still damage growth, the marginal loss is diminishing, suggesting a debt saturation effect in the Greek case. The findings are in line with Hu et al. (2021), who study 20 countries spanning two centuries and estimate a positive effect on growth up to 70% debt-to-GDP, which turns negative after that. However, the debt-growth link is not uniformly negative. Murungi and Okiro (2018) review Kenya's literature and note varied findings—some studies record debt-financed public expenditure growth-enhancing effects, while others speak of crowding-out dangers. Grobety (2018) complicates the picture by differentiating between domestic and international debt, arguing that domestic borrowing will enhance growth in liquidity-restricted sectors, while external debt does not. These two differ from Pegkas and Hu et al., who are concerned with the aggregate debt effects and emphasize the importance of debt composition—a dimension often overlooked in macroeconomic analyses.

The debt-growth relationship tends to exhibit nonlinear characteristics, as Jacobo and Jalile (2017) reveal in their examination of 16 Latin American economies (1960–2015). Using panel fixed-effects and instrumental variable estimation, they establish an inverted U-shaped relationship: for levels of debt below 64–71% of GDP, debt is conducive to growth, but excessive debt becomes negative. They identify that short-run debt is stimulative, while high debt over the long run is growth-constraining, a point of subtlety missing from Pegkas' Greece-focused analysis. Their work also emphasizes the moderating effect of democratic institutions, implying that good governance can soften debt-related growth limits. Similarly, Swamy (2020) employs panel vector autoregressions (VAR) across international data (1960–2009), confirming a nonlinear and mostly negative debt-growth relationship. A rise in debt-to-GDP by 10 percentage points reduces growth by 23 basis points, though the effect varies with debt regimes. This confirms Pegkas (2018) and Hu et al. (2021) in confirming threshold effects but introduces some additional moderators—inflation, trade openness, and FDI, over which the strength of the relationship varies.

Country-specific factors heavily intervene in the debt-growth link. Burhanudin et al. (2017) investigate Malaysia (1970–2015) through an ARDL model and find a positive long- and short-run relationship with no adverse effects even at high debt levels. This is in sharp contrast to Greece and Latin America, and it testifies to the effectiveness of debt management—i.e., investing borrowed funds into productive assets to sustain growth. Malaysia's ability to keep its finances in order and reallocate debts shrewdly stands starkly against Greece's debt woes, illustrating the magic of

policy excellence. For Ghana, Awadzie et al. (2022) apply a threshold autoregressive (TAR) model to establish a 57.09% debt-to-GDP tipping point—when debt is below it, it sustains growth, but above it, it hampers it. This concurs with the nonlinear consensus but accounts for Ghana's structural deficiencies. These are currency volatility and fiscal irresponsibility. The study particularly warns against foreign debt buildup, something Yusuf and Mohd (2021) affirmed in Nigeria, when foreign debt constrains expansion, but domestic borrowing can fuel growth. Indonesia's experience also defines the contingent debt effect.

Budgetary expansions and foreign debt are positively related to GDP employing the multiple regression estimation (1976–2021), but outcomes depend on political regime, as Junaedi et al. (2022) assert. Suharto's regime exceeded subsequent administrations, implying that institutional performance and debt allocation matter in a significant manner. Handra and Kurniawan (2020) corroborate, using an ARDL model, with a debt level above which growth is negatively impacted but noting that sound deficit management can maintain risk within bounds. The debt sustainability literature in the developing world has expanded exponentially in recent years, but there remains one key knowledge gap: no systematic work has investigated the long-run relationship between government debt and growth in Mali. The primary objective is to estimate the long-run relationship between government debt and growth in Mali. This study tries to close this important knowledge gap through cautious empirical analysis of debt-growth dynamics in Mali.

## 3. Materials and Methods

### 3.1. Data and Variable Selection

This study investigates the long-run relationship between public debt and economic growth in Mali using annual time-series data from 1980 to 2024. The data were obtained from the Malian Ministry of Economics and Finance, the World Bank, and BCEAO. The dependent variable in this study is the real GDP growth rate (GDPGR), which serves as a direct measure of economic performance over time. To explain variations in economic growth, the model includes a set of independent variables grounded in established economic growth theories—specifically the neoclassical and endogenous growth models—as well as empirical literature on the debt-growth nexus in developing countries. These variables are selected to capture the most relevant channels through which public debt and other macroeconomic factors influence growth in the context of Mali.

The debt-to-GDP ratio (DEBT/GDP) is the central explanatory variable of interest. It represents the size of the government's debt relative to the overall economy. From a theoretical perspective, public debt can either support growth by financing productive investments or hinder it when debt accumulation becomes unsustainable or inefficiently managed. Accordingly, the first hypothesis (H1) posits that government debt has a non-linear—and potentially negative—long-run effect on economic growth. The population growth rate (POPGR) is included as a proxy for labor force expansion and potential demographic dividends. A growing population can drive demand, stimulate production, and increase the workforce, especially when supported by adequate investment in human capital and employment opportunities. This leads to the second hypothesis (H2), which states that population growth has a positive long-run impact on economic growth.

Next, gross fixed capital formation (GFCF) is introduced as a proxy for physical capital investment. Under neoclassical theory, capital accumulation is a key engine of growth, as it enhances productive capacity and spurs economic development. Thus, the third hypothesis (H3) suggests that investment, as measured by GFCF, exerts a positive influence on long-run economic growth. Trade openness (TRD/GDP) is measured by the ratio of total trade (exports and imports) to GDP. In theory, open economies benefit from specialization, access to larger markets, and knowledge spillovers, all of which contribute to higher productivity and growth. However, excessive openness may also expose the economy to external shocks. The fourth hypothesis (H4) proposes that trade openness has a positive long-run effect on economic growth.

The inflation rate (INF) is used as an indicator of macroeconomic stability. While moderate inflation may reflect healthy demand, high or unpredictable inflation undermines purchasing power, disrupts investment, and introduces uncertainty. As such, the fifth hypothesis (H5) holds that inflation has a negative long-run effect on economic growth. Finally, human capital (HC) is proxied by the primary school enrollment rate, reflecting the population's access to basic education. In line with endogenous growth theory, education is essential for increasing labor productivity, fostering innovation, and sustaining long-term development. Therefore, the sixth hypothesis (H6) suggests that human capital development has a positive long-run effect on economic growth. Together, these variables form a comprehensive framework for analyzing the factors that influence Mali's economic growth trajectory. They also facilitate a nuanced understanding of how public debt interacts with demographic, structural, and policy-related drivers of long-run growth.

### 3.2. Econometric Approach

The study employs the Autoregressive Distributed Lag (ARDL) bounds testing approach proposed by Pesaran et al. (2001). This method is particularly suited for small samples and can handle regressors that are either integrated of

order zero, I(0), or order one, I(1), but not I(2). The ARDL approach is used to test for the existence of a long-run equilibrium relationship among the variables and to estimate both long-run and short-run dynamics.

### 3.3. Model Specification

ARDL is a regression model that includes a variable value that explains the present value or the lag value of the dependent variable as one of the explanatory variables (Gujarati, 2009). The ARDL model specification is guided by Kharusi and Ada (2018), capturing the long-run relationship between GDP growth and the explanatory variables:

$$\text{GDPGR}_t = \beta_0 + \beta_1 \text{DEBT/GDP}_t + \beta_2 \text{POPGR}_t + \beta_3 \text{GFCF}_t + \beta_4 \text{TRD/GDP}_t + \beta_5 \text{INF}_t + \beta_6 \text{HC}_t + \mu_t$$

Where: $\beta_0$ is the intercept, $\beta_1$ to $\beta_6$ are the long-run coefficients, $\mu_t$ is the stochastic error term and $t$ represents time (1980–2024)

### 3.4. Unit Root Test (Stationary)

To confirm that no variable is integrated of order two (I(2)), the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests are applied at both level and first-difference. The results show that the dataset contains a mix of I(0) and I(1) variables, validating the use of the ARDL method.

### 3.5. Lag Length Selection

The optimal lag structure for the ARDL model is selected using the Akaike Information Criterion (AIC). The final model specification is ARDL(1,0,0,1,0,0,0), ensuring parsimony while effectively capturing both short-run dynamics and long-run equilibrium.

### 3.6. Diagnostic and Robustness Tests

To ensure the reliability of the model, several diagnostic tests are run. First, serial correlation is checked with the assistance of the Breusch-Godfrey LM test, so it can be ensured that the residuals are not autocorrelated. This ensures that model errors are not correlated systematically over time. Second, heteroskedasticity is checked using both the Breusch–Pagan and White tests. The results of the above tests confirm that the error terms are homoscedastic, i.e., of constant variance, which is a requirement for valid statistical inferences. Normality of the residuals is subsequently verified by employing the Jarque-Bera test. The test confirms that the residuals are normally distributed, adding strength to the assumptions of the classical regression model. To validate the specification of the model, the Ramsey RESET test is employed. The outcome reaffirms that the model is correctly specified and does not suggest omitted variables or incorrect functional form. Finally, the stability of model parameters over time is also confirmed by CUSUM and CUSUMSQ plots. The plots indicate the model to be structurally stable with no parameter instability. All these tests validate the robustness of the model, making it suitable for policy interpretation as well as an academic contribution, and also reliable.

## 4. Results

### 4.1. Stationarity Tests

This study assesses the stationarity properties of the time series data by using the Dickey-Fuller (DF) and Phillips-Perron (PP) unit root tests were employed. The results of these tests at the level form are summarized in Table 1.

**Table 1.** Result of Dickey-Fuller (DF) and Phillips-Perron (PP) at Level (I(0)

| Variable | DF Z(t) | DF p-value | PP Z(t) | PP p-value | Decision |
|---|---|---|---|---|---|
| GDPGR | -5.560 | 0.0000 | -5.604 | 0.0000 | Stationary |
| DEBT/GDP | -1.139 | 0.8285 | -1.275 | 0.6405 | Non-stationary |
| POPGR | -0.267 | 0.9300 | -0.494 | 0.8932 | Stationary |
| GFCF | -2.558 | 0.1021 | -2.562 | 0.1011 | Non-stationary |
| TRD/GDP | -2.155 | 0.2231 | -1.897 | 0.3335 | Non-stationary |
| INF | -4.651 | 0.0001 | -4.523 | 0.0002 | Stationary |
| HC | -1.219 | 0.6654 | -0.961 | 0.7671. | Non-stationary |

**Table 2.** Result of Dickey-Fuller (DF) and Phillips-Perron (PP) at first difference (I(1))

| Variable | DF Z(t) | DF p-value | PP Z(t) | PP p-value | Decision |
|---|---|---|---|---|---|
| GDPGR | -12.501 | 0.0000 | -15.191 | 0.0000 | Stationary |
| DEBT/GDP | -5.463 | 0.0000 | -5.421 | 0.0000 | Stationary |
| POPGR | -5.335 | 0.0000 | -5.361 | 0.0000 | Stationarity |
| GFCF | -7.060 | 0.0000 | -7.074 | 0.0000 | Stationary |
| TRD/GDP | -9.129 | 0.0000 | -9.685 | 0.0000 | Strongly |
| INF | -7.628 | 0.0000 | -8.662 | 0.0000 | Stationary |
| HC | -3.749 | 0.0035 | -3.721 | 0.0038 | Stationary |

To verify the suitability of the ARDL approach, the stationarity properties of all variables were assessed using the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests at level and first differences (see Table 2). The results indicate that the dependent variable (GDPGR) and some explanatory variables (e.g., INF) are stationary at level, I(0), while others such as DEBT/GDP, GFCF, and HC are stationary only after first differencing, I(1). No variable is integrated of order two, I(2), confirming the appropriateness of the ARDL bounds testing approach. At the level form, the results from both the ADF and PP tests indicate that only GDP growth (GDPGR) and inflation (INF) are stationary, as their test statistics are significant at the 1% level. This means that these two variables do not exhibit a unit root and are integrated of order zero, I(0). On the other hand, the variables Debt-to-GDP ratio (DEBT/GDP), Gross Fixed Capital Formation (GFCF), Trade Openness (TRD/GDP), Population Growth (POPGR) and Human Capital (HC) are non-stationary at level, with statistically insignificant test statistics, implying the presence of a unit root. At first difference, all the previously non-stationary variables become stationary, as both the ADF and PP tests produce highly significant results with p-values below the 1% threshold. This confirms that these variables are integrated of order one, I(1), meaning they become stationary after differencing once. These findings justify the use of the ARDL modeling approach, which can accommodate a mix of I(0) and I(1) variables but not I(2). Thus, the stationarity analysis provides a sound statistical foundation for the ARDL bounds testing procedure used in the subsequent stages of the empirical analysis.

## 4.2. Lag Length Selection and Model Specification

To determine the optimal lag length for the ARDL model, we applied a model selection procedure using the Akaike Information Criterion (AIC). The ARDL framework requires careful lag selection to appropriately capture both the short-run and long-run dynamics among variables. Using the ARDL command in Stata with the AIC option, the model evaluates a set of candidate lag structures up to a specified maximum lag (in this case, maxlags(2)), and automatically selects the combination of lags for each regressor that minimizes the AIC. The AIC is particularly suited for smaller samples, balancing model fit and complexity by penalizing excessive lags that may overfit the data. This data-driven approach helps ensure parsimony and robustness in the model specification.

Following this estimation, the selected lag structure can be retrieved and interpreted using the matrix list e(lags) command. The resulting matrix summarizes the number of lags chosen for each variable included in the ARDL model. In our case, the matrix output shows that GDP Growth, the dependent variable, enters the model with one lag, reflecting the presence of inertia or dynamic adjustment in economic output. Gross Fixed Capital Formation is also included with one lag, consistent with the notion that investment effects take time to influence GDP. All other explanatory variables—Debt-to-GDP, Population Growth, Trade Openness, Inflation Rate, and Primary School Enrollment—are included at level (i.e., with zero lags), suggesting that their contemporaneous (immediate) effects are most relevant for explaining variations in GDP growth. This configuration yields an ARDL (1,0,0,1,0,0,0) model. This lag structure reflects both theoretical plausibility and empirical support. It captures short-run fluctuations where appropriate while preserving the long-run equilibrium relationships necessary for the bounds testing approach. Moreover, the relatively low number of lags avoids overparameterization, making the model efficient and reliable for further diagnostic and cointegration analysis.

**Table 3.** Result of Optimal Lag Length Selection

| Variable(s) | Optimal Lag | Selected By |
|---|---|---|
| GDP Growth | 0 | FPE, AIC, HQIC, SBIC |
| Debt-to-GDP | 1 | LR, FPE, AIC, HQIC, SBIC |
| Population Growth | 1 | LR, FPE, AIC, HQIC, SBIC |
| Gross Fixed Capital Formation | 1 | FPE, AIC, HQIC, SBIC |
| Trade Openness (of GDP) | 2 | FPE, AIC |
| Inflation Rate | 2 | FPE, AIC, HQIC |

| Variable(s) | Optimal Lag | Selected By |
|---|---|---|
| Primary School Enrollment | 2 | LR, FPE, AIC, HQIC, SBIC |

## 4.3. Long-Run Estimates

To evaluate the long-term relationships among the variables, long-run estimations were conducted using the appropriate econometric model. The outcomes of these estimations are detailed in Table 4 below.

**Table 4.** Result of Long-run estimation.

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| Debt-to-GDP | 0.0294584 | 0.0305039 | 0.97 | 0.341 |
| Population Growth | 4.641029 | 1.622871 | 2.86 | 0.007 |
| Gross Fixed Capital Formation | 0.2269053 | 0.2625441 | 0.86 | 0.393 |
| Trade Openness (% of GDP) | -0.1365813 | 0.145967 | -0.94 | 0.356 |
| Inflation Rate | -0.0461217 | 0.0900869 | -0.51 | 0.612 |
| Primary School Enrollment | -0.0181267 | 0.0977151 | -0.19 | 0.854 |
| **Constant (c)** | -6.686537 | 7.259878 | -0.92 | 0.363 |

The estimated long-run coefficients from the ARDL model (Table 4) yield insightful results on the determinants of economic growth in Mali over the 1980–2024 period. These findings help evaluate the validity of the hypotheses outlined earlier and shed light on the structural dynamics of the Malian economy. The Debt-to-GDP ratio exhibits a positive coefficient of 0.029, implying a potential pro-growth effect of public debt. However, the p-value of 0.341 indicates that this effect is not statistically significant. This suggests that public debt in Mali, while not inherently detrimental, has not had a consistent or meaningful influence on long-run economic growth. The insignificance may reflect suboptimal allocation of borrowed resources, limited absorption capacity, or inefficiencies in project execution. Thus, Hypothesis H1—expecting a clear long-run relationship between public debt and growth—is not supported. It highlights the importance of improving fiscal governance, targeting debt toward high-return investments, and strengthening public financial management to maximize the growth benefits of debt.

In contrast, population growth stands out as the only variable with a statistically significant and positive long-run impact on economic growth. With a coefficient of 4.641 and a p-value of 0.007, the model indicates that a one-percentage-point increase in population growth is associated with a 4.64 percentage point rise in GDP growth, holding other factors constant. This finding strongly supports Hypothesis H2 and underlines the potential of Mali's demographic expansion to serve as a driver of growth. However, this potential can only be realized if accompanied by strategic investments in education, health, and labor market integration. The result resonates with demographic dividend theory, which emphasizes that economic gains from a growing population hinge on the ability of institutions to convert human quantity into quality. The coefficient for Gross Fixed Capital Formation (GFCF)—a proxy for investment—is positive (0.227), aligning with theoretical expectations. However, the effect is statistically insignificant ($p = 0.393$), suggesting that investment has not contributed significantly to Mali's long-run economic performance. This finding does not support Hypothesis H3. It may reflect inefficiencies in investment implementation, delays in project completion, or the prevalence of unproductive capital expenditures. Public and private investments in Mali may not be generating the expected multiplier effects, possibly due to weak institutional capacity, lack of infrastructure maintenance, or corruption in procurement processes.

Turning to trade openness, the coefficient is negative (-0.137) and statistically insignificant ($p = 0.356$). This implies that greater exposure to international trade has not translated into sustained long-term economic gains. Thus, Hypothesis H4 is not supported. Mali's trade structure—dominated by raw gold, cotton, and livestock—likely limits the benefits of openness, especially in the absence of value addition and export diversification. Moreover, the country's vulnerability to global commodity price shocks and dependence on imports may further dampen the positive effects of trade. This result suggests a need for policies that deepen regional integration, promote industrialization, and enhance the competitiveness of domestic production. The inflation rate also has a negative coefficient (-0.046), but the effect is not statistically significant ($p = 0.612$). This suggests that inflation, while theoretically harmful to macroeconomic stability and purchasing power, has not played a decisive role in influencing Mali's long-run growth. The insignificance means Hypothesis H5 is only weakly supported and statistically inconclusive. While this result may reflect relatively moderate inflation rates during the study period, it also emphasizes the importance of maintaining price stability to preserve investor confidence and safeguard the welfare of vulnerable households.

Finally, the coefficient for human capital, proxied by primary school enrollment, is negative (-0.018) and highly insignificant ($p = 0.854$). This unexpected result contradicts Hypothesis H6 and raises concerns about the quality and effectiveness of basic education in contributing to economic growth. It may indicate that primary education alone is insufficient for productivity gains or that Mali's education system faces challenges such as poor learning outcomes, low

progression to secondary and tertiary levels, and limited alignment with labor market needs. This finding reinforces the need for comprehensive reforms in the education sector, with a focus on learning quality, technical and vocational training, and higher education development. While population growth shows a robust positive impact on economic growth in Mali, other variables, particularly public debt, investment, trade, inflation, and basic education—do not demonstrate significant long-run effects. These results highlight the complex and context-specific nature of growth dynamics in low-income economies and point toward the critical role of institutional quality, efficient policy implementation, and structural transformation.

## 4.4. Diagnostic Tests

To ensure the reliability and validity of the estimated ARDL (1,0,0,1,0,0,0) model, a series of diagnostic and robustness tests were performed. The results of these checks are presented in Table 5 below.

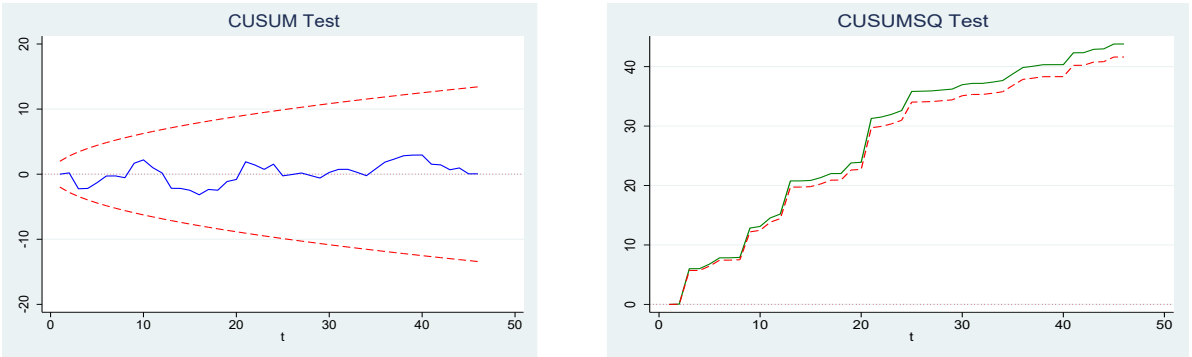
**Table 5.** Robustness and Diagnostic Checks for ARDL (1,0,0,1,0,0,0) Model

| Test | Purpose | Test Statistic | p-value | Decision |
|---|---|---|---|---|
| Breusch-Godfrey LM test | Serial correlation | $Chi^2(1) = 0.685$ | 0.4078 | No autocorrelation |
| Breusch–Pagan/Cook–Weisberg test | Heteroskedasticity | $Chi^2(1) = 0.02$ | 0.9008 | Homoskedasticity |
| White's test | | $Chi^2(43) = 44.00$ | 0.4290 | Homoskedasticity |
| Skewness/Kurtosis normality test | Normality | Adj $Chi^2(2) = 2.28$ | 0.3199 | Normally distributed |
| Ramsey RESET test | Model specification | $F(3,32) = 0.05$ | 0.9837 | Model fit |

The Breusch-Godfrey LM test was employed to assess the presence of serial correlation in the residuals of the ARDL model. With a p-value of 0.4078—well above the conventional 5% significance level—the null hypothesis of no serial correlation cannot be rejected. This suggests that the residuals are independent over time, indicating the absence of autocorrelation, which is a crucial condition for ensuring valid inference in time-series models. To evaluate heteroskedasticity, both the Breusch–Pagan/Cook–Weisberg test and White's test were conducted. The results revealed p-values of 0.9008 and 0.4290, respectively, both significantly above the 0.05 threshold. These findings support the assumption of homoskedasticity, implying that the variance of residuals remains constant. This enhances the reliability of the model's standard errors and subsequent statistical inferences. Regarding the normality of residuals, the skewness/kurtosis test (commonly referred to as the Jarque-Bera test) was used. The joint p-value of 0.3199 indicates that the null hypothesis of normally distributed residuals cannot be rejected. Confirming normality ensures the validity of hypothesis testing and the construction of accurate confidence intervals within the model. Lastly, to assess the model specification or functional form, the Ramsey RESET test was performed. The resulting p-value of 0.9837 provides strong evidence that the model is correctly specified. This suggests that the regression includes all relevant variables and follows an appropriate functional form, further supporting the robustness and adequacy of the model used.

## 4.5. Parameter Stability (CUSUM and CUSUMSQ Tests)

Figures 1 (a) and (b) present the CUSUM and CUSUMSQ plots, respectively, to assess the stability of the ARDL(1,0,0,1,0,0,0) model over the period 1981–2024. In both plots, the recursive residuals and their squared values remained within the 5% significance boundaries throughout the sample period. This suggests that the estimated model is structurally stable, with no significant parameter instability or structural breaks detected.




(a) CUSUM Test (b) CUSUMSQ Test

**Figure1. (a)** CUSUM Test and CUSUMSQ Test

## 5. Discussion

The econometric analysis of the determinants of Mali's economic growth between 1980 and 2024 presents a nuanced picture, revealing both expected and unexpected outcomes. Among the variables examined, population growth stands out as having a statistically significant and positive influence on long-term economic growth. In contrast, variables such as public debt, gross fixed capital formation (GFCF), trade openness, inflation, and human capital did not show statistically significant long-run effects, despite some of them aligning with theoretical expectations in direction. The positive but statistically insignificant coefficient for public debt suggests that while debt levels have not exerted a lasting adverse effect on growth, they also have not significantly boosted it. This finding aligns with the thresholds proposed in previous studies. For instance, Law et al., (2021) identify a debt-to-GDP threshold of 51.65% for developing countries, beyond which debt begins to negatively affect growth. Similarly, Ndoricimpa (2020) places the African threshold slightly higher, at 62–66%. These results imply that while Mali's debt may be within manageable levels, its growth impact remains muted unless managed prudently and efficiently.

On the other hand, the strong and statistically significant positive effect of population growth supports the theory of demographic dividends. As theorized by Bloom and Williamson (1998), and later confirmed in regional studies like Asogwa et al. (2022), demographic momentum can contribute to economic expansion—particularly when accompanied by strategic investments in health, education, and employment. For Mali, this finding suggests a latent potential: with targeted investments in human capital and job creation, the country could harness its demographic trends to accelerate growth. Contrary to expectations, gross fixed capital formation (GFCF) does not exhibit a significant relationship with economic growth in the long run. This challenges classical growth theories, which posit capital accumulation as a core driver of economic development. However, Appiah et al. (2024) explain that in many sub-Saharan African contexts, capital investment yields limited growth benefits unless it is backed by institutional reform and efficient public investment management. Similarly, Kolawole et al. (2024) argue that governance weaknesses, delays in infrastructure delivery, and project mismanagement can blunt the impact of GFCF, which might explain the results observed in Mali.

The insignificant and negative coefficient for trade openness diverges from the predictions of traditional neoclassical growth models, which typically view openness as beneficial. Nonetheless, emerging literature offers alternative perspectives. Sowrov (2024), for example, finds that the growth-enhancing effects of trade openness are contingent on factors such as export diversification and value addition. In Mali's case, a narrow export base and high vulnerability to external shocks may neutralize the benefits of openness. The results, therefore, suggest that without structural transformation and diversification, trade liberalization alone is insufficient to drive sustained growth. Similarly, the neutral effect of inflation on long-term growth is consistent with recent empirical findings. Fernandes (2023), focusing on the WAEMU region, shows that inflation in recent years has been driven largely by external shocks such as food and energy prices. With inflation expected to return to target ranges as these shocks subside, its long-run influence on economic performance remains limited. Mali's stable inflation environment may, therefore, explain its insignificant impact on growth during the study period.

Perhaps most striking is the negative and highly insignificant effect of human capital, proxied by primary school enrollment, on economic growth. This challenges a cornerstone of growth theory, which identifies education as a primary engine of productivity and innovation. However, Musah et al., (2024) argue that in sub-Saharan Africa, quality of education matters more than mere access or enrollment figures. Factors such as poor learning outcomes, inadequate teacher training, and weak alignment between education and labor market demands diminish the productivity-enhancing effects of human capital. Thus, the findings suggest that without improving the quality and relevance of education, human capital development in Mali may not translate into economic gains. Thus, while the analysis confirms the positive role of population growth in Mali's economic development, it also reveals significant gaps in the effectiveness of other macroeconomic variables. The results underscore the importance of contextualizing economic policies within the structural realities of the country, particularly concerning governance, institutional quality, education systems, and export structures. For Mali to realize sustained economic growth, reforms must go beyond quantitative targets and address the qualitative dimensions of policy implementation and development planning.

## 6. Conclusions

This study considered the long-term relationship between economic growth and public debt in Mali, 1980–2024, using the Autoregressive Distributed Lag (ARDL) bounds testing approach. The stationarity tests confirmed that the data set contained a mixture of I(0) and I(1) variables, thereby making it necessary to use ARDL modeling. Empirical evidence indicates that among the explanation variables considered—debt-to-GDP ratio, gross fixed capital formation, openness of the economy to trade, inflation, primary school enrollment, and population growth—population growth was the only one with a statistically significant long-term effect on economic growth in Mali. Specifically, it was noted that population growth was positively and strongly influencing GDP growth, which suggests that population dynamics may also be an engine of growth when optimally tapped. Conversely, government debt had no statistically significant long-run relationship with growth, indicating that the accumulation of debts has not systematically helped or hindered Mali's

economic experience during the specified period. The outcome points towards a neutral impact of public debt on long-run economic performance.

Such outcome may be due to inefficiency in financing from borrowed capital, bad fiscal discipline, or low payoffs from projects financed by debt. Other important explanatory variables such as investment (gross fixed capital formation), openness to trade, inflation, and human capital (measured in terms of primary school enrollment) also showed no statistically significant long-term correlations with GDP growth, but with the correct signs in most cases. This suggests that even if these variables theoretically determine growth, their actual impacts in the real economy in the case of Mali may be constrained by structural weaknesses, governance issues, and policy implementation issues. As a whole, the findings highlight the intricacy of growth patterns in Mali. They point out that in addition to demographic trends, long-term economic growth entails more deliberate and effective utilization of public resources, coupled with policy initiatives toward enhancing the efficiency of investment, trade, and human capital development.

## 6.1. Policy Implications

The findings of this study show several policy actions that can enable sustainable economic development in Mali. Due to the enormous positive contribution of population growth to GDP, the country can gain from expenditure on human capital improvement in major fields. Improving access to quality education beyond primary level, strengthening vocational training schemes, and improving health systems will be crucial in unlocking the demographic dividend of Mali. By linking skills development with the needs of the labor market, the expanding youth population can become the driver of increased productivity and job opportunities. While the long-term effect of public debt on growth was not evident, its role in financing development cannot be overlooked. The key is ensuring the borrowed funds are utilized and invested in high-impact sectors such as infrastructure, energy, and technology. The construction of strong public financial management systems enhanced fiscal transparency, and deepened accountability systems will guarantee that public debt delivers its highest possible impact for growth without breaching investor and donor trust. Investment, while theoretically most critical, contributed very little to growth in this study, possibly due to inefficiencies in the allocation process, project lags, or governance.

Policymakers can correct this by improving the business climate by removing administrative hurdles, combating corruption, and fostering public-private partnerships (PPPs) in building infrastructure. Streamlining the regulation process and efficient monitoring of projects can increase the productivity of capital and stimulate economic expansion. Trade openness exerted a negative effect, indicating structural weaknesses in the trade sector of Mali. The economy remains largely based on a variety of low-value commodity exports, which limits its gains from world trade. Export diversification, regional integration, and value addition in major industries such as agro-processing and textiles need to be accorded priority consideration by embracing more strategic approach. Policies of industrialization and labor-intensive manufacturing can propel Mali along the value chain and derive greater benefits from world trade. Although inflation did not have a statistically significant long-term impact, price stability should be ensured in a way that there is economic stability. Unstable or high inflation will erode investor confidence and reduce households' purchasing power, particularly those of low-income households. Mali should continue to pursue good monetary policies to ensure inflation is contained and there is a stable economic setting for sustainable and inclusive growth. Together, these policies can help Mali achieve its economic potential while protecting against risks and structural bottlenecks.

## 6.2. Recommendations for Future Research

While this study offers some intriguing insights into long-run debt-growth interaction in Mali, there are several areas worthy of further research to deepen knowledge and inform policy-making. This work focused on long-run effects, and there remains room for future work to examine short-run dynamics. Error correction models (ECM) would be insightful in measuring how deviations from equilibrium are adjusted over time. Additionally, Granger causality tests could clarify the direction of influence between debt and growth, determining whether debt drives economic expansion, growth leads to higher borrowing, or a feedback loop exists. A more granular analysis of Mali's public debt structure—such as distinguishing between domestic and external debt or concessional and non-concessional borrowing—could reveal which forms of debt are more growth-friendly.

In addition, analyzing sectoral debt distribution (for example, infrastructure and discretionary spending) could reveal differential economic effects, assisting policymakers in making productive investment choices. Institutional quality probably plays a significant role in determining the impact of debt on growth. Future research could investigate how corruption control, regulatory efficiency, and political stability mediate between debt and growth. The inclusion of governance indicators in econometric models may yield a better understanding of how institutional strengths or weaknesses affect fiscal policy performance. A cross-country study across the nations in West African Economic and Monetary Union (WAEMU) may bring out regional patterns or country-specific differences in the debt-growth relationship. Applying panel data techniques would allow researchers to identify common patterns and assess whether Mali's experience aligns with or diverges from its neighbors, offering broader policy lessons.

The debt-growth relationship may not follow a linear pattern, with potential turning points where debt shifts from beneficial to harmful. Future research could employ threshold regression models or spline regressions to detect critical debt levels, providing policymakers with evidence-based benchmarks for sustainable borrowing. This study reinforces the significance of demographic and fiscal factors in Mali's economic trajectory while highlighting the need for strategic debt management and investment policies. These research gaps can be filled with targeted studies, and this could enhance evidence-based decision-making for Mali and other such economies in the WAEMU region.

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