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30 Years of Macroeconomic Effects in Zambia-VECM, ARDL & IRF Approaches

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Abstract

Purpose: This study examines the impact of selected time series macroeconomic variables on Zambia's economic progress for thirty (30) years (1992 to 2022)

Methodology: The study employs the autoregressive distributed lag (ARDL), vector error correction models (VECMs) and the impulse response functions (IRFs) approaches.

Findings: The VECM regression estimates indicate that in the long-run, ceteris paribus, a 1% increase in inflation and population growth rates cause a significant positive impact on economic progress of 0.36% and 0.68 % respectively whereas the total public debt stock causes decrease in economic growth of 0.45%. The ARDL long-run regression estimates indicate that ceteris paribus, a 1% increase in inflation and public debt significantly reduces real GDP by 0.2% and 0.03%, respectively, but a 1% increase in population growth rate increases real GDP by 23.11%. The IRF estimates show that a negative shock to the real GDP causes a mildly negative effect on the inflation rate, causes a significant positive increase in the population growth rate, which dissipates after 9.5 years and causes a significant positive increase in public debt, which dissipates after 10 years.

Unique Contribution to Theory, Policy and Practice: Therefore, the study recommends that the Zambian government should prioritize repayment of the outstanding public debt by bringing down the debt-to-GDP ratio to sustainable levels, adhering to prudent public financial management and continuing to grow the domestic revenue base. The policies to promote population growth should be pursued cautiously because rapid population growth rates could erode the future economic growth prospects of Zambia.

JEL Classification: F4, E6, H63

Keywords: ARDL, *Economic Progress, Public Debt, Impulse Response, Macroeconomics, Zambia*

1. Introduction and Background

This study examines the impact of selected macroeconomic variables on Zambia's economic progress (real gross domestic product, GDP) for thirty (30) years. The study employs three (3) models, the vector error correction model (VECM), the autoregressive distributed lag (ARDL) and the impulse response functions (IRFs) to conduct the empirical data analyses. The literature review seems to suggest that there is no study focusing on Zambia that has applied the three methodological approaches. In the realm of economic progress, understanding the intricate relationship between macroeconomic variables and the growth of the economy is paramount for policymakers, economists and other stakeholders alike. Zambia is one country that continues to grapple with mechanisms of sustainable and inclusive growth amidst the complex interplay of macroeconomic variables such as inflation, public debt and population growth during the debt restructuring and post-debt restructuring periods. Inflation refers to the general rise in the prices of goods and services in an economy over a given period. Inflation is used as a broad measure to assess the economic performance of a country, especially the cost of a basket of essentials goods for consumption or production purposes (Foster, 2023).

Zambia, like other developing nations, grapples with the challenge of achieving robust and sustainable economic growth amidst internal and external shocks. Over the years, Zambia has witnessed fluctuations in its economic performance, with periods of growth interspersed with episodes of stagnation or contraction. Amidst these fluctuations, understanding how the macroeconomic variables influence economic growth is imperative for policymakers and stakeholders seeking to steer the nation towards the Vision 2030 target (Middle-income country status). Among the macroeconomic variables in our sample, the inflation rate stands as a key indicator of price stability, with implications for consumer purchasing power and overall economic performance (Mankiw, 2012). Public debt, on the other hand, reflects the government's fiscal management and borrowing activities, bearing consequences on fiscal sustainability and investor confidence (Kabemba & Kabwe,2024). Population dynamics, including factors such as population growth rate, influence market dynamics, thus exerting a profound impact on the trajectories of economic (Growth) progress of Zambia.

Inflation is one of the macroeconomic indicators that policymakers, including monetary authorities, focus on. This is because excessive inflation places significant economic and financial pressure on the domestic economy, which ultimately leads to a slowdown in future economic growth prospects. Moreover, inflation can lower a nation's external competitiveness by creating uncertainty for businesses and consumers over their spending and investment decisions (Mankiw, 2012; Foster, 2023). Given the challenges that surround the phenomenon of inflation, the Central Bank of Zambia and most other central banks around the globe have made inflation targeting their top monetary policy.

1.1 Situational Analysis

Figure 1 traces the trajectory of inflation in Zambia from 1991 to 2022.

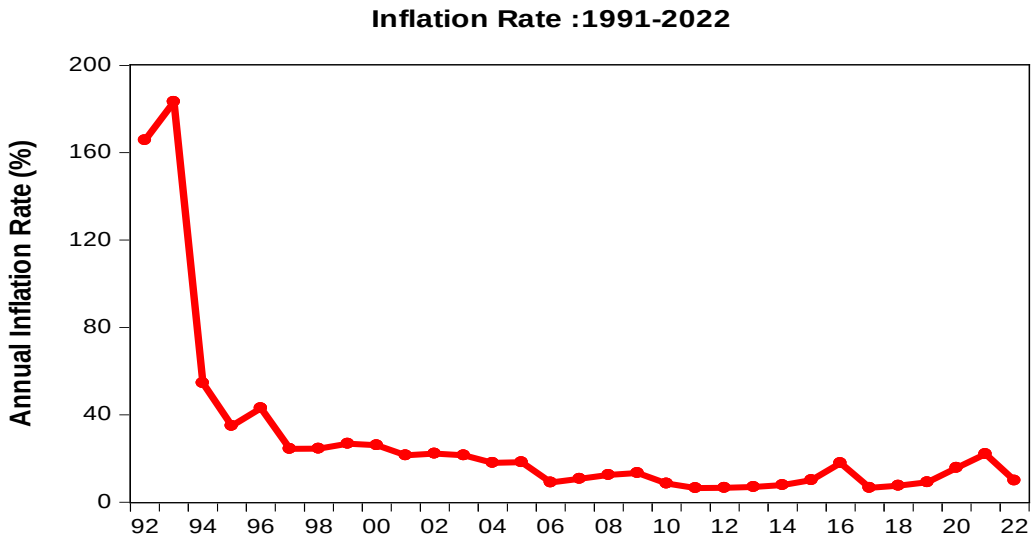

Figure1: Inflation rate, 1991-2022

Source: Authors' elaboration on data from IMF, 2024.

From Figure 1, it is evident that inflation was rising prior to 1992 and was measured at 183.3% when it reached its peak in 1993. During this period, the primary causes of inflation were the high money supply, which resulted from financing the fiscal deficit, among other things. Stricter financial management, tight monetary policy, liberalization of foreign exchange and pricing deregulation resulted in a decrease in inflation to 30% in 1997(Chibwe, 2014). It plummeted to 7.9% in December 2014 but rose again, reaching a peak of 22.9% in February 2016, and fell to 6.6% in 2017. The kwacha's appreciation against the US dollar, the ease of monetary policies like cutting the policy rate from 15.5% to 12.5%, the decline in food prices, and growing market confidence in Zambia's economic policy direction were the main reasons why inflation fell to 6.6% in 2017. As a precursor to inflation targeting, the Zambian government established a target range of 6% - 8% for inflation in 2014. Zambia's inflation from 2019 to 2021 was higher than the projected range of 6% to 8%. Inflation in 2019 was 9.1%; it spiked to 15.6% in 2020 and then to 22.1% in 2021. The kwacha's decline against major trading currencies like the dollar, rising energy and fuel costs, mounting debt levels and rising food prices as a result of the COVID-19 crisis at the start of 2020 as well as the negative effects of trade disruptions in 2018 and 2019 were the main causes of the inflationary pressures in recent times (Chipili, 2022). Food costs continued to rise in 2021, and the kwacha continued to weaken all the way until 2022.

In terms of debt, Figure 2 illustrates that throughout the years, the public debt of Zambia has been generally that of an upward trend, punctuated by occasional spikes, in 1992, it stood at

164.70% of GDP indicating a significant burden on the country's finances and debt servicing capacity. While there were fluctuations in subsequent years, and significant reduction in public debt in the early 2000s attributed to the debt relief obtained from international creditors such as the International Monetary Fund (IMF), the World Bank and the African development bank, there was a notable increase in public debt in 2014, reaching 44.40% of GDP, and another substantial rise in 2020, soaring to 103.70% of GDP, likely due to economic challenges such as recessions, COVID-19 pandemic shock and increased government spending. This accumulation of debt suggests potential challenges in fiscal management and could erode future economic stability and growth progress of Zambia (Kabemba & Kabwe, 2024).

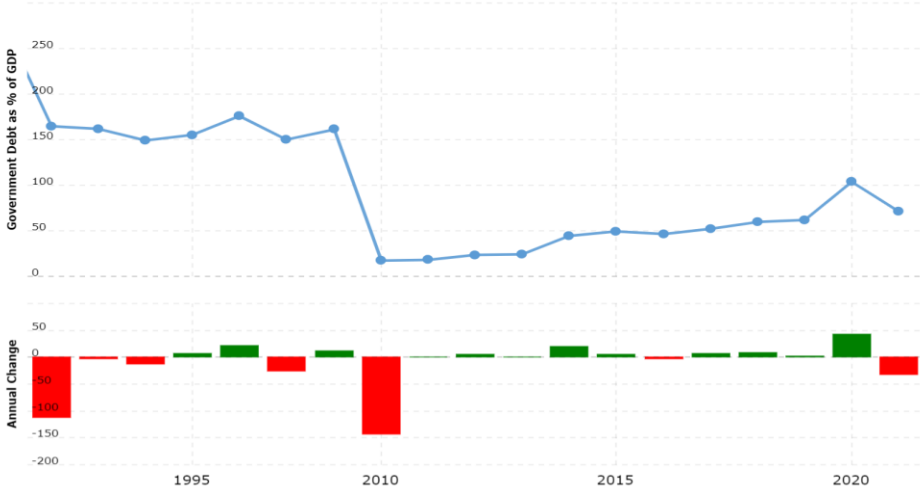

Figure 2: Public Debt as a % of GDP in Zambia from 1990 to 2020

Source: Authors elaboration on data from World Development Indicators (2024)

Figure 3 shows the growth rate of gross domestic product (GDP) for Zambia from 1964 and 2022.

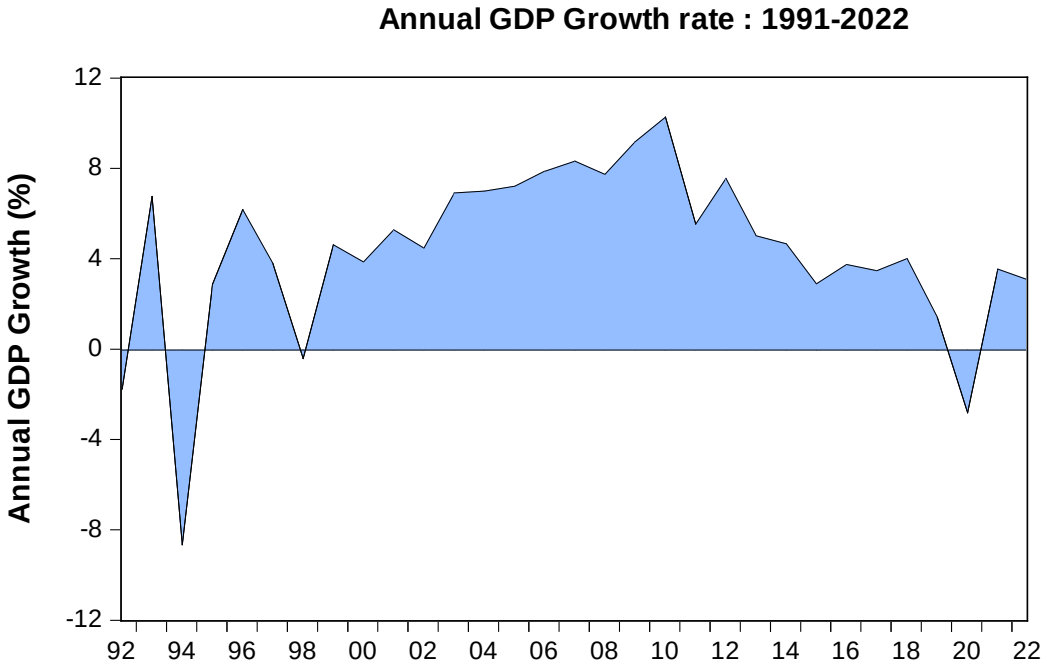

Figure 3: GDP growth rate, 1991-2022

Source: Authors' elaboration on World Bank's World Development Indicators.

From Figure 3, it is easy to observe that the GDP growth rate in 1991 into 1992 was negative. Zambia saw positive GDP growth rates of 7.7% between 1992 and 1993 but it plummeted steeply to -8.6% in 1994. It grew to an average of 4.8% per annum between 1996 and 1997 but declined to -1.8% in 1999. From 2000, it remained above the 3%, reaching the largest annual growth rate of 10.3% in 2010 and later declined to -2.3% in 2020 due to the COVID-19 global economic shock. GDP growth rate grew to around 3% in 2021 and hovered around 3% until 2022. The country's failed attempt to diversify the economy, macroeconomic instability, and the failure to realize the anticipated benefits of privatization are the main causes of the instability of the GDP growth rate. Additionally, the country's reliance on copper export earnings makes the economy of Zambia be vulnerable to fluctuations in commodity prices (Bank of Zambia, BOZ, 2010; Chipili, 2022).

While existing literature offers insights into the relationship between macroeconomic variables and economic growth in various contexts, there remains a notable gap in the literature concerning Zambia. For instance, Kabemba and Kabwe (2024) delved into investigating the effects of public debt on economic growth with empirical evidence from Zambia between 2011 and 2021. This research lacked comparative analysis, and the timeframe only spanned 10 years with its focus only on public debt and economic growth. By addressing this gap, this study provides evidence-based insights that can inform policymaking and strategic decision-making processes as well as contribute to the body of knowledge surrounding Zambia's economic progress. Through an

analysis of the interplay between inflation, public debt, population dynamics and economic growth, this study aims to offer nuanced perspectives that can guide efforts towards promoting sustainable economic development in Zambia.

The justification for conducting this study is multi-pronged. The literature review seems to suggest that there are few studies that have focused on Zambia with respect to the selected macroeconomic variables' effects on Zambia economic progress (whose proxy is real gross domestic product, real GDP). The literature only unravels only two relatively recent studies done by Mwale and Mulenga (2024) and Kabemba and Kabwe (2024) focusing on Zambia. However, the study by Mwale and Mulenga (2024) though focused on Zambia, employed two models, the VECM and ARDL in the study and study focused on the effect of expansionary fiscal policy (debt financing) on the economic growth of Zambia for a period of 20 years. Kabemba and Kabwe (2024) only employed the ARDL models covering a period of 10 years. This study is different from the two previous relatively recent studies on Zambia in that it extends the period to 30 years and includes population growth and inflation[1] in the models. Additionally, our study methodology differs from the two studies in that our empirical analyses of data employ three models, the VECM, ARDL and impulse response functions (IRFs). The literature review seems to indicate that no study has employed the three models and thus this study fills the gap. The interplay of these macroeconomic variables on the economic growth of countries from across various world regions gives mixed results. It is necessary to conduct a reassessment of these variables, specifically on the economic progress of Zambia. Inflationary pressure has ramifications on the monetary and fiscal policies as well as on the welfare of the citizens. Filling this knowledge gap is necessary to promote the sustainable economic growth and development goals targets embedded in the Vision 2030. We envisage that studies of this nature are essential to foster an atmosphere of economic growth in the light of sustainable debt and population growth rates. Prevention of debt crises and maintenance of macroeconomic stability demand a continuous revaluation of how the population growth rates, rising debt and inflation rates impact the economic growth of developing or emerging countries like Zambia. We envision that the recommendations backed by data-driven evidence will help policymakers in Zambia craft policies that will drive equitable and sustainable economic progress for Zambia. The general objective of this study is to analyze the impact of selected macroeconomic factors, namely, inflation, public debt and population growth on the economic

[1] There is intense debate in the empirical literature regarding the determinants of inflation. The monetarist view contends that inflation is principally caused by increase in the quantity of money (Friedman, 1970, Mankiw, 2012). Monetarists assert that a higher rate of expected inflation corresponds with an increasing growth rate of nominal public debt. However, Keynesians or neo-Keynesians argue that inflation is driven by demand-pull phenomenon at full employment (Keynes, 1936). Thus, two strands of empirical literature exist; those that project a positive relationship between public debt and inflation, and those that project a negative effect of public debt and inflation.

growth of Zambia from 1992 to 2022 using the VECM, ARDL and impulse response functions (IRFs). The corresponding compact null and alternative hypotheses are:

$\boldsymbol{H_0}$ **:** Do Inflation, public debt and population growth have a negative impact on economic progress (growth) in Zambia?

$\boldsymbol{H_1}$**:** Do Inflation, public debt and population growth have a positive impact on economic progress (growth) in Zambia?

The next section focuses on the literature review.

2. Literature Review

2.1 Theoretical Literature Review

The theoretical framework elucidates the underlying theories of the relationship among inflation, public debt, population and the country's growth of the economy. These theories create the groundwork for the empirical framework and ultimately help to explain the findings.

2.1.1 Keynesian Theory

The Keynesian theory's primary belief is based on the belief that government intervention can achieve full production (Keynes, 1936). The theory argues that a movement in elements such as expectations, monetary policy and prices of production inputs including labour, among others. This theory asserts that a positive relationship in the beginning between inflation and economic growth gradually becomes negative as the adjustment path comes to an end. The initial positive association between inflation and economic growth can be attributed to the problem of time inconsistency (Kiyotaki and Blanchard, 1987). Keynesians or neo-Keynesians argue that inflation is driven by demand-pull phenomenon at full employment (Keynes, 1936**).**

2.1.2 Monetarist Theory

Generally, the monetarist theory contends that inflation is principally caused by increase in the quantity of money (Friedman, 1970, Mankiw, 2012). Monetarists assert that a higher rate of expected inflation corresponds with an increasing growth rate of nominal public debt**.** According to this theory, the only factor that influences the price level in the economy is the money supply. Monetarists argue that government intervention to stabilize inflation must involve monitoring how quickly money grows in order to match it to long-run economic growth. This may involve tight monetary policy and tight fiscal policy. They content that inflation arises when the money supply rapidly expands relative to the rate at which national income grows. Friedman (1994) opined that "inflation is always and everywhere a monetary phenomenon." High inflation rate has negative ramifications on the economy in terms of suppressing investments and discouraging foreign direct investment (FDI) and elevated unemployment rates.

2.2 Empirical Review of Related Literature

Kyalo (2020) conducted a study aimed at exploring how specific macroeconomic factors affect the economic growth of Kenya. Using descriptive methodology, the study analyzed secondary data from 1970 to 2018, focusing on inflation, foreign direct investment (FDI) and exchange rates as independent variables and GDP as the dependent variable. Regression analysis was then performed to examine the effects among the variables, with ANOVA used to confirm findings. Results showed that inflation had a significant negative effect on the economic growth of Kenya. Conversely, FDI was positively associated with growth, suggesting that higher investment leads to increased growth. Similarly, a higher exchange rate was linked to greater economic growth. Based on these findings, the study recommended that Kenyan policymakers should focus on attracting more foreign investment to stimulate economic growth.

Phiri (2013) studied the impact of inflation on economic growth in Zambia between 1998 to 2011. The study employed a threshold autoregressive (TAR) model and the conditional least squares (CLS) methodological approaches. The findings revealed a threshold inflation rate of 22.5% for Zambia during the specified period, suggesting that economic growth can still be fostered even amidst moderately high inflation. Additionally, the analysis indicated that developments in the credit sector and exchange rates play pivotal roles in promoting economic performance in Zambia.

Tajudeen (2012) analyzed the relationship between public debt and economic growth in Nigeria from 1970 to 2010 using Vector Autoregressive (VAR) analysis. Stationarity of the variables was assessed using the Augmented Dickey-Fuller and Philip Perron tests, which confirmed stationarity upon first differencing. Co-integration analysis indicated a long-term relationship between public debt and economic growth. Results from the VAR model demonstrated that public debt had a significant positive impact on economic growth both in the short-run and in the long run, contingent upon the government's genuine utilization of loans for economic progress rather than personal gains.

Sanusi et. al (2019) studied the non-linear effects of public debt on economic growth in the Southern Africa Development Community (SADC) countries. Employing a non-linear autoregressive distributed lag model (NARDL) within a panel framework, the study examined the non-linear impacts of public debt on economic growth. Findings from the investigation validated the presence of non-linearity between public debt and economic growth over the long term. The study indicated that initially, public debt fuels economic expansion but starts to impede growth once it surpasses a specific threshold level of 57% of GDP for the SADC region in the long run. The study underscores that while public debt can serve as a vital tool for expansionary fiscal policy within the SADC region, its effectiveness hinges on prudent utilization and maintenance within an optimal range.

Anyanwu (2014) did a comparative study regarding the factors that affect economic growth in Africa and China. This study was focused on both North and Sub-Saharan Africa. Utilizing data from 1996 to 2010, the study unraveled determinants such as population, domestic investment, net Official Development Assistance (ODA) inflows, education, government effectiveness and metal prices as having positive and significant effects on economic growth in Africa. On the other hand, with regard to China, the study found that the key drivers of economic growth include domestic investment, trade openness, initial income, and the rural population share. Conversely, factors such as inflation rate, domestic credit to the private sector, net ODA inflows, population growth, telephone density and oil and raw agricultural materials prices were found to hinder China's growth. This disparity was attributed to Africa's import-heavy trade pattern, particularly in consumer goods, compared to China's export-oriented model, which has progressively shifted towards manufactured goods.

Ncanywa and Masoga (2018) conducted a study to determine whether public debt can stimulate public investment and economic growth in South Africa. The study found a long-run significant negative effect between public debt and investment, implying an inverse impact on the economic growth of these two variables. The study recommended cautious borrowing for capital-scarce countries to accumulate capital, highlighting the potential for subdued growth with excessive debt levels.

Kabemba and Kabwe (2024) investigated the effects of public debt on economic growth using empirical evidence from Zambia from 2011 to 2021. The Autoregressive Distributed Lag (ARDL) model was utilized to identify the long-term dynamic effects among the variables. The model included the Prime Lending Rate, Exchange Rate, External Debt Stock, Domestic Debt Stock, and Real Gross Domestic Product (GDP) as the dependent variable. The findings indicated that these factors significantly impacted Zambia's economic growth over the specified period. This study considered a period of 10 years while our study considers a period of 30years with different variables.

Mwale and Mulenga (2024) investigated the impact of fiscal policy and public debt on the economic growth (GDP) of Zambia on data from 1991 to 2021. They employed autoregressive distributed lag (ARDL) and vector autoregression (VEC) models. The VECM and ARDL found that, ceteris paribus, a 1% increase in public debt in the long run long significantly reduced GDP by 6.14% and 1.92% respectively. The study recommends that government should strategize on measures to reduce public debt.

Harmon (2012) studied the impact of public debt on inflation, GDP growth and interest rates in Kenya from 1996 to 2011. Employing simple linear regression (SLR) models, the study finds a weak positive effect of public debt and inflation on GDP growth in Kenya.

Yeboah (2024) carried out research on the effect of external debt, unemployment rate and inflation on economic growth in Ghana for the period 1991 to 2021. Employing econometric

techniques such as the Johansen cointegration test and ordinary least squares (OLS) regression, the findings found a positive correlation between eternal debt and growth in Ghana, whereas inflation and unemployment were detrimental to growth. Findings also revealed that external debt led to increased inflation, while GDP mitigated inflation, with no discernible influence from unemployment.

Previous studies have shown varied results, with some indicating positive correlations, others negative, and some showing no significant links. Even though there have been numerous studies on the influence of the macroeconomic variables on economic growth around the globe, it seems that there are few studies focusing on Zambia. The existing literature on the subject lacks a comprehensive understanding of how these macroeconomic factors collectively influence economic growth in Zambian, especially post-COVID-19 and post-debt restructuring periods (at the time of publication, the year is 2024). While individual studies may examine the impact of one or two macroeconomic variables on economic growth, a holistic assessment integrating all three factors, inflation, public debt and population, is absent. For instance, Phiri (2013) studied the impact of inflation on economic growth in Zambia between 1998 to 2011. This study explores a new perspective on the effect of the selected macroeconomic variables and economic growth. Also, the timeframe for this study is much longer timeframe used by other researchers such as Phiri (2013), who used a timeframe of 13 years (1998-2011). Additionally, the study employs different variables in addition to inflation and extends the timeframe from 13 years to 30 years (1992-2022).

2 Methodology

Research Design

3.1 Conceptual Framework

The interaction of regressors and the dependent variable along with mediating variables is expressed conceptually as shown in Figure 4.

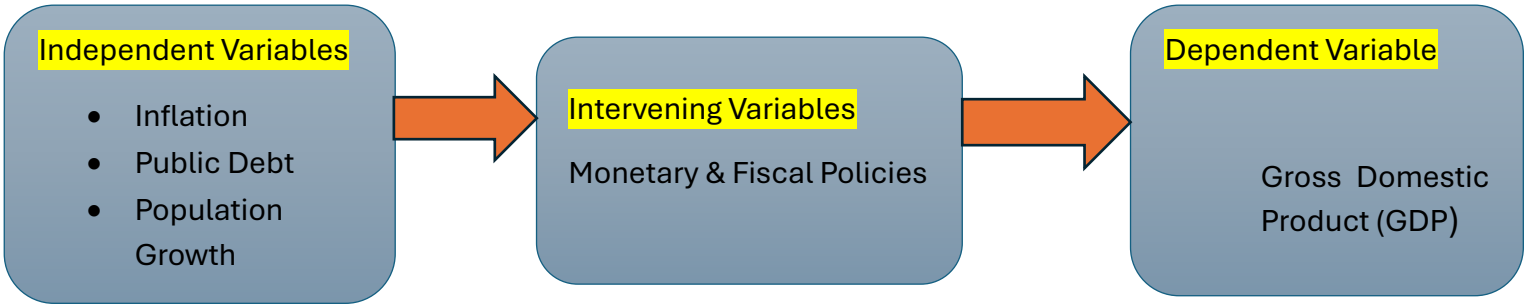

Figure 4: Conceptual Framework

Source: Authors' elaboration.

The independent variables in this research are inflation whose proxy is consumer price index (CPI), public debt and population growth whereas the dependent variable is real GDP, proxy for economic progress (growth) and the intervening variables are the monetary policy and fiscal policy.

Inflation is defined as a general rise in the cost of goods and services across the economy over time thereby diminishing consumers' purchasing power**.** Put differently, a kwacha today has less value than a kwacha of yesterday. Inflation indicates a decrease in purchasing power per currency unit as well as a decrease in the real value of the economy's medium of exchange and unit of account (Foster, 2023).

Public debt, also known as government debt, refers to the total amount of outstanding bonds and other securities. A ratio of percentage of the Gross Domestic Product (GDP is used to express it. Public debt can be raised from both internal and external sources. A government's ability to fulfil its future obligations is typically gauged by looking at its public debt as a percentage of GDP (Tahin, 2022). The term "population growth" describes the gradual increase in a population's size. It is commonly expressed annually and calculated as the percentage increase in population size during a given time frame, usually a year. Numerous factors such as immigration, birth and death rates affect population growth (Kyalo,2020).

3.1.2 Data and materials

The study employs a quantitative, deductive case study in this study. The deductive approach is adopted to test the hypothesis and to determine the cause-effect among the selected macroeconomic variables on Zambia's economic progress (real GDP). The annual time series secondary data from 1992 to 2022 were obtained from the World Bank's World Development Indicators (WDI, 2024) on inflation whose proxy is consumer price index (CPI), public debt (total public debt), population growth rate (annual percentage change) and economic progress whose proxy is real GDP (annual percentage change).

Diagnostic tests involving unit root tests on each variable were done using Augmented Dickey Fuller tests, ADF (1979). Each ADF test that was conducted helped in determining the order of integration. Equation 1 shows the basic ADF model.

$$\Delta y_i = \alpha y_{i-t} + \sum_{j=1}^{\rho_i} \beta ij \Delta y_{i-j} + \varepsilon_i \qquad (1)$$

Where y_i represents macroeconomic time-series data, ρ_i refers to the autoregressive coefficients, ε_i refers to the vector of error terms assumed to be independent and identically distributed (i.i.d). Lutkepohl (1991) explains that, if $|\rho_i| < 1$, y_i is said to be stationary. However, if $|\rho_i| > 1$, y_i has a unit root.

3.2. The Econometric models: Multiple Regressions

The study follows Kabemba and Kabwe (2024) and Mwale and Mulenga (2024) in the construction of the empirical ARDL and VECM models[2]. Given the various data variables included in the model, we employ a multiple regression model to analyze the data**.** In consideration of $\boldsymbol{K+1}$ random variables, the general multiple linear or linearized regression model can be expressed as in equation 2:

$$y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \cdots \beta_k X_k + \varepsilon \qquad (2)$$

Where y is the dependent variable of interest (economic progress whose proxy is real gross domestic product, real GDP), β_0 is the intercept, and $\beta_1, \beta_2, .., \beta_k$ are slope parameters. $X_1, X_2, .., X_k$ are explanatory variables representing the selected macroeconomic variables and ε is the stochastic error term. Furthermore, given the assumption that the data may have mixed order of integration, the autoregressive distributed lag (ARDL) model was employed in conducting data analyses.

3.2.1 The ARDL Models

The general format of the ARDL can be expressed as shown in equation 3:

$$\Delta y_t = \alpha_0 + \sum_{i=1}^{p} \beta_1 \Delta y_{t-i} + \sum_{i=1}^{p} \delta_i \Delta X_{t-i} + \sum_{i=1}^{p} \varepsilon_i \Delta Z_{t-i} + \lambda_1 y_{t-1} + \lambda_2 X_{t-1} + \lambda_3 Z_{t-1} + u \qquad (3)$$

The first part of equation 3 with parameters $\beta, \delta \; and \; \varepsilon$ represent the short-run dynamics, whereas the second part of equation 3 with parameters λs represents the long-run relationship. The null hypothesis, according to the ARDL model, assumes that if $\lambda_1 + \lambda_2 + \lambda_3 = 0$, then there is no long-run relationship among the variables (Samor et al., 2023). Additionally, the ARDL model assumes that the dependent variable is a function of its lagged values as well as the current and lagged independent variables. Therefore, equation 3 can be expressed as a specific ARDL model, as shown in equation 4:

[2] The study by Kabemba and Kabwe (2024) employ only the ARDL models. However, the study by Mwale and Mulenga (2024) employs both the ARDL and VECM models. Methodologically, our study differs from both Kabemba and Kabwe (2024), and Mwale and Mulenga (2024) in that our study employs 3 models; the VECM, the ARDL and impulse response functions (IRFs).

$$\Delta RGDP_t = \alpha_0 + \beta_1 RGDP_{t-1} + \beta_2 \pi_{t-1} + \beta_3 P\_Debt_{t-1} + \beta_4 Pop\_Growth_{t-1} + \sum_{i=1}^{p} \theta_{1i} \Delta RGDP_{t-i} \sum_{i=0}^{q_1} \theta_{2i} \Delta \pi_{t-i} + \sum_{i=0}^{q_2} \theta_{3i} \Delta P\_Debt_{t-i} + \sum_{i=0}^{q_3} \theta_{4i} \Delta Pop\_Growth_{t-i} + u_t \quad (4)$$

Where $\Delta RGDP_t$ is a change in real GDP (dependent variable), α_0 is the y-intercept/constant

$RGDP_{t-1}$ is the lagged real GDP

π_{t-1} is the lagged value of inflation (CPI)

P_Debt_{t-1} is the lagged value public debt

Pop_Growth_{t-1} is the lagged value of population growth

p, q_1, q_2, q_3 are the upper limit of the number of lags

$\beta_1 - \beta_4$ are parameter coefficient estimates of the long run effects among the variables.

$\theta_1 \_ \theta_4$ are parameter coefficient estimates of the short-run effects among the variables.

3.2.2 Vector Error Correction Models (VECMs)

Vector Error Correction Models (VECMs) are restricted variants of vector autoregression regression (VAR) models[3]. This study employs VECMs to analyze cointegrated time series macroeconomic variables. According to Lutkepohl (1999), the VECM can be modelled, as shown in equation 5.

$$\Delta y_t = \varphi_{yt-1} + \Gamma_1 \Delta y_t + \cdots \Gamma_{p-1} \Delta y_{t-p+1} + u_t \quad (5)$$

Where $\varphi = -(I_k - A_1 - \cdots A_p$, and $\Gamma_i = -(A_{i+1} + \cdots A_p)$ for I = 1, 2, …p-1

It is assumed that when Δy_t contains no stochastic trends, all variables will be integrated of order 1, (I (1)). The presence of cointegration is exhibited by the term; φ_{yt-1} be an integration of order 0, (I (0)). When y_t is cointegrated with cointegration rank, r, rank (φ) = r<K and $\varphi = \alpha A'$ where α *and* A are $K \; x \; r$ vectors. The term $\Gamma_j (j = 1,2, \ldots p-1)$ is interpreted as the short-

[3] We do not provide details of VAR models here because they are well established in the extant economic, econometrics, and financial literature elsewhere. For details, see, for example, Simms (1980), Lutkepohl (1991), and Stock and Watson (2001).

run parameters. The term φ_{yt-1} is interpreted as the long-run effects or association of the VECM. The unknown order, p, in equation 5 is estimated using the Akaike Information Criterion (AIC).

The study follows Johansen (1988) in determining the cointegration rank and estimating the unknown parameters in the VECM of equation 5. This is estimated based on the maximum likelihood (ML) principle. Additionally, Johansen's (1988) trace and maximum eigenvalue tests are used to calculate the rank.

3.2.3 Modeling the Impulse Response Functions (IRFs)

According to Lutkepohl (1999), impulse response functions (IRFs) are employed to track responses of a vector error regression's (VAR) systems variables to impulses of the systems' shocks(innovations). This implies that IFRs assess how a one standard deviation shock to a variable of interest is transmitted to other variables over time. In this study, we use IFRs to test for causality between two variables based on the assumption that zero (0) impulse signifies no causality (Johansen, 1988). Lutkepohl (1999) elaborates that estimating the effects or impacts of shocks in the variables of a system is basically estimating causality between variables. The variables are integrated of order zero (I (0)), it is assumed to have a moving average described as follows:

$$y_t = \phi_0 u_{t-1} + \phi_1 u_{t-1} + \phi_2 u_{t-2} + \cdots, \qquad (6)$$

Where $\phi_0 = I_k, \phi_s$ is recursively estimated and traces the expected response of $y_{i,t}$ to a unit change in $y_{j,t}$ holding constant all past values of y_t. Therefore, $\Delta y_{i,t}$ given $\{y_{t-1}, y_{t-2,\ldots}\}$ is determined by the shocks in $u_{i,t}$. It follows that the elements in ϕ_0 are impulse responses of y_t with respect to $u_{i,t}$ shocks or innovations. If the variables are integrated of order 1

(I (1)), then $\phi_s \to \infty$. This implies that the impulse response will dissipate over time, assuming stationary co-integrated processes. But if the variables are cointegrated of order

I (1), then ϕ_s does not converge to infinity (Lutkepohl ,1999). The effect of non-convergence of ϕ_s to infinity is that the effect of the shocks will dissipate over time, and this gives rise to permanent effects.

4. Empirical Results and Discussions

Table 1 provides summary statistics of the variables in the sample.

Table1: Summary Statistics

	REAL_GDP	INFLATION(CPI)	PUB_DEBT	POP_GROWTH
Mean	4.348	27.913	100.038	3.054
Median	4.657	17.869	71.250	3.110
Max	10.296	183.316	254.000	3.640
Min	-8.637	6.4294	17.322	2.430
Std. Dev.	3.829	40.765	66.669	0.385
Obs.	**30**	**30**	**30**	**30**

Source: Authors elaboration on data

The mean and median for GDP and population growth are close, whereas they are far apart for inflation and public debt. The minimum and standard deviation for all the variables is dispersed, indicating non-symmetric data. Table 2 reports summaries of unit root test[4] conducted via the Augmented Dickey Fuller (ADF) test on the variables in the sample.

Table 2: ADF Summary of Unit Root Tests

Variable	t-test at Levels	P-value at Levels	t-test after differencing	P-value after differencing	Order of Cointegration
Real GDP	-4.28*	0.002	N/A	N/A	I(0)
Inflation (CPI)	-4.23*	0.003	N/A	N/A	I(0)
Pub. Debt	-1.34	0.059	-4.75**	0.00	I(1)
Pop. Growth rate	-2.54	0.123	-6.7***	0.01	I(1)

[4] Extant literature in Economics, Statistics and Finance, among others, asserts that using data with unit roots for empirical analyses results in spurious regressions and inferences (See, for, example, Granger and Newbold, 1974; Green, 2003). Therefore, to mitigate incidences of spurious regressions and false conclusions, it was necessary to conduct unit root tests.

Source: The author elaborates on data from WDI. The null hypothesis assumes a common unit root process. *, **, and * denote that the time series data is stationary at a level, 5% and 10% significance levels, respectively. Unit root tests included individual intercepts only. N/A denotes not applicable.**

Table 3 reports the correlational relationships among the variables. This was done to identify the linear relationships among the variables in this study.

Table 3: Correlation Matrix

	Real Growth	Inflation Rate (CPI)	Pop. Growth Rate	Public Debt
Real Growth	1			
Inflation Rate (CPI)	-0.2385	1		
Pop_Growth_Rate	0.61836	-0.5956	1	
Pub Debt	-0.3424	0.4295	-0.7479	1

Source: Authors' elaboration on data from WDI

Table 4 reports a summary of Johansen (1988) cointegration test results. From Table 3, it is easy to observe that there is a weak negative relationship between real economic progress (real GDP) and inflation rate (whose proxy is consumer price index, CPI) and total public debt. However, there is a moderate positive correlation between economic progress (real GDP) and population growth. There is a weak but positive correlation between public debt and inflation rate. Finally, there a strong negative correlation between public debt and population growth rate in Zambia.

Table 4: Summary of Johansen Cointegration Tests

	Trace	Max Eigen
r= 0	49.34*	21.42*
r≤ 1	27.11*	19.31*
r≤ 2	5.78	9.16
r≤ 3	34.27	23.2

Results are based on the VAR model with lag order 2 as guided by the Akaike Information Criterion (AIC). Trace denotes Johansen's Trace statistic; Max denotes Johansen's Max-Eigen value rank test statistic. * Denotes rejection of the null hypothesis at 5% level.

The cointegration test results in Table 4 show that there were at least two (2) cointegrating vectors among the variables. This means that there is a long run association or cointegration among the variables. Consequently, we estimate the VECM in accordance with equation 5 because VAR models at levels are not a suitable estimator for cointegrated vectors (Luitkepohl, 1999). We use data in natural logs to mitigate the effects of skewed data or to achieve constant variance. Moreover, coefficients on the natural log scale are directly interpretable as elasticities or percentages (Green, 2003).

4.1.1 VECM Regression Analyses

Table 5 shows the VECM long-run (LR) and short-run (SR) cointegration (speed of adjustments) estimates of our data variables. From Table 5, we observe that the natural logs of inflation rate and population growth rates have a long-run significant positive impact on the real GDP growth in Zambia. Specifically, a 1% change in consumer price index, CPI, (inflation) causes a long-run increase in economic progress (real GDP) by 0.36% ceteris paribus.

Table 5: Vector Error Correction Model (VECM) Estimates

	Long Run Cointegration Estimates			**Speed of Adjustment Estimates**			
Variables	ECT Coeff	t-stat	Std. Errors	Coeff	t-stats	Std. Errors	R^2
lnReal_GDP	1			-0.07	4.33**	0.05	0.64
lnInflation (CPI)	0.36	6.73**	0.26	-0.57	9.13**	0.13	0.45
lnPub_Debt	-0.45	4.75**	0.07	-0.75	6.21**	0.11	0.71
lnPop_Growth rate	0.68	11.23**	0.11	-0.14	5.02**	0.14	0.34

Source: Authors elaboration on data from WDI. Notes: ECT denotes error correction term. ** denotes statistically significant at 0.05 level. VECM models include intercept only. With reference to the Akaike Information Criterion (AIC), the appropriate lag length for data variables was lag 2 less 1 in accordance with the guide on VEC modelling.

Similarly, a 1% increase in population growth rate results in a long-run significant increase in real GDP growth of Zambia by 0.68%, holding all things equal. However, a 1% increase in total debt stock causes a long-run significant decline in Zambia's economic progress by 0.45%. Perhaps this is because funds directed towards debt servicing caused a fiscal gap in terms of creating economic growth opportunities for Zambia. Our findings regarding the long-run negative significant impact of public debt on the economic growth of Zambia corroborate earlier findings in the empirical literature. For example, Ncanywa and Masoga (2018) found that public debt had a negative significant impact on the economic growth of South Africa. Similarly, Sanusi et. al (2019) found that initially, public debt-fueled economic expansion among a panel of Southern Africa Development Community (SADC) countries but started to impede growth once the public debt levels surpassed 57% of GDP for the SADC region in the long run. The debt-economic growth results for Zambia are supported by data. According to Statista (2024), the debt to GDP ratio was 115.23% in 2023,99.5% in 2022,71.41% in 2021, 103.7% in 2020 and 61.93% in 2019, way above the 57% sustainable debt-GDP ratio threshold recommended by Sanusi et., al (2019). In terms of the short-run dynamics, the error correction coefficient is -0.07 and statistically significant at 5% level. This implies that the three variables; inflation, public debt and population growth rate, significantly impact Zambia's real GDP growth rate in the short run. Regarding speed of adjustment, inflation, public debt, and population growth rate variables return to a long-run equilibrium after experiencing a shock at the speed of adjustment of 0.57%, 0.75% and 0.14%,

respectively. Notably, the public debt variable has the fastest long-run equilibrium convergence rate of 0.75%, while the population growth rate seems to have the slowest long-run equilibrium convergence rate of 0.14%.

4.1.2 ARDL Regression Outcome Analyses

Table 6 reports a summary of the ARDL regressions according to Equation 4. The ARDL long-run regression estimates indicate that all regressors have a long-run impact on economic progress in Zambia. Specifically, ceteris paribus, at lag 1, a 1% per cent increase in inflation or consumer prices (CPI) reduces economic progress (GDP) by 0.2%. A 1% increase in total public debt at lag 3 reduces Zambia's economic growth by 0.03%. A 1% increase in population at lag 3 increases real GDP in Zambia by 23.11% in the long term.

Table 6: ARDL Long-Run and Short-Run Estimates

Estimated Long -run coefficients: Dependent variable: log of real GDP				
Regressors	**Coefficient**	**Std.Error**	**t-stats**	**p-value**
Constant	-17.061	14.38	-1.19	0.26
lnReal_GDP (-1)	-0.39	0.19	-2.04*	0.08
lnInflation (CPI)(-1)	-0.204	0.07	4.13*	0.06
lnPub_Debt (-3)	-0.032	0.02	-2.32**	0.04
lnPop_Growth Rate (-2)	39.12	0.14	8.78**	0.01
Estimated Short-run Coefficients: Dependent variable: log of real GDP				
Regressors	**Coefficient**	**Std. Error**	**t-stats**	**p-value**
lnReal_GDP (-1)	1.014	0.32	3.21*	0.07
Ln_Inflation (CPI)(-2)	0.641	0.05	2.94**	0.03
lnPub_Debt (-1)	-0.52	0.04	3.12*	0.06
lnPop_Growth Rate (-3)	23.11	0.01	6.41**	0.01

Adjusted R-Squared:).85, F-Statistic: 11.48, Prob[F-Statistic]:0.00, DW Statistic: 2.48,

Akaike info criterion: 3.31. Note: * and ** denote statistically significant at 10% and 5% levels, respectively.

The short-run ARDL regression estimates also show that the regressors have a significant short-run effect on real GDP in Zambia. In specific terms, holding other things constant, at lag 2, a 1% increase in inflation (CPI) increases real GDP by 0.64%, whereas a 1% increase rise in total public debt causes real GDP to plummet in the short run by 0.52%. Finally, a 1% increase in population growth rates, at lag 3, causes a short-run increase in real GDP in Zambia by 23.11%.

Test for Normality, Homoskedasticity and Bound Test

We conducted diagnostic tests related to the normal distribution of the residuals. Employing the Breush-Pagn -Godfrey Heteroscedasticity test and the Breusch Godfrey Serial correlation LM test (not shown here). The tests showed R-squared p-values of 41.32% and 5.77%, respectively. Consequently, the null hypothesis for heteroscedasticity was rejected. The conclusion is that the residuals are normally distributed, and the model is homoscedastic.

The bound test confirmed and validated the long-run relationship between the regressors and the dependent variable, given that the F-statistic of 14.12 was greater than the upper bound and lower bounds of 5.12 and 3.24, respectively, at a 5% significance level. That is, the bound test confirmed that there is a long-run relationship between real GDP, inflation (CPI), total public debt and population growth rates.

Assessment of Reliability

The Cumulative Sum (CUSUM) test was utilized in this research to validate the reliability of the variables and establish whether they are stable over time. Figure 5 shows that the variables used are stable, as they are within the 5% level of significance band and the estimated results are consistently reliable.

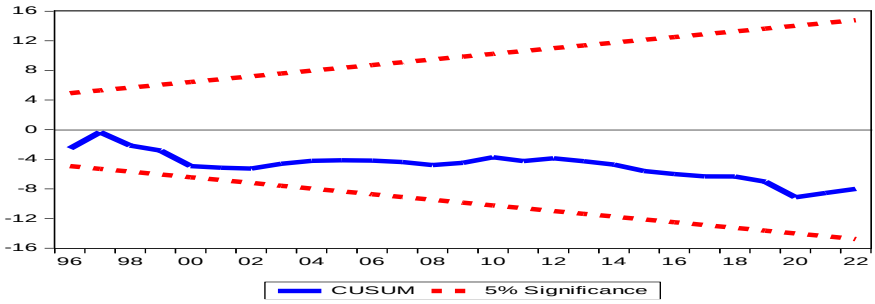

Figure 5: The CUSUM Plot.

4.1.3 Impulse Response Function Analyses

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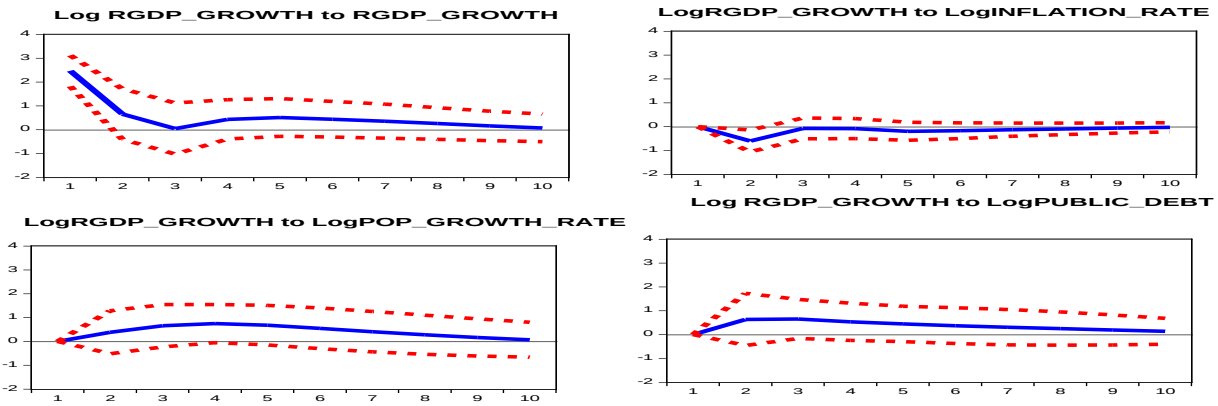

Figure 6: Macroeconomic Variable Impulse Responses to a negative shock to real GDP.

Source: Author's calculations based on equation 6

Impulse responses of endogenous variables to Cholesky's one standard deviation innovation. The dotted lines indicate ±2 standard errors. The horizontal axis represents years from the occurrence of exogenous shocks.

From Figure 6, it is easy to observe that a negative shock to the real GDP causes a mild negative effect on the inflation rate in Zambia after a 1-year lag and dissipates in year 3. A negative shock to real GDP causes a significant positive increase in the population growth rate in Zambia a year later and dissipates 9.5 years later.[5] Finally, a negative shock to the real GDP causes a significant positive increase in public debt with a lag of 1 year which effect begins to die out after the 10th year. This result aligns with the Keynesian theory that asserts that government intervention is necessary during recessions through budget deficits financed by borrowing to aid in restoring the economy to full employment (Keynes, 1936).

4.2 Hypothesis Testing

The null and alternative hypotheses this study set out to test are:

$\boldsymbol{H_0}$ **:** Do Inflation, public debt and population growth have a negative impact on economic progress (growth) in Zambia?

$\boldsymbol{H_1}$**:** Do Inflation, public debt and population growth have a positive impact on economic

[5] This result is in tandem with Solow's growth model (Solow,1956), and numerous other empirical studies that have predicted a negative effect of high population growth rates on real national income through the investment diversion effect and capital shallowing. However, other empirical studies that employ the same Solow model have found a positive effect of population growth rates on economic growth rates. They contend that through the saving channel, the Solow model can be used to achieve sustainability of consumption despite population growth unless the population growth rates are very high relative to steady state capital- labor ratio to support growth.

progress (growth) in Zambia?

From the VECM regression estimates, we observed that the inflation rate and population growth rate have a long-run significant positive impact on Zambia's real GDP growth of 0.36% and 0.68%, respectively, for every 1% increase in each variable. However, we accept the null that public debt has a negative impact on Zambia's economic progress as empirical evidence confirms that a 1% increase in total public debt reduces Zambia's economic progress by 0.45% in the long term.

When we test the hypothesis using the ARDL models, we accept the null that inflation and public debt have a negative long-run significant impact on economic progress (real GDP) in Zambia of 0.2% and 0.03%, respectively, for every 1% increase in each variable. However, we reject the null population growth rate that has a negative impact on economic progress in Zambia because empirical findings indicate that a 1% increase in population increases GDP in Zambia by 23.11% in the long term.

5. Conclusions and Recommendations

This study focused on assessing the impact of selected macroeconomic variables on Zambia's economic progress (whose proxy is real gross domestic product, real GDP) for a period spanning thirty (30) years from 1992 to 2022. The study employed the autoregressive distributed lag (ARDL), vector error correction models (VECM) and the impulse response functions (IRFs) approaches to conduct the analyses**.** Findings from the VECM regression estimates indicate that the inflation rate and population growth rates have a long-run significant positive impact on the real GDP. Specifically, a 1% on inflation (proxied by consumer price index, CPI) causes a long-run positive impact on economic progress (real GDP) by 0.36% ceteris paribus. Similarly, a 1% increase in population growth rate results in a long-run significant impact in real GDP growth in Zambia by 0.68%, holding other factors constant. However, a 1% increase in total public debt stock causes a significant decrease in economic growth of 0.45% in the long run, ceteri paribus. Our findings regarding the long-run negative significant impact of public debt on the economic growth of Zambia corroborate earlier findings in the empirical literature such as Ncanywa and Masoga (2018) who found that public debt had a negative significant impact on the economic growth of South Africa. Similarly, Sanusi et. al(2019) found that initially, public debt-fueled economic expansion among a panel of Southern Africa Development Community (SADC) countries but started to impede growth once the public debt levels surpassed 57% of GDP. The ARDL long-run regression estimates indicate that ceteris paribus, at lag 1, a 1% increase in inflation (CPI) significantly reduce real GDP by 0.2% whereas a 1% increase in total public debt at lag 3 reduces Zambia's economic growth by 0.03%. A 1% increase in population at lag 3 has a significant positive impact on real GDP to the tune of 23.11% in the long term. The IRFs models show that a negative shock to the real GDP causes a mild negative effect on the inflation rate in Zambia after a 1-year lag and dissipates in year 3. A negative shock to real GDP causes a significant

positive increase in the population growth rate in Zambia a year later and dissipates 9.5 years later. Finally, a negative shock to the real GDP causes a significant positive increase in public debt with a lag of 1 year which effect begins to die out after the 10th year. This result aligns with the Keynesian theory that asserts that government intervention is necessary during recessions through budget deficits financed by borrowing to aid in restoring the economy to full employment (Keynes, 1936). Given these findings, this study recommends that the government of Zambia prioritize repayment of the outstanding public debt by leveraging debt restructuring mechanisms concluded in this current year (2024) in the hopes of bringing down the debt-to-GDP ratio to sustainable levels and adhere to prudent financial management of public resources. Additionally, the government should continue to grow the domestic revenue base. The policies to promote population growth should be pursued cautiously because exponential population growth rates could negatively impact the future economic growth fortunes of Zambia.

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Declaration of Competing Interests

The authors hereby declare that there are no known financial or non-financial competing interests that may influence the work reported in this research article.

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