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DOES PUBLIC DEBT GRANGER-CAUSE INFLATION IN TANZANIA? A MULTIVARIATE ANALYSIS

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Abstract

The optimal balance between fiscal and monetary policy in achieving price stability has been contested in literature. In the main, however, it is widely recognised that whether public debts are financed in a monetary way or otherwise, the choice of policy action affects the effectiveness of monetary policy in ensuring price stability. This study contributes to the debate by testing the dynamic causal relationship between public debt and inflation in Tanzania covering the period 1970-2020. The study applies the autoregressive distributed lag (ARDL) bounds testing technique to cointegration and the ECM-based Granger-causality test to explore this relationship. In order to address the omission-of-variable bias, which has been the major methodological deficiency detected in some previous studies, two monetary variables, namely money supply and interest rate, were added as intermittent variables alongside public debt and inflation. The findings from this study show that there is a consistent long-run cointegrating relationship between public debt, inflation, money supply and interest rate in Tanzania. However, the results fail to find evidence of causality between public debt and inflation in Tanzania, irrespective of whether the causality is estimated in the short run or in the long run. The findings of this study, therefore, show that Tanzania's current debt is not inflationary; hence, policymakers may continue to pursue the desirable fiscal policies necessary for the country's long-term optimal growth path.

Keywords: Public debt, inflation, ARDL, Granger-causality, Tanzania

JEL classification: C32; E31; H63

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1. Introduction

The relationship between public debt and inflation has been widely discussed in both theoretical and empirical literature. Despite the abundance of literature on the subject, the relationship between these variables remains complex and largely determined by cross-country policy differences. For instance, the control of inflation processes is strictly intertwined with public sector financial management and the developments in the real and external sectors (Aimola and Odhiambo, 2021; Chirwa and Odhiambo, 2016: 438). More so, fiscal imbalances elicit the monetisation of public debt (deficit financing), which has in many instances proven to have significant inflationary effects and other multiple macroeconomic problems (Mohanty, 2012). Policymakers across world economies, including Tanzania, are therefore seeking to implement balanced fiscal–monetary policies that ensure the attainment of sustainable economic growth and price stability, particularly in the current coronavirus pandemic period (United Nations, 2020).

Although many empirical studies have been conducted on the causal relationship between public debt and inflation, involving a handful of African countries, most of these studies were prevalent in the 1980s and early 1990s. In addition, most of these studies suffer from a number of methodological paucities, including the omission-of-variable bias and spurious regressions (see, for example, Burdekin and Wohar, 1990; Darrat, 1990; Guess and Koford, 1986). Although numerous related studies have been conducted on the subject in Tanzania, the bulk of these studies have focused mainly on (i) the impact of inflation on economic growth (see Odhiambo, 2012); (ii) the relationship between public debt and economic growth (see Were and Mollel, 2020); (iii) the relationship between exchange rate and inflation (see Rutasitara, 2004); and (iv) the linkage between food prices and inflation (see Adam *et al.,* 2012).

In order to fill the void and to address the weaknesses identified in previous studies, the current study contributes to the literature in numerous ways. First, this study extends the debt–inflation debate to Tanzania by testing the causal relationship between public debt and inflation in a multivariate Granger-causality model. By including two intermittent variables, namely, money supply and interest rate, the omission-of-variable bias, which has not been addressed adequately by many previous studies, is addressed in this study (see Odhiambo, 2021). The added intermittent variables also increase the overall causation test (Lütkepohl, 1982). Secondly, the current study applies an ARDL procedure to cointegration in order to eliminate spurious correlations. The chosen approach has been proven to be superior when compared to other traditional time-series techniques. For example, the ARDL approach does not require mutual integration of the time-series for estimation, and the technique may provide unbiased estimates

of the long-run model and valid t-statistics even when some of the regressors are endogenous (Odhiambo, 2021; Pesaran *et al.*, 2001). Finally, to our knowledge, this may be the first study of its kind to examine in detail the dynamic causal relationship between public debt and inflation in Tanzania using a more recent dataset and applying modern time-series methods.

In light of the above, the results of the study are set to help policymakers in Tanzania in understanding the relationship between public debt and inflation, and therefore to implement macroeconomic policies that promote optimal growth and price stability. The study is also conducted at a time when the country needs to design and prioritise public expenditures carefully in order to realise high rates of economic growth, clear the backlog of expenditure arrears, and minimise the human and economic impact of the coronavirus pandemic (International Monetary Fund/IMF, 2020a; 2020b).

The remainder of the paper is organised as follows: In Section 2, the dynamics of public debt and inflation in Tanzania are highlighted. In Section 3, the theoretical and empirical literature review is discussed, while in Section 4, the estimation techniques are presented. Section 5 presents the empirical analysis and the discussion of the results. Section 6 concludes the study.

2. Highlights the Dynamics of Public Debt and Inflation in Tanzania

Public debt and inflation dynamics in Tanzania were a compounded outcome of internal and external drivers. Soon after political independence in 1961, the country embarked on an extensive structural reform strategy which was termed "socialism with self-reliance" – that is a combination of socialism and nationalism approach (see Malima, 1985). The development strategy was meant to reconstruct the country and diversify the economy (Holtom, 2005). During this era, foreign capital inflows contributed the bulk of financial resources required to achieve the country's development initiatives (Lane, 1984). Tanzania's fortunes were, however, cut short in the late 1960s to early 1970s when a combination of (i) a swift deterioration in terms of trade, (ii) dwindling levels of foreign aid and the oil crisis, combined with (iii) unfavourable weather conditions led to (i) a sharp rise in fiscal imbalances, (ii) growing inflationary pressures, (iii) a build-up of foreign payments arrears and (iv) an increase in dependence on foreign borrowing (World Bank, 2001a; 2001b; Agrawal *et al*., 1993; IMF, 1999; 1988; 1986). There was a considerable shift of donor funding from developmental projects to balance of payments support, which was given with conditions (Biermann and Wagao, 1986).

From an economic perspective, Tanzania experienced its worst economic slump during the period from 1975 to 1985. It is during this era that the IMF and the World Bank played the double task of extending non-concessional credits to Tanzania to solve the short-time insolvencies and to fund economic restructuring programmes (Biermann and Wagao, 1986). Between the mid-1980s and early 1990s, the overall debt stock continued to rise, becoming unsustainable by 1994 (Holtom, 2005: 552). This rapid deterioration in the economic sectors and the debt crisis prompted the government to intensify its efforts of seeking debt relief measures from the world creditor community in 1995, largely from the IMF, World Bank and African Development Bank (Bigsten and Danielsson, 1999). Table 1 presents foreign public debt of Tanzania during the period 1970-1985.

TABLE 1 - Foreign Public Debt of Tanzania (1970-86)

	Foreign public debt	
	US$ million	*% of GDP*
1970	248	19.4
1975	1094	21.7
1980	1338	28.6
1981	1497	21.2
1982	1646	32.7
1983	3119	40.4
1984	3001	51.1
1985	3356	68.3

Source: Author compilation from IMF (1986) and World Bank (2002; 1985; 1981)

The drastic rise in indebtedness between 1980 and 1985 was partly a result of contracting production and export base, rising real interest rates in global financial markets (which increased the real cost of debt servicing), and increased foreign borrowing on a non-concessionary basis (World Bank, 2002). The country's military involvement in Uganda in 1978 further aggravated the already precarious financial position (Biermann and Wagao, 1986: 92). The financial and economic crises forced Tanzania to approach the IMF for loans to finance the basic industrial inputs (World Bank, 1981). It is apparent to note that although there was a measure of debt relief and foreign public debt restructuring to Tanzania in the 1970s under the London and Paris Clubs, the country remained heavily indebted, particularly to the IMF and World Bank (International Development Association/IDA and IMF, 2000; 1999). By the end of 1992, the magnitude of the

structural economic weaknesses and debt crisis had come to full light compelling Tanzania to approach the Breton Woods institutions for assistance and to scale up efforts in mobilising foreign donor support (Biermann and Wagao, 1986). In 1993, the IMF, World Bank, and other bilateral donors suspended their financial support to the country, which led to a sharp decline in international reserves, and continuing high inflation as the government relied on the central bank to finance its fiscal deficits (World Bank, 2001a; 2001b).

It was from 1996 that the economic, financial and public sector reforms began to pay back. The reforms included, among a series of revenue and expenditure measures, institutional rearrangements, such as the establishment of the Tanzania Revenue Authority in 1996, which is a semi-autonomous revenue collection and administration entity (World Bank, 1996). On the expenditure front, the government widened its fiscal space by implementing the Public Financial Management system, which helped to instil public sector financial discipline and accountability (World Bank, 1997).

Following the implementation of the Highly Indebted Poor Countries (HIPC), Enhanced HIPC and the Multilateral Debt Relief Initiatives (MDRI), which spanned from 1996 to 2008, Tanzania's foreign public debt declined dramatically – and since then, it has remained well below the widely accepted debt sustainability thresholds (IMF, 2020a; 2001; World Bank and IMF, 2009; World Bank, 2008). In 2001, the government of Tanzania also completed a Paris Club VI agreement which made Paris Club members to cancel part of the debt and to reschedule the balance (World Bank, 2001a). The implication was the creation of the much-needed fiscal space to finance government development and poverty alleviation programs (World Bank and IMF, 2009). Table 2 presents debt service relief from HIPC and MDRI initiatives in Tanzania.

TABLE 2 - HIPC and MDRI Debt Service Relief Initiatives in Tanzania (2000-2008)

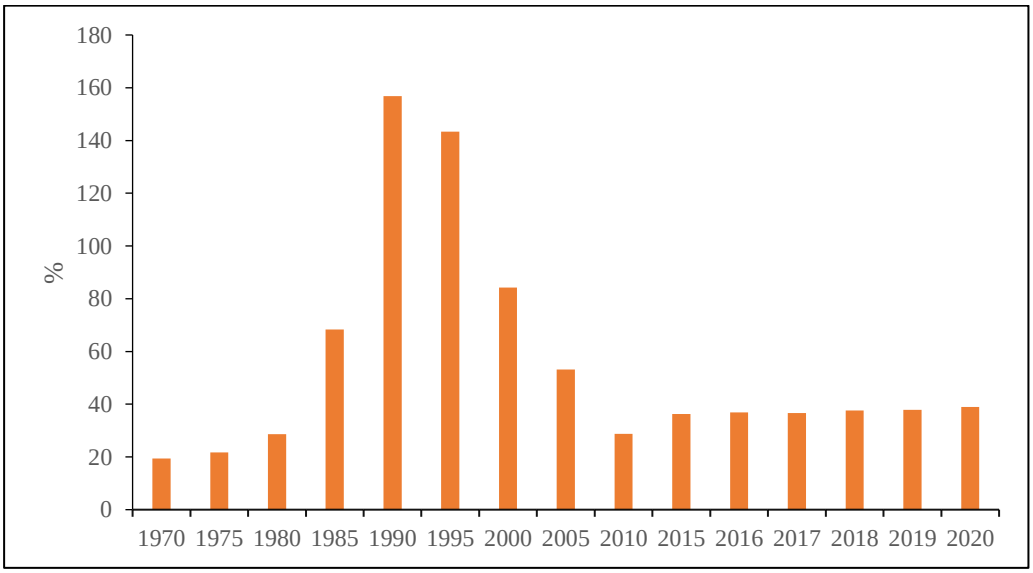
	US$ millions								
	2000	2001	2002	2003	2004	2005	2006	2007	2008
HIPC	42	64	69	72	66	67	13	0	0
MDRI	0	0	0	0	0	29	164	178	162
Total	**42**	**64**	**69**	**72**	**66**	**96**	**177**	**178**	**162**

Source: Author compilation from World Bank and IMF (2009); IMF (2004)

When Tanzania reached its HIPC completion point in 2001, it became eligible to receive debt relief from the IMF, World Bank and African Development Bank (AfDB) (IMF, 2001). In 2005, the IMF, World Bank and AfDB cancelled 100% of their debt claims owed by Tanzania as of

2004, 2003 and 2001, respectively (World Bank and IMF, 2009). On balance, since 2007, total public debt has increased from around 16% of GDP in 2007 to about 38.9% in December 2020 (IMF, 2020a; World Bank, 2020). Further, public debt/GDP ratio averaged 30.7% between 2006 and 2020 (World Bank, 2020). Public debt is likely to remain sustainable, at least in the near future, given that the country received a debt relief of US$14.3 million in 2020 under the Catastrophe Containment and Relief Trust (IMF, 2020b). Figure 1 presents the trend of public debt (as a % of GDP) from 1970 to 2020.

FIGURE 1 - Public Debt (% of GDP) – 1970-2020



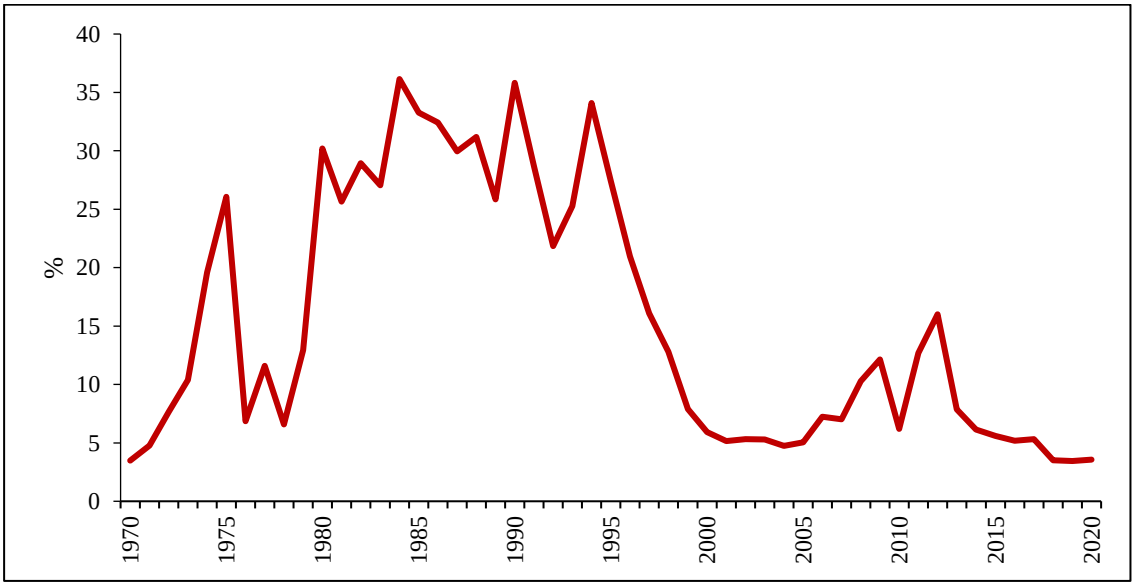
Source: Author compilation from IMF (2020a; 2004; 1986), World Bank (2020; 1985; 1981)

The expansionary fiscal and monetary policies in Tanzania between 1970 and 1990 contributed to the worsening debt problem. Between 1970 and 1998, total foreign public debt stock grew from US$1445 million to US$7973 million (World Bank, 2002). However, under the Paris Club arrangements, Tanzania's debt amounting to US$1617 million was cancelled, with US$2453.5 million rescheduled between September 1986 and January 1997. As Figure 1 shows, as at the end of 1995, Tanzania's public debt stock stood at 143.4% of GDP, which was unsustainable. In view of its high indebtedness, Tanzania's creditors initially declared the country eligible for assistance under the HIPC initiative in September 1999. More so, in 1998, the Tanzanian government had established the multilateral debt fund in collaboration with donors to reduce the build-up of arrears to multilateral creditors (Bank of Tanzania/BOT, 2003; World Bank, 2002). These efforts resulted in Iran, Kuwait and China also offering debt relief to Tanzania (BOT,

2003). In 2003, scheduled interest payments decreased by 11.7% to US$73.4 million, largely on account of HIPC debt relief initiative (BOT, 2003; 43).

On the inflation viewpoint, the government of Tanzania employed a combination of fiscal and monetary policy measures to restrain inflation between 1961 and 1974. These measures comprised of the use of a fixed exchange rate pegged to the dollar until 1974, and implementation of price and income controls, among others (Potts, 2008). Nonetheless, growing fiscal imbalances in 1967, owing to substantial deterioration in terms of trade, exerted inflationary pressures on the Tanzanian economy (Edwards, 2012). As a result, inflation rose from 6.7% in 1966 to a period peak of 10.4% in 1969, before receding to 3.4% in 1970 (World Bank, 2020). Figure 2 presents the trends of inflation (consumer price) in Tanzania between 1970 and 2020.

FIGURE 2 - Inflation Dynamics in Tanzania (1970-2020)



Source: Author's compilation from World Bank (2020) dataset

Figure 2 shows that after 1972, consumer prices rose sharply, reaching a peak of 19.6% and 26.0% in 1974 and 1975, respectively. This increase may have been triggered by severe food problems and the first and second global oil price shocks (World Bank, 2002; Kilindo, 1997). The period 1976-78 was a moderate inflation period. This can be attributed to the change in price control measures by the National Price Commission (Bigsten and Danielsson, 1999). The second round of global fuel price increases and growing budget imbalances towards the end of 1978 pushed prices up (Potts, 2008). Inflation pressures, therefore, picked up, and the country entered into an inflationary environment, which lasted until 1995 (see Figure 2). Between 1980 and 1995, Tanzania experienced low to negative growth in real GDP as capacity utilisation, production and

exports grossly dropped (Agrawal *et al*., 1993). The economy registered a large balance of payments imbalance of the period, and a severe shortage of foreign exchange reserves, leading to a buildup in foreign public debt payment arrears (Agrawal *et al*., 1993). Annual inflation was high, ranging between 25-36% and averaging 31%, much higher than what the country recorded until 1979 (World Bank, 2020).

As the impact of inflation became serious, the government implemented a series of policy packages such as: (i) the engagement of the creditor community to ease public debt service problems; (ii) implementation of new economic policies such as the National Economic Survival Programme (NESP I and NESP II); the Structural Adjustment Programme (SAP); and the Economic Recovery Programme (ERP I and ERP II); (iii) establishment of Tanzania Revenue Authority and cash budgeting system in 1996; (iv) introduction of Value-Added Tax in 1998; and (v) local government reforms in 1999; among others (Naschold and Fozzard, 2002; United Republic of Tanzania, 2000; 1999; 1998; World Bank, 2001b; Bigsten and Danielsson, 1999). Other reforms were in the form of increased public sector financial accountability, which helped to ease budget imbalances and seignorage revenues (World Bank, 2001b). The success of these policies is evidenced by the drop in inflation from 34.1% in 1994 to 7.8% and 5.1% by 1999 and 2000, respectively (World Bank, 2020). Since then, inflation remained low and stable, averaging 6.8% annually between 2000 and 2020 (World Bank, 2020).

From the review of theoretical, empirical and country-based literature, it can be generally construed that there exists a relationship between public debt and inflation rate. However, it remains uncertain if the former influence the latter or vice versa, and this can be established empirically.

3. Literature Review

The relationship between government debt and price level can predominantly be divided into two clusters, namely, the non-Ricardian hypothesis and the Ricardian hypothesis. The non-Ricardian hypothesis comprises the Keynesian and monetarist views. Following the Keynesian view, short-term deficit financed government spending stimulates the economy when output is below full employment (Afonso, 1993). In the long-term, however, higher levels of consumption and aggregate demand for goods and services can be matched by a rise in the price level (Barnhart and Darrat, 1989; 1988). Theoretically, fiscal policy can positively or negatively affect output and inflation dynamics through many channels, such as (i) public education spending on human capital formation; (ii) the provision of public sector infrastructure which has a crowding-in effect

on private investment; and (iii) taxation on capital and personal incomes (see, also, IMF, 1998). In the main, therefore, the Keynesian view, also known as the Fiscal Theory of the Price Level, asserts that fiscal policy, including present and future public debt and taxes, is the primary determinant of inflation processes (see Kwon *et al.*, 2009).

On the contrary, the monetarist view asserts that high public debt affects domestic interest rates and money supply growth. By increasing the monetary base and through the monetisation of government debt, the central bank may lower interest rates, but cause a rise in the price level (Afonso, 1993). The unexpected rise in price level has a reducing effect on the real value of outstanding public domestic debt (Afonso, 1993).

There is yet another channel through which public debt and inflation are interconnected, namely, the time–inconsistency problem of monetary policymaking and central bank independence. The Theory of Time-Inconsistency was first proposed in the seminal contributions of Kydland and Prescott (1977) and was later expanded by Barro and Gordon (1983) and Martin (2015; 2013). According to Martin (2015), the volume of debt acquired by the government affects its monetary policy since inflation reduces the real value of nominal liabilities. The projected response of future monetary policy, therefore, influences the current demand for money and bonds, and how the government thereby internalises policy trade-offs (Martin, 2013).

As opposed to the above hypothesis, in the Ricardian equivalence, Barro (1989) and other proponents are of the view that government-financed deficits do not affect the economy. Unlike the Keynesian and monetarist views, current tax cuts are assumed to be offset by proportionate future tax hikes, thereby ensuring the neutrality of government deficit on real variables (Barro, 1989).

Several empirical papers have examined the relationship between public debt and inflation. These include Jakob de Haan and Eijffinger (2017), Martin (2015), Niemann *et al*. (2013), and Niemann (2011), among others.

In their study of central bank independence, Jakob de Haan and Eijffinger (2017) concluded that in an environment of high public debt levels, the government might intentionally depend on seignorage to generate additional inflation to lighten the sovereign debt problem – fiscal dominance. Similarly, Bernanke (2010) asserts that undue government influence on the central

bank's decisions, such as the ability to demand the monetisation of its debt, is inflationary and should, therefore, be avoided at all costs.

Martin (2013) analysed the economy of the United States and concluded that in the long run, debt over GDP would increase from 21.2% to 23.8% and that annual inflation would drop from 3.5% to 2.3% in cases where there is central bank independence. He added that if policymakers have a targeted rate of inflation, then inflation is independent of the level of public debt. Niemann *et al.* (2013) further argue that the money supply growth rate and nominal interest rate may not be corresponding policy instruments in situations where the monetary and fiscal authorities disagree on how much to discount the future.

On the causality front, studies that have tested the direction of flow between public debt and inflation were very prevalent in the 1980s and early 1990s. Several authors were motivated to examine the causality between the two variables due to economic problems associated with rising public debt and inflation in some world economies during that period. These studies include Burdekin and Wohar (1990), Darrat (1990), Hafer and Hein (1988), Barnhart and Darrat (1988), Guess and Koford (1986), and Cox (1985). Recent studies on the causality between debt and inflation include Kwon *et al.* (2009) and Wolde-Rufael (2008). Table 3 gives a summary of previous empirical studies on the debt–inflation causal relationship.

TABLE 3 - Summary of Previous Empirical Studies on the Debt-Inflation Causal Relationship

Author(s)	**Sample (period)**	**Research method(s)**	**Outcome**
Kwon *et al.* (2009)	Cross-country study (1963-2004)	Panel data regressions	No causality
Wolde-Rufael (2008)	Ethopia (1964-2003)	Annual data (time-series) ARDL Granger causality tests	Budget deficit → inflation

Burdekin and Wohar (1990)	9 European Union countries (1923-1982)	Annual data (time-series) Granger causality tests	No causality (1923-1960) Debt → inflation (1961-1982)
Darrat (1990)	United States of America (1961:1 to 1987:3)	Quarterly data (time-series) Granger causality tests	Debt → inflation (stock prices)
Hafer and Hein (1988)	United States of America	Granger causality tests	No causality
Guess and Koford (1986)	17 Organisation for Economic Co-operation and Development countries (1949-1981)	Annual data (time-series) Granger causality tests	No causality
Cox (1985)	United States of America (1942-1984)	Monthly data (time-series) Granger causality tests	Debt → inflation

Based on the analysis presented in Table 3, it is clear that no consensus has been reached on the direction of causality between public debt and inflation in previous empirical studies, as both the non-Ricardian and the Ricardian hypotheses have been widely supported

4. Estimation Techniques

4.1.Data Sources, Regression Variables and Statistical Package

The study utilises annual time-series data for the period from 1970 to 2020 to explore the dynamic causal relationship between public debt and inflation in Tanzania. Two intermittent variables, namely money supply and interest rate, were incorporated in a bivariate model between public debt and inflation, leading to a multivariate causality analysis. The inclusion of the two intermittent variables is underpinned by both theoretical and empirical literature, as discussed in section one of this study. More so, the inclusion of the two monetary variables makes it possible then to study not only the direct causality between public debt and inflation, but also the indirect effect through the money supply and interest rate. The data for all variables came from World Development Indicators, an electronic database of the World Bank, Bank of Tanzania and IMF yearly publications. The empirical analysis was performed using the E-views version 10 statistical package. Table 4 gives a description of the variables.

TABLE 4 - Variable Description

Variable	Variable description
Public debt	Total public debt (% of GDP)
Inflation	Consumer prices (annual %)
Money supply	Broad money supply (% of GDP)
Interest rate	Monetary policy rate (annual %)

4.2. ARDL Specification for Cointegration

In this study, the relationship between public debt and inflation is estimated using an ARDL bounds testing approach. In the selected approach, the shortcomings of previous cointegration techniques are addressed, which include the requirement to have mutual integration of the time-series data for estimation (Odhiambo, 2021; Pesaran *et al.,* 2001). The other advantages of the ARDL modelling approach is that it can provide reliable and consistent results even when the sample size is small, such as in the current case (Narayan and Smyth, 2009). The chosen approach also provides unbiased estimates of the long-run model and valid t-statistics even when some of the regressors are endogenous (Odhiambo, 2021). The system of ARDL-based cointegrating equations associated with the causality model employed in this study can be given as follows (see also Odhiambo, 2021; Pesaran *et al.*, 2001):

$$\Delta PD_t = \phi_0 + \sum_{i=1}^{n} \phi_{1i} \Delta PD_{t-i} + \sum_{i=0}^{n} \phi_{2i} \Delta INF_{t-i} + \sum_{i=0}^{n} \phi_{3i} \Delta MS_{t-i} + \sum_{i=0}^{n} \phi_{4i} \Delta INT_{t-i}$$

$$+ \phi_5 PD_{t-1} + \phi_6 INFL_{t-1} + \phi_7 MS_{t-1} + \phi_8 INT_{t-1} + \varepsilon_{1t} \dots\dots\dots\dots\dots\dots\dots\dots (1)$$

$$\Delta INFL_t = \lambda_0 + \sum_{i=0}^{n} \lambda_{1i} \Delta PD_{t-i} + \sum_{i=1}^{n} \lambda_{2i} \Delta INFL_{t-i} + \sum_{i=0}^{n} \lambda_{3i} \Delta MS_{t-i} + \sum_{i=0}^{n} \lambda_{4i} \Delta INT_{t-i}$$

$$+ \lambda_5 PD_{t-1} + \lambda_6 INFL_{t-1} + \lambda_7 MS_{t-1} + \lambda_8 INT_{t-1} + \varepsilon_{2t} \dots\dots\dots\dots\dots\dots\dots\dots (2)$$

$$\Delta MS_t = \beta_0 + \sum_{i=0}^{n} \beta_{1i} \Delta PD_{t-i} + \sum_{i=0}^{n} \beta_{2i} \Delta INFL_{t-i} + \sum_{i=1}^{n} \beta_{3i} \Delta MS_{t-i} + \sum_{i=0}^{n} \beta_{4i} \Delta INT_{t-i}$$

$$+ \beta_5 PD_{t-1} + \beta_6 INFL_{t-1} + \beta_7 MS_{t-1} + \beta_8 INT_{t-1} + \varepsilon_{3t} \dots\dots\dots\dots\dots\dots\dots\dots (3)$$

$$\Delta INT_t = \omega_0 + \sum_{i=0}^{n} \omega_{1i} \Delta PD_{t-i} + \sum_{i=0}^{n} \omega_{2i} \Delta INFL_{t-i} + \sum_{i=0}^{n} \omega_{3i} \Delta MS_{t-i} + \sum_{i=1}^{n} \omega_{4i} \Delta INT_{t-i}$$

$$+ \omega_5 PD_{t-1} + \omega_6 INFL_{t-1} + \omega_7 MS_{t-1} + \omega_8 INT_{t-1} + \varepsilon_{4t} \ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

Where ϕ_0, λ_0, β_0 and ω_0 are respective constants; $\phi_1 - \phi_4$, $\lambda_1 - \lambda_4$, $\beta_1 - \beta_4$ and $\omega_1 - \omega_4$ are respective short-run coefficients; $\phi_5 - \phi_8$, $\lambda_5 - \lambda_8$, $\beta_5 - \beta_8$ and $\omega_5 - \omega_8$ are respective long-run coefficients; $\varepsilon_1 - \varepsilon_4$ are the error terms; Δ is the difference operator; n is the lag length; t is the time period; and all the other variables are as described in Table 3.

In the ARDL bounds testing approach to cointegration, the null hypothesis of no cointegration is examined against the alternative hypothesis of cointegration. The study applies a two-step procedure, i.e. the determination of optimal lag length using Akaike information criteria, and the application of the bounds F-test to the same set of equations to establish the existence or non-existence of a long-run relationship among the four variables under study. The calculated F-statistic value is compared with the Pesaran *et al.* (2001) – unrestricted intercept and no trend critical values at the 1%, 5% and 10% levels. If the calculated F-statistic is greater (lower) than the upper-bound (lower-bound) level of the critical values, the null hypothesis of no cointegration is rejected (accepted), signifying the presence (absence) of a long-run relationship. Should the calculated F-statistic fall within the lower- and the upper-bound levels, the results are considered inconclusive.

4.3. A Granger-causality Model Specification

A statistical relationship in itself cannot logically imply causation, but one can only infer causation by subjecting the relationship to empirical testing. More so, although cointegration indicates the existence of Granger-causality, at least in one direction, it does not indicate the direction of flow between the variables (Granger, 1988). The ECM-based Granger-causality models associated with equations (1)-(4) are therefore specified. In the causality models, a one-period lagged error correction term is incorporated to re-establish the long-run association that could have been lost with differencing of series (see Odhiambo, 2009). The use of the ECM-based causality test in this research, therefore, makes it possible to perform causality analysis in both the short run and the long run (Narayan and Smyth, 2009). The F-statistics obtained from the Wald test give the short-run causality, while the long-run relationship is given by the t-statistic on the one period lagged error correction term (Narayan and Smyth,

2009). According to Granger (1988), in causality tests, it is the past that predicts the future, not the other way round. Hence, the ECM-based Granger-causality model used in this study can be given as equations 5 to 8:

$$\Delta PD_t = \phi_0 + \sum_{i=1}^{n} \phi_{1i} \Delta PD_{t-i} + \sum_{i=1}^{n} \phi_{2i} \Delta INFL_{t-i} + \sum_{i=1}^{n} \phi_{3i} \Delta MS_{t-i} + \sum_{i=1}^{n} \phi_{4i} \Delta INT_{t-i} + \phi_9 ECM_{t-1} + \mu_{1t} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (5)$$

$$\Delta INFL_t = \lambda_0 + \sum_{i=1}^{n} \lambda_{1i} \Delta PD_{t-i} + \sum_{i=1}^{n} \lambda_{2i} \Delta INFL_{t-i} + \sum_{i=1}^{n} \lambda_{3i} \Delta MS_{t-i} + \sum_{i=1}^{n} \lambda_{4i} \Delta INT_{t-i} + \lambda_9 ECM_{t-1} + \mu_{2t} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (6)$$

$$\Delta MS_t = \beta_0 + \sum_{i=1}^{n} \beta_{1i} \Delta PD_{t-i} + \sum_{i=1}^{n} \beta_{2i} \Delta INFL_{t-i} + \sum_{i=1}^{n} \beta_{3i} \Delta MS_{t-i} + \sum_{i=1}^{n} \beta_{4i} \Delta INT_{t-i} + \beta_9 ECM_{t-1} + \mu_{3t} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (7)$$

$$\Delta INT_t = \omega_0 + \sum_{i=1}^{n} \omega_{1i} \Delta PD_{t-i} + \sum_{i=1}^{n} \omega_{2i} \Delta INFL_{t-i} + \sum_{i=1}^{n} \omega_{3i} \Delta MS_{t-i} + \sum_{i=1}^{n} \omega_{4i} \Delta INT_{t-i} + \omega_9 ECM_{t-1} + \mu_{4t} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (8)$$

Where ϕ_9, λ_9, β_9 and ω_9 are coefficients of ECM_{t-1}; ECM_{t-1} is the error correction term lagged by one period; and all the other variables are as described in the cointegration model (Equations 1-4). In equations 5–8, the short-run causality is established by the probability of the F-statistic, while the long-run causality is determined by the statistical significance of the t-statistic on the coefficient of the lagged error-correction term (see Narayan and Smyth, 2009).

5. Empirical Analysis

5.1 Unit Root Test

In order to correctly ascertain the order of integration, this study applied the Perron (1997) (PPURoot) and Zivot-Andrews (1992) (ZAU Root) techniques. According to Perron (1997), the stationarity of series can be influenced by the existence of breaking points. Therefore, the selected unit root testing techniques by Perron (1997) and Zivot-Andrews (1992) corrects for

structural breaks and, thereofee, correctly determine the order of integration among the variables. The results of the stationarity tests are presented in Tables 5 and 6.

TABLE 5 - Unit Root Test Results: PPURoot Test

Variable	Stationarity of all variables in levels	Stationarity of all variables in first difference
PD	-4.088	-10.469***
INFL	-3.564	-7.693***
MS	-1.975	-6.911**
INT	-4.220	-9.768***

*Notes: *** and ** denote stationarity at 1%, and 5% significance levels, respectively.*

TABLE 6 - Unit Root Test Results: ZAU Root Test

Variable	Stationarity of all variables in levels	Stationarity of all variables in first difference
PD	-3.782	-7.992***
INFL	-4.496	-9.353***
MS	-2.662	-5.907*
INT	-3.877	-8.278***

*Notes: ***, ** and * imply stationarity at 1%, 5% and 10% levels, respectively.*

The results reported in Tables 5 and 6 indicate that all the variables are integrated of order one. This confirms the appropriateness of the ARDL bounds testing approach in examining the cointegration relationship between public debt, inflation, money supply and interest rates.

5.2 ARDL Bounds Testing Approach to Cointegration

The selected optimal lags for each cointegration equation (1-4) were ARDL (1, 0, 0, 1), ARDL(1, 1, 0, 0), ARDL (1, 0, 0, 0), and ARDL (1, 0, 1, 0), respectively, based on Akaike Information Criterion. The cointegration results are reported in Table 7.

TABLE 7 - ARDL Bounds Test for Cointegration Results

Dependent Variable	Function	F-statistic	Cointegration Status
INFL	F(INFL| PD, MS, INT)	8.450***	Cointegrated
PD	F(PD| INFL, MS, INT)	5.654***	Cointegrated
MS	F(MS| INFL, PD, INT)	3.767*	Cointegrated

INT	F(INT| INFL, PD, MS)	6.536***	Cointegrated

Asymptotic critical values (Unrestricted intercept and no trend)						
Pesaran *et al.* (2001: 300) Table CI(iii) Case III	10%		5%		1%	
	I(0)	*I(1)*	*I(0)*	*I(1)*	*I(0)*	*I(1)*
	2.45	3.52	2.86	4.01	3.74	5.06

*Notes: *** and * imply significance at 1% and 10% levels, respectively.*

The cointegration results presented in Table 7 show that there is a long-run relationship among the variables used in this study when all the model variables are used as dependent variables. This can be confirmed by the calculated F-statistics in each equation, which have been found to be higher than the Pesaran *et al.* (2001) bound critical values. These results suggest the presence of causality in at least one direction for all specified multivariate models – Equations 5-8.

5.3 ECM-Based Causality Testing

The multivariate Granger-causality test results are reported in Table 8. In Table 8, the Wald-F test results for all coefficient restrictions show causal effect in the short run, while the t-statistic of the ECM term gives the long-run causality.

TABLE 8 - Granger-Causality Test Results – Wald F Test

Dependent Variable	**F-statistics (*probability*)**				ECT_{t-1} **[t-statistics]**
	$\Delta INFL_t$	ΔPD_t	ΔMS_t	ΔINT_t	
$\Delta INFL_t$	-	-0.026 (0.259)	0.223** (0.011)	0.016 (0.917)	-0.798** [-2.583]
ΔPD_t	-1.479 (0.173)	-	0.031 (0.409)	-0.086 (0.847)	-0.086 [-1.539]
ΔMS_t	0.382 (0.337)	0.288 (0.066)	-	-0.223 (0.581)	-0.007 [-1.061]
ΔINT_t	0.421** (0.049)	-0.007 (0.719)	0.171** (0.026)	-	-0.171*** [3.221]

While there is evidence for a long-run cointegrating relation between public debt, inflation, money supply and interest rate in Tanzania, the empirical results presented in Table 8 show no evidence of causality between public debt and inflation in Tanzania, irrespective of whether the causality is estimated in the short run or in the long run. The corresponding F-statistics of ΔPD_t in the $\Delta INFL_t$ function, and $\Delta INFL_t$ in the ΔPD_t function, are both statistically insignificant. Whereas the Fiscal Theory of the Price Level suggests that the wealth effect of public debt could affect inflation, the current study failed to find supportive evidence. This

result, though unexpected, can be due to the fact that domestic public debt in Tanzania is less dominant than its foreign counterpart (IMF, 2020a). This, in addition to the country's adherence to prudent public financial and debt management practises, potentially limit the monetisation of domestic public debt and, hence, inflation levels (IMF, 2020a). The finding in this study compares favourably with those in Kwon *et al.* (2009).

The results further reveal that there is:

(i) a unidirectional Granger-causality running from money supply to inflation, both in the short run and in the long run. That is, a greater supply of money in the economy of Tanzania is a precursor to rising inflation, both in the short run and in the long run.
(ii) no causality between public debt and money supply growth, both in short run and in the long run.
(iii) a unidirectional causality from inflation to interest rate and from money supply to interest rate, irrespective of the estimation period considered.

6. Conclusion

This paper investigated the causal relationship between public debt and inflation in Tanzania using time-series from 1970 to 2020. In order to address the methodological deficiencies associated with some of the previous studies on the subject, the current study incorporated money supply and interest rate as intermittent variables to form a multivariate Granger-causality framework. These intermittent variables were used to overcome the problem of omission-of-variable bias and to improve the overall causation test. The study employed a dynamic multivariate ARDL bounds testing approach and the ECM-based causality test to investigate the existence or non-existence of cointegration and Granger-causality relationships, respectively. This study was undertaken at a time when there is little known work for Tanzania concerning the issue of the relation between public debt and inflation.

The findings from this study show evidence consistent with a long-run cointegrating relationship between public debt, inflation, money supply and interest rate in Tanzania. However, the results fail to find evidence of causality between public debt and inflation in Tanzania, irrespective of whether the causality is estimated in the short run or in the long run. The findings of this study, therefore, show that Tanzania's current public debt does not Granger-cause inflation; hence, policymakers may continue to pursue the desirable fiscal policies necessary for the country's long-term optimal growth path. In view of the findings of this study, it would be prudent for future studies to re-estimate a multivariate Granger-causality model that disentangles public debt into domestic and foreign.

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