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SOVEREIGN DEBT THRESHOLDS, DEVALUATION AND THE CROWDING-OUT OF INFRASTRUCTURES AND PUBLIC INVESTMENTS: TESTING THE DEBT LAFFER CURVE HYPOTHESIS IN DEVELOPING ECONOMIES

DAVID UMORU
Department of Economics, Edo State University Uzairue, Iyamho, Nigeria, Km 7 Auchi-Abuja Expressway, Iyamho, Edo State, Nigeria. Email: david.umoru@yahoo.com/david.umoru@edouniversity.edu.ng
ORCID: https://orcid.org/0000-0002-1198-299X

BEAUTY IGBINOVIA
Department of Economics, Edo State University Uzairue Iyamho, Nigeria, Km 7 Auchi-Abuja Expressway, Iyamho, Edo State, Nigeria. Email: beauty.igbinovia@edouniversity.edu.ng;
ORCID: https://orcid.org/0009-0005-6820-1110

ETIM VICTOR NDUM
Institute of Public Policy and Administration, University of Calabar, Nigeria. ORCID: 0000-0002-3791-0943

TAKIM, TIKU ORU
Department of Social Works, University of Calabar, Nigeria, Nigeria. ORCID: 0000-0002-9359-8288

EKUNKE PAULINUS AGABI
Department of Public Administration, University of Calabar, Nigeria. ORCID: 0009-0000-5329-6819

ELE, AUGUSTINE AUGUSTINE
Department of Business Management, University of Calabar, Nigeria. ORCID: 0000-0002-6617-9467

ANTHONY AZIEGBEMIN EKEOBA
Department of Economics, Edo State University Uzairue, Iyamho, Km 7 Auchi-Abuja Expressway, Iyamho, Edo State, Nigeria. Email: tonyekeoba2000@yahoo.com; ORCID: https://orcid.org/0009-0006-7766-8967

Abstract

This study investigated the crowding-out effects of sovereign debt accumulation and nominal exchange rate devaluation on infrastructure and educational investments in developing countries within the framework of the Debt Laffer Curve hypothesis. The study was motivated by the increasing debt burdens and persistent exchange rate instability experienced by many developing economies, which have significantly constrained fiscal space for productive public investment. Specifically, the study examined the nonlinear relationship between sovereign debt and public investment, identified the debt threshold at which crowding-out effects become significant, and analyzed how nominal exchange rate devaluation aggravates fiscal pressure on infrastructure and educational expenditure. The study employed panel data for 30 developing countries covering the period from 1995Q1 to 2025Q4. Utilizing a robust Dynamic Panel Threshold Regression framework complemented by a Split-Sample Two-Step System GMM estimator as a core robustness check, the empirical architecture explicitly evaluates the validity of an inverted U-shaped Debt Laffer Curve. The empirical results reveal a distinct, significant structural threshold at a public debt-to-GDP ratio of 62.14 percent. Below this critical tipping point, moderate sovereign borrowing exerts a positive and statistically significant influence on public capital expenditures, fostering essential physical infrastructure and human capital development. Nevertheless, once the 62.14 percent threshold is breached, further debt

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accumulation triggers a severe debt overhang effect, violently crowding out discretionary public investments. The inclusion of a multiplicative interaction term demonstrates that nominal exchange rate devaluations drastically exacerbate this crowding-out effect, serving as a destructive fiscal accelerator specifically within the high-debt regime where foreign-denominated obligations become unmanageable. Complementary panel variance decomposition results confirm that sovereign debt shocks explain approximately 42 percent of the long-term volatility in public investment, emphasizing the extreme sensitivity of national capital budgeting to uncoordinated fiscal shocks. Ultimately, the study concludes that shielding the public investment pipeline from the destabilizing feedback loops of debt overhang and currency depreciation is not merely a strategy for achieving short-term fiscal balance, but the fundamental basis for sustaining human capital development, infrastructural continuity, and generational economic growth. In effect, that long-term debt sustainability is a remarkable prerequisite for predictable public capital deployment, advocating for the institutionalization of rule-based fiscal anchors, aggressive domestic revenue mobilization, and advanced external currency risk mitigation strategies to insulate developing economies from catastrophic debt-servicing spirals.

Keywords: Sovereign Debt, Debt Laffer curve, Exchange Rate Devaluation, Crowding-Out Effect, Infrastructure Investment, Educational Investment, Developing Countries, Fiscal Space, System GMM.

JEL Classification: H63, H54, E62, F34, F31, O11, O23, C33, C24, E44.

1. INTRODUCTION

Sovereign debt has emerged as a prominent instrument through which developing countries finance infrastructure expansion, human capital development, and overall economic transformation in the past decade (Bamba, 2020). An increasing number of governments are borrowing domestically and externally to plug revenue deficits and fund public investment and speedy development objectives (Al-Guthmy & Yan, 2020). When managed properly, public borrowing is expected to add to productive capacity (Durand et al., 2021). Nevertheless, the rising sovereign debt across developing countries has raised concern over debt sustainability and the ability of governments to maintain developmental expenditure (UNDP, 2024). Growing debt-service obligations absorb a growing share of fiscal resources that could otherwise be devoted to infrastructure, education, health, and other growth-enhancing investments (UNDP, 2024). Developing countries, especially in Sub-Saharan Africa and Latin America, are facing unprecedented debt-service burdens (AfD, 2025). Debt repayments are taking up a larger share of government revenues and export earnings thereby reducing fiscal space for productive investment and sustainable development.

Many studies that theorize and provide empirical evidence for the relationship between sovereign debt and economic growth have been published. Nevertheless, the debate regarding the amount of public borrowing that stops enhancing growth and starts hampering development remains largely unresolved. The standard approach of linear models is to assume that any debt, whether low, medium, or high, will have the same impact on investment. New evidence appears to indicate that the relationship between debt and investment may possess an inherent nonlinear character. More specifically, the idea is that moderate amounts of borrowing support investment, whereas high amounts of debt generate debt-overhang effects that restrain capital formation and degrade economic conditions. According to Dawood, Feng, Ilyas and Abbas (2024), the external debt has an effect on growth through nonlinear transmission channels and excessive debt tends to crowd out investment through debt overhang mechanisms. Despite this, existing research is overwhelmingly focused on aggregate growth results and provides insufficient information about sovereign debt's impact on infrastructure and public investment spending in developing countries. The modern-day debt scenario has further complicated matters as many developing countries

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now face simultaneous exposure to excessive debts and currency instability. Increasingly, currency devaluations are observed currency devaluations across Africa, Latin America and other emerging regions due to a number of factors such as external shocks, tighter global financial conditions, a drop in export revenue and fickle capital flows. In economies with large debts in foreign currency, depreciation of the exchange rate increases the domestic currency cost of servicing external debt. This worsens the fiscal position and reduces the resources available for development spending. Recent global assessments alert that exchange-rate vulnerabilities are becoming increasingly associated with challenges in debt sustainability. Yet, empirical studies have rarely examined the impact of exchange-rate devaluation on sovereign debt and public investments.

In addition, global debt reports state that debt servicing costs have surged to unprecedented highs forcing governments to reduce expenditure in productive areas for debt servicing (Bekri, 2025). Evidence from international institutions shows that debt-service obligations are growing faster than spending on critical development sectors such as education and infrastructure (UNDP, 2023). This raises concern about the long-run consequences of debt accumulation for capital formation and human development. Along the same lines, many developing nations suffer from threats of debt distress, liquidity crisis and fiscal stress due to increasing costs of borrowing and rising debt-service obligations (Bekri, 2025; UNDP, 2023). One of the major weaknesses of the literature is that it does not identify or agree on a sovereign debt threshold above which borrowing begins to crowd out infrastructure and public investment. Even if the Debt Laffer Curve (DLC) and Debt Overhang theories suggest the existence of creditworthiness thresholds, the evidence remains mixed and inconclusive (Heimberger, 2022; Panizza & Presbitero, 2013). This is especially true for developing economies with weak fiscal institutions, limited domestic revenue mobilization, and high external debt dependence (Bekri, 2025). Additionally, most recent research investigates the debt-growth relationship without investigating the extent to which exchange rate devaluation increases the crowding-out effect due to debt when debt exceeds sustainable levels. As a consequence, policymakers lack empirical guidance on the debt levels that can be sustained without compromising long-run objectives like public investment. This is crucial because infrastructure and public investment are the pillars of economic transformation, productivity growth, employment generation, and human capital development. Continuous cuts in such spending as a result of over-indebtedness may generate long-standing structural effects, including slower growth, lower productivity, reduced competitiveness and increased poverty (Bekri, 2025). With the growing debt vulnerabilities facing developing economies and the increasingly frequent occurrence of exchange-rate shocks, there is an urgent need to check if sovereign debt has nonlinear threshold effects and if currency devaluation intensifies the crowding-out of developmental expenditure.

The aim of the study is to provide an empirical analysis on the economic consequences of public debt. Specifically, on the threshold beyond which public borrowing would stop being an instrument of developmental intervention and become a constraint on crucial infrastructure and public investments. Also, the extent to which devaluation exacerbates this threshold is unresolved. The lack of dynamic panel data evidence on the Debt Laffer Curve hypothesis is a serious gap in the literature. Thus, this study aims to fill such a useful gap and to provide policy-relevant evidence on debt sustainability a 9exchange-rate management and the maintaining of fiscal space. Increasing fiscal deficits along with continuous foreign and domestic borrowing to meet developmental deficits have led to the accumulation of sovereign debt beyond sustainable levels (World Bank, 2024; IMF, 2024). As a result, governments are increasingly forced to use disproportionately large shares of domestic revenues to respond to fast-increasing debt-servicing

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obligations that produces a severe crowding-out impact that starves vital capital projects, transport systems, schools and social programs of financing (Agyeman & Frimpong, 2023; Bank, 2024b, 2024a). The devaluation of the nominal exchange rate severely aggravates the current fiscal crisis, as it drastically changes the domestic cost structure of sovereign debt management. Due to the fact that developing economies hold a large share of their public debt in debt too, a depreciation of the domestic currency will sharply and almost immediately inflate the overall debt-servicing needing in local currency terms (ADB, 2024; UNDP, 2025). Because of currency volatility, there is pressure on public expenditures, which the government has to use liquid resources aggressively from capital infrastructure and education to avoid a sovereign default (2024; Njoroge & Mensah, 2023). Additionally, nominal depreciation reduces government purchasing power by increasing import prices of heavy machinery, construction materials, and special technologies which are essential for infrastructure and education development (ADB, 2025a, 2025b; Fund, 2025a, 2025b). The macroeconomic conditions created by the crisis would lead to inflation, loss of confidence by investors and capital flight in a severe dilemma such that long-term developmental investments will never take place or will be delayed.While the literature analyzes the linear relationship between higher aggregate sovereign debt and economic growth, the empirical gap is nevertheless seriously examined. Researchers and economists have not paid enough attention to how the Debt Laffer Curve and nominal exchange rate devaluation can deter in interactive ways two investment types. This is the case in infrastructure and education (ADB, 2024; Kose et al., 2025). In addition, existing empirical frameworks have not identified the specific and non-linear threshold values of sovereign debt at which sovereign debt becomes a destructive force for public capital expenditure. The failure to establish exactly these numerical limits denies policymakers any empirical insights into exchange rate shocks and into debt-servicing traps with respect to the long-term socio-economic trajectory of developing countries.

The specific objectives of the study have been framed so as to systematically address the core research problem. Further, they would disaggregate the various linkages between macroeconomic shocks and developmental expenditures. The main analysis will investigate the non-linear impact of sovereign debt accumulation on government investment in infrastructure and education in the developing world, thereby validating the structural assumptions of the Debt Laffer Curve hypothesis. In keeping with this macro-fiscal analysis, the study investigates the impact of nominal exchange rate devaluation on the allocation of public expenditure to physical infrastructure and education. The empirical framework is developed to examine the interactive compounding dynamics between the nominal exchange rate shocks and sovereign debt to assess whether depreciation aggravates the systematic crowding-out of public capital and human capital. Through this investigation into the interplay between public debt and exchange rate fluctuations, our analysis helps identify the two specific macro-financial transmission channels, namely, compression of fiscal space and rising import costs, through which public debt distress and currency fluctuations inhibit development spending. The objective of these lines of inquiry is to estimate the non-linear threshold parameters for the sovereign debt-to-GDP ratio and nominal exchange rate devaluation, beyond which the crowding-out effects on infrastructure and education are statistically significant. In light of these objectives, the present study formulates a set of interrelated research questions to clarify how fiscal erosion occurs in developing countries. The main question examines how higher levels of sovereign debt affect the structure of public investment in infrastructure and education at different debt levels, as per the predictions of the Debt Laffer Curve (Bhimjee, 2023). The next question addresses how the nominal exchange rate devaluation restricts public financing of development sectors and interacts with existing debt to add to the fiscal vulnerability (Uribe & Valencia, 2024). To dig deeper into the inner workings

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underlying these movements, this study identifies the specific macro-financial transmission channels are through which public debt accumulation and currency depreciation systematically hamper public capital and social infrastructure spending. This last question is the important one regarding the empirical threshold levels of the debt to GDP ratio and devaluation of the nominal exchange rate which significantly crowds out public investment at elevated levels.

This research sets out formal null and alternative hypotheses to empirically answer these questions and validate the theoretical framework respectively. The initial hypothesis investigates the strict linearity of the correlation between the accumulation of sovereign debts and public investment in infrastructure and education. This position will be the null stance, which will be tested against the alternative hypothesis, which asserts that this correlation takes the shape of an inverted U-shaped Debt Laffer Curve, transitioning from a supportive role to a statistically significant negative crowding-out impact once a certain structural threshold is crossed. The second hypothesis is similarly structured regarding the external shocks compounding effect and states as the null position that nominal exchange rate devaluation does not interact with or exacerbate the crowding-out effect of sovereign debt on infrastructure and education. The alternative hypothesis states that devaluation of the nominal exchange rate significantly interacts and intensifies the crowding-out of public investments, squeezing fiscal space specifically in high-debt regimes and this is directly countered. With this logical chain of objectives, questions and hypotheses that can be tested, the analysis illustrates how the interaction of shocks produces a variety of non-linear effects, a phenomenon that is pertinent to the effects of public debt and currency shocks. There are various reasons this study is significant. To begin with, it adds to the literature on sovereign debt sustainability by empirically researching the crowding-out effects of debt accumulation and exchange rate devaluation on infrastructure and educational investments in developing countries. In addition, it provides policymakers with insight into trade-offs involving debt servicing, exchange rate management and allocation of developmental expenditure. It is crucial to understand these trade-offs for creating sustained fiscal policy without losing investment in key sectors. Researchers have effectively pinpointed the threshold of the Debt Laffer Curve, which, when surpassed, can compromise public investment strategies. This will help governments and international financial institutions to set sustainable debt limits. The research offers policy recommendations which improve debt-management strategies, ensure exchange rate stability and protect long-term investment in infrastructure and education, necessary for sustainable economic growth and development. As macro-fiscal policies are central for economic growth and development, this paper is of significant importance. In theory, the study contributes to the structural use of the Debt Laffer Curve hypothesis by consciously redirecting academic attention away from aggregate economic growth measures and towards explicitly specified, disaggregated components of public expenditure, namely physical infrastructure and education. This study brings direct nominal exchange rate devaluation into the analytical framework, closing a persistent gap in open-economy macroeconomics. It depicts external currency shocks as a compounding catalyst that alters the conventional tipping points of fiscal sustainability. The study offers a complex, non-linear analytical model that replaces the outdated linear model with accurate threshold parameters. This statistical accuracy enables economists to identify the precise points of debt accumulation that turn debt from a development enabler into an aggressive crowding-out force. As such, the results provide a definitive guide for central banks, ministries of finance and international financial institutions to build better debt sustainability frameworks that factor in currency fluctuations. The results of this study help fiscal planners assess their borrowing capacity without compromising public investments that drive growth in times of macroeconomic stress. By laying down definable empirical boundaries, the study raises a shield against systematic

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underfunding of crucial transport, energy and digital networks in developing nations. At the same time, it protects social infrastructure by demonstrating how unmitigated debt-servicing obligations directly destroy human capital formation by degrading education systems and local schools. In the end, by clarifying the exact economic channel through which currency shocks and sovereign debt interact, this paper constitutes a fundamental strategic guide for the preservation of long-term productivity, poverty reduction, and the structural transformation of developing economies. This study is significant in several ways. The research also contributes to the existing literature on sovereign debt sustainability by empirically examining the crowding-out effects of debt accumulation and exchange rate devaluation on infrastructure and educational investments in developing nations.

Second, the study provides policymakers with insights into the trade-offs associated with debt servicing, exchange rate management, and developmental expenditure allocation. Understanding these trade-offs is important for designing sustainable fiscal policies that preserve investments in critical sectors. The study empirically identifies the Debt Laffer Curve threshold beyond which additional debt accumulation becomes detrimental to public investment. This finding will assist governments and international financial institutions in determining sustainable debt limits. The study offers policy recommendations aimed at improving debt management strategies, enhancing exchange rate stability, and protecting long-term investments in infrastructure and education necessary for sustainable economic growth and development. This study holds profound significance for contemporary macro-fiscal policy formulation, academic literature, and international development strategies across vulnerable developing regions. On a theoretical level, the research significantly advances the structural application of the Debt Laffer Curve hypothesis by intentionally shifting the academic focus away from aggregate economic growth metrics toward explicit, disaggregated components of public spending, specifically physical infrastructure and education. By integrating nominal exchange rate devaluation directly into the analytical framework, this study bridges a persistent gap in open-economy macroeconomics, offering a more realistic view of how external currency shocks act as a compounding catalyst that alters the traditional tipping points of fiscal sustainability.

Empirically, the investigation presents a sophisticated, non-linear analytical model that replaces outdated linear assumptions with precise threshold parameters. This statistical precision allows economists to capture the exact coordinates where debt accumulation transitions from a development facilitator into a detrimental crowding-out mechanism.

Consequently, these findings offer a definitive diagnostic tool for central banks, ministries of finance, and international financial institutions to design more resilient debt sustainability frameworks that actively account for currency volatility. From a pragmatic policy perspective, the insights generated from this research empower fiscal planners to determine their optimal borrowing capacities while safeguarding growth-sustaining public investments during periods of macroeconomic stress. By establishing clear empirical boundaries, the study provides a defense mechanism for developing nations against the systematic underfunding of vital transport, energy, and digital networks. Simultaneously, it protects social infrastructure by demonstrating how unmitigated debt-servicing obligations directly degrade human capital formation through the erosion of educational systems (Fosu, 2010; Mbewe, 2024). By clarifying the precise economic transmission channels through which currency shocks and sovereign debt interact, this study serves as an essential strategic blueprint for preserving long-term productivity, poverty reduction efforts, and the overall structural transformation of developing economies.

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2. LITERATURE REVIEW

Theoretical Review

According to the Debt Overhang Theory, debt service absorbs expected returns from future investment when a country runs up too much sovereign debt. Essentially, debt is a tax on expected returns of future investments. This dynamic deters both private and public investments since economic agents know that future revenues which can result from productive activities will not be invested in their own development but will go to debt servicing. Recent academic literature illustrates that high debt burdens in developing countries can greatly diminish fiscal flexibility and undermines long-term capital formation, particularly in critical infrastructure and educational sectors (Kose, Ohnsorge, & Sugawara, 2024). Moreover, taking on too much debt acts as a marginal tax on future production and investment. This happens as governments in debt distress are often compelled to adopt severe austerity measures that explicitly reduce capital expenditure. As a result, in developing economies, high sovereign debt has increasingly diverted public expenditure from infrastructure and social investment towards debt servicing (IMF, 2024). Using the same logic, the Debt Laffer Curve hypothesis gives a critical non-linearity to sovereign borrowing. When debt is at a manageable level, it can cause growth in the economy and public investment. Thus, it equips governments with cash. However, when borrowing exceeds a certain level, further debt becomes self-defeating as rising costs of debt servicing deplete government revenue and neutralize investment capacity. Numerous developing countries are now either at or exceeding this dangerous threshold level given fiscal deficits and serious exchange rate pressures, according to recent empirical analyses (Presbitero & Goodwin, 2025). The practical operation of the Debt Laffer Curve is best explained by the Fiscal Space and Crowding-Out hypotheses. Fiscal space is a government's ability to finance productive spending without threatening macro-economic stability, but this ability is mathematically limited by debt servicing. When more and more of the revenues of the government are used for debt repayment, there are fewer resources left for development. As noted in recent assessments, a growing number of developing economies now allocate between 30 and 50 percent of public revenue solely to debt servicing, which in turn crowds out essential investments in transport systems, schools, energy systems, and people (World Bank, 2024). When governments undergo depreciation of their nominal exchange rate, the fiscal effect of crowding-out becomes increasingly severe due to the cost associated with servicing debt in local currency terms, which African Development Bank (2025) notes is inescapably more expensive. In the end, the Debt Laffer Curve shows that above a threshold, servicing costs will constrain policies and ultimately force the government to prioritize external repayment and not internal development. This theory has also received strong empirical support, with recent studies investigating the relationship between sovereign debt and public investment in developing countries. A detailed study of 95 developing countries revealed that the rising level of sovereign debt reduces government capital expenditure. Countries with debt-to-GDP ratios higher than 70 per cent experience significant deteriorations in investment efficiency and delays in infrastructure development (Kose et al., 2024). Likewise, panel data from developing countries reveal that sovereign debt levels exhibit a non-linear relationship with public investment. Specifically, while moderate borrowing does finance infrastructure, excessive accumulation will ultimately crowd out development spending due to interest payments (Presbitero & Goodwin, 2025). In various regional contexts, the debt dynamics of African economies illustrate that debt servicing needs have heavily constrained educational expenditure, resulting in governments reallocating scarce budgetary resources away from human capital formation (expenditure) toward debt servicing (Mensah & Ndlovu, 2023). According to the World Bank (2025), the increasing sovereign debt burden is linked to the widening infrastructure

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financing gaps in developing countries that are vulnerable to global shocks. This is because budget-distressed governments are repeatedly delaying physical infrastructure projects and cutting back on maintenance.

Empirical Review

A rising body of empirical work has provided strong evidence of crowding-out as sovereign debt burdens rise in developing countries. An increase in debt servicing significantly hampers public investments consequently shifting government priorities. Rising debt servicing costs in developing countries have been shown to intensify a trade-off between debt service and development spending (UNDP, 2025). This is corroborated by the United Nations Development Programme (2024), which states that, due to debt distress, many developing nations were forced to pull back from zealously investing in electricity infrastructure, public schools, and digital connectivity. Debt distress hampers sustainable development investment and exacerbates fiscal constraints. Panel studies confirm that debt servicing obligations reduce capital expenditure on roads, healthcare infrastructure, and educational facilities (Antoniadis et al., 2019).

Accountability in resource management and spending affects the public investment prospects as well. Similarly, debt distress hampers developmental prospects and weakens long-term growth potentials. Due to debt distress, governments often face difficult choices to cut development spending as part of fiscal consolidation (UNDP, 2025). The adverse effect of sovereign debt is greatly exacerbated by nominal exchange rate devaluation due to the implications it holds for public investment. Developing countries rely heavily on imported capital goods. High inflation and increasing cost of capital also contribute to this trend.

According to recent studies, depreciation of the currency significantly increases the domestic price of machinery, construction materials, and technological equipment. Depreciation of exchange rates in developing countries can increase the cost of infrastructure projects, especially where contracts are denominated in foreign currencies (Gray & Irwin, 2003). Subsequently, governments reduced their capital expenditure owing to increasing import costs. Exchange rate volatility introduces risks that may reduce investment below socially optimal levels (Castro et al., 2025). The instability in the currency is responsible for broader macroeconomic imbalances.

Identification of the Literature Gap

Notwithstanding the extensive body of literature analyzing sovereign debt and economic performance, significant empirical gaps remain. Most existing studies tend to examine debt and exchange rate effects in isolation or treat them as purely linear variables affecting aggregate GDP growth.

Consequently, there is a distinct lack of research that specifically models the non-linear Debt Laffer Curve threshold and its intricate interaction with exchange rate devaluation to explain crowding-out effects on targeted developmental sectors such as infrastructure and education. Furthermore, the literature has not sufficiently addressed the precise transmission mechanisms through which exchange rate devaluation amplifies the crowding-out effects of excessive debt via heightened debt servicing costs, inflationary pressures, and fiscal constraints. Therefore, a critical need exists to empirically investigate these combined, non-linear dynamics to fully understand how sovereign debt and currency devaluation jointly constrain vital public investments in developing nations.

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3. METHODOLOGIES

Research Design

Employing the quantitative longitudinal panel research design, the study has sought to investigate the crowding-out effects of sovereign debt accumulation and nominal exchange rate devaluation on investment in infrastructure and education in developing countries. The selection of a panel design is appropriate because it allowed the study to investigate both cross-country variations and time-series dynamics over an extensive time. The study used dynamic panel econometric methods to capture nonlinear threshold effects, endogeneity, regime-switching behaviour and long-run equilibrium relationships between the variables. Data for the second quantitative quarterly was obtained from the WDI, IFS, and African Development Bank statistical database. The study takes into account a quarterly period of 30 years starting from 1995Q1 to 2025Q4. This long time frame allowed the study to properly account for debt cycles, exchange rate crises, structural fiscal adjustments, and long-term investment patterns across developing countries.

Study Sample

The researchers utilized a purposive sampling technique for selecting a balanced panel of 30 developing countries from SSA, Latin America, and emerging economies in Asia from 1995Q1 to 2025Q4. The research covered a 30-year quarterly period from 1995Q1 to 2025Q4. This extended time horizon allowed the study to adequately capture debt cycles, exchange rate crises, structural fiscal adjustments, and long-term investment behavior across developing economies. The chosen nations under the current study consist of Nigeria, Ghana, Kenya, South Africa, Zambia, Ethiopia, Tanzania, Uganda, Cameroon, Senegal, Angola, Côte d'Ivoire, Botswana, Rwanda, Mozambique, Argentina, Brazil, Mexico, Chile, Colombia, Peru, Ecuador, Bolivia, Paraguay, Uruguay, Venezuela, Guatemala, Honduras, El Salvador, and Dominican Republic. Selected countries have accumulated massive sovereign debts, suffered repeated devaluations of their exchange rates, created fiscal imbalances and experienced macroeconomic instability in the period of study (Köse et al., 2021). The chosen countries are also developing economies that rely heavily on external borrowing and are vulnerable to exchange rate shocks and debt servicing pressures (Dinh, n.d.). According to the study, accumulating sovereign debt and devaluing the nominal exchange rate affect public spending on infrastructure and education. Infrastructure investment consists of government spending on transport, energy, communication, building of roads, public utilities and other physical capital projects. Educational investment, on the other hand, refers to government spending on primary, secondary and tertiary-level education and more broadly human capital. The study specifically employed dynamic panel econometric techniques to capture nonlinear threshold effects, endogeneity, regime-switching behavior, and long-run equilibrium relationships among the variables.

Research Framework

The study's methodological scheme was structurally designed mathematically and theoretically with the Debt Laffer Curve, exchange rate and public sector budget constraint to empirically capture the crowding-out effect on developmental investments. The estimation model is based on the Debt Laffer Curve hypothesis, which establishes a non-linear relationship between sovereign debt and economic growth (Megersa, 2015), and is adapted here to analyze public investment. Moderate borrowing provides the essential capital required for growth and early public investment. However, above a point, marginal borrowing will hamper sustainability of finances, and, in fact, end up restraining government spending on productive sectors. To capture the inverted U-shaped

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relationship, the study uses a quadratic econometric specification in which public investment is a function of sovereign debt, more formally stated as follows:

Methodological Framework

The methodological framework of this study is structurally designed around the mathematical and theoretical integration of the DLC, exchange rate dynamics, and public sector budgetary constraints to empirically capture the crowding-out effects on developmental investments. The fundamental basis of the estimation model is rooted in the DLC hypothesis, which establishes a non-linear relationship between sovereign debt and economic growth (Megersa, 2015), and is adapted here to analyze public investment. Theoretically, while moderate borrowing provides the necessary capital to stimulate economic growth and facilitate early-stage public investment, exceeding a critical threshold triggers a negative feedback loop where additional borrowing compromises fiscal sustainability and actively constrains government expenditure on productive sectors. To capture this inverted U-shaped dynamic, the study employs a quadratic econometric specification where public investment is defined as a function of sovereign debt, expressed formally as:

$$I = \beta_0 + \beta_1 D + \beta_2 D^2 + \varepsilon \quad (1)$$

In this structural equation, I represents public investment and D denotes sovereign debt, with the quadratic term D^2 explicitly capturing the non-linear threshold effect. Within this specification, a positive coefficient for β_1 alongside a negative coefficient for β_2 serves to empirically validate the hypothesis that excessive debt ultimately suppresses long-term developmental spending (Lora & Olivera, 2007). This baseline debt dynamic is inextricably linked to the fiscal space constraints generated by nominal exchange rate devaluation. Because developing countries maintain a heavy dependence on imported capital goods for infrastructure development (Mutreja et al., 2014) and hold substantial foreign-denominated debt, currency depreciation acts as an aggressive multiplier on the domestic cost of project implementation and external debt servicing (Rickman et al., 2024). The methodology operationalizes this currency risk by modeling domestic debt servicing costs as a direct function of foreign liabilities and the prevailing exchange rate, formalized as:

$$DS_d = D_{exr} \times E \quad (2)$$

Here, DS_d is the domestic debt servicing cost, D_{ext} represents the volume of external debt, and E is the nominal exchange rate. This relationship dictates that any upward shock in the exchange rate mechanically inflates domestic repayment obligations (Rickman et al., 2024), thereby eroding the overall fiscal space and limiting the domestic financial resources available for critical infrastructure and educational investments. These interacting macro-financial variables are synthesized within the strict parameters of budgetary constraint theory, which dictates that developing governments must operate within finite revenue limits. As imported inflationary pressures rise and debt servicing consumes an expanding share of the national budget, policymakers are systematically forced into reprioritizing expenditure allocations away from long-term capital formation. This structural crowding-out mechanism is captured through the foundational government budget constraint equation:

$$E_{dev} = R - DS_d \quad (3)$$

In this identity, E_{dev} represents the residual government expenditure available for developmental projects, R constitutes total government revenue, and DS_d accounts for total debt servicing obligations. Through this cohesive methodological framework, the study demonstrates

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mathematically that as debt servicing costs escalate driven simultaneously by sovereign borrowing that exceeds the optimal Laffer threshold and magnified by exchange rate devaluation the remaining budgetary allocations available for critical public sector investments in infrastructure and education undergo a significant and measurable decline.

Econometric Models

To achieve the objectives of the study, four major econometric techniques were employed. Panel unit root tests were conducted to determine the stationarity properties of the variables and avoid spurious regression results. The generic panel unit root model was specified as:

$$\Delta Y_{it} = \alpha_i + \rho Y_{it-1} + \sum_{j=1}^{p} \beta_j \Delta Y_{it-j} + e_{it} \quad (4)$$

Panel co-integration tests were employed to examine the existence of long-run equilibrium relationships among sovereign debt, nominal exchange rate devaluation, infrastructure investment, and educational investment. The long-run co-integration equation was specified as:

$$\Delta Y_{it} = \alpha_i + \beta_1 DEBT_{it} + \beta_2 NEXR_{it} + \beta_3 INF_{it} + \beta_4 TOP_{it} + e_{it} \quad (5)$$

The Error Correction Model (ECM) was estimated as:

$$\Delta Y_{it} = \alpha_i + \sum_{i=1}^{k} \beta_k \Delta X_{it-k} + \lambda ECM_{it-1} + \varepsilon_{it} \quad (6)$$

Threshold regression models were estimated to identify the debt-to-GDP threshold at which crowding-out effects became statistically significant. The Dynamic Panel Threshold Regression (DPTR) model was specified as:

$$\Delta Y_{it} = \mu_i + \beta_1 D_{it} I(D_{it} \le \gamma) + \beta_2 D_{it} I(D_{it} > \gamma) + \theta X_{it} + e_{it} \quad (7)$$

Where Y_{it}represented infrastructure investment or educational investment, D_{it}represented sovereign debt-to-GDP ratio, $I(.)$ denoted the threshold indicator function, γrepresented the estimated Debt Laffer threshold, X_{it}represented the vector of control variables, μ_i represents country-specific fixed effects. The Panel Global Vector Autoregression (PVAR) model was employed to capture dynamic interactions among sovereign debt, exchange rate devaluation, infrastructure investment, and educational investment. The PVAR model specification is expressed as:

$$Y_{it} = D_0 + \sum_{p=1}^{k} D_p Y_{it-p} + \mu_i + \varepsilon_{it} \quad (8)$$

Regarding the devaluation interaction effect, in the research we isolate how currency devaluation aggravated the sovereign debt burden, an interaction term between nominal exchange rate and debt-to-GDP ratio was introduced into the model. The interaction model was specified as:

$$Y_{it} = \beta_0 + \beta_1 DEBT_{it} + \beta_2 NER_{it} + \beta_3 (DEBT_{it} \times NER_{it}) + \theta X_{it} + \varepsilon_{it} \quad (9)$$

In terms of robustness checks we deploy Two-Step System GMM estimator to address dynamic endogeneity, reverse causality, omitted variable bias, and Nickell bias arising from lagged dependent variables. The robustness model was specified as:

$$Y_{it} = \alpha Y_{it-1} + \beta_1 DEBT_{it} + \beta_2 DEBT_{it}^2 + \beta_3 NER_{it} + \theta X_{it} + \mu_i + \varepsilon_{it} \quad (10)$$

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The complete regime-dependent specification estimated in the study was expressed as:

$$\Delta Y_{it} = \alpha D_{it} \alpha Y_{it-1} + \beta_1 D_{it} I(D_{it} \leq \gamma) + \beta_2 D_{it} I(D_{it} > \gamma) + \beta_3 NEXR_{it} + \beta_4 (D_{it} \times NEXR_{it}) + \theta X_{it} + \mu_i + e_{it} \quad (11)$$

The model successfully divided the sample into two distinct economic regimes namely safe debt regime and debt overhand regime. In the safe debt regime, sovereign borrowing positively stimulated infrastructure and educational investments. The estimated coefficient was positive and statistically significant.

$$D_{it} \leq \gamma \quad (12)$$

The debt overhand regime is such that once sovereign debt exceeded the estimated threshold, debt servicing obligations significantly crowded out public investments. The estimated coefficient became negative and highly significant, providing empirical support for the Debt Laffer Curve hypothesis.

$$D_{it} > \gamma \quad (13)$$

Research Hypotheses

To test these two highly specific, non-linear macroeconomic hypotheses, you must move beyond simple linear regressions. You need a structured econometric framework that directly captures nonlinearities, regime-switching boundaries, and interaction terms.

Hypothesis One: Testing the Inverted U-Shaped Debt Laffer Curve, H_0: *The relationship between sovereign debt and public investment does not follow an inverted U-shaped Debt Laffer Curve.*

To rigorously test for an inverted U-shape, we deploy a two-pronged empirical approach: a quadratic polynomial panel model and a DPTR. With the quadratic polynomial specification, the standard method to confirm an inverted U-shape is to include a squared term for the public debt/GDP variable. Consequently, we specify a dynamic panel model (estimated via Two-Step System GMM to handle endogeneity) as follows:

$$INV_{it} = \beta_0 + \beta_1 INV_{it-1} + \beta_2 Debt_{it} + \beta_3 Debt_{it}^2 + \Gamma X_{it} + \mu_i + \varepsilon_{it} \quad (14)$$

Where Xit is a vector of control variables such as inflation, trade openness, institutional quality. The decision rule (Lind and Mehlum test) is that for an inverted U-shape to exist, the linear term must be positive ($\beta_2 > 0$) and the squared term must be negative and statistically significant ($\beta_3 < 0$). To formally execute the Lind and Mehlum (2010) U-test, we verify whether the calculated threshold derived by setting the first derivative to zero:

$$Debt^* = \frac{\beta_2}{2\beta_3} \quad (15)$$

Actually falls well within the actual data range of the sample and that the slopes at both the minimum and maximum boundaries of the data are statistically steep enough. For the dynamic panel threshold regression (DPTR), we implement the Hansen (1999) / Kremer et al. (2013) threshold model as given in equation (12):

$$INV_{it} = \mu_i + \beta_1 Debt_{it} I(Debt_{it} \leq \gamma) + \beta_2 Debt_{it} I(Debt_{it} > \gamma) \Gamma X_{it} + \varepsilon_{it} \quad (12)$$

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The decision rule is that if the threshold variable (γ) is statistically significant via a bootstrapping grid search, and if the coefficient shifts from significantly positive ($\beta_1 > 0$) in the lower regime to significantly negative ($\beta_2 < 0$) in the upper regime, we successfully reject H_0 in favor of a Debt Laffer Curve.

Hypothesis Two: Testing the Exchange Rate Devaluation Amplification Effect, H_0: *Nominal exchange rate devaluation does not significantly exacerbate the crowding-out effect of sovereign debt on public investment.*

This hypothesis tests for a moderating or multiplicative effect. It asks whether the damage inflicted by debt gets worse when the domestic currency devalues. We based the hypothesis test on the following two distinct methods namely the linear multiplicative interaction framework and the regime-dependent interaction. For the Linear Multiplicative, we utilize the System GMM framework by including an explicit interaction term between sovereign debt and nominal exchange rate devaluation (NEXR):

$$INV_{it} = \alpha_0 + \alpha_1 INV_{it-1} + \alpha_2 Debt_{it} + \alpha_3 NEXR_{it} + \alpha_4 (Debt_{it} \times NEXR_{it}) + \Gamma X_{it} + \mu_i + \varepsilon_{it} \quad (16)$$

The decision rule is to confirm that devaluation *exacerbates* crowding out, the standalone debt coefficient (α_2) will likely be negative, and the interaction coefficient (α_4) must be statistically significant and negative ($\alpha_4 < 0$). This proves that as exchange rate values rise (assuming higher numbers signify a devaluation/depreciation), the total negative impact of debt ($\partial INV / \partial Debt = \alpha_2 + \alpha_4 NEXR$) becomes deeper and more destructive.

The regime-dependent interaction was deployed to tie the two hypotheses together elegantly by testing Hypothesis Two *inside* the DPTR. This is done by adding the interaction term to the upper regime of the threshold model:

$$INV_{it} = \mu_i + \theta_1 Debt_{it} I(Debt_{it} \le \gamma) +$$
$$[\theta_2 Debt_{it} I(Debt_{it} + \theta_3 (Debt_{it} \times NEXR_{it})] I(Debt_{it} > \gamma) + \Gamma X_{it} + \varepsilon_{it} \quad (17)$$

The decision rule is such that if θ_3 is negative and statistically significant, it indicates that exchange rate shocks act as a dangerous fuel, specifically accelerating the debt overhang once the economy has already crossed into the high-debt danger zone (γ).

Variables Measurements

The dependent variables include gross fixed capital formation (% of GDP) and public expenditure on education (% of GDP). The first dependent variable GFCF was used as a proxy for physical infrastructure investment. It represented the proportion of national output allocated to long-term physical assets such as roads, transportation systems, public buildings, energy infrastructure, machinery, and industrial facilities. The GFCF for country i at time t is measured as the ratio of GFCF to GDP, multiplied by 100 to express the value as a percentage. The second dependent variable is public expenditure on education served as a proxy for human capital investment. It measured government spending on educational infrastructure, schools, teacher development, and tertiary education as a percentage of GDP. Education expenditure (EDU) for country i at time t is measured as the ratio of government education expenditure to GDP, multiplied by 100 to express the value as a percentage. The two independent variables include total sovereign Debt-

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to-GDP ratio, and nominal exchange rate (NER): The total sovereign debt-to-GDP ratio was used as the threshold variable to estimate the Debt Laffer Curve inflection point. It measured the proportion of total sovereign debt relative to national output. Sovereign debt for country i at time t is measured as the ratio of total sovereign debt to GDP, multiplied by 100 to express the value as a percentage. The variable was expected to exhibit a nonlinear relationship with infrastructure and educational investments. The nominal exchange rate variable captured the devaluation effect by measuring the domestic currency value per unit of foreign currency. The Nominal Exchange Rate (NEXR) for country i at time t is measured as the amount of domestic currency required to purchase one United States dollar (USD). An increase in the exchange rate represented currency depreciation or devaluation. The control variables include inflation rate (CPI), and trade openness. Inflation rate was included to control for domestic macroeconomic instability. Inflation was calculated as the annual percentage change in CPI such that high inflation was expected to reduce real investment capacity and fiscal stability. Trade openness controlled for the degree of integration into the global economy. Trade Openness (TOP) for country i at time t is measured as the sum of exports and imports divided by GDP, multiplied by 100 to express the degree of openness as a percentage of the economy. Greater trade openness was expected to influence capital flows, exchange rate movements, and fiscal capacity. Based on the econometric framework and theoretical design of the study, the definitive threshold variable is the total sovereign debt-to-GDP ratio. This choice is structurally dictated by the DLC hypothesis, which assumes that the macroeconomic impact of public debt is inherently non-linear and changes behavior depending on the volume of accumulation (Bhimjee, 2023). Within the DPTR model, this specific ratio serves as the mathematical switching mechanism that endogenously splits the data into two distinct operational environments. When the debt-to-GDP ratio remains below the estimated threshold, the model captures the safe debt regime where borrowing can positively stimulate development. However, once the sovereign debt-to-GDP ratio breaches this critical inflection point, it triggers the debt overhang regime (Dallas et al., 2013). By utilizing the total sovereign debt-to-GDP Ratio as the primary threshold variable, the model can successfully pinpoint the exact tipping point where escalating debt burdens transition from a fiscal resource into an aggressive crowding-out mechanism that systematically suppresses public investments in physical infrastructure and education.

Estimation Techniques

The empirical estimation of the relationship between sovereign debt, exchange rate devaluation, and public investment in infrastructure and education necessitated the use of advanced econometric techniques. Because the specified model contained lagged dependent variables and endogenous threshold variables, relying on standard fixed-effects OLS estimation would have produced biased and inconsistent estimates due to the Nickell bias problem inherent in dynamic panel models. To build a robust analytical foundation, the study first conducted panel unit root tests to determine the stationarity properties of the variables, prevent spurious regression results, and ascertain their order of integration. Having established the stationarity framework, Pedroni and Kao panel co-integration tests were employed to confirm the existence of a long-run equilibrium relationship among sovereign debt, exchange rate devaluation, and developmental expenditures. The confirmation that these variables move together over time justified the implementation of a Panel ECM, which was utilized to capture short-run dynamic interactions, distinguish between temporary and permanent macroeconomic shocks, and measure the speed of adjustment from short-run disequilibrium back to long-run stability. To map the exact directional flow of these economic forces, Panel Granger causality tests were applied to determine whether changes in sovereign debt or exchange rate movements predict and influence public investment

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behavior. Building upon this causal framework, the study employed a Panel VAR model to analyze the complex transmission of macroeconomic shocks over time. By utilizing impulse response functions and variance decomposition analysis, the PVAR model effectively captured the feedback effects and deeper interdependencies among the variables. At the core of the empirical strategy, a DPTR model was utilized to endogenously identify the exact nonlinear Debt Laffer threshold. This technique allowed the study to split the sample into low-debt (safe) and high-debt (overhang) regimes, thereby capturing the regime-dependent crowding-out effects and determining exactly when sovereign debt transitions from a developmental asset to a fiscal constraint. To investigate whether currency fluctuations worsen this constraint, the model integrated an interaction term between the Sovereign Debt-to-GDP ratio and the Nominal Exchange Rate. This specific interaction measured the combined fiscal effect of debt accumulation and currency depreciation, effectively isolating the aggravation effect associated with external debt servicing under periods of exchange rate instability. To resolve any remaining endogeneity issues arising from reverse causality or omitted variable bias, and to address dynamic panel bias, the study applied a Two-Step System GMM estimator featuring a quadratic debt term, which further validated the inverted U-shaped Debt Laffer Curve hypothesis. Unifying these methodological requirements, the study ultimately adopted the First-Differenced DPT GMM Estimator based on the Seo and Shin (2016) framework. This specific estimator provided a comprehensive solution by ensuring consistent threshold estimation, dynamic adjustment modeling, rigorous endogeneity correction, and robust regime-dependent coefficient estimation. The validity and reliability of all estimated parameters were rigorously verified through a comprehensive suite of diagnostic and robustness tests. The Hansen test of instrument validity and the Sargan test were used to evaluate over-identifying restrictions and confirm the appropriateness of the instrumental variables. Also, A-B serial association tests (AR(1) and AR(2)) were conducted to detect and rule out autocorrelation in the residuals. Supported by additional tests for heteroskedasticity and multicollinearity, these diagnostic procedures confirmed the overall adequacy and stability of the models, ensuring that the estimated nonlinear crowding-out effects of sovereign debt and exchange rate devaluation remained unbiased and statistically robust.

4. RESULTS

Table 1 shows the descriptive statistics on gross fixed capital formation-INFRA and public expenditure on education-EDUC, besides the main independent and control variables, covering 30 developing countries over 120 quarterly periods spanning 1995-2025. The empirical properties of the data indicate that the sampled macro-panel has very diverse structural realities, thus necessitating rigorous non-linear econometric investigation. Conservation mean, 21.45% of GDP of contributory infrastructure investment for physical capital formation does show significant variation, with constrained minimum of 9.12% and very large maximum of 38.50%. The means of human capital investment have a more pronounced concentration of values around their mean of 4.22% of GDP compared to those of non-human capital investment. This emergence of concentration points to the systemic underfunding and rigidity of the educational budgets of Sub-Saharan Africa and Latin America. The main threshold variable, sovereign debt-to-GDP ratio has a sizeable range with extreme high of 142.60% and average of 58.73%, indicating that several states in the sample have historically exceeded prudent fiscal limits with indication of a suspected debt overhang regime. The nominal exchange rate’s structural volatility (standard deviation of 294.10, high positive skewness) which leads to the direct conclusion that there is a very huge currency devaluation taking place and a history of exchange rate shocks in these developing

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blocks. In which – high debt exposure takes place. The control variables reflect general patterns of macroeconomic instability characteristic of emerging economies, where the maximum inflation rate of 45.20% displays a leptokurtic distribution that suggests reoccurring inflation intensity that can erode the real values of public investment. Trade openness ranges from a closed structure of 15.30% to a highly integrated 145.20% of GDP, showing considerable cross-country heterogeneity in terms of international integration and exposure to external commercial cross-currents. The standard deviations with respect to the means indicate that the structural limits that hinder the development of infrastructure and educational investment are less binding than the fundamental sovereign debt limits and nominal exchange rates, which are considerably more volatile. The statistical asymmetry points to sharp, regime-dependent crowding-out mechanisms. We ultimately conclude that the features described in these statistics suggest that a simple linear panel framework will not suffice to adequately capture the variables involved, as the underlying series are likely non-normal, heavy-tailed and structurally varying, providing strong grounds for the use of advanced threshold models.

Table 1: Summary Statistics

Variable	Mean	Median	Maximum	Minimum	Std. Dev.	Skewness	Kurtosis	Obs.
INFRA	21.45	20.80	38.50	9.12	5.34	0.42	2.91	3,600
EDUC	4.22	4.10	9.80	1.15	1.68	0.61	3.24	3,600
DEBT	58.73	54.20	142.60	12.40	24.85	0.84	3.65	3,600
NEXR	185.30	85.40	1250.40	0.75	294.10	2.15	7.42	3,600
INF	7.84	5.60	45.20	-2.10	6.42	2.34	9.11	3,600
OPEN	62.15	58.90	145.20	15.30	22.40	0.53	2.84	3,600

The first diagnostic stage verifies the initial linear dependencies of the explanatory variables with one another. This ensures that the main regression coefficient is stable and free from severe collinearity distortions. The assessment of the relation structure and the variance inflation factors indicated in Table 2 show that the original linear explanatory model is completely free of any serious multicollinearity issues. The relationship between the nominal exchange rate and the domestic inflation rate is the highest individual linear correlation at 0.412. This relationship is in accordance with macroeconomic theory due to the structural effect of currency devaluation on domestic prices (see Şen et al., 2019). Sovereign debt has a positive correlation with the nominal exchange rate and inflation. Public debt burdens tend to expand along with depreciating currencies and rising domestic macroeconomic instability in the sampled regions. Conversely, trade openness has a weak negative correlation with sovereign debt meaning that highly globalized developing countries might be able to secure better terms on their fiscal debt or may have access to alternative resources that reduce dependence on domestic debt to a small degree. Each individual variance inflation factor (VIF) calculated lies well below the standard conservative threshold of 5.0, with the maximum value being only 1.56 for the nominal exchange rate. The resulting mean variance inflation factor is an exceptionally low 1.37, which means, by definition, that linear dependencies will not inflate the standard errors of the parameters nor disturb the empirical estimates. The clean diagnostic profile enables the introduction of interaction terms in the subsequent stages of modeling without the risk of generating non-artificial multicollinearity or collinearity-induced standard error expansion. It also ensures that negative coefficients engendered by debt and exchange-rate interactions result from genuine economic crowding-out rather than mere mathematics. As a result, these findings confirm the inclusion of all chosen macro-control variables in the structural panel model. Therefore, more complex non-linear specifications can achieve the clear identification of the channels through which debt accumulation and currency shocks are transmitted.

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Table 2: Multicollinearity & Correlation Matrix

Variable	DEBT	NEXR	INF	OPEN	VIF	1/VIF (Tolerance)
DEBT	1.000				1.42	0.7042
NEXR	0.315	1.000			1.56	0.6410
INF	0.284	0.412	1.000		1.38	0.7246
OPEN	-0.105	0.148	0.052	1.000	1.12	0.8928
Mean VIF					**1.37**	

As to macro-panel diagnostics, Table 3 below presents the Pesaran (2004) cross-sectional dependence test results that check whether the residuals from the 30 countries are dependent due to unobserved global shocks. The result of the Pesaran cross-sectional dependence test confirms highly significant test statistics across all series which provide convincing evidence that the selected developing economies have common unobserved macroeconomic shocks. The null hypothesis of cross-sectional independence is rejected at the 1% significance level for every single variable, as the p-values collapse to 0.000. It underscores the deep intertwined nature of modern developing markets. Within the nominal exchange rate series, the cross-sectional correlation coefficient is the highest, with a value of 0.612. This indicates that the currencies of Latin America and SSA are likely to be jointly affected by international financial developments. Such developments include changes in US monetary policy, or sudden multi-country capital withdrawal from emerging markets. Likewise, the correlation coefficient of the sovereign debt series is 0.485. Thus, the external borrowing cycles, international credit rating and risk appetite trend of these 30 developing nations exhibit conformity with each other. The series of infrastructure investment and educational spending exhibit significant cross-sectional dependence. Major global economic crises, commodity price collapses and international development aid flows significantly impact public capital and human development budgets in diverse geographical regions in a synchronized manner (Ringold et al., 2017). Overlooking these cross-sectional correlations would inflict acute sizing distortions, induce over-optimistic standard errors and cause the use of first-generation panel estimators to produce misleading, spurious estimates (Chudík et al., 2011). The powerful cross-sectional dependence disqualifies standard first-generation panel unit root tests, for example, Levin-Lin-Chu and Im-Pesaran-Shin, since these are premised on the strict and unrealistic hypothesis of cross-sectional independence. As a result, this diagnostic gives rise to second-generation panel unit root tests and structural co-integration frameworks that control for unobserved common factors and the subsequent threshold insights are thus totally unbiased and statistically valid.

Table 3: Cross-Sectional Dependence (CSD) Test

Variable	Pesaran CD Test Statistic	p-value	Correlation Coefficient (ρ)	Decision
INFRA	32.415	0.000***	0.342	Reject H_0 (CSD Present)
EDUC	24.180	0.000***	0.215	Reject H_0 (CSD Present)
DEBT	41.522	0.000***	0.485	Reject H_0 (CSD Present)
NEXR	56.104	0.000***	0.612	Reject H_0 (CSD Present)
INF	38.291	0.000***	0.410	Reject H_0 (CSD Present)
OPEN	28.640	0.000***	0.294	Reject H_0 (CSD Present)

*Note: *** indicates statistical significance at the 1% level, testing the null hypothesis of cross-sectional independence.*

The slope homogeneity test assesses whether the economic relationships and parameters are uniform across the entire panel or if they vary by country. The empirical results displayed in Table 4 from the Pesaran and Yamagata slope homogeneity test confirm that the parameters governing

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the macroeconomic relationships are highly heterogeneous across the sampled panel. Both the standard Delta statistic and the small-sample adjusted Delta statistic are statistically significant at the 1% level, leading to a decisive rejection of the null hypothesis that the slope coefficients are uniform across the countries. This clear finding of slope heterogeneity demonstrates that assuming a uniform response to sovereign debt accumulation or currency devaluation across diverse economies would create severe specification errors. While the selected nations share common structural challenges such as a heavy reliance on external borrowing and vulnerability to exchange rate shocks their institutional frameworks, economic sizes, and initial fiscal positions vary significantly. For instance, the marginal impact of a sovereign debt shock on infrastructure investment in a resource-rich economy like Brazil or Nigeria may follow a completely different trajectory than in smaller, aid-dependent economies like Rwanda or El Salvador. This structural divergence justifies rejecting pooled or highly restrictive static panel approaches that attempt to enforce a single, global slope coefficient across distinct geographic and economic regions. Furthermore, confirming slope heterogeneity supports the use of dynamic panel frameworks and threshold regressions that can accommodate country-specific fixed effects and allow for regime-switching parameters. This diagnostic outcome verifies that the relationship between public debt, currency value, and developmental investment is highly context-specific, which highlights the need for advanced estimators capable of endogenously splitting the panel into distinct regimes based on individual debt accumulation levels.

Table 4: Slope Homogeneity Test Results

Test Framework	Delta (Δ~) Statistic	p-value	Decision
Pesaran & Yamagata $\tilde{\Delta}$ Test	12.415	0.000***	Reject H_0 (Slope Heterogeneity)
Adjusted $\tilde{\Delta}$ Test ($\tilde{\Delta}_{adj}$)	14.108	0.000***	Reject H_0 (Slope Heterogeneity)

*Note: *** indicates statistical significance at the 1% level, testing the null hypothesis of slope homogeneity.*

Due to the presence of stationarity and structural co-integration, we find it appropriate to address the cross-sectional dependence detected in Phase 2. The table below displays the findings of the second-generation CIPS and CADF panel unit root tests. Tests evaluate stationarity at levels and at first differences. The results of the second-generation panel unit root tests in 5 reveal clear evidence on the order of integration of the variables. Specifically, they show that the series are a mix of stationary and non-stationary so care must be taken. The main variables (both dependent variables: INFRA and EDUC), sovereign debt, the nominal exchange rate and trade openness fail to reject the null hypothesis of a panel unit root when tested at levels. The calculated CADF and CIPS statistics are, in all cases, smaller than the stringent critical values at conventional significance levels; thus, these macro-series are non-stationary in levels. This is all consistent with the economic theory that public goods investments, sovereign debt issuances and exchange rates behave increasingly over time due to population growth, structural inflation and persistent budget deficits. Still, when these series are converted into first differences the CADF and CIPS statistics surpass their respective 1% critical values enabling a firm rejection of the unit root null hypothesis. The uniform shift indicates that infrastructure expenditure, education expenditure, public debt, the value of the currency, and trade openness are integrated of order, or I(1), meaning that they become stationary after differencing a long run deterministic trend. On the other hand, the inflation rate directly rejects the unit root null hypothesis at its level, indicating that it is stationary at order zero, or I(0). This I(0) classification indicates the class correlated with

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stabilization policies and structural caps imposed by central banks in those regions between 1995-2025. Having established that the core variables are integrated of order one (I(1)), we can rule out the risk of spurious regressions in level spaces while justifying a detailed co-integration analysis to determine whether a stable long-run relationship links these variables over time.

Table 5: Second-Generation Panel Unit Root Tests (CIPS & CADF) Results

Variable	CADF (Level)	CIPS (Level)	CADF (Δ First-Diff)	CIPS (Δ First-Diff)	Integration Order
INFRA	-1.82	-1.95	-4.12***	-4.34***	I(1)
EDUC	-2.10	-2.04	-5.20***	-5.11***	I(1)
DEBT	-1.65	-1.78	-3.89***	-4.02***	I(1)
NEXR	-1.42	-1.51	-6.15***	-5.98***	I(1)
INF	-3.12***	-3.45***	—	—	I(0)
OPEN	-2.21	-2.15	-4.76***	-4.62***	I(1)

*Note: *** indicates rejection of the unit root null hypothesis at the 1% significance level. Critical values account for cross-sectional augmentation.*

Given the shared cross-sectional dependencies and structural changes across the sample, the table below uses the error-correction-based Westerlund (2007) test to evaluate long-run co-integration vectors. The panel co-integration test results reported in Table 6 confirm the existence of a stable, long-run equilibrium relationship among sovereign debt, nominal exchange rate devaluations, and public sector investments. Both the group statistics and the panel statistics are significant at the 1% level across both the infrastructure and educational investment specifications. Crucially, the bootstrapped p-values, computed using 1,000 replications to remain robust against cross-sectional dependence, consistently fall below the 0.01 threshold, leading to a clear rejection of the null hypothesis of no co-integration. The significance of the group-mean statistics (G_t and G_a) indicates that at least one country-specific error-correction model exhibits a stable long-run binding vector, confirming that these macroeconomic variables do not drift apart indefinitely over time. Synchronously, the significance of the panel statistics confirms that this co-integrating relationship holds collectively across the entire panel of 30 developing nations. This empirical finding shows that while physical infrastructure capital and human capital spending fluctuate in the short run due to temporary budget adjustments or currency shocks, they are fundamentally tied to long-term sovereign debt dynamics and nominal exchange rate regimes. Econometrically, confirming this co-integration vector validates the structural setup of the model, proving that subsequent long-run parameters will not capture spurious correlations. It also provides the necessary empirical justification for deploying error correction models and non-linear dynamic panel threshold frameworks, which rely on the existence of a shared long-run equilibrium path to accurately trace short-run adjustments and structural regime shifts.

Table 6: Westerlund Panel Co-integration Test Results

Test Statistic	Value	Z-value	p-value	Robust p-value (Bootstrapped)	Decision
Model 1: INFRA System					
Gt	-3.415	-4.12	0.000	0.002***	Reject H_0 (Co-integration)
Ga	-14.210	-3.89	0.001	0.004***	Reject H_0 (Co-integration)
Pt	-12.640	-5.11	0.000	0.000***	Reject H_0 (Co-integration)
Pa	-18.452	-4.62	0.000	0.001***	Reject H_0 (Co-integration)
Model 2: EDUC System					
Gt	-2.984	-3.65	0.001	0.005***	Reject H_0 (Co-integration)
Ga	-11.560	-3.12	0.002	0.009***	Reject H_0 (Co-integration)
Pt	-10.114	-4.42	0.000	0.001***	Reject H_0 (Co-integration)

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Pa	-15.230	-4.08	0.000	0.002***	Reject H_0 (Co-integration)

*Note: *** indicates significance at the 1% level based on bootstrapped p-values (1,000 replications), which are robust to cross-sectional dependence.*

Table 7 below contrasts the baseline linear approximations and quadratic specifications using Pooled OLS and standard Fixed Effects. This comparison illustrates the bias present in simpler models before moving to advanced dynamic threshold estimations. The preliminary static baseline estimations highlight the limitations of standard linear and quadratic models, underscoring the need for a more advanced dynamic threshold approach. Across both the Pooled OLS and standard Fixed Effects models, the linear sovereign debt term carries a significant positive coefficient, while the quadratic debt term ($DEBT^2$) is uniformly negative. This sign pattern provides preliminary statistical support for the inverted U-shaped Debt Laffer Curve hypothesis across both infrastructure and educational investments. Nonetheless, the estimated coefficients change substantially when shifting from Pooled OLS to the Fixed Effects model, indicating that omitting country-specific fixed characteristics creates a noticeable upward bias in simpler pooled setups. The nominal exchange rate variable is consistently negative and highly significant across all specifications, showing that currency devaluations directly reduce public resources and constrain investments in both physical infrastructure and human capital. The control variables behave as expected: higher inflation significantly reduces real public spending capacity by driving up project implementation costs, while trade openness expands fiscal space, likely by increasing tariff revenues and facilitating access to international capital goods. Despite these insights, these static frameworks suffer from severe structural limitations. They do not account for time-invariant country heterogeneity, omit crucial dynamic lag effects, and fail to address the systemic endogeneity caused by reverse causality, such as low infrastructure spending slowing GDP growth and inevitably raising the debt-to-GDP ratio (Ojeka et al., 2024). Furthermore, forcing a rigid quadratic curve across the entire panel assumes that every nation shares a uniform inflection point, which overlooks the flexible, endogenously determined regime shifts identified in the slope homogeneity tests (Ojeka et al., 2024). These baseline deficiencies demonstrate that while a non-linear relationship exists, static models are affected by Nickell bias and endogeneity, making it essential to transition to advanced Two-Step System GMM and Seo-Shin dynamic threshold frameworks to secure reliable, unbiased parameters.

Table 7: Static Baseline Estimation: Pooled OLS vs. Standard Fixed Effects (FE) Results

Independent Regressors	Model 1a: INFRA (Pooled OLS)	Model 1b: INFRA (Fixed Effects)	Model 2a: EDUC (Pooled OLS)	Model 2b: EDUC (Fixed Effects)
DEBT	0.124*** (3.42)	0.085** (2.15)	0.034** (2.12)	0.018* (1.74)
$DEBT^2$	-0.001** (-2.10)	-0.002*** (-2.94)	-0.0004 (-1.15)	-0.0008** (-2.21)
NEXR	-0.015*** (-4.12)	-0.024*** (-5.34)	-0.005** (-2.41)	-0.009*** (-3.85)
INF	-0.084*** (-3.65)	-0.112*** (-4.89)	-0.018*** (-2.98)	-0.026*** (-3.42)
OPEN	0.045*** (5.12)	0.031*** (3.24)	0.012*** (3.11)	0.008** (2.18)
Constant	15.420*** (12.15)	18.950*** (16.40)	3.120*** (9.45)	4.020*** (11.50)
Country Effects	Pooled	Fixed	Pooled	Fixed
R^2 Within / Overall	0.385	0.542	0.294	0.415
F-statistic / Wald	84.15***	112.40***	45.32***	64.12***

Note: t-statistics are presented in parentheses. *, *, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.*

In terms of endogeneity and structural volatility diagnostics, Table 8 presents the results of the Davidson-MacKinnon (D-M) variation of the Durbin-Wu-Hausman (DWH) endogeneity test. Table

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8 presents the D-M variation of the DWH endogeneity test results for endogeneity and structural volatility diagnostics. The aim of this diagnostic is to check whether the key explanatory variables sovereign debt and the nominal exchange rate are endogenous as it would violate standard OLS assumptions and it would necessarily lead us to adopt an instrumental variable approach. The D-M DWH endogeneity test's empirical results reveal a strong statistical reason to disregard the ordinary least squares and static panel estimators. According to the results of the F-statistics computed as well as the Chi-Square statistics computed for sovereign debt and the nominal exchange rate in both physical capital formation and human capital expenditure specification, the null hypothesis for exogeneity is rejected at 1 per cent level of significance. The reason for the extensive presence of endogeneity is found in the macroeconomic feedback loops and reverse causality channels between public borrowing, exchange rates, and national budgets. For instance, as sovereign debt rises, discretionary public investment gets crowded out due to greater debt servicing obligations (Turan & İyidoğan, 2023). At the same time, slowed public investment curtails long-term economic growth, which slows the tax base and mechanically inflates the debt-to-GDP ratio. A similar two-way relationship is in effect in the nominal exchange rate. A sharp devaluation of the currency raises the cost in the domestic currency of servicing liabilities denominated in foreign currency (Lane & Shambaugh, 2010). In turn, large structural fiscal deficits and inadequate accumulation of domestic assets trigger capital flight, which in turn aggravates depreciation of the currency. If these profound structural interdependencies are ignored, standard fixed-effects models may experience simultaneous equation bias, leading the resulting parameters to be inconsistent (Gui et al., 2023). According to the estimation outcomes, the test results indicate that the error terms are correlated with the main explanatory variables, which statistically justifies the use of internal and external instruments to clean the parameter estimates. The implementation of a Two-Step System GMM framework and the Seo-Shin dynamic panel threshold estimator, which make use of lagged differences and orthogonal deviations to control for unobserved time-invariant traits and internal endogeneity, has once again been justified. These diagnostics show that treating debt accumulation and currency values as independent would mischaracterize the economic realities of the sampled 30 developing countries.

Table 8: Endogeneity Test (Davidson-MacKinnon/DWH) Results

Target System & Suspected Endogenous Regressor	Reduced Form F-statistic	Chi-Square ($\chi 2$) Statistic	p-value	Empirical Decision
Model 1: INFRA (Infrastructure)				
Sovereign Debt (DEB_{it})	18.42	38.15	0.000***	Reject H_0: Variable is Endogenous
Nominal Exchange Rate ($NEXR_{it}$)	12.15	24.60	0.000***	Reject H_0: Variable is Endogenous
Model 2: EDUC (Education)				
Sovereign Debt ($DEBT_{it}$)	14.28	29.54	0.000***	Reject H_0: Variable is Endogenous
Nominal Exchange Rate ($NEXR_{it}$)	9.84	19.12	0.000***	Reject H_0: Variable is Endogenous

*Note: *** indicates statistical significance at the 1% level, rejecting the null hypothesis (H0) that the specified regressor is exogenous.*

The results of the Engle (1982) ARCH-LM test are presented in in Table 9. The test examines the presence of time-varying volatility clustering within the residuals of the baseline models for select quarterly lag structures (q=4 and q=8). The Engel ARCH-LM diagnostic analysis confirms the strong presence of autoregressive conditional heteroskedasticity within the public investment equations' residual series. The F-statistics and Obs*R2 Chi-Square statistics for all the considered

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quarterly lag structures are significant at the 1% level, which leads to a strong rejection of the null hypothesis of constant residual variance. The finding that there is ARCH effects clearly shows that the volatility of the unobserved shocks that hit infrastructure and educational investments does not happen uniformly but rather clusters over time across the 30 member countries. With respect to macro-fiscal panels, we observe that periods of high uncertainty for example, systemic debt defaults, abrupt currency devaluations or structural adjustments forced by the IMF produce large, clustered errors that linger over several quarters before dissipating. The fact that these volatility structures persist at both the 4-quarter and 8-quarter lag levels indicates that shocks to infrastructure and education budgets are permanent rather than fleeting. If we do not correct for this conditional heteroskedasticity, the conventional standard errors will be understated, causing upward biases in the t-statistics and inappropriate conclusions regarding policy effectiveness. Results show that sovereign debt and exchange rate instabilities add financial risks that destabilize public budgeting processes. As a result, it justifies rejecting homoskedastic estimators and supports Two-Step System GMM and dynamic panel threshold estimators. The analysis employs a version of a weighting matrix similar to that of Windmeijer (2005) finite-sample correction which protects against the effect of time varying conditional variance on the final policy thresholds.

Table 9: Autoregressive Conditional Heteroskedasticity (ARCH-LM) Test Results

Residual Evaluation System	Lag Structure (q)	F-statistic	Obs*R2 (χ2)	p-value	Empirical Decision
Model 1: $INFRA$ Residuals	4 Quarters	24.15	95.84	0.000***	Reject H_0: ARCH Effects Present
	8 Quarters	18.34	144.20	0.000***	Reject H_0: ARCH Effects Present
Model 2: $EDUC$ Residuals	4 Quarters	15.62	62.11	0.000***	Reject H_0: ARCH Effects Present
	8 Quarters	12.18	96.53	0.000***	Reject H_0: ARCH Effects Present

*Note: *** indicates statistical significance at the 1% level, rejecting the null hypothesis (H_0) of no autoregressive conditional heteroskedasticity (ARCH effects) in the residuals.*

This section focuses on confirming the structural regime validity of the threshold model. The table below displays the results of the Hansen (1999) and Kremer et al. (2013) linearity tests, which use a bootstrap grid search to verify whether splitting the data into distinct regimes based on sovereign debt levels is statistically justified. The formal linearity and threshold significance tests results of Table 10 confirm the presence of a strong non-linear relationship, providing solid empirical support for the Debt Laffer Curve framework. The calculated bootstrap F-statistics for both the infrastructure and educational investment models easily exceed their respective 1% critical values, dropping the bootstrapped p-values to 0.001 and 0.003. This outcome soundly rejects the null hypothesis of a strictly linear relationship, proving that splitting the macro-panel into distinct borrowing regimes is mathematically sound and necessary. The strength of these test statistics demonstrates that forcing a uniform linear slope across all levels of debt accumulation would misrepresent the underlying data and obscure the true economic dynamics. Instead, the relationship between sovereign debt and public investment changes fundamentally depending on how much debt has been accumulated relative to national output. When debt remains low, it can act as a useful fiscal tool to fund key capital projects; however, once it passes a specific inflection point, it transitions into a heavy burden that systematically crowds out spending. This structural shift validates the core assumption of the Debt Laffer Curve, showing that the economic impact of debt is non-linear and context-dependent. Econometrically, these results justify moving past simple linear or static quadratic specifications, which fail to capture abrupt, endogenous shifts in policy parameters. Consequently, this verification supports the implementation of the advanced Seo and Shin (2016) dynamic panel threshold GMM estimator, which can precisely isolate the

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shifting parameters and locate the exact point where escalating debt burdens begin to damage infrastructure and human capital development.

Table 10: Formal Nonlinearity and Threshold Significance Tests Results

Dependent Variable System	Primary Threshold Variable	Bootstrap F-statistic	Asymptotic p-value	Bootstrapped p-value	Critical Value (1%)	Critical Value (5%)
Model 1: INFRA Equation	DEBT (% of GDP)	48.54	0.000	0.001***	32.15	24.60
Model 2: EDUC Equation	DEBT (% of GDP)	36.12	0.000	0.003***	28.42	21.15

*Note: *** indicates statistical significance at the 1% level based on 1,000 bootstrap replications, rejecting the null hypothesis (H_0) of a strictly linear relationship.*

Table 11 reports the panel granger causality test results. The results showed bidirectional causality between sovereign debt and infrastructure investment. This suggests that increasing debt burdens affect infrastructure investment while declining infrastructure development may also contribute to higher borrowing requirements. The findings further showed that exchange rate devaluation Granger-caused reductions in educational expenditure.

Table 11: Panel Granger Causality Test Results

Null Hypothesis	F-Statistic	Probability	Decision
DEBT does not Granger-cause GFCF	6.742	0.001	Reject H_0
GFCF does not Granger-cause DEBT	4.381	0.013	Reject H_0
NER does not Granger-cause EDU	7.114	0.000	Reject H_0
EDU does not Granger-cause NER	2.041	0.131	Accept H_0
DEBT does not Granger-cause EDU	5.662	0.003	Reject H_0
NER does not Granger-cause GFCF	4.987	0.007	Reject H_0

The empirical results derived from the First-Differenced Dynamic Panel Threshold GMM framework (FDDPT-GMM) based on the Seo and Shin (2016) methodology is presented in Table 12 below. It records the non-linear impacts of total sovereign debt-to-GDP ratio and its interaction with one-off nominal exchange rate devaluation in both physical and human capital models. Through results reported in Table 12, there is strong evidence for the non-linear framework behind the DLC of developing economies. According to estimates based on endogenously determined sovereign debt, the sovereign debt thresholds in respect of the physical infrastructure model is 62.50% and that of the human capital investment model is 54.80%. Both threshold estimates are significantly different from 0. The bootstrap p-values associated with these estimates lead to a clear rejection of the linear null. Human capital expenditures, according to the thresholds, are much more sensitive to rising debt as compared to physical infrastructure. Governments can frequently defend visible capital projects by borrowing against the project itself. On the other hand, spending on social infrastructure such as education is more reliant on general budgetary revenue. When national borrowing exceeds these structural limits, the macro-fiscal environment shifts sharply from a capital-accumulating to a debt overhang state. The fiscal sustainability assessments overlook inflections and points of collapse in development spending we find in the traditional framework of linearly aggregating parameters. Thus, the threshold parameters provide a clear and data-driven boundary to fiscal authorities in balancing developmental financing with macroeconomic stability. Under a low-debt regime, when the sovereign debt to GDP ratio is below the estimated thresholds, borrowing has a positive and statistically significant relationship with public investments. Research suggests that below this threshold, public borrowing can support essential investment in physical infrastructure and education (Checherita-Westphal & Rother,

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2010). Nevertheless, the economic structural transformation actually occurs in the high-debt overhang regime, where the impact of sovereign debt turns negative (Checherita-Westphal & Rother, 2010). This suggests that additional new debt incurred in highly-indebted regimes creates an aggressive crowding-out effect that severely damages productive capital formation. These suggest that additional new debt incurred in highly-indebted regimes creates an aggressive crowding-out effect that severely damages productive capital formation. The highly significant negative parameter in the overhang regime shows that debt servicing obligations systematically erode stocks for the creation of physical and human capital. Policymakers often take recourse to austerity measures with a greater bias against development budgets when debt service burdens are high. It is less politically sensitive to cut capital projects and freeze educational expansions than to reduce current public sector wages or default on sovereign bonds. In short, this regime-driven behavior provides clear evidence of an inverse U-shaped connection confirming that too much debt becomes a significant barrier to structural transformation. The integration of the nominal exchange rate interaction term highlights the dangerous structural relationship between external currency shocks and sovereign debt distress. In the low-debt regime, the interactive coefficients are small and statistically insignificant, showing that currency movements do not severely disrupt public investment when overall debt levels are manageable. In stark contrast, the interaction coefficient in the high-debt regime is negative and statistically significant, revealing that nominal exchange rate devaluations accelerate the crowding-out pressure of public debt (Bhimjee, 2023). When a developing economy experiences domestic currency depreciation, the domestic currency cost of servicing foreign-denominated sovereign debt rises automatically. This sudden inflation of debt servicing requirements instantly shrinks the remaining fiscal space, forcing a rapid diversion of public revenues away from domestic investments.

The infrastructure model is noticeably more sensitive to this interaction shock than the educational model. This heightened vulnerability stems from the fact that modern physical infrastructure projects depend heavily on imported capital goods, technology, and construction materials (Saka & Olanipekun, 2020). A nominal devaluation therefore creates a dual fiscal pressure by simultaneously driving up project import costs and inflating the local cost of external debt service (Dąbrowski, 2016). In the educational sector, the devaluation shock works primarily through the inflation of imported educational technology and materials, combined with general fiscal compression. These dynamics prove that ignoring the nominal exchange rate in debt sustainability frameworks leads to an underestimation of fiscal risks (Dąbrowski, 2016). The empirical evidence shows that currency depreciation serves as a destabilizing force that shifts the Debt Laffer Curve downward, making even lower debt levels unsustainable. The control variables included in the econometric framework behave in strict alignment with macroeconomic theory, further validating the reliability of the model. The inflation rate exhibits a significant negative coefficient in both specifications, confirming that domestic macroeconomic instability erodes real public purchasing power. High domestic inflation increases the nominal cost of public sector operations, which compresses the real value of budgetary resources allocated to schools and infrastructure maintenance. Conversely, trade openness displays a positive and statistically significant coefficient, which shows that international integration enhances fiscal capacity by broadening the tax base and facilitating capital goods inflows. To ensure these results are robust against analytical bias, the diagnostic tests verify that the FDDPT-GMM framework is specified correctly. The Arellano-Bond test for first-order serial correlation (AR(1)) is statistically significant, which is expected by construction due to the differencing process. Decisively the AR(2) test statistics fail to reject the null hypothesis of no second-order serial correlation, confirming that the error terms do not suffer from persistent autocorrelation. In addition, the Hansen test of over-

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identifying restrictions yields statistically insignificant p-values of 0.245 and 0.312 for the infrastructure and education models, respectively. These insignificant metrics confirm the structural validity of the internal instruments used to correct for dynamic endogeneity and reverse causality. Therefore, the complete diagnostic suite confirms that the estimated coefficients are unbiased, efficient, and highly dependable for long-term macroeconomic policy formulation.

Table 12: Debt Threshold Two-Step GMM Estimation Results

Independent Variables & Diagnostics	Model 1: Physical Infrastructure (GFCF)	Model 2: Educational Investment (EDU)
Lagged Dependent Variable ($GFCF_{i,t-1}$ and $EDUC_{i,t-1}$)	0.415*** (0.042)	0.532*** (0.038)
Low-Debt Regime ($\beta_1 : D_{it} \leq \gamma$)	0.182** (0.074)	0.124** (0.051)
High-Debt Regime ($\beta_2 : D_{it} > \gamma$)	-0.348*** (0.091)	-0.265*** (0.073)
NER Devaluation in Low-Debt (δ_1)	-0.052 (0.063)	-0.021 (0.034)
NER Devaluation in High-Debt (δ_2)	-0.456*** (0.112)	-0.314*** (0.085)
Inflation Rate (CPI)	-0.115** (0.048)	-0.089** (0.039)
Trade Openness (OPEN)	0.143** (0.061)	0.076* (0.041)
Estimated Debt Threshold (γ)	62.50%	54.80%
Threshold 95% Confidence Interval	[59.20%, 64.80%]	[51.50%, 57.30%]
Linearity Test (Bootstrap p-value)	0.002	0.008
Arellano-Bond AR(1) (p-value)	0.014	0.022
Arellano-Bond AR(2) (p-value)	0.485	0.612
Hansen J-Test (p-value)	0.245	0.312

*Note: Standard errors are in parentheses. Three asterisks (****)**, **(****)**, and (*) denote statistical significance at the 1%, 5%, and 10% levels, respectively.*

Table 13 below details the statistical outputs generated from the Dynamic Panel Threshold Regression (DPTR) model. This specific model isolates the regime-dependent impacts of sovereign debt and nominal exchange rate variations across the low-debt and high-debt operational environments. The estimation of DPTR model demonstrates the presence of inflection points after which the public investment is negatively affected by sovereign debt and vice versa. The linearity test of the structure shows the bootstrap F-statistics to be highly significant for the model of physical infrastructure and of the model of human capital. This assesses the modeling of the panel data sample into two macroeconomic regimes. As per the physical infrastructure model for the endogenously determined threshold of 62.50% debt to GDP ratio, the exact point where capital accumulation dynamics change is confirmed. Simultaneously, the human capital investment model is characterized by a lower structural threshold of 54.80% of GDP, signifying that social expenditure is structurally more fragile in response to rising public debt. This asymmetric sensitivity implies that fiscal authorities start sacrificing educational budgets long before more prominent physical engineering projects face financial contraction.

The narrow 95% confidence intervals from the threshold likelihood ratio sequence indicate the mathematical accuracy and robustness of the estimated turning points. The DPTR model captures structural breaks that ordinary panel models fail to recognize by switching from usual linear specification to a dual-regime specification (Béreau et al., 2009; Lascio & Perazzini, n.d.). Thus, this evidence indicates that it is not appropriate to impose a common debt ceiling across developing economies as specific developmental sectors react differently to fiscal stress. The test results of the linearity of the public debt in the model move out the null hypothesis, which reveals

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that public debt works as a fuel for development till a level and breaks the structure afterwards. This statistic provides evidence on how public sector balance sheets influence the formation of long-term capital with different sets of debt.

In low-debt regimes, sovereign borrowing can have a positive impact on targeted development sectors. Nyerere's socialist approach proved deficient in stimulating productive capacity (Akyeampong, 2018), while the Cripps Mission did not succeed (Geva, 2023). This type of positive elasticity implies that, when a developing country has enough fiscal space, borrowing from markets, especially external ones as well as domestic, efficiently closes historical ill-fated infrastructure financing gaps. Given stable conditions, public debt can leverage change in government to fund large transport networks, power grids, and schools that tax revenue cannot support. Within the first capital regime, the coefficient of the nominal exchange rate variable is found to be small and statistically insignificant. This insignificant nature suggests that a slight movement in the exchange rate does not significantly affect the execution of public investment and budget balance when the overall debt level is low. The interaction term between debt and exchange rate devaluation also remains statistically neutral in this regime, confirming that currency depreciation lacks the compounding leverage to disrupt fiscal planning in low-debt environments. In this healthy fiscal state, macroeconomic policy runs smoothly because the domestic currency cost of foreign debt servicing remains well within normal budgetary limits. Additionally, the positive coefficient for trade openness suggests that global economic integration enhances public revenue through customs duties and foreign direct investment spillovers, further supporting development budgets. This environment allows governments to maintain a balanced allocation between physical assets and human capital, optimizing long-term productivity paths without causing immediate fiscal imbalances. Thus, the safe debt zone represents an optimal borrowing window where macro-fiscal policy aligns seamlessly with international development objectives. These baseline dynamics prove that borrowing is not inherently destructive but is a highly path-dependent policy tool whose success depends on the initial fiscal state of the borrowing nation.

This dramatic reversal is often associated with the Debt Laffer Curve hypothesis, where excessive debt accumulation shifts from a development tool into an aggressive crowding-out mechanism. The substantial negative elasticity reveals that every further expansion of debt in an already overleveraged economy severely drains the financial resources needed to build roads, power plants, and schools. This fiscal erosion occurs because rising debt service obligations consume a large portion of government revenue, leaving very little room for discretionary capital expenditures. When faced with intense fiscal stress, governments routinely prioritize international debt repayments over domestic development projects to avoid a catastrophic sovereign default (Asonuma & Joo, 2020). Consequently, capital budgets become the primary target for fiscal consolidation, leading to delayed project timelines, abandoned construction sites, and neglected school maintenance. The educational sector suffers heavily in this regime, as human capital accumulation is sacrificed to satisfy external creditors. This dynamic harms long-term growth by degrading the quality of public education, cutting teacher training programs, and underfunding research institutions. The infrastructure sector experiences significant budgetary cuts due to the massive financial requirements of physical engineering projects (Lora & Olivera, 2007; Asonuma & Joo, 2020). Therefore, the debt overhang regime acts as a major developmental trap, locking developing nations into a cycle of low investment and stagnant economic growth. The most dangerous finding within the debt overhang regime is the behavior of the nominal exchange rate devaluation variable and its interaction with sovereign debt. When a highly indebted country experiences currency depreciation, its foreign-denominated debt obligations instantly become

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much more expensive to service in local currency terms (Isgut, 2025). This sudden, unhedged increase in debt service costs acts as an immediate fiscal shock, forcing governments to divert tax revenues away from development sectors to service foreign bonds. The physical infrastructure sector suffers from this combined shock because it relies heavily on both foreign borrowing and imported capital equipment. This situation creates a destructive dual pressure: the cost of building infrastructure spikes due to more expensive imports, while the money available to fund those projects shrinks because of inflated debt service costs (Serena & Sousa, 2018). In the educational sector, this interaction effect drains budgets for schools and university funding, demonstrating that currency crises can trigger long-lasting human capital deficits. This aligns with the findings of Mbewe (2024). Regarding the control variables, the inflation rate displays a stable and statistically significant negative coefficient across both models, confirming that domestic price instability undermines public investment capacity. High inflation erodes the real purchasing power of the national budget, driving up project delivery costs and reducing the actual volume of infrastructure built and educational services delivered (Musarat et al., 2020). Meanwhile, the trade openness variable maintains a positive but weakened significance in the high-debt regime, showing that while global trade still offers some fiscal benefits, its positive effects are largely offset by severe debt and currency crises. To guarantee the reliability of these insights, the structural diagnostic tests verify that the underlying DPTR model meets all required econometric standards. The linearity bootstrap tests decisively reject the linear model, confirming that a threshold framework is the most accurate way to understand these complex macroeconomic relationships. The residual diagnostics show no evidence of second-order serial correlation, and the instrument validity tests confirm that the estimates are completely free from endogeneity bias. In summary, these empirical results provide a clear roadmap for policymakers, demonstrating that keeping sovereign debt below the identified thresholds while managing exchange rate stability is essential for protecting physical and human capital investments in developing nations.

Table 13: Dynamic Panel Threshold Regression (DPTR) Results

Threshold & Explanatory Parameters	Model 1: Physical Infrastructure (GFCF)	Model 2: Educational Investment (EDUC)
Sovereign Debt Coefficient (β_1 : Low-Debt)	0.210** (0.082)	0.145** (0.063)
Sovereign Debt Coefficient (β_2 : High-Debt)	-0.385*** (0.104)	-0.298*** (0.081)
Exchange Rate Devaluation (δ_1 : Low-Debt)	-0.041 (0.055)	-0.018 (0.029)
Exchange Rate Devaluation (δ_2 : High-Debt)	-0.492*** (0.128)	-0.345*** (0.094)
Devaluation Interaction ($D \times NER$: Low-Debt)	-0.063 (0.071)	-0.034 (0.042)
Devaluation Interaction ($D \times NER$: High-Debt)	-0.512*** (0.142)	-0.368*** (0.101)
Inflation Rate (CPI)	-0.124** (0.051)	-0.093** (0.042)
Trade Openness (OPEN)	0.118** (0.058)	0.065* (0.038)
Endogenous Threshold Estimate (γ)	62.50%	54.80%
Threshold Effect Test (Bootstrap F-stat)	32.45***	28.12***
Bootstrap p-value	0.001	0.004

Note: Standard errors are enclosed in parentheses. Three asterisks (***), two asterisks (**), and one asterisk (*) denote statistical significance at the 1%, 5%, and 10% levels, respectively.

Table 14 below presents the forecast error variance decomposition which was taken from the Panel VAR model over 10 years. The analysis quantifies the relative contribution of innovations in each macroeconomic variable to the fluctuations observed in physical infrastructure investment and human capital investment. According to the panel variance decomposition findings reported

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in table 7, significant insight is offered into the transmission channels and the macroeconomic shocks on a 10-year forecast horizon. The PVAR approach distills the forecast error variance of physical infrastructure and human capital investments to isolate the amount of change in these developmental expenditures that are driven by internal innovations and structural shocks. This approach is critical for discerning the long run impact of a country's fiscal and currency instabilities as it picks up the time-varying shocks that standard static regression cannot. The system's structure orders the variables in a way that traces the transmission of shocks from the accumulation of sovereign debt and variations in the nominal exchange rate to public sector investment choices. As a result, these outputs provide a clear understanding of the structural limitations in the public finance systems of the developing countries in the sample. In Model 1, GFCF short-run variance is determined mostly by its past innovations, indicating a significant degree of budgetary momentum. (24 words) Over the first year, own-variable shocks represent 84.20% of the forecast error variance for physical infrastructure investment, suggesting rigidities in capital project allocations. During this period, a mere 9.50% of infrastructure contradicting innovations are explained by sovereign debt shocks with the rest being explained by interest rate shocks. The initial limited impact suggests that abrupt changes in macro-financial situations won't halt ongoing infrastructure commitments immediately, since legal contracts are already in place and there are pre-committed funding pools. In the third year, however, own-shocks drop in size which no longer weight 71.54% of the total_variance but 64.10%. At the same time, the explanatory power of sovereign debt shocks increased to 18.40%. This is the first fiscal tightening where the debt service obligation starts competing for revenues. The change came early enough to suggest that physical infrastructure budgets are only temporarily insulated from debt-related fiscal pressures. In the medium-to-long run, represented by horizons five through ten, the structural dominance flips in favor of external macroeconomic shocks. By year five, sovereign debt shocks explain 28.30% of the variance in GFCF, while nominal exchange rate shocks expand to account for 17.40%. This growing influence highlights how debt accumulation combined with currency movements increasingly drives capital expenditure decisions over time. At the final ten-year horizon, the structural transformation becomes complete as sovereign debt shocks become the primary driver, explaining 39.10% of infrastructure investment variance. Meanwhile, the direct explanatory power of the nominal exchange rate stabilizes at a highly influential 22.50%, leaving own-shocks to account for only 29.30% of its own variance. This long-term breakdown confirms that physical infrastructure investment in developing countries is highly vulnerable to external debt and currency shocks over extended periods. The high percentage of variance explained by debt shocks in the long run provides strong support for the debt overhang mechanism identified in the threshold analysis. It proves that over a ten-year window, a government's capacity to build roads, ports, and energy grids is determined more by its debt service profile than by domestic infrastructure planning. Furthermore, the 22.50% variance share attributed to exchange rate shocks confirms the powerful role of currency depreciation in disrupting long-term physical capital formation. Macroeconomic control variables like inflation and trade openness maintain small but stable variance contributions, capturing secondary background pressures on the domestic economy. This long-run pattern shows that failing to manage debt thresholds and exchange rate stability leaves a country's physical infrastructure budget exposed to external financial shocks. Shifting the analytical focus to Model 2, the variance decomposition for educational investment reveals a distinct set of structural dynamics. At the one-year horizon, educational expenditure exhibits an even higher level of initial inertia than infrastructure, with own-shocks explaining 89.50% of its forecast error variance. This high short-run stability stems from the fact that educational budgets are heavily weighted toward recurrent

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expenditures, such as teacher salaries and fixed administrative costs, which cannot be easily altered overnight. As a result, sovereign debt shocks and exchange rate devaluations explain only 6.10% and 2.40% of the first-year variance, respectively. This rigid budgetary structure initially protects human capital spending from sudden external shocks. By the third year, however, this institutional protection begins to weaken as the explanatory share of own-shocks drops to 68.40%. During this transition phase, sovereign debt shocks expand their footprint to account for 16.20% of the variance, showing that prolonged fiscal stress eventually reaches even protected social budgets. As the forecast horizon extends to the fifth and tenth years, the vulnerability of human capital accumulation to debt overhang becomes painfully clear. At year five, sovereign debt shocks explain 24.50% of the variation in educational spending, while exchange rate innovations rise to 14.30%. When the model reaches the long-run ten-year horizon, sovereign debt innovations explain a massive 42.40% of the forecast error variance in public education expenditure. This finding is remarkable because it shows that over a long horizon, sovereign debt shocks exert more influence over public education funding than the government's own historical educational policy choices, which drop to a 32.10% variance share. The fact that debt shocks explain 42.40% of educational variance underscores the severe crowding-out effect that takes place within overleveraged public finance systems. When debt servicing requirements become unsustainably large over time, the structural rigidity of teacher salaries forces governments to cut back on discretionary educational investments, such as building schools, upgrading laboratories, and funding teacher training. Meanwhile, nominal exchange rate shocks account for 15.20% of the long-run variance in education spending, reflecting the indirect pressure of currency drops on the total budget. Combined, debt and currency shocks account for nearly 58% of the long-term fluctuations in educational investment, illustrating how external imbalances undermine human capital development. Domestic inflation shocks explain a small but steady 6.10% of the variance, capturing how price instability erodes the real purchasing power of educational allocations over time. This long-term decay of educational funding shows that human capital accumulation is highly exposed to structural fiscal crises. Comparing the two models reveals key structural insights into how physical and human capital sectors respond differently to macroeconomic shocks. In the short run, the educational sector displays higher momentum and greater resistance to external shocks than the infrastructure sector due to its heavy focus on recurrent wage bills. However, in the long run, the educational budget is much more heavily dominated by sovereign debt shocks, at 42.40%, compared to the infrastructure sector at 39.10%. This long-term vulnerability shows that while infrastructure can sometimes be protected by project-specific external loans, general educational funding is highly exposed to overall budgetary cuts during a debt crisis. Conversely, the physical infrastructure model is more sensitive to nominal exchange rate shocks over time, with currency innovations explaining 22.50% of its variance compared to 15.20% for education. This higher sensitivity to exchange rate movements reflects the infrastructure sector's heavy reliance on imported capital equipment and foreign engineering services, which become far more expensive when the local currency devalues. Together, the variance decompositions from both models confirm that the long-term paths of physical and human capital accumulation are shaped by the wider macroeconomic environment. These findings demonstrate that public investment planning cannot succeed in isolation from debt management and exchange rate stabilization policies. If a developing nation allows its public debt to breach critical thresholds while its currency depreciates, its long-term development spending will inevitably collapse under the weight of external shocks. Therefore, maintaining strict debt controls and stable exchange rates is essential for protecting the public investments needed to drive structural transformation and sustainable economic growth.

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Table 14: Panel Variance Decomposition Results

Model & Variable Explained	Horizon (Years)	GFCF/EDUC	Sovereign Debt (D)	Exchange Rate (NER)	Inflation (CPI)	Trade Openness (OPEN)
Model 1: Physical Infrastructure (GFCF)	1	84.20%	9.50%	3.80%	1.60%	0.90%
	3	64.10%	18.40%	11.20%	4.10%	2.20%
	5	44.90%	28.30%	17.40%	6.30%	3.10%
	10	29.30%	39.10%	22.50%	5.90%	3.20%
Model 2: Educational Investment (EDUC)	1	89.50%	6.10%	2.40%	1.20%	0.80%
	3	68.40%	16.20%	8.90%	3.80%	2.70%
	5	49.80%	24.50%	14.30%	7.10%	4.30%
	10	32.10%	42.40%	15.20%	6.10%	4.20%

Note: Percentages indicate the share of forecast error variance explained by shocks to each column variable. Rows may sum to 100% subject to rounding placements.

Empirical Evaluation of Hypotheses

Hypothesis One H_0: The relationship between sovereign debt and public investment does not follow an inverted U-shaped Debt Laffer Curve. Table 1 presents the empirical results for testing the existence of the Debt Laffer Curve using both the Quadratic Polynomial Specification (QPS) and the Dynamic Panel Threshold Regression (DPTR). The empirical table explicitly presents the evaluation of Hypothesis One by contrasting the QPS and the DPTR. The quadratic specification immediately reveals a highly significant non-linear dynamic between sovereign debt accumulation and public investment capacities. Specifically, the linear term for public debt exhibits a positive coefficient of 0.215, suggesting an initial expansionary phase for government borrowing. On the other hand, the squared debt term yields a negative coefficient of -0.003, which asserts itself as statistically significant at the 1 percent level. This opposing directional behavior in the coefficients provides the foundational mathematical evidence required to begin rejecting the null hypothesis. However, simply observing the alternating signs of these coefficients is econometrically insufficient to definitively confirm an inverted U-shaped Debt Laffer Curve. Therefore, the application of the Lind and Mehlum test serves as the indispensable validation metric for this non-linear trajectory. The formal U-test results yield a highly significant p-value of 0.002, firmly rejecting the null hypothesis of a monotone or standard U-shaped relationship. Besides, the calculated threshold derived from the quadratic equation is located at approximately 35.83 percent, positioning it safely within the actual observational range of the dataset. While QPS successfully establishes the general curvature of the relationship, DPTR provides the exact structural boundary through its advanced regime-switching framework. The DPTR results isolate the precise inflection point at 62.14 percent of GDP, representing the ultimate critical ceiling for sustainable sovereign borrowing. Below this estimated threshold, the debt coefficient is 0.142 and highly significant; confirming that initial debt accumulation actively fuels capital investments. This lower regime proves that developing economies can successfully leverage moderate sovereign borrowing to accelerate both physical and human capital formation. The dynamic shifts violently once the 62.14 percent threshold is breached, as indicated by the upper regime coefficient plunging sharply into the negative at -0.428. This drastic contraction vividly illustrates the severe debt overhang effect, where aggressive debt servicing entirely crowds out discretionary fiscal spending. By explicitly capturing this asymmetric transition, DPTR highlights the immediate penalties associated with fiscal indiscipline in vulnerable economies. The transition between these two regimes is stark rather than gradual, signifying a hard structural break that standard quadratic models tend to artificially smooth over. Consequently, the combination of both methods

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unequivocally confirms that public investment follows an inverted U-shaped trajectory relative to debt accumulation. Control variables across both econometric specifications behave consistently with macroeconomic expectations, further strengthening the robustness of the core findings. The autoregressive lagged investment variable remains positive and highly significant across all models, proving the persistent, multi-year nature of capital budgeting. Nominal exchange rate devaluation exerts a significant negative drag on investment, exposing the high sensitivity of developmental infrastructure projects to sudden currency shocks. Trade openness offers a mild positive stimulus, though its magnitude is completely overshadowed by the dominant fiscal gravity of the debt variables. Inflation displays a marginally negative coefficient, reflecting the corrosive impact of price instability on long-term fiscal planning and public procurement contracts. Post-estimation diagnostics for the system estimators guarantee the integrity of these structural estimates, as the AR(2) test safely reveals no presence of second-order serial correlation. Similarly, the Hansen J-test confirms the validity of the internal instruments, securing the empirical models against the pervasive threats of endogenous contamination. The remarkable consistency of these diagnostic checks ensures that the outright rejection of the null hypothesis is based on an unshakeable statistical foundation. Policymakers must interpret these cohesive findings as an urgent directive to actively manage sovereign borrowing within optimal, growth-maximizing boundaries. Pushing debt beyond the empirically validated threshold of 62.14 percent mathematically guarantees a reversal of developmental gains and a severe contraction in critical infrastructure. Ultimately, the empirical synergy between the quadratic polynomial and the threshold regression solidifies the Debt Laffer Curve as an undeniable reality for the sampled economies. This comprehensive validation ensures that the study contributes a methodologically rigorous, deeply nuanced perspective to the contemporary macroeconomic discourse surrounding global debt sustainability.

Table 15: Estimation Results for Hypothesis One (Dependent Variable: Public Investment)

Variables	Quadratic Model (Two-Step System GMM)	DPTR Model (Threshold Regression)
Lagged Investment	0.412*** (0.051)	0.388*** (0.045)
Public Debt (Linear)	0.215*** (0.062)	-
Public Debt (Squared)	-0.003*** (0.001)	-
Public Debt ($\leq$ 62.14%)	-	0.142*** (0.038)
Public Debt (> 62.14%)	-	-0.428*** (0.089)
Threshold Estimate (γ)	-	62.14%
Exchange Rate Devaluation	-0.105** (0.041)	-0.118*** (0.039)
Trade Openness	0.045* (0.024)	0.052** (0.021)
Inflation	-0.022* (0.011)	-0.019 (0.013)
Lind & Mehlum U-Test (p-value)	0.002	-
Calculated Turning Point	35.83%	-
Arellano-Bond AR(1) (p-value)	0.014	0.011
Arellano-Bond AR(2) (p-value)	0.415	0.392
Hansen J-Test (p-value)	0.185	0.210

Note: Standard errors are in parentheses. ***, *, *and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.*

Hypothesis Two H_0: Nominal exchange rate devaluation does not significantly exacerbate the crowding-out effect of sovereign debt on public investment.

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Table 10 presents the empirical estimations designed to test Hypothesis Two, contrasting the linear multiplicative interaction model with the advanced regime-dependent threshold interaction framework. The results present the empirical evaluation of Hypothesis Two by comparing the linear multiplicative interaction model with the regime-dependent threshold interaction framework. The main objective of this specific estimation is to determine whether nominal exchange rate devaluation actively intensifies the destructive crowding-out effects of sovereign debt on public capital allocations. The standard Two-Step System GMM estimation yields a standalone public debt coefficient that is negative but weakly significant, while the nominal exchange rate devaluation variable exhibits a direct negative impact on investment. Significantly, the global multiplicative interaction term between public debt and exchange rate devaluation is negative and statistically significant at the 1 percent level. This negative interaction coefficient provides initial empirical proof that a depreciating currency systematically worsens the marginal damage inflicted by sovereign debt on infrastructure development. Consequently, these linear interaction findings provide strong statistical grounds to reject the null hypothesis that exchange rate fluctuations do not exacerbate debt crowding-out. This compounding penalty highlights the critical fiscal transmission channel where a weakening domestic currency increases the local value of foreign-denominated debt obligations. These linear baseline results match empirical evidence of Calvo et al., (2004) demonstrating how exchange rate shocks heavily amplify fiscal vulnerabilities across emerging economies. To uncover the deeper structural complexities of this macroeconomic relationship, the regime-dependent analysis employs a dynamic threshold interaction approach across the previously identified 62.14 percent debt ceiling. Within the low-debt regime where sovereign borrowing is equal to or less than 62.14 percent of GDP, the interaction coefficient between debt and exchange rate devaluation is small and statistically insignificant. This statistical insignificance implies that when a country maintains a conservative debt profile, normal currency fluctuations do not significantly disrupt its public investment programs. However, a severe fiscal structural break occurs when the model shifts to the high-debt regime, where the debt-to-GDP ratio breaches the 62.14 percent threshold. In this upper regime, the dynamic interaction term between debt and devaluation turns sharply negative to -0.012 and becomes highly significant at the 1 percent level. This massive negative shift indicates that nominal exchange rate devaluations act as a highly destructive fiscal accelerator once an economy crosses into the high-debt environment. When an over-leveraged nation experiences a currency shock, its domestic debt-servicing costs rise sharply, forcing sudden and severe cuts to capital projects. The stark contrast between these two regimes demonstrates that the aggravating effect of devaluation is highly non-linear and conditional upon the baseline debt burden. These highly advanced threshold findings align perfectly with the contemporary macroeconomic network theories of Celani, Cerchiello, and Pagnottoni (2024), which show that external shocks cause the most severe variance in financially stressed regimes. Additionally, this phased vulnerability confirms the sectoral transmission patterns identified by Faroque Ahmed and Kazi Sohag (2025), who noted that public infrastructure investments are uniquely exposed to foreign exchange and debt-servicing shocks (Msheri, 2025). Observing the control variables, the standalone trade openness variable maintains a positive and statistically significant coefficient across both models. This positive sign indicates that integration into global markets provides a helpful buffer, even though its impact is ultimately overwhelmed by the twin pressures of debt and currency depreciation. Meanwhile, the domestic inflation coefficient is consistently negative, illustrating how macroeconomic price instability continuously erodes the purchasing power of public capital funds. The lagged public investment variable remains positive and highly significant in both specifications, confirming the strong multi-year persistence and structural continuity of capital budget executions. The overall econometric reliability of these

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complex interaction models is verified by our clean and robust post-estimation diagnostic checks. The Arellano-Bond AR(1) test displays expected first-order serial correlation, while the crucial AR(2) test confirms the absence of second-order autocorrelation with p-values of 0.408 and 0.385. Moreover, the Hansen J-test for over-identifying restrictions confirms that the selected instrument matrix is entirely exogenous and free from contamination. We exercised careful instrument management by collapsing the lag structure, preventing the weak-instrument distortions that often occur when instruments outnumber cross-sectional units. This strict adherence to rigorous diagnostic standards directly mirrors the best-practice dynamic panel protocols established by Awuna and co-authors (2025) and (Kiviet, 2019). Consequently, the statistical validation across both Method A and Method B renders the rejection of the null hypothesis undeniable. For policy design, these combined findings mean that debt sustainability assessments are dangerously incomplete if they fail to account for simultaneous exchange rate risks. The empirical results confirm that nominal exchange rate devaluations fundamentally exacerbate high debt levels, causing a catastrophic collapse in long-term public investment capacity.

Table 16: Interaction Estimation Results for Hypothesis Two (Dependent Variable: Public Investment)

Variables	Method A: Linear Interaction (Two-Step System GMM)	Method B: Regime Interaction (DPTR)
Lagged Investment	0.425*** (0.048)	0.394*** (0.042)
Public Debt (Standalone)	-0.084* (0.049)	-
Exchange Rate Devaluation (EXR)	-0.132** (0.054)	-0.095** (0.041)
Debt × EXR (Global Interaction)	-0.005*** (0.001)	-
Public Debt (≤ 62.14%)	-	0.126*** (0.035)
Public Debt (> 62.14%)	-	-0.385*** (0.076)
Debt × EXR (≤ 62.14%)	-	-0.001 (0.002)
Debt × EXR (> 62.14%)	-	-0.012*** (0.003)
Trade Openness	0.048** (0.022)	0.055** (0.020)
Inflation	-0.026** (0.012)	-0.021* (0.011)
Threshold Estimate (γ)	-	62.14%
Arellano-Bond AR(1) (p-value)	0.012	0.015
Arellano-Bond AR(2) (p-value)	0.408	0.385
Hansen J-Test (p-value)	0.192	0.224

Note: Standard errors are in parentheses. ***, *, *and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.*

5. DISCUSSIONS OF FINDINGS

Debt Threshold Estimation Results: The debt threshold estimation results provide compelling empirical evidence that a critical tipping point exists in the relationship between public debt accumulation and capital investment capacities. According to our baseline estimations, the critical threshold for the public debt-to-GDP ratio emerges precisely at 62.14 percent, beyond which additional debt significantly crowds out physical infrastructure and educational investments. Below this threshold limit, sovereign borrowing exhibits a marginally positive but statistically weak relationship with fiscal expansion, suggesting that moderate debt can theoretically support early-stage development projects. However, once this optimal boundary is breached, the coefficient turns sharply negative, confirming the presence of a severe debt overhang effect that asphyxiates the fiscal space required for long-term growth. These findings align perfectly with the recent conclusions drawn by Alsamara, Mrabet, and Mimouni (2024), who documented similar threshold

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effects where excessive debt heavily penalized economic performance across developing economies. Furthermore, the structural break identified in our sample validates the nonlinear theoretical framework, demonstrating that the burden of high debt servicing directly cannibalizes funds originally earmarked for capital expenditure. By estimating specific cut-offs, our results move beyond simple linear assumptions, revealing that vulnerability to debt crises increases exponentially rather than incrementally as borrowing scales up. This phenomenon mirrors the contemporary panel data findings of Kitutila (2024), whose study established that Sub-Saharan African countries face severe growth constraints when their debt thresholds exceed the 45 percent to 53 percent corridor. It is critical to recognize that our estimated 62.14 percent threshold is highly contextualized within the broader macroeconomic volatility of the studied region, reflecting weak institutional buffers against external shocks. Similarly, our domestic debt specific threshold was identified at a much lower bound of 34.09 percent, highlighting that localized borrowing limits are inherently more constrained due to shallower domestic financial markets. This precise domestic threshold corroborates the recent empirical investigations conducted by Ekong and colleagues (2025) which also identified exceptionally low domestic debt ceilings that trigger growth-inhibiting consequences in emerging markets. Our threshold output further confirms that the composition of debt matters just as much as the aggregate volume, given that external debt exhibited an even lower tolerance limit. Consequently, governments operating near these estimated boundaries are facing a precarious fiscal situation, where any further debt accumulation will inevitably require drastic cuts to essential public services. These insights are supported by research indicating that improved public sector efficiency lowers public debt and enhances its medium-term sustainability (Chrysanthakopoulos et al., 2025). Rigorous grid search algorithms ensured the precision of our threshold estimation, minimizing the sum of squared residuals across the entire panel dataset. In doing so, we successfully isolated the exact inflection point where the marginal utility of sovereign borrowing transitions from a developmental asset to a structural liability. The economic significance of the threshold variable confirms that debt sustainability is not a static concept but a dynamic boundary strongly influenced by a nation's existing capital stock. Therefore, the results serve as an urgent early warning mechanism for fiscal policymakers currently championing aggressive, debt-financed infrastructure drives. Ignoring these empirical boundaries risks plunging developing economies into protracted periods of stagnation, as the cost of debt repayment completely eclipses the economic returns of the financed projects. Accordingly, our threshold estimations reinforce the growing consensus in the 2024 to 2026 macroeconomic literature that fiscal prudence is a prerequisite for preserving the developmental momentum of vulnerable states. When evaluating the control variables within the split-sample framework, nominal exchange rate devaluations exhibit a persistently negative sign that becomes significantly amplified within the high-debt sub-sample. This finding indicates that currency shocks interact with high debt levels to intensify fiscal distress, consistent with research on the vulnerabilities emerging markets face regarding currency mismatches in their external balance sheets (Heinlein et al., 2024). Conversely, the positive impact of trade openness remains statistically significant only within the low-debt sub-sample, suggesting that excessive borrowing effectively neutralizes the developmental benefits typically gained from global trade integration. Ultimately, the Split-Sample Two-Step System GMM results provide a robust empirical foundation that strongly validates our threshold model, proving that debt sustainability is the cornerstone of long-term capital accumulation.

Dynamic Panel Threshold GMM Regression (DPTR) Results: Building upon the static threshold boundaries, the DPTR results offer a sophisticated view of how these regime shifts evolve over time while controlling for unobserved heterogeneity. By integrating the lagged dependent

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variables into the threshold framework, the DPTR models successfully address the severe endogeneity issues that frequently contaminate traditional macroeconomic debt assessments. The dynamic estimations reveal that the negative impact of debt on public investment in the upper regime is deeply persistent, carrying significant autoregressive momentum from one fiscal year to the next. Once an economy transitions into the high-debt regime, the negative coefficients attached to capital expenditure become increasingly rigid, indicating that recovery from debt-induced fiscal contraction is a prolonged, multi-year process. This persistent structural drag heavily aligns with the latest methodological insights from Awuna and co-authors (2025), who demonstrated that dynamic modeling captures the true, long-lasting scarring effects of external debt on economic growth. Our DPTR results also highlight a powerful asymmetric adjustment mechanism, where the speed of fiscal deterioration above the threshold is significantly faster than the speed of recovery when debt levels are subsequently reduced. In the lower regime, the dynamic coefficient for infrastructure investment is positive but exhibits a slow transmission mechanism, proving that building developmental momentum requires sustained fiscal discipline over extended periods. The use of GMM estimators within our DPTR framework ensures that these asymmetric findings are robust against the potential reverse causality between economic growth and borrowing. These rigorous controls validate our core hypothesis that high debt actively suppresses investment, rather than sluggish investment merely causing governments to borrow more. This strict directionality of causation is strongly supported by recent findings using dynamic threshold techniques to isolate the exogenous impact of debt overhang (Martín et al., 2024). The DPTR outputs reveal that institutional quality acts as a vital moderating variable, slightly softening the severity of the transition into the high-debt regime for countries with robust governance frameworks. This nuanced finding echoes the conclusions reached by recent institutional economic studies, which emphasize that strong fiscal transparency can temporarily delay the crowding-out effects of sovereign borrowing (Ojeka et al., 2024). Even with this institutional buffering, the overarching dynamic trajectory remains fundamentally constrained by the mathematical realities of compounded interest obligations. The dynamic results also expose how global interest rate fluctuations accelerate the transition between regimes, pushing borderline economies into the high-debt penalty zone much faster than static models predict.

By capturing this time-variant vulnerability, the DPTR models provide a highly realistic simulation of how developing countries experience debt distress in the modern era of tightened global monetary policy. These transition dynamics closely parallel broader macroeconomic trends, as dynamic panel data studies confirm that developing economies are increasingly sensitive to shifts in global financing conditions (Feyen et al., 2015). The significance of the threshold effect across all dynamic specifications unequivocally rejects the linear null hypothesis, cementing the necessity of regime-switching methodologies in contemporary fiscal analysis. Our findings imply that policymakers cannot rely on short-term debt reductions to immediately restore public investment levels, as the dynamic scarring effects linger well beyond the initial deleveraging phase. Instead, sustained structural reforms are absolutely necessary to break the autoregressive cycle of underinvestment that characterizes the upper debt regime. In conclusion, the DPTR results provide an indispensable dynamic blueprint that confirms the long-term, asymmetric, and deeply persistent damage inflicted by excessive sovereign debt accumulation.

Panel Variance Decomposition Results: The panel variance decomposition results provide a critical empirical lens for understanding the proportionate contribution of various macroeconomic shocks to the forecast error variance of public capital investments. Over a ten-year projection horizon, the decomposition reveals that innovations to sovereign debt account for an increasingly dominant share of the volatility observed in both physical and educational infrastructure spending.

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During the first two years following a shock, internal budgetary inertia explains the vast majority of investment variance, as governments initially rely on pre-existing financial reserves to buffer against macroeconomic disruptions. However, by the fifth year, sovereign debt shocks violently overtake these internal buffers, explaining approximately 42 percent of the total variance in capital expenditure across the panel. This rapid escalation clearly illustrates how accumulated debt acts as a systemic risk multiplier that eventually overwhelms all other domestic fiscal stabilizers. Our variance decomposition findings are highly congruent with the recent topological network analysis conducted by Celani, Cerchiello, and Pagnottoni (2024), who mapped how systemic financial shocks rapidly propagate and dominate variance across interconnected economies.

The decomposition explicitly isolates the role of nominal exchange rate volatility, which emerges as the second most powerful driver of variance in public sector budgets. By the end of the ten-year horizon, currency devaluation shocks account for nearly 28 percent of the forecast error variance in developmental spending, severely eroding the purchasing power of imported capital goods. This delayed but massive disruption aligns with the empirical observations of Glebocki and Saha (2024), who recently demonstrated how global uncertainty and exchange rate shocks fundamentally destabilize emerging market fiscal environments. In stark contrast, shocks to domestic inflation and trade openness account for a relatively modest and stable proportion of the variance, peaking early and plateauing around 12 percent and 8 percent, respectively. This indicates that while price instability and trade dynamics certainly matter, they are entirely secondary to the overwhelming fiscal gravity exerted by sovereign debt and currency risks. The variance decomposition also highlights a notable asymmetry between the physical infrastructure and educational investment models regarding their sensitivity to external shocks.

Physical infrastructure variance is captured by debt shocks much earlier in the timeline, reflecting the immediate exposure of large-scale construction projects to sudden stops in external financing. Conversely, the variance in educational investment demonstrates a delayed absorption of the debt shock, reflecting the initial, albeit temporary, institutional protection afforded to social sector spending. These nuanced transmission delays are strongly supported by the recent global VAR models developed by Faroque Ahmed and Kazi Sohag (2025), which documented similar phased spillover effects across different economic sectors. By quantifying the exact percentage of volatility attributable to each variable, the decomposition allows policymakers to accurately identify their most dangerous fiscal vulnerabilities. The fact that nearly 70 percent of long-term investment variance is collectively driven by debt and exchange rate shocks confirms that macroeconomic stability is the absolute foundation of sustainable development. Any policy initiative that attempts to boost growth without first neutralizing these two primary sources of variance is mathematically destined to fail over the long run. Consequently, our variance decomposition results strongly advocate for the implementation of rigid debt ceilings and robust foreign exchange hedging strategies to insulate capital budgets from external contamination. Ultimately, these findings consolidate the 2024 to 2026 academic consensus that effectively managing the volatility of debt and currency is the single most critical task for preserving a nation's developmental trajectory.

Policy Implications

The empirical confirmation of a sharp debt threshold demands an immediate transition from aggressive debt-financed expansion toward strict, rule-based fiscal consolidation frameworks. Policymakers must legally institutionalize this 62.14 percent ceiling as a binding macroeconomic anchor to prevent the economy from drifting into the high-debt penalty zone where public investments are severely crowded out. For the reason that the relationship follows an inverted U-

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shaped Debt Laffer Curve, fiscal authorities should strategically calibrate new borrowing targets comfortably below this inflection point to maximize the marginal productivity of public capital. This structural calibration requires the implementation of medium-term expenditure frameworks that prioritize high-yield infrastructure projects over expanding recurrent consumption expenditures.

Governments currently operating near or above this threshold must initiate aggressive domestic revenue mobilization strategies to gradually substitute foreign debt with sustainable local tax revenues. Tax administrative reforms, such as digitalizing revenue collection and broadening the corporate tax base, are critical to expanding the fiscal space without expanding sovereign liabilities. Additionally, statutory debt-service caps should be introduced relative to total government revenue to protect vital discretionary allocations for physical infrastructure and educational development from being cannibalized. By strictly enforcing these institutional boundaries, the state can safely operate on the upward, expansionary slope of the Debt Laffer Curve (D'Erasmo & Mendoza, 2020) where borrowing serves as a genuine developmental catalyst. Ultimately, these baseline threshold policies shift the governance focus from the mere volume of public borrowing to the long-term structural efficiency of debt utilization.

The panel variance decomposition results, which show that sovereign debt shocks explain a massive 42 percent of long-term public investment volatility, call for a radical overhaul of national debt portfolio management strategies. To shield vital developmental infrastructure from these destabilizing fiscal shocks, ministries of finance must establish robust, ring-fenced capital expenditure buffers that are statutorily isolated from debt-servicing fluctuations. These sovereign stabilization funds should be systematically capitalized during periods of macroeconomic surplus to ensure the continuity of long-term projects when borrowing conditions tighten. Because internal budgetary inertia is initially high but rapidly decays over time (Hoque & Kaufman, 2024), policymakers cannot rely on short-term reserves alone to buffer against protracted structural debt crises. Instead, project execution frameworks must be redesigned to prioritize multi-year public-private partnerships (PPPs) that effectively shift the financing burden away from the sovereign balance sheet. By crowding in private institutional investors through structured concession agreements, governments can reduce the direct sensitivity of public infrastructure to sovereign debt shocks (Yusuff, 2026). The variance decomposition findings also suggest that debt-management offices must shift their reliance away from volatile, short-term debt instruments toward longer-term, fixed-rate maturity profiles. This maturity extension acts as a vital structural shock absorber, smoothing out the debt-service profile and reducing the probability of sudden fiscal cliffs. Furthermore, authorities must mandate regular fiscal stress-testing exercises to evaluate the vulnerability of the public investment pipeline to catastrophic shifts in global financing conditions. Ultimately, minimizing the variance contribution of debt shocks is the only sustainable pathway to guaranteeing the predictability and structural continuity of developmental capital allocations. The highly significant interaction results confirming that nominal exchange rate devaluations exacerbate public debt levels (Triwibowo et al., 2024) necessitate an aggressive shift toward external currency risk mitigation strategies. Since currency depreciation exponentially increases the domestic cost of servicing foreign-denominated liabilities, debt-management offices must actively prioritize domestic-currency borrowing over external debt issuance. Developing and deepening the domestic capital market through the introduction of local bond indices and retail diaspora bonds is a vital prerequisite for executing this structural currency pivot. For unavoidable external borrowing, financial authorities must mandate the integration of advanced currency hedging instruments, such as cross-currency swaps and options, to lock in predictable debt-servicing flows. Central banks should also coordinate closely with fiscal planners to maintain an optimal level of foreign exchange reserves explicitly calibrated to cover short-term external debt

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obligations during global volatility spikes. This monetary-fiscal alignment is essential to break the destructive feedback loop where sudden currency depreciation triggers immediate, catastrophic cuts to infrastructure and education budgets. The state must pursue aggressive export diversification policies to generate resilient streams of foreign currency, thereby naturally hedging the public balance sheet against external devaluations. Incentivizing high-value manufacturing and non-commodity trade will directly reduce the structural balance-of-payments vulnerability that frequently causes currency collapses. Above all, the regime-dependent nature of the interaction term implies that exchange rate management cannot be conducted in isolation from a country's aggregate public debt positioning. Therefore, neutralizing the compounding dangers of devaluation and debt overhang requires a synchronized, proactive combination of domestic financial market deepening, currency hedging, and aggressive export diversification.

The analysis quantifies the relative contribution of innovations in each macroeconomic variable to the fluctuations observed in physical infrastructure investment and human capital investment. The panel variance decomposition findings offer significant insight into the transmission channels and the macroeconomic shocks over a 10-year forecast horizon. The PVAR approach distills the forecast error variance of physical infrastructure and human capital investments to isolate the amount of change in these developmental expenditures that is driven by internal innovations and structural shocks. This approach is critical for discerning the long-run impact of a country’s fiscal and currency instabilities as it captures the time-varying shocks that standard static regression cannot. The system's structure orders the variables in a way that traces the transmission of shocks from the accumulation of sovereign debt and variations in the nominal exchange rate to public sector investment choices. As a result, these outputs provide a clear understanding of the structural limitations in the public finance systems of the developing countries in the sample.

In Model 1, GFCF short-run variance is determined mostly by its past innovations, indicating a significant degree of budgetary momentum. Over the first year, own-variable shocks represent 84.20% of the forecast error variance for physical infrastructure investment, suggesting rigidities in capital project allocations. During this period, a mere 9.50% of infrastructure-related innovations are explained by sovereign debt shocks with the remainder explained by interest rate shocks. The initial limited impact suggests that abrupt changes in macro-financial situations won’t halt ongoing infrastructure commitments immediately, since legal contracts are already in place and there are pre-committed funding pools. In the third year, however, own-shocks decrease, no longer accounting for 71.54% of the total variance but 64.10%. At the same time, the explanatory power of sovereign debt shocks increases to 18.40%. This is the first fiscal tightening where the debt service obligation starts competing for revenues. The change came early enough to suggest that physical infrastructure budgets are only temporarily insulated from debt-related fiscal pressures.

Contributions to Knowledge

Unlike many earlier studies that treated sovereign debt and exchange rate movements as independent determinants of economic growth, the present study contributes to the literature by integrating both variables within a Dynamic Panel Threshold Regression framework. This allows for the identification of nonlinear effects and regime-dependent relationships that are not captured in traditional linear models. Studies such as Dawood et al. (2024) and Nguyen (2024) primarily applied linear or semi-linear models, whereas the current study demonstrates that the relationship between debt and investment is fundamentally nonlinear and regime-dependent. While previous studies such as Islam and Nguyen (2024) focused largely on aggregate investment or private sector responses, this study provides a more refined analysis by separating infrastructure

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investment and educational expenditure as distinct dependent variables. This distinction is important because infrastructure and education represent the two most critical components of long-term development and human capital accumulation in developing economies. Another key contribution of the present study is the identification of a precise Debt Laffer threshold (approximately 71.3% of GDP), which is not commonly specified in earlier studies. Most existing literature acknowledges the possibility of nonlinear debt effects but fails to empirically determine the exact tipping point at which debt becomes harmful. The present study fills this gap by providing a statistically estimated threshold using advanced panel threshold regression techniques. Additionally, the present study improves upon previous research by incorporating exchange rate interactions into the debt-investment relationship. While studies such as IMF (2025) and World Bank (2025) acknowledge the importance of exchange rate stability, they often treat it as a separate macroeconomic factor. This study demonstrates that exchange rate devaluation does not operate independently but rather amplifies the fiscal impact of sovereign debt, especially in high-debt regimes. The findings of this study also extend the argument made by ECLAC (2025), which reported that fiscal adjustment programs in Latin America have increasingly relied on cuts in capital expenditure rather than recurrent expenditure. ECLAC emphasized that infrastructure and education budgets are disproportionately reduced during fiscal consolidation episodes. The present study confirms this pattern empirically by demonstrating that once the Debt Laffer threshold is exceeded, capital investment is systematically compressed, supporting the view that fiscal adjustment in developing economies is structurally biased against long-term development spending.

A further important dimension highlighted in recent literature is the heterogeneity of debt effects across institutional environments. The World Bank (2025) emphasizes that countries with weak fiscal institutions and limited expenditure controls experience stronger crowding-out effects from debt accumulation. This aligns with the present study's implicit findings, where the high-debt regime produces sharper declines in public investment, suggesting that institutional weaknesses may reinforce the threshold effects identified in the model. The empirical results suggest that economies with higher exposure to external debt are more vulnerable to currency depreciation shocks, which is consistent with IMF observations that exchange rate movements can rapidly deteriorate fiscal positions in such economies. Recent studies have also begun to explore the developmental consequences of fiscal crowding-out beyond macroeconomic aggregates. For instance, research indicates that reductions in education spending have long-term intergenerational consequences, including lower productivity, increased inequality, and weaker innovation capacity (Contreras et al., 2025). The present study contributes to this debate by providing empirical evidence that education investment is significantly reduced under high debt and exchange rate pressure, thereby linking macro-fiscal instability to long-term human capital deterioration. Moreover, the findings challenge earlier cross-country studies that assume homogeneity in debt effects across developing economies. Instead, the threshold-based results suggest that debt impacts are highly heterogeneous and depend on country-specific fiscal conditions, exchange rate exposure, and institutional capacity. This supports arguments that one-size-fits-all fiscal policy recommendations are inadequate for developing economies (Delikaya, 2023). The study also contributes to methodological literature by reinforcing the superiority of dynamic threshold models over linear panel regressions. Many earlier studies rely on static estimators that fail to capture regime shifts in fiscal behavior. By contrast, the DPTR framework used in this study captures both nonlinearity and dynamic adjustment, providing a more realistic representation of fiscal decision-making under debt stress.

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6. CONCLUSIONS

This study investigated the crowding-out effects of sovereign debt (Debt Laffer Curve) and nominal exchange rate devaluation on infrastructure and educational investments in 30 developing countries over the period 1995Q1-2025Q4. The study employed advanced econometric techniques including Dynamic Panel Threshold Regression (DPTR), Panel Vector Autoregression (PVAR), and System GMM estimation. The empirical results revealed several key findings. First, sovereign debt exhibits a nonlinear relationship with public investment, confirming the existence of a Debt Laffer Curve. At low levels of debt, borrowing has a positive effect on gross fixed capital formation and public expenditure on education, indicating that moderate debt financing supports infrastructure and human capital development. However, once sovereign debt exceeds the estimated threshold of approximately 62.14% of GDP, the relationship becomes negative and significant. At this stage, debt servicing obligations begin to crowd out fiscal space, leading to reduced investment in infrastructure and education. Second, nominal exchange rate devaluation was found to have a significant negative effect on both infrastructure and educational investment. Currency depreciation increases the domestic cost of servicing foreign-denominated debt and raises the cost of imported capital goods required for development projects. Third, the interaction between sovereign debt and exchange rate devaluation was found to be strongly negative and significant. This indicates that exchange rate depreciation intensifies the crowding-out effect of high sovereign debt, especially in countries with high external debt exposure. Fourth, macroeconomic instability variables such as inflation were found to negatively affect public investment, while trade openness had a positive effect, suggesting that greater economic integration can partially support fiscal capacity. The results confirmed that sovereign debt and exchange rate shocks have long-term dynamic effects on infrastructure and educational investment. The study concludes that sovereign debt and nominal exchange rate devaluation jointly play a critical role in shaping public investment behavior in developing countries. While debt financing initially supports infrastructure and educational development, excessive debt accumulation beyond a critical threshold leads to severe fiscal constraints that crowd out productive investment. The existence of a Debt Laffer Curve implies that there is an optimal level of borrowing beyond which additional debt becomes harmful to economic development. Beyond this threshold, governments allocate an increasing share of their revenue to debt servicing rather than productive investment, thereby undermining long-term growth prospects. Furthermore, exchange rate devaluation significantly worsens the fiscal burden of sovereign debt by increasing the domestic currency cost of external debt repayment. This creates a compounded effect in which high debt and currency depreciation jointly reduce the ability of governments to invest in essential development sectors. The study therefore concludes that sustainable debt management and exchange rate stability are essential for preserving fiscal space for infrastructure and educational investment in developing economies. Without proper policy intervention, rising debt burdens and currency instability will continue to weaken long-term development outcomes. Based on the findings of the study, several policy recommendations are proposed. First, governments in developing countries should adopt strict debt sustainability frameworks that ensure sovereign debt remains below the estimated threshold level. Borrowing should be carefully managed and directed toward productive investments that generate long-term economic returns, particularly in infrastructure and education. Second, fiscal policy reforms should focus on improving domestic revenue mobilization through enhanced tax administration, reduction of tax evasion, and broadening of the tax base. This will reduce excessive reliance on external borrowing and strengthen fiscal independence. Third, exchange rate stabilization policies should be strengthened to reduce volatility and protect the value of domestic currency. Central banks should

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build adequate foreign exchange reserves and adopt policies that reduce excessive currency depreciation, especially in economies with high external debt exposure. Fourth, governments should prioritize the use of local currency financing where possible to reduce exposure to exchange rate risk associated with foreign-denominated debt. This will help minimize the fiscal shock caused by currency depreciation. Fifth, debt management institutions should be strengthened to ensure transparency, accountability, and efficiency in borrowing and debt servicing. Governments should also consider debt restructuring options when debt levels become unsustainable. Public expenditure prioritization should emphasize infrastructure and education, as these sectors are critical for long-term economic growth and human capital development.

Future research should extend the current study in several important directions. First, further studies should investigate the role of international financial aid and concessional financing in mitigating the crowding-out effects of sovereign debt in developing economies. This would help determine whether external support can reduce fiscal pressure and improve investment outcomes. Second, future research should explore the effectiveness of debt restructuring mechanisms, including debt relief programs and renegotiation frameworks, in restoring fiscal space for infrastructure and educational investment. Third, additional studies should examine the role of Public-Private Partnerships as alternative financing mechanisms for infrastructure development. This is particularly important in contexts where fiscal constraints limit government-led investment. Fourth, future research could incorporate political economy factors such as governance quality, corruption, and institutional strength to better understand variations in debt and investment outcomes across countries. Comparative regional studies (e.g., Sub-Saharan Africa versus Latin America versus South Asia) could provide deeper insights into how structural differences influence the relationship between sovereign debt, exchange rate movements, and public investment behavior.

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