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THE ROLE OF [redacted] Real Sector Investments IN STABILISING The Exchange Rate in Zambia

An Analysis of the Mining, Manufacturing, Agriculture and Energy Sectors

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EXECUTIVE SUMMARY

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Zambia's economy remains heavily reliant on mining, particularly copper, which accounts for over 70% of export earnings. This dependence exposes the country to external shocks, including global commodity price fluctuations, underscoring the need for economic diversification as outlined in the Eighth National Development Plan (8NDP) and Vision 2030. This policy paper therefore examines the impact of real-sector investments on exchange rate volatility in Zambia, with a focus on the mining, manufacturing, agriculture, and energy sectors.

Using quarterly data from 2010 to 2024, an Autoregressive Distributed Lag (ARDL) Bounds test was used; the analysis finds that manufacturing and mining significantly support kwacha appreciation in the short run, though these effects are not sustained over the long term due to weak structural linkages. The energy sector consistently contributes to currency depreciation, driven by high energy demand resulting from reliance on imported petroleum, green energy equipment, and electricity to cover hydroelectric power deficits. The agriculture sector has little influence on exchange rate stability, while trade openness enhances domestic currency strength, underscoring the importance of expanding the export base and deepening regional integration.

These findings highlight that exchange rate volatility is rooted in structural weaknesses and uneven sectoral performance. Achieving sustainable currency stability requires targeted interventions. Manufacturing should prioritise value addition, diversification, and technological adoption, while mining must focus on refining and processing of minerals to increase export value. The energy sector reforms should accelerate diversification toward domestic renewable sources, including solar and biofuels. On the other hand, agricultural modernisation through mechanisation, irrigation and improved market access is critical. These should be supplemented by promoting agro-processing to derive greater value from the sector.

To complement this, coordinated macroeconomic policies on exchange rate management that align with sectoral investments are imperative. Overall, strengthening and diversifying real sectors is central to Zambia's exchange rate resilience. Deepening industrial capacity, promoting energy independence, and enhancing trade competitiveness will reduce vulnerability to external shocks and support a stable exchange rate, in line with the national development objective.

INTRODUCTION

1. INTRODUCTION

1.1. Background

Zambia's experience with macroeconomic instability dates back to the 1970s, when both domestic and external factors combined to weaken the economy. Domestically, the Government shifted from a private-sector-led development model to one dominated by state intervention and nationalisation. This meant that the Government obtained mines owned by the Anglo-American Corporation (AAC) and the Roan Selection Trust (RST), giving the Government a stake of 51%[1]. This policy transition introduced a fixed exchange rate regime, expansionary monetary policies, and rising fiscal deficits as the state increased its involvement in production and trade. Externally, the country faced significant headwinds, including a collapse in global copper prices and sharp increases in oil prices following the Organisation of the Petroleum Exporting Countries (OPEC) oil embargo. These pressures eroded the Balance of Payments (BOP) and triggered one of the decade's most destructive outcomes, a rapid depreciation of the exchange rate.

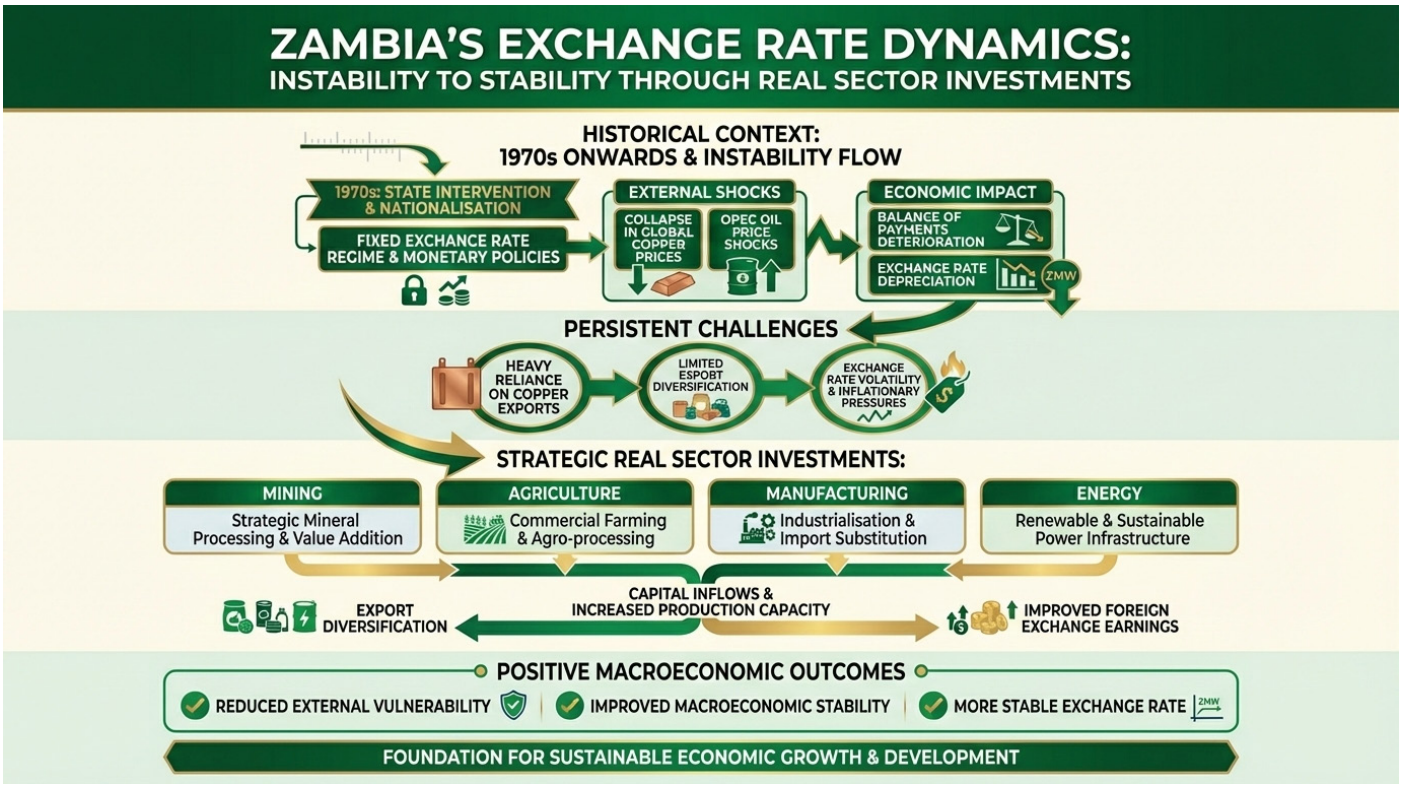
Since then, Zambia's economy has continued to struggle with exchange-rate volatility, highlighting deep-seated structural weaknesses and a heavy reliance on external conditions. The kwacha's volatility is mainly due to the country's limited export base, dominated by primary commodities, such as copper, which makes the economy vulnerable to changes in global demand and prices. When copper prices fall, foreign-exchange inflows decline, leading to currency depreciation and inflationary pressures. These dynamics have extensive implications for investment, debt repayment, and economic growth.

Therefore, to reduce reliance on exchange rates for primary commodities, it is essential to complement monetary policy with strategic investments in key productive sectors, such as Mining, Agriculture, Energy, and Manufacturing, to strengthen the real economy and lower external vulnerability. For example, in 2024 alone, several significant initiatives were undertaken, including addressing management challenges at Mopani Copper Mines and Konkola Copper Mines, and initiating geophysical surveys to locate new mineral and water resources. These efforts were supported by private capital inflows surpassing US$400 million during the year, with a further US$2.5 billion in prospective investments across mining, manufacturing, and energy sectors. Such investments are expected to increase production capacity, boost export earnings, and facilitate the formalisation of gold trading, thereby diversifying Zambia's sources of foreign exchange.

In light of the above, this report examines the role of real-sector investments in stabilising exchange rate volatility in Zambia, focusing on four key sectors: mining, manufacturing, agriculture, and energy. Additionally, it aims to determine whether targeted investments in these areas can help achieve a more stable exchange rate by boosting exports, improving productivity, and diversifying sources of foreign exchange. The study also explores how coordinated policy frameworks between sectoral development and macroeconomic management can reduce external vulnerabilities. To achieve the objectives of this paper, the study utilised the Autoregressive Distributed Lag (ARDL) model[2], which is discussed in detail in the appendix and part of the methodology.

1 *Sikamo, J. (2016). Copper mining in Zambia — history and future. Journal of the Southern African Institute of Mining and Metallurgy, 116(6).*

2 *See: Pesaran, H.M., Shin, Y. and Smith, R.J. (2001). Bounds Testing Approaches to the Analysis of Level Relationships. Journal of Applied Econometrics, [online] 16(3), pp.289–326. Available at: http://www.jstor.org/stable/2678547 [Accessed 3 Nov. 2025].*



1.2. Structure of the Report

The rest of the report is arranged as follows. Section 2, which follows, presents the methodological approach to this study's analysis. Section 3, Country Perspectives on Real Sector Influence, benchmarks the Zambian case against countries with similar realities, such as Peru, Ghana, and Kenya. Section 4 provides an analytical overview of the real sectors' impact on the exchange rate, with a specific focus on how the exchange rate has been related to and affected by mining, manufacturing, agriculture, and energy sectors. Section 5 presents the empirical results, which are threefold: the estimation techniques, the results, and the discussion of findings. The last section concludes this study by presenting empirical outcomes and making recommendations on how policy can be instituted to deliver the greatest benefits for the exchange rate and the economy at large.

METHODOLOGICAL APPROACH

2. METHODOLOGICAL APPROACH

Over the past decade, Zambia's real sector has faced mixed performance. Developments across its key productive sectors closely shape Zambia's exchange rate, given the country's reliance on commodity exports and imported inputs. The mining sector remains the primary source of foreign exchange, making the Kwacha highly sensitive to changes in copper prices and output. Manufacturing, though still small, has the potential to stabilise the currency by boosting non-traditional exports and reducing import dependence. On the other hand, agriculture supports stability by improving food security and limiting costly food imports, while also contributing some export earnings. Meanwhile, energy dynamics, especially hydropower availability and fuel import needs, directly influence production levels, foreign exchange flows, and overall external stability.

The empirical analysis has its theoretical underpinning on macroeconomic stabilisation theory that posits that strong real sector investments drive higher employment, output and fiscal stability, ultimately reducing macroeconomic shocks.[3] Thereby stabilising the exchange rate. Narrowly, the theoretical underpinning between real sector investments and exchange rate stability is backed by the Balassa-Samuelson Effect that emphasises that productivity gains in tradable sectors, including manufacturing, agro-processing and extractives, can lead to appreciation of the exchange rate and enhance overall macroeconomic stability[4]. This study will also benchmark Zambia against other countries so that lesson can be compared in order for government to determine how best the forex market and overall economy can benefit from a well performing real sector as per the focus of this study.

2.1. Data Description and Sources

This study utilises quarterly data, covering the period from 2010q1 to 2024q4. The dependent variable is the nominal exchange rate, whilst the independent variables include manufacturing value added, agricultural value added, energy use, mineral royalties and trade openness. These are abbreviated and explained in Table 1 below.

Table 1: Variables, Abbreviations and Description

Variable	Abbreviation	Description
Nominal Exchange Rate	EXR	The amount of Kwacha required to purchase one US Dollar in the foreign exchange market.
Manufacturing Value Added	MVA	The net output of the manufacturing sector, measured as a contribution of the sector to GDP
Agriculture Value Added	AVA	The net output of the agricultural sector, measured as a contribution of the sector to GDP
Energy Usage	ENU	The economy's primary energy usage, including indigenous production
Mineral Royalties	MNR	Tax payment for the extraction of minerals and charged based on the extraction or production
Trade Openness	TRO	A measure of an economy's global market integration

3 *Mankiw, N.G. (2020). Macroeconomics. 11th ed. New York: Worth Publishers.*
4 *Samuelson, P.A. (1964). Theoretical Notes on Trade Problems. Review of Economics and Statistics.*

Data on exchange rate and trade openness were obtained from the Bank of Zambia, whilst data on mineral royalties were obtained from the Ministry of Finance and National Planning. Manufacturing Value Added and Agricultural Value-Added data were obtained from the Zambia Statistical Agency (ZamStats). Lastly, energy use data were obtained from the World Development Indicators (WDI).

2.2. Estimation Technique

The impact of real-sector investments on exchange rate volatility is modelled using a sectoral analysis that investigates the differential effects of sector investments on the nominal exchange rate. An Auto Regressive Distributed Lag (ARDL) model captures the short- and long-run dynamics of the relationship between the different sectors and the exchange rate. This ascertains whether investments in these sectors have an immediate bearing on exchange rate volatility. Further, a cointegration analysis is deployed to determine the long-run relationship and ultimately the error correction model to ascertain if the model converges to equilibrium in the long run. The long run is important for determining whether investments undertaken in the current period yield significant returns, necessary to stabilise the exchange rate in subsequent periods.

The generalised ARDL (p, q) model, also based on Pesaran, Shin and Smith (2001), is specified as follows:

$$Y_t = \gamma_0 + \sum_{i=1}^{p} \delta_i Y_{t-i} + \sum_{j=0}^{q} \beta_j X_{t-j} + \varepsilon_t$$

Where: Y_t' Is a vector and the variables in $(X_t')'$ are allowed to be pure integrated of orders $I(0)$ or $I(1)$ or cointegrated; β and δ are coefficients; γ Is the constant; $j, i = 1, \ldots, K; p, q$ Are optimal lag orders (where p,q Are lag lengths for the dependent and independent variables, respectively), ε_{jt} It is a vector of the error terms – an unobservable zero-mean white noise vector process (which is serially uncorrelated or independent). Based on the generalised ARDL model above, the applied model is specified as:

$$\Delta EXR_t = \beta_0 + \sum_{j=1}^{p} \beta_j \Delta EXR_{t-j} + \sum_{j=0}^{q} \beta_j \Delta MVA_{t-j} + \sum_{j=0}^{q} \beta_j \Delta AVA_{t-j} + \sum_{j=0}^{q} \beta_j \Delta \ln MNR_{t-j} + \beta_j \Delta \ln ENU_{t-j} + \beta_j \Delta TRO_{t-j} + e_t$$

The exchange, mining sector and energy proxies were transformed into natural logs so that their estimates are presented as percentage changes like the rest of the variables. Prior to the estimation, unit root tests are conducted. Specifically, the Augmented Dickey-Fuller unit root tests and the Zivot and Andrews breakpoint test were applied. Additionally, the optimal lag length was determined using the Akaike Information Criterion (AIC). Meanwhile, the F-test bounds test was performed to check for cointegration.

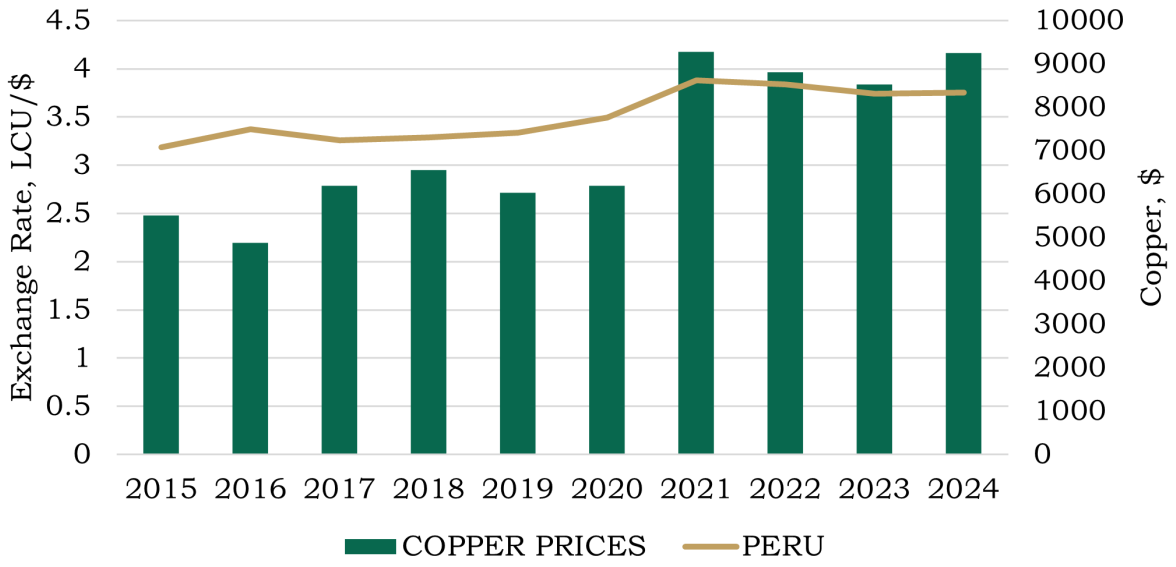
3. COUNTRY PERSPECTIVES ON REAL SECTOR INFLUENCE

To understand how developments in the real sector shape exchange rate dynamics, this section reviews countries with economic structures comparable to Zambia's that have either achieved relatively stable exchange rates or adopted real-sector–focused policies that support currency stability.

3.1. Peru

Peru is the third-largest copper exporter in the world, with 2024 exports totalling 2.74 million tons, down 0.7% from 2023[5]. Its currency has maintained a relatively stable exchange rate against major convertible currencies, particularly the US dollar. Between 2015 and 2025, the exchange rate fluctuated between about 2.5 and 4 Peruvian Sol per dollar, as illustrated in Figure 1. Overall, the exchange rate for Peru is relatively stable despite fluctuations in copper prices as shown in Figure 1.

Figure 1: Copper Prices and Exchange Rate (2015-2024).



Source: World Development Indicators and Bank of Zambia

The stability of the Peruvian Sol stems from the country's strong macroeconomic fundamentals, including low inflation and a prudent monetary policy under a managed floating exchange rate regime. Furthermore, independent and credible institutions, large foreign reserves, and constitutional safeguards that prevent reckless fiscal and monetary policies have also contributed to this stability.

i. Export Growth and Diversification

Beyond macroeconomic management, Peru's exchange rate stability is strongly underpinned by sustained export growth and diversification. Empirical evidence shows that Peru's export expansion since the early 2000s has been driven not only by its mineral exports but also by rapid growth in non-traditional exports, particularly high-value agricultural products and agro-processing. According to Illescas et al, (2011) Peru successfully expanded both the intensive margin (higher volumes of existing

5 *Aquino, M. and Solomon, D.B. (2025). Peru copper output edges down in 2024 to 2.74 million tons. MINING.COM. [online] 14 Feb. Available at: https://www.mining.com/web/peru-copper-output-edges-down-in-2024-to-2-74-million-tons [Accessed 29 Oct. 2025].*

exports) and the extensive margin (new export products and markets), reducing vulnerability to commodity price shocks[6].

As such, between 2005 and 2023, non-traditional exports, especially fruits, vegetables, and processed foods, grew at rates exceeding traditional exports, contributing to a more stable current account and more predictable foreign exchange inflows[7]. This diversification has helped insulate the exchange rate from volatility associated with fluctuations in global copper prices, reinforcing the relative stability observed in Figure 1.

ii. Trade Policy and Export Structure[8]

Peru's trade policy framework has played a central role in reinforcing export performance and, by extension, exchange-rate stability. According to the World Trade Organisation (WTO), Peru maintains an open and liberal trade regime, characterised by low tariff levels, minimal non-tariff barriers, and strong adherence to multilateral trade rules. In 2018, the trade-to-GDP ratio was 48%, indicating the economy's high degree of integration into global markets.

Despite this openness, Peru's export structure remains resource-intensive, with mining products accounting for over 60% of total exports. Copper alone represented approximately 31% of total exports in 2018, followed by gold and zinc. This concentration has historically exposed the economy to commodity price cycles; however, Peru has mitigated these risks through policy-driven export diversification, particularly into non-traditional agricultural exports. The share of agricultural products in total exports rose from 15.2% in 2012 to 19.1% in 2018, reflecting deliberate efforts to expand the tradable base beyond minerals.

Furthermore, Peru has strengthened trade openness through a broad network of agreements with 53 countries, diversifying export markets beyond key partners like China, the US, and the EU. The National Strategic Export Plan (PENX 2025) enhances competitiveness by promoting value-added exports, improving logistics and trade facilitation, and streamlining customs procedures. Supportive tariff and trade policies—including low average MFN tariffs, no export taxes, duty drawback schemes, and export financing for SMEs—further reduce trade costs and encourage participation in global markets, sustaining foreign exchange inflows.

Taken together, Peru's open trade regime, declining tariff structure, active trade facilitation agenda, and strategic export diversification policies have strengthened the external sector's resilience. These structural features have helped stabilise export earnings and reduce balance-of-payments volatility, contributing indirectly but materially to the observed stability of the exchange rate despite fluctuations in global commodity prices.

6 *Illescas, Javier and Jaramillo, C. Felipe (2011). Export Growth and Diversification: The Case of Peru. https://openknowledge.worldbank.org/entities/publication/af266d8c-d9e3-58d2-b84a-191d72780908*

7 *UNCTAD (2023). Productive Capacities and Structural Transformation: Peru. https://unctad.org/publication/productive-capacities-and-structural-transformation*

8 *World Trade Organization (2018). Trade Policy Review: Peru. https://www.wto.org/english/tratop_e/tpr_e/s393_sum_e.pdf*

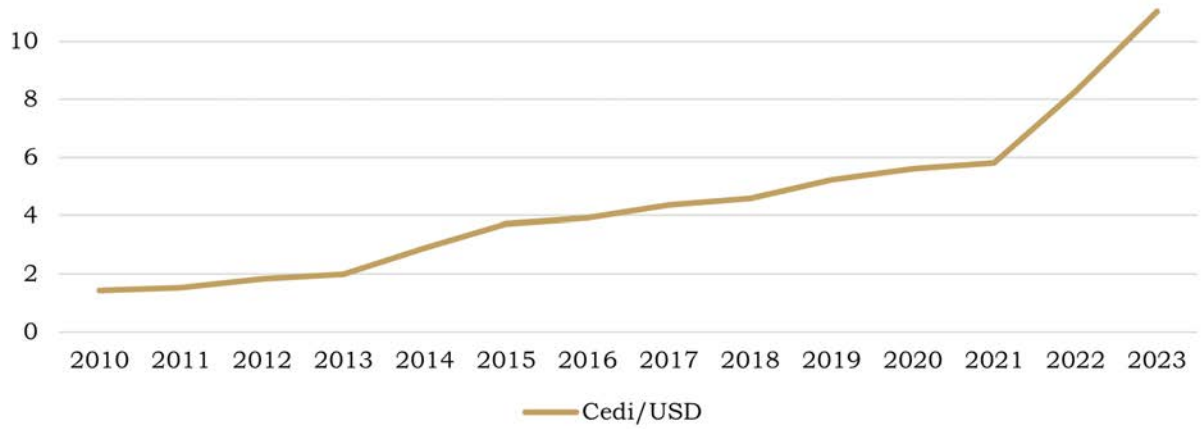
3.2. Ghana

Another case in Sub-Saharan Africa is Ghana. Ghana ranks higher than Zambia in the diversification score, with 26.8 against 23.7[9], respectively, according to the African Transformation Index. However, historically, the country has depended on gold and cocoa exports, leaving its currency, the cedi, volatile[10]. This makes its economy vulnerable to external shocks, ultimately creating uncertainty and hindering investment. Nonetheless, reforms have been implemented, notably, the establishment of the Ghana Gold Board (GoldBod) to formalise gold trading. This helps curb smuggling, improve traceability, boost foreign exchange earnings, and ensure greater value retention from the country's gold resources[11].

Additionally, formalising export channels and investing in value addition may boost foreign-exchange inflows, ultimately improving the country's exchange rate stability. Since the introduction of the GoldBod, total earnings in the first half of 2025 alone reached US$8.3 billion, double the receipts in 2024[12]. This helped increase foreign reserves to approximately 4.5 months of import cover, thereby providing exchange rate support. The IMF reports that the Ghana Cedi appreciated by about 36% (Year-to-date to October)[13].

What makes the GoldBod a unique institution as compared to Zambia Gold Company Limited (ZGCL)? The Ghana Gold Board is institutionally distinct because it was designed as a macroeconomic and regulatory instrument rather than merely a commercial enterprise. Its mandate explicitly links gold-sector governance to foreign-exchange generation, reserve accumulation, and exchange-rate stability. GoldBod combines regulatory authority with market coordination by licensing buyers, standardising export procedures, enforcing traceability, and centralising gold exports through formal channels, particularly for the artisanal and small-scale sector, where smuggling and FX leakages are most severe. This structure allows the state to improve price transparency, align production with recorded exports, and ensure that gold revenues are captured within the official financial system and transmitted to the central bank.

Figure 2: Ghana's Exchange Rate, 2010 to 2023



Source: World Development Indicators

9 *The Diversification Score measures an economy's capability to produce and export a widening array of goods and services within the Growth with DEPTH framework designed by Africa Centre for Economic Transformation (ACET). See Also: Zambia Country Economic Transformation Outlook (CETO) by ZIPAR and ACET*

10 *Refer to Figure 2*

11 *See also: https://goldbod.gov.gh/about-us/*

12 *GoldBod (2025). Ghana's gold export receipts reach record levels this year- Ghana Gold Board. [online] Ghana Gold Board. Available at: https://goldbod.gov.gh/ghanas-gold-export-receipts-reach-record-levels-this-year/? [Accessed 12 Jan. 2026].*

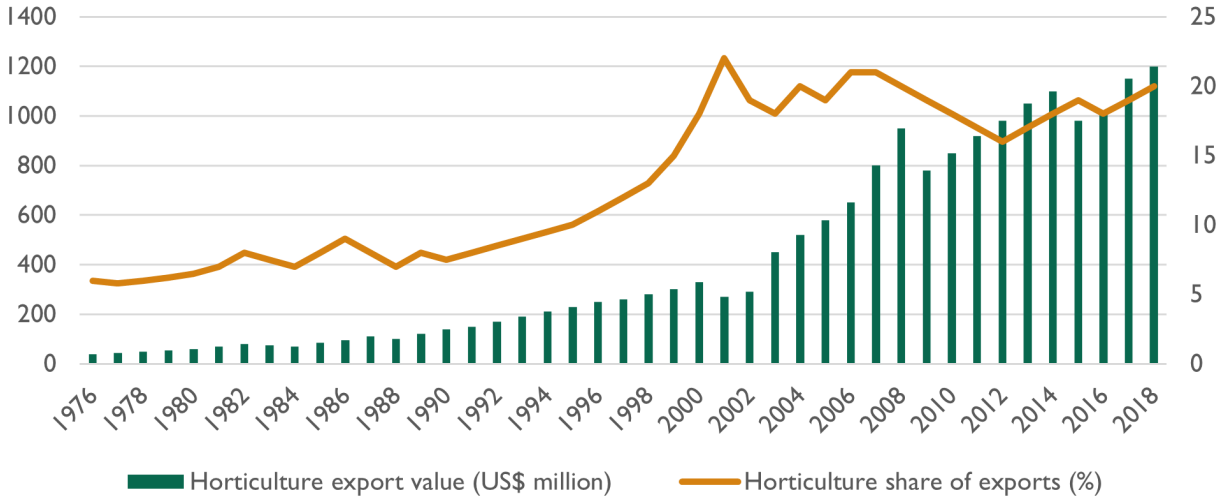
13 *International Monetary Fund (2025). IMF Country Report No. 25/343. [online] Available at: https://www.imf.org/-/media/files/publications/cr/2025/english/1ghaea2025002-source-pdf.pdf [Accessed 12 Jan. 2026].*

In contrast, Zambia Gold Company Limited is primarily structured as a state-owned commercial entity, operating within existing regulatory frameworks rather than reshaping them, with objectives centred on participation in mining and trading activities rather than systemic macroeconomic stabilisation. Consequently, while both entities operate in the gold sector, GoldBod's legal centralisation, regulatory reach, and integration with monetary and reserve policy give it a broader, economy-wide role in influencing foreign-exchange outcomes that a conventional state-owned company lacks.

3.3. Kenya

Kenya has a relatively diversified economy compared to its regional peers, with key sectors contributing significantly to GDP and foreign-exchange earnings. Agriculture accounts for 19.1% of GDP, real estate contributes 10.2%, and transport and storage represent 9%, collectively supporting a broader export and FX base that reduces vulnerability to sector-specific shocks[14]. According to the African Transformation Index (ATI), Africa's diversification score is 52.2, more than twice that of Zambia's. One notable policy that amplifies Kenya's diversification is its intentional development of supply chains. This has been achieved through targeted value-chain development, particularly in horticulture. In this sub-sector, early foreign investment, contract farming, compliance with international standards, and cold-chain logistics have enabled local farmers to integrate into global value chains and upgrade into higher-value segments[15]. To complement this, policy actions such as trade liberalisation, export facilitation, and support to industry associations have reinforced the private-sector dynamics. Further, diversified real-sector growth supports currency stability and provides a buffer against external shocks.

Figure 3: Kenya's horticulture export performance, 1976–2018



Source: Heher and Steenbergen (2021)

14 *Percentages in brackets represent the share of GDP, as reported by Cytonn Investments (2025) in Kenya Q1 2025 GDP Note. Retrieved from https://www.cytonn.com/uploads/downloads/kenya-q12025-gdp-note-vf.pdf*

15 *Please refer to Figure 2 for more insight on the growth of Kenya's Horticultural sector*

EMPIRICAL AND ANALYTICAL FINDINGS

4. EMPIRICAL AND ANALYTICAL FINDINGS

4.1. Unit Root Test

The results from the Augmented Dickey-Fuller (ADF) and Zivot-Andrews tests indicate that while some variables are stationary at levels, others become stationary only after first differencing, as shown in APPENDIX B. This suggests a mixture of I(0) and I(1) variables, meaning that some variables are integrated of order zero, while others are integrated of order one, making the ARDL Bounds test the most appropriate estimation test, which further found a cointegration relationship amongst the variables. The appropriate lag was selected based on the AIC information criterion, which indicated a maximum of 4 lags, as shown in APPENDIX B.

4.2. ARDL Bounds Test

To test for cointegration, the ARDL bounds test was conducted. The results confirmed cointegration between the exchange rate and the dependent variable, as evidenced by the negative, highly significant cointegrating equation shown below. The results from the short-run and long-run ARDL model are given in Table 2. The short-run results indicate that the exchange rate is influenced by its trends only up to a quarter lag, indicating exchange rate inertia, where past values strongly affect current values[16]. Further, Table 2 indicates that an increase in manufacturing is associated with an appreciation of the exchange rate. Further, an increase in mineral royalty is associated with an immediate depreciation, which is sharply reversed.

Additionally, a 1% increase in trade openness results in an immediate 0.03% appreciation in the exchange rate. This signals that the more globally integrated a nation is, the more it attracts short-term capital inflows and increases exports, thereby increasing the foreign currency. Further, agriculture has no significant impact on exchange rate volatility in the short run. This had been due to the fact that agriculture contribution to GDP had be declining[17], and the value addition is low and as result the country export products of little value as compared to other countries like South Africa and Kenya, and the country mainly relies on exporting few agriculture products with limited diversity and periods of continuous high value dollar exports[18],[19],noting the fact that most of the produce is consumed domestically.

16 *A quarter lag effect entails that changes to independent variables or reaction to macroeconomic shocks will subsequently take 3 months (a quarter) to a effect that the exchange rate and this will be so in corresponding quarters, for example lag 2 will entail 6 months and so and so forth. The short short run cointegration had a speed of adjustment of 40%. This mean it will take 2.5 quarters, which is 10 months (1/0.4) for the changes in the real sector to convert to influencing exchange rate stability in the long – run.*

17 *Phiri, J., 2023. Faculty of Economics and Management (Doctoral dissertation, Doctoral dissertation, Czech University of Life Sciences Prague).*

18 *Mbewe, M., Kalikeka, M., Phiri, J., Masilokwa, I., Mwimba, T., Mungu, M., Chileshe, K., Sakala, H., Chongo Chanda, B. & Commodore, R. (2025) ZAMBIA COUNTRY ECONOMIC TRANSFORMATION OUTLOOK (CETO) 2025. Lusaka: Zambia Institute for Policy Analysis and Research & African Center for Economic Transformation. Available at: https://www.zipar.org.zm/wpfd_file/zambia-country-economic-transformation-outlook/ (Accessed: 13 January 2026).*

19 *Phiri, J., Malec, K., Majune, S. K., Appiah-Kubi, S. N. K., Gebeltová, Z., Kotásková, S. K., Maitah, M., Maitah, K., & Naluwooza, P., 2021. Durability of Zambia's Agricultural Exports. Agriculture, 11(1), 73. https://doi.org/10.3390/agriculture11010073*

Table 2: ARDL Estimates

Variable	Coefficient	P-value
Adjustment		
EXR		
L1	-0.405	0.000***
Long Run Results		
MVA	-0.025	0.483
AVA	0.015	0.276
TRO	-0.078	0.000***
lENU	2.728	0.001***
lMNR	0.108	0.278
Short Run Results		
EXR		
L1	0.775	0.000***
L2	-0.180	0.138
MVA		
--	0.217	0.161
L1	-0.002	0.884
L2	-0.02	0.040***
AVA	0.006	0.262
TRO	-0.031	0.000***
lENU	1.106	0.000***
lMNR		
--	2.162	0.001***
L1	-1.76	0.007***
_cons	-5.117	0.000***

*Notes: *** p<.01, ** p<.05 & *p<.1 (Stationarity at the 1, 5 and 10 per cent significance levels)*

Lastly, there is convergence of the exchange rate in the long run to equilibrium with the speed of adjustment of 40%, as depicted in Table 2 Above. This implies that any disturbances or shocks to the exchange rate are corrected for in the long run, indicating stability. Specifically, the long-run results indicate that higher energy demand is associated with long-term currency depreciation and, in the last 6 quarters, has been matched by a reduction in crude oil prices, a key factor in enhancing the domestic currency's appreciation. While trade openness leads to long-run exchange rate appreciation. The sector-specific results and their relevance are discussed in the subsequent sections.

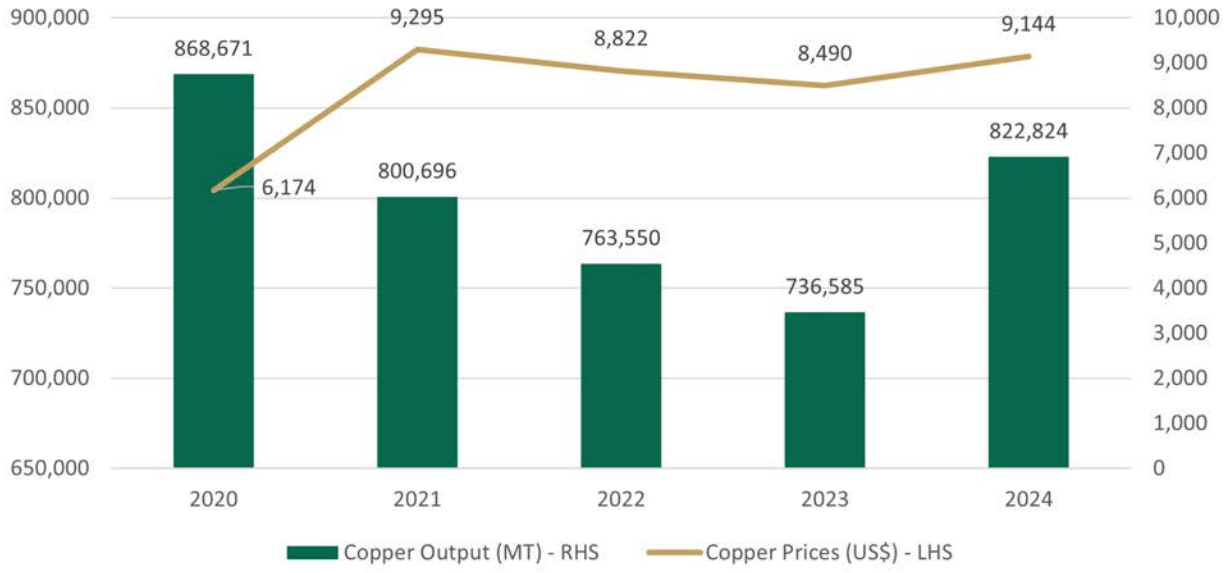
4.3. Mining Sector Synamics and their Influence on Exchange Rate Movements

Mining remains the backbone of Zambia's economy, supported by abundant mineral endowments, including metals, gemstones, industrial and building materials, and emerging critical minerals. The sector is primarily driven by the extraction of metallic minerals, most notably copper and its by-product, cobalt, while gold production has also grown steadily in recent years. Zambia contributes about 5% of global copper output, with domestic production reaching 822,824 metric tonnes (MT) in 2024 and projected to increase to 1 million

MT by the end of 2025. In 2024, the mining sector accounted for 17.4% of GDP[20]. Furthermore, copper exports account for approximately 70% of total export earnings, making the sector the largest foreign-exchange earner and exerting a significant influence on the exchange rate and overall macroeconomic stability[21].

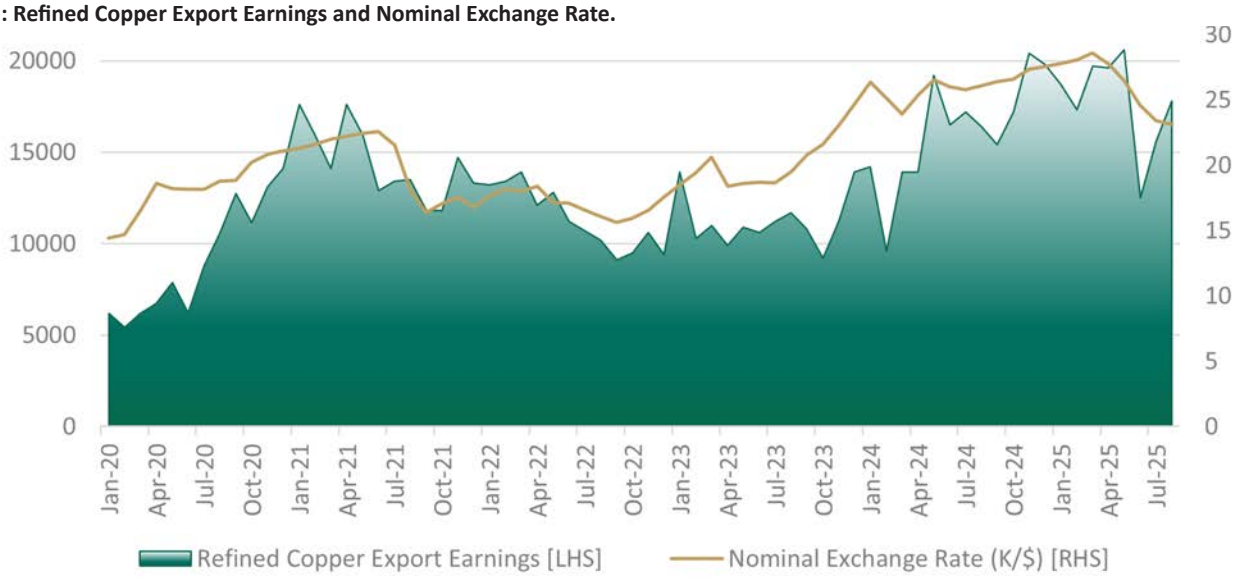
Over time, Zambia's copper output has been shaped by domestic policy dynamics, particularly mining tax reforms, while prices have followed mainly global commodity cycles. Frequent changes to the mining fiscal regime undermined investor confidence and delayed capital expenditure decisions at major mines. This policy uncertainty constrained production growth and foreign-exchange earnings, even during periods of favourable global prices. Combined with rising structural demand for foreign currency, the resulting supply-side constraints placed sustained depreciation pressure on the Kwacha.

Figure 4: Performance of Copper Prices and Output (2020-2024).



Source: Ministry of Finance and National Planning – Annual Economic Reports (2020-2024)

Figure 5: Refined Copper Export Earnings and Nominal Exchange Rate.



Source: Authors' Compilation of data from Bank of Zambia and ZAMSTAT.

20 *Ministry of Finance and National Planning (2024). Annual Economic Report 2024.*

21 *Zambia Development Agency – Mining Sector Profile. https://www.zda.org.zm/wp-content/uploads/2024/09/ZDA-Mining-Sector-Profile-2024.pdf*

The post-pandemic global recovery and the acceleration of the green-energy transition drove copper prices sharply higher, rising from US$6,174 per MT in 2020 to US$9,295 per MT in 2021. However, Zambia recorded only limited benefits from this price upswing as copper production continued to decline due to persistent operational challenges at major mines, including Mopani, Konkola Copper Mines, Kansanshi, and Nchanga. Output fell from 868,671 MT in 2020 to 800,686 MT in 2021, and further to 736,585 MT in 2023, as shown in Figure 4.

Despite falling volumes, the surge in prices in 2021 temporarily boosted export earnings, contributing to an appreciation of the Kwacha from K22.4/US$ in 2020 to K16.08/US$ in 2021. In early 2022, the Government policy responded by reintroducing the deductibility of mineral royalties for corporate income tax purposes, aligning Zambia's fiscal regime with international best practice and reducing the effective tax burden on mining companies. This reform, reinforced by subsequent institutional changes under the Minerals Regulation Commission Act (2024) and the Geological and Minerals Development Act (2025), aimed to restore policy credibility, strengthen regulation, and revive investment.

Nevertheless, production remained subdued as legacy operational constraints persisted. As copper export earnings weakened, depreciation pressures re-emerged, with the Kwacha depreciating from K16.08/US$ in 2022 Q3 to K25.9/US$ by 2025 Q2. This pattern highlights Zambia's continued structural dependence on copper as its primary source of foreign exchange and the exchange rate's vulnerability to sector-specific shocks, as illustrated in Figure 5.

Recent policy developments have introduced a new transmission channel between mining and exchange-rate dynamics. In January 2026, Zambia became the first African country to allow mining tax payments in Chinese yuan. This measure reflects the growing integration of Zambia's copper sector with China-linked trade, procurement, and financing arrangements. Rather than signalling a shift away from the US dollar, the policy serves as a complementary settlement mechanism to ease short-term dollar liquidity pressures, particularly during peak tax-payment periods.

By enabling firms with yuan-denominated revenues or financing to meet statutory obligations without converting into US dollars, the policy has the potential to smooth episodic foreign-exchange demand and moderate short-term volatility. However, its effectiveness will depend on uptake, transparent conversion rules, and prudent exposure management, given that reserves and external debt obligations remain overwhelmingly dollar-denominated.

Empirical results from the study reinforce these dynamics. An increase in mining earnings through mineral royalties is associated with an immediate depreciation of about 2% in the exchange rate, reflecting short-run FX demand effects and timing mismatches in inflows. This depreciation is reversed in the subsequent quarter, with an appreciation of over 1% as mining revenues are absorbed into the financial system and channelled into foreign-exchange reserves. This lagged adjustment underscores the importance of institutional mechanisms that accelerate the capture and transmission of mining-related FX inflows.

Comparative evidence from Peru and Ghana offers essential insights for Zambia. Peru demonstrates that strong macroeconomic institutions, credible monetary policy, and deliberate export diversification can significantly dampen exchange rate volatility, even in a mining-dependent economy. Ghana's experience, particularly through the Ghana Gold Board, illustrates how institutional centralisation of mineral marketing and export

proceeds can reduce FX leakages, improve reserve accumulation, and support exchange-rate stability. In contrast, Zambia's mining governance framework, while strengthened through recent legislative reform, still relies heavily on production volumes and global prices, with limited institutional mechanisms to smooth FX inflows or insulate the exchange rate from sectoral shocks.

4.4. Interlinkages Between Manufacturing Performance and Povements in the Exchange Rate

The manufacturing sector is one of Zambia's key drivers of economic transformation and job creation, enabling local value addition through the development of full value chains. This strategic role has, over the past 15 years, been reinforced through Zambia's industrial policy framework, including the Industrialisation and Job Creation Strategy (2012–2021), the National Industrial Policy (2018), and successive National Development Plans, all of which identify manufacturing-led value addition as central to economic diversification[22]. Priority sub-sectors include:

i. Processed Foods;
ii. Textiles and Garments;
iii. Engineering Products;
iv. Wood and Wood products;
v. Leather and Leather Products;
vi. Mineral processing and products
vii. Pharmaceuticals; and
viii. Blue Economy.

These priority sub-sectors are consistent with policy interventions under the Multi-Facility Economic Zones (MFEZs), Industrial Parks, and the National Local Content Strategy (2022), which target agro-processing, mineral beneficiation, pharmaceuticals, and engineering fabrication as anchor industries for domestic industrial deepening. Manufacturing contributed 9.3% to the country's GDP in 2024, against the Vision 2030 target of 36.1% by 2030, representing a large performance gap. This underperformance has prompted renewed focus with industrial policy measures, including enhanced fiscal and non-fiscal incentives being extended through the Zambia Development Agency and renewed emphasis on export-oriented manufacturing under recent trade and industrial strategies.

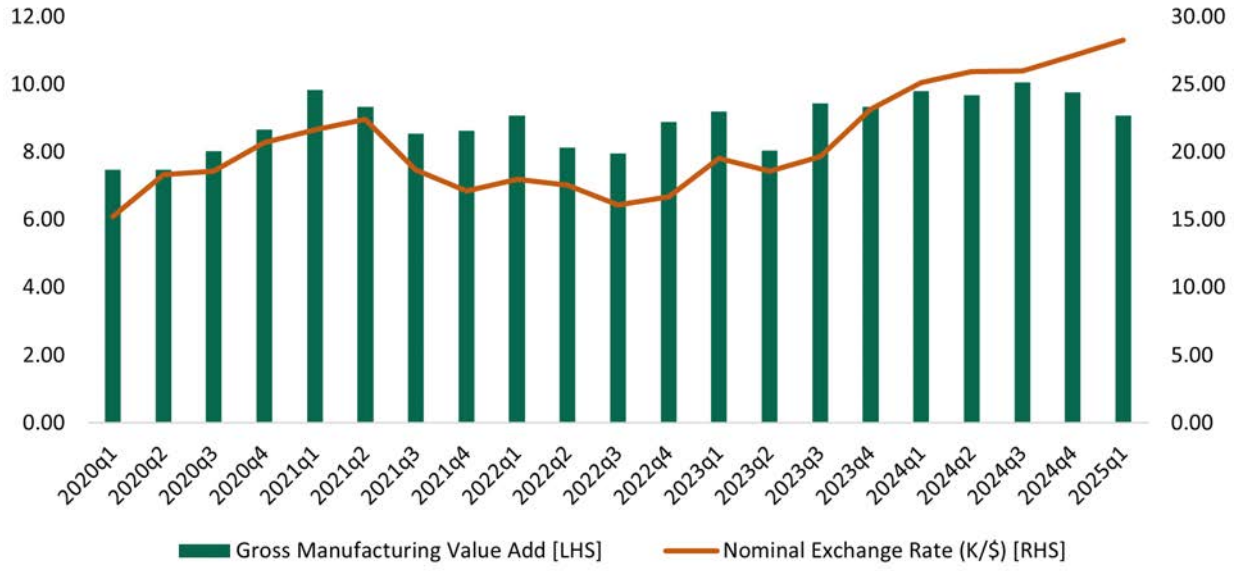
The development and growth of the manufacturing sector are expected to stimulate value addition to primary commodities, thereby increasing national export earnings and ultimately stabilising the exchange rate. This objective is explicitly articulated in Zambia's National Export Strategy and AfCFTA Implementation Frameworks, which position manufacturing as a key mechanism for reducing dependence on copper exports for foreign exchange. Ideally, a competitive manufacturing sector would boost export earnings, attract foreign direct investment, and lessen import dependence, thereby increasing foreign exchange supply and strengthening the Kwacha. Recent policy reforms—particularly improvements in fiscal governance, debt restructuring, and energy sector reforms—are intended to complement industrial policy by reducing macroeconomic volatility and boosting investor confidence in manufacturing.

22 *Zambia Development Agency – Manufacturing Sector Profile- https://www.zda.org.zm/wp-content/uploads/2024/09/ZDA-Agriculture-Sector-Profile-2024-Final.pdf*

Zambia was among the most industrialised countries in Africa during the early 1990s, but this position has eroded over time. The sector's growth has been constrained by limited access to finance – particularly for startups and emerging enterprises, – unreliable energy supply, skills mismatches for innovation, and exposure to external market shocks. These constraints are acknowledged in recent industrial and development policies, which propose targeted financing mechanisms such as credit guarantees, skills development through TEVET reforms, and expanded energy generation capacity to support industrial productivity. These challenges have been compounded by frequent changes in industrial policies over the past two decades. Shifts between liberalisation-oriented and state-led industrialisation frameworks have contributed to policy uncertainty, undermining long-term investment planning in the manufacturing sector. Maintaining consistent policies over a longer period is therefore critical to providing investors with predictability, sustaining industrial growth, and, by extension, supporting exchange-rate stability, as observed in countries such as Kenya, Ghana, Morocco, and South Africa.

From the empirical results of this study, an increase in manufacturing activity in Zambia has no significant effect on the exchange rate. However, manufacturing value added is associated with an appreciation of 0.03% with a two-quarter lag, indicating that higher manufacturing activity in the two previous quarters strengthens the currency, thereby contributing to exchange rate stability. This lagged relationship is consistent with Zambia's medium- to long-term industrial policy orientation, in which manufacturing-led export growth gradually rather than instantaneously improves foreign exchange inflows and macroeconomic stability.

Figure 6: Gross Manufacturing Value Add and Nominal Exchange Rate.



Source: Authors' Compilation of data from Bank of Zambia and ZAMSTAT.

Figure 6 illustrates how developments in the manufacturing sector have contributed to exchange rate stability between 2020 and mid-2025. Over this period, manufacturing value added generally trended upward, reflecting gradual improvements in domestic production capacity, industrial diversification efforts, and the operationalisation of key investment hubs such as Multi-Facility Economic Zones (MFEZs) and Industrial Parks (IPs). These initiatives have attracted both domestic and foreign investment, expanded production of export-oriented and import-substituting goods, and strengthened supply chain linkages. This has increased foreign-exchange rate inflows, thereby supporting the stability of the Kwacha, albeit with a lag. Therefore, a vibrant manufacturing base is critical, as it supports the export of processed and semi-finished goods, broadens the scope of non-traditional exports, and generates additional foreign exchange earnings. In line with a related

study on the CETO for Zambia (cited in footnote 24), it is hoped that the trajectory highlighted in the figure above, supplemented by industrial policy stability (cited in footnote 22), continues and eventually lead to quality high-value exports on the foreign market, and as a result contribute to a statistically significant effect on the exchange rate and the economy as a whole.

4.5. Agricultural Sector and Exchange Rate Movements

Zambia's agricultural sector is a key driver of economic transformation and job creation, though it is characterised by relatively low productivity. In 2024, the sector contributed 2.8% to GDP[23] and employs about 70% of the country's population. Because of its central role in ensuring national food security, agriculture also indirectly contributes to exchange rate stability.

Despite agriculture's important role in the economy and the National Agricultural Policy of Zambia (2012-2030), which targets improved productivity, diversification, and value addition, the sector faces several constraints that limit its potential. These include limited access to appropriate technology for enhanced yields, as well as processing of produce, input constraints, including energy shortages such as load shedding and the inability to competitively produce and process domestically[24]. Navigating these challenges will improve productivity in the sector, ultimately increasing its contribution to GDP.

Notwithstanding, countries in the region whose agricultural sector is thriving, specifically Kenya, credit the strong performance of the sector to political commitment, appropriate infrastructure and strong input supply[25]. The Kenyan government has deliberately moved beyond supportive policies to the actualisation of infrastructure and irrigation investments.

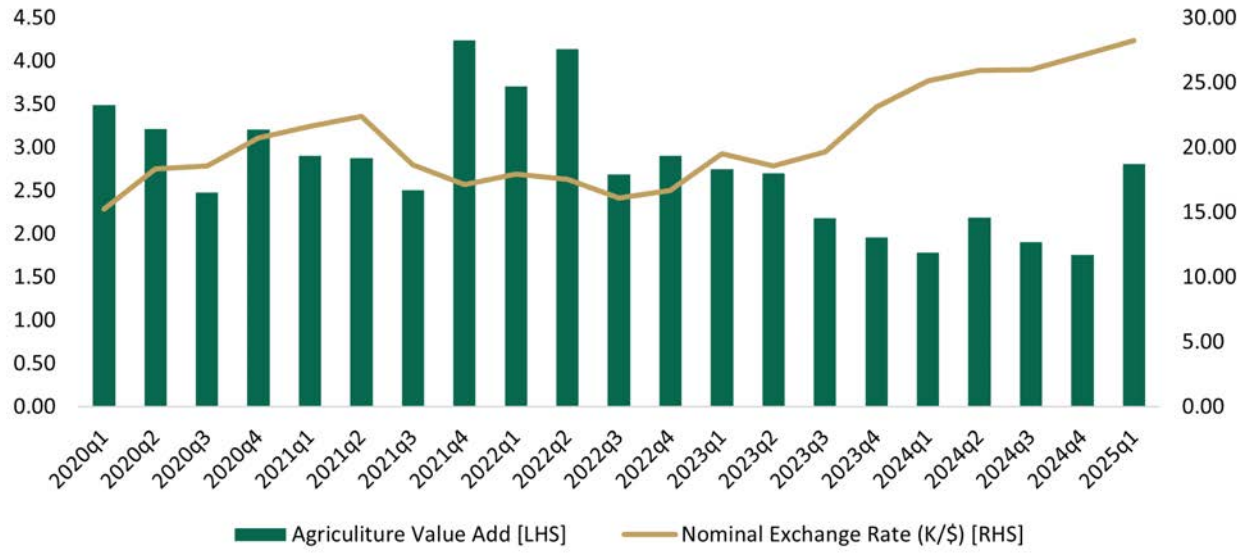
Further, the country has accelerated adoption of technology, particularly climate-smart agriculture practices, prioritising value addition on high-value crops alongside staple food crops and modernising value chains[26]. These initiatives have not only fostered growth in Kenya's agricultural sector but have also ensured that the country's agricultural export commodities are competitive, thereby increasing foreign exchange inflows from the sector.

In Zambia, the quest to increase domestic food production not only reduces reliance on imports but also lowers the demand for foreign currency and helps ease pressure on the exchange rate. Furthermore, agricultural exports, such as maize, tobacco, and horticultural products, generate foreign exchange earnings that support the external balance. Therefore, Zambia's agricultural sector supports exchange rate stability primarily through indirect channels, thereby reducing dependence on food imports and generating foreign-exchange earnings from non-traditional exports.

However, its overall impact remains constrained by limited technology, especially among subsistence farmers who make up the majority of the farming population; heavy reliance on rainfall; inadequate irrigation; limited value addition, and inconsistent grain export policies, all of which continue to suppress productivity and export capacity.

23 *Ministry of Finance and National Planning (2024). Annual Economic Report 2024.*
24 *ACET. (2025). Zambia Country Economic Transformation Outlook.*
25 *Kenya Ministry of Agriculture, Livestock, Fisheries and Irrigation (2019) Agricultural Sector Transformation and Growth Strategy Report.*
26 *Kenya Ministry of Agriculture, Livestock, Fisheries and Irrigation (2019) Agricultural Sector Transformation and Growth Strategy Report.*

Figure 7: Agriculture Value Added and Nominal Exchange Rate.



Source: Authors' Compilation of data from ZAMSTAT.

Figure 7 shows that agricultural value added in Zambia exhibits pronounced volatility, reflecting the sector's strong exposure to weather conditions, input constraints, and structural limitations. Agricultural value added as a share of total value added was relatively strong between 2020 and 2021, peaking at 3.49% in Q1 2020 and 4.24% in Q4 2021. Over the same period, the nominal exchange rate depreciated from K15.23/US$ in Q1 2020 to K17.12/US$ in Q4 2021, as shown in Figure 7.

Between Q1 2022 and Q4 2024, agricultural value added declined sharply from 3.71% to 1.76%, coinciding with adverse climatic conditions and drought-related shocks that constrained output and highlighted the sector's limited resilience to exogenous shocks. During this period, the nominal exchange rate continued to depreciate significantly, rising from K17.96/US$ in Q1 2022 to K27.10/US$ by Q4 2024.

This co-movement indicates that periods of declining agricultural value added broadly coincide with episodes of exchange rate depreciation, highlighting the sector's limited capacity to act as a stabilising buffer for the Kwacha. While the agricultural sector provides some indirect support for exchange rate stability through reduced dependence on imported food items and its role in generating foreign exchange through non-traditional exports, these effects remain insufficient to offset broader external pressures.

In terms of export performance, agriculture's contribution to non-traditional exports moderated between 2020 and 2021, reaching 29.1% by end-2021, before declining to 21.6% in Q2 2024 and recovering modestly to 26% in Q1 2025. Over the same period, agricultural export earnings increased from K1.3 billion in Q1 2021 to K1.6 billion in Q2 2024, before rising further to K2.0 billion in Q1 2025. However, despite this nominal increase, export earnings have remained insufficient to materially strengthen agriculture's stabilising role in the external sector.

On the other hand, imported agricultural inputs are largely supplied through the Farmer Input Support Programme (FISP), which remains a major source of foreign exchange demand. For instance, in 2022, foreign exchange demand increased to US$7.6 billion from US$6.3 billion in 2021, and a large portion of this demand was for the procurement of agricultural inputs under FISP.

Given that a large share of inputs is imported, these allocations translate into significant foreign exchange

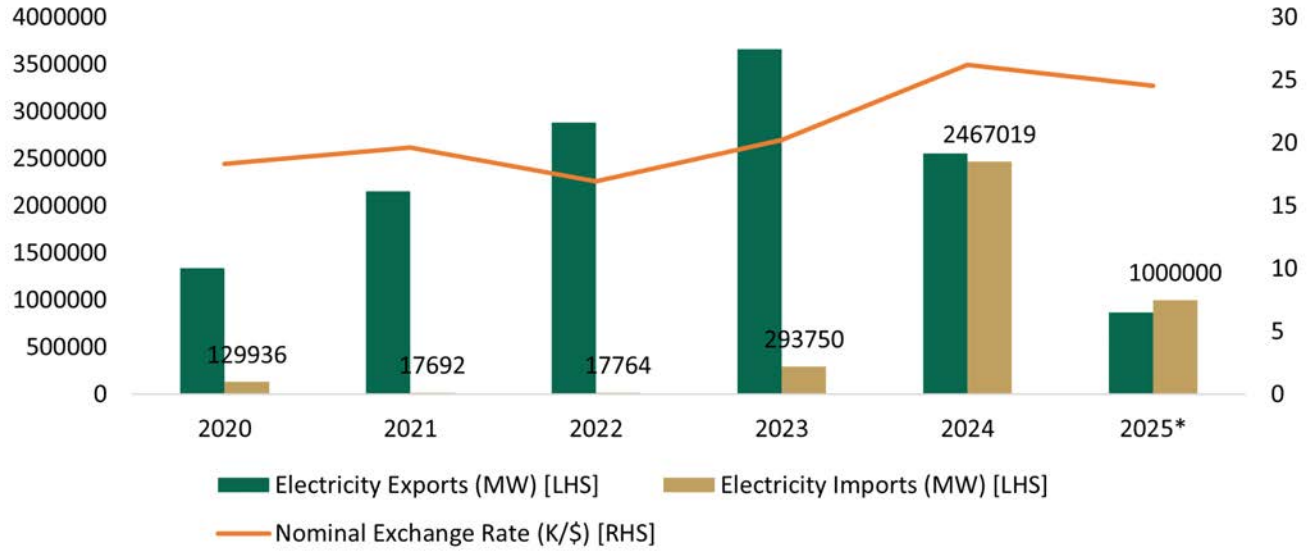
demand, particularly when the Kwacha is under pressure. As such, while FISP aims to enhance smallholder productivity and food security, its heavy reliance on imported inputs at a time when agricultural value added remains low can intensify exchange rate volatility by elevating demand for foreign currency, particularly during periods of Kwacha depreciation and constrained external balances. This is compounded by inconsistent grain export policies that do not support long-term planning and investment for commercially oriented agricultural and agro-processing enterprises.

4.6. Energy Sector and its Impact on Movements in the Exchange Rate

Energy dynamics, particularly electricity supply and fuel import dependence, play a significant role in shaping exchange rate movements in Zambia. This is because of their role as key inputs in production processes. However, for electricity, the country's heavy reliance on hydropower makes generation susceptible to rainfall patterns. During periods of drought, reduced hydropower output constrains industrial activity, especially in mining and manufacturing, which together account for the bulk of Zambia's export earnings. In such periods of deficit, the country may increase electricity imports from its neighbours, as shown in Figure 8.

Zambia's most recent drought (2023/2024), for instance, resulted in a 750-megawatt (MW) electricity deficit, leading to widespread load shedding and reduced mining output. Generally, electricity deficits, if unaddressed, undermine investor confidence and ultimately export performance, lowering competitiveness and output, further narrowing the country's export base and amplifying exchange rate volatility. To mitigate this, the Government increased electricity imports by 739.8%, from 293,750 Mega Watt Hours (MWh) in 2023 to 2,467,019 MWh in 2024, as shown in Figure 8. This also contributed to the increasing demand for foreign exchange.

Figure 8: Electricity Imports, Exports and Exchange Rate.



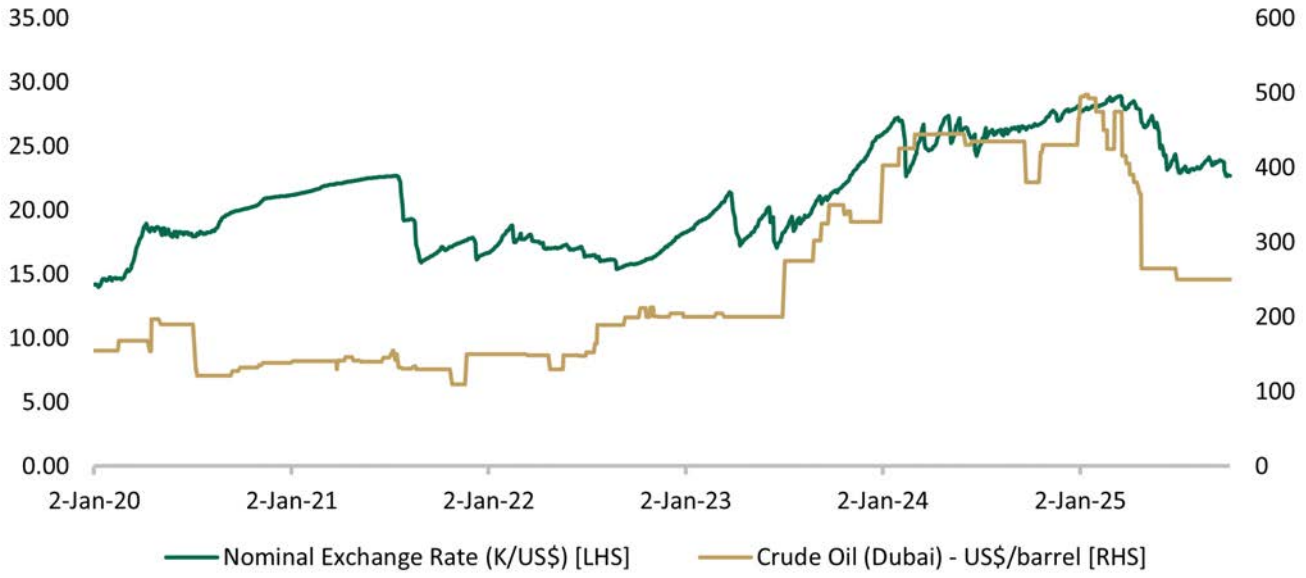
*Source: Authors' Compilation of data from the Ministry of Finance and National Planning; *Jan-June 2025 recordings*

In response to these vulnerabilities, Zambia has implemented a range of long-term measures. These include the introduction of net metering and open-access frameworks to incentivise private and renewable energy producers; diversification of the energy mix through solar, wind, and thermal generation; and investments in grid infrastructure to enhance transmission efficiency. These policy instruments, anchored in the National

Energy Policy (2019), the Electricity Act (2019), and the Integrated Resource Plan (2023–2043), are intended to strengthen energy security, reduce hydro-dependency shocks, and support export competitiveness, indirectly mitigating exchange-rate pressures. Nevertheless, policy implementation gaps remain: renewable integration is progressing slowly. Private-sector participation is limited by regulatory bottlenecks and financing constraints. Unless comprehensively addressed, energy deficits and the associated load shedding will continue to undermine total factor productivity, leaving Zambia vulnerable to cyclical FX demand surges.

Petroleum dynamics constitute a separate but equally critical channel influencing the exchange rate. As a net importer of refined petroleum products, Zambia faces structural pressure on its foreign-exchange reserves. Petroleum consumption rose from 1,627,406 MT in 2023 to 1,906,383 MT in 2024, largely due to increased diesel use for electricity generation and elevated industrial and household demand for Liquefied Petroleum Gas (LPG) (Figure 9). Concurrently, rising global crude oil prices between 2022 and 2024 amplified import bills, increasing the demand for foreign currency and placing downward pressure on the Kwacha (Figure 10). Conversely, periods of declining crude prices temporarily alleviate FX pressures, illustrating the sensitivity of Zambia's exchange rate to both international price shocks and domestic energy consumption patterns.

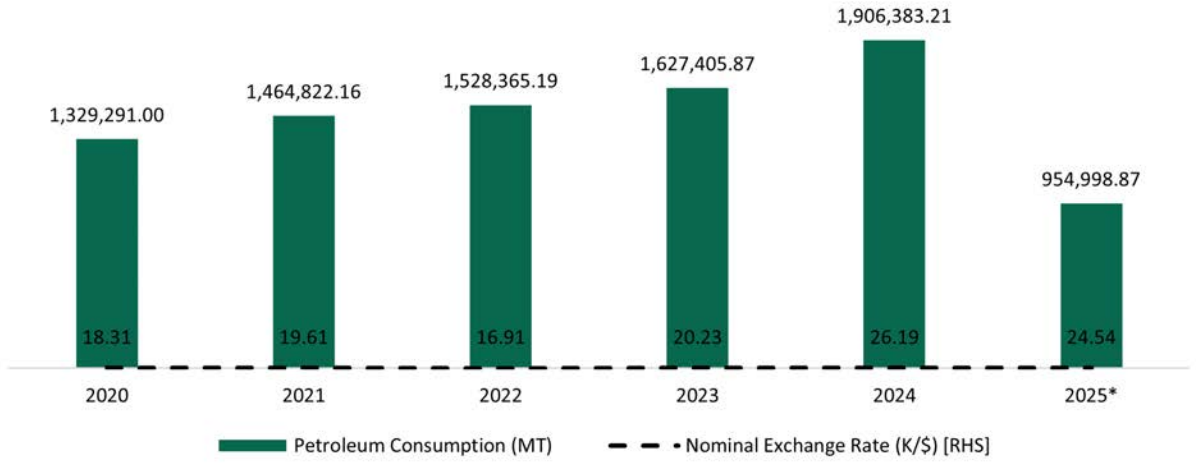
Figure 9: Global Prices of Crude vs Nominal Exchange Rate.



Source: Authors' Compilation of data from the Bank of Zambia.

These international price movements interact closely with domestic consumption patterns. Zambia, as a net importer of refined petroleum products, allocates a substantial portion of its import bill to fuel. The increase in domestic demand, between 2023 and 2024, was driven primarily by higher use of diesel for electricity generation and increased consumption of Liquefied Petroleum Gas (LPG) for industrial and household heating and cooking. The combination of elevated global crude prices and growing domestic demand amplifies pressure on foreign currency reserves, thereby directly influencing exchange rate dynamics.

Figure 10: Consumption of Petroleum and Exchange Rates.



Source: Authors' Compilation of data from the Ministry of Finance and National Planning; Jan-June 2025 recordings.

Empirical results reveal a strongly significant positive relationship between energy consumption (aggregate of petroleum and electricity) and the stability of the exchange rate. Specifically, a 1% increase in energy consumption is associated with a 1.1% depreciation in the exchange rate. During periods of significant deficit, energy imports accounted for a substantial share of the country's total import bill, creating additional demand for foreign currency and exerting downward pressure on the exchange rate.

Furthermore, fluctuations in fuel prices are transmitted indirectly through inflationary and fiscal channels. Specifically, higher fuel costs increase transportation and food prices, thereby raising overall inflation and potentially influencing monetary and fiscal policy responses, which, in turn, further affect exchange rate dynamics.

Regarding electricity supply, despite the progress in promoting electricity diversification through the Electricity (Open Access) Regulations of 2024 and broader market reforms, including liberalisation, significant structural gaps that contribute to exchange-rate volatility remain. The adoption of renewable energy sources remains limited as private-sector participation in electricity generation and distribution is still constrained by regulatory and financing challenges that undermine the full potential of market liberalisation.

At the same time, heavy reliance on fossil fuels exposes the economy to global price shocks and heightened foreign-exchange vulnerability. While initiatives such as the TAZAMA Pipeline and the Open Access Framework for diesel imports encourage private-sector participation and improve the reliability of commodity supply, their full stabilising impact on the exchange rate is yet to be seen. The full impact will depend on further strengthening the reform implementation, improving key player coordination and subsequently scaling.

CONCLUSION AND RECOMMENDATIONS

5. CONCLUSION AND RECOMMENDATIONS

In conclusion, this study examined the impact of real-sector investments on exchange rate volatility in Zambia, focusing on the mining, manufacturing, agriculture, and energy sectors. The empirical results confirm a short-run appreciating influence of the manufacturing and mining sectors, which are not sustained over the long term due to weak structural linkages, while the energy sector has a depreciating effect on the exchange rate.

In the long run, trade openness strengthens the domestic currency, ultimately appreciating the exchange rate, while the energy sector continues to exert an adverse influence on the exchange rate. Further, it is worth noting that the agricultural sector has a limited and insignificant influence on the exchange rate. This is due to the limited, raw exports from the sector, which do not generate sufficient foreign exchange earnings. Based on these results, therefore, the following policy recommendations are proposed:

1. **Promote Domestic Mineral Processing and Value Addition**

   To enhance currency stability and maximise foreign-exchange benefits, the government should accelerate the development of local mineral value chains. This includes promoting local smelting, refining, and beneficiation of critical minerals, particularly copper and other strategic metals. Establishing linkages between mining companies and Zambian manufacturers will encourage local sourcing of inputs, stimulate domestic industrial growth, and reduce foreign currency repatriation. Expediting the implementation of the Critical Minerals Strategy's value-addition goals will also improve investor confidence and increase foreign-exchange inflows.

2. **Optimise Foreign-Exchange Collection and Manage Volatility**

   Efficient collection and timely conversion of mineral royalties should be strengthened to ensure that foreign-exchange inflows are immediately available to support the national currency. Establishing and safeguarding an Exchange Rate Stabilisation Fund, managed by the Bank of Zambia, can buffer the economy against external shocks such as commodity price swings, smoothing short-term volatility and supporting macroeconomic stability.

3. **Drive Manufacturing Growth and Export-Oriented Value Addition**

   The government should intensify support for industrial growth through fully operational Multi-Facility Economic Zones (MFEZs) and export-oriented industrial parks, especially along mining hubs and transport corridors. Reliable energy supply, infrastructure, and export incentives for value-added products are critical. Special attention should be paid to agro-processing, metal fabrication, electrical cables, industrial chemicals, and other mining-input industries. Encouraging domestic production of these inputs reduces the need for imports, eases foreign-exchange pressure, and strengthens the Kwacha while creating jobs and stimulating economic growth.

4. **Accelerate Agricultural Productivity, Diversification, and Value Addition**

   Zambia's agricultural sector should move beyond policy targets to actual implementation of infrastructure and technological improvements. This includes expanding irrigation, modernising value chains, and promoting climate-smart agriculture practices. Support for high-value crops with export potential, alongside staple food production, will increase foreign-exchange earnings while reducing

dependence on food imports. Linking agricultural production to processing and export markets is key to translating productivity gains into FX stability.

5. Secure Energy Supply and Improve Efficiency

Ensuring a reliable and diversified energy supply is critical for production and foreign-exchange generation. The government should accelerate renewable energy investments via public-private partnerships and power purchase agreements, reduce reliance on hydropower, and encourage domestic biofuel production from agricultural feedstocks to replace imported petroleum. Petroleum products should be fully incorporated into the TAZAMA Open Access Framework to encourage greater private-sector participation, and plans to import fuel from Angola's Lobito refinery should be expedited to diversify supply and reduce foreign-exchange vulnerability. Enforcing energy-efficiency standards in high-consumption sectors, such as mining and manufacturing, will also reduce overall energy demand and relieve pressure on foreign-exchange reserves.

6. Enhance Trade Integration and Export Diversification

Zambia should pursue a proactive trade policy that strengthens export competitiveness and diversifies foreign-exchange sources. Expanding regional and extra-regional market access, including full exploitation of the AfCFTA, will reduce reliance on a few commodity buyers. Modernising customs procedures, introducing single-window border clearance systems, and establishing one-stop border posts will improve trade facilitation, reduce delays, and increase exports. Complementing these measures with investment promotion, targeted export incentives, and export-financing mechanisms for high-value products will further stabilise foreign-exchange inflows.

APPENDIX

APPENDIX A - Empirical and Econometric Steps

The empirical analysis applied the econometrics procedure in examining the impact of the variables of interest on exchange rate in Zambia. The data used in the study were collected from multiple sources as described in the main text.

The model's general formula is as follows:

$$\mathrm{EXR} = \mathrm{f}(\mathrm{MVA} + \mathrm{AVA} + \mathrm{ENU} + \mathrm{MNR} + \mathrm{TR\,O})$$

Where the above variables in the model represent Nominal Exchange Rate $/K, Manufacturing Value Added [27], Agriculture Value Added, Energy Use, Mineral Royalties[28], and Trade Openness, respectively. The pre – pre-estimation tests all the way up to post–estimation tests follow.

i. Unit Root Test

An important step before carrying out any econometric procedure is a unit root test, which indicates whether the variables in the sample data are stationary or not. This is done to avoid running a spurious regression if any of the variables of interest were nonstationary, which makes it hard and unreliable for any inference when carrying out estimations (Engle & Granger, 1987[29]; Nelson & Plosser, 1982[30]; Pesaran et al., 2001[31]). To determine whether the variables of interest exhibit stationarity, the two most common test procedures are the Augmented Dickey-Fuller (ADF) test (Dickey & Fuller, 1981) and the Phillips-Perron (PP) test (Phillips & Perron, 1988)[32]. However, the most preferred between the two is the Augmented Dickey-Fuller (ADF) because it takes care of any problems of serial autocorrelation (Dickey & Fuller, 1981). A test for the impact of structural breaks conducted on the variables of interest was necessary and also saved as a confirmatory test to the ADF and PP test, using the Zivot-Andrews (Z-A), which was superior to other tests at the PP and ADF tests that are not able to account for any shock and structural breaks in the model, by recording them as a unit-root, a premise that the Z-A test can account for (Zivot & Andrews, 2002)[33]. The results in Table 3 below indicate the variable-specific structural breaks and give an empirical justification for the shift.

27 *Manufacturing is defined as industries involving the physical or chemical transformation of materials or components into new products. According to the World Bank data, which often aligns with ZamStats' National Accounts, Manufacturing refers to industries classified in ISIC divisions 15-37 (or major division C in ISIC Rev. 3): https://databank.worldbank.org/metadataglossary/world-development-indicators/series/NV.IND.MANF.ZS*

28 *Mineral royalties was used as a proxy for mining investment due to ready availability as compared to other related variables. Its served as a proxy for percentages for mining output remitted to the state. Mining royalties policies have changed over the year but data availability limitations have made it the most reliable proxy for mining investment in Zambia; and its empirical effect on the model was statistically significant making it reliable for inference.*

29 *Engle, R.F. & Granger, C.W.J. (1987) 'Co-integration and error correction: Representation, estimation, and testing', Econometrica, 55(2), pp. 251–276. https://doi.org/10.2307/1913236*

30 *Nelson, C.R. & Plosser, C.R. (1982) 'Trends and random walks in macroeconomic time series: Some evidence and implications', Journal of Monetary Economics, 10(2), pp. 139–162. https://doi.org/10.1016/0304-3932(82)90012-5*

31 *https://doi.org/10.1002/jae.616*

32 *Phillips, P.C.B. & Perron, P. (1988) 'Testing for a unit root in time series regression', Biometrika, 75(2), pp. 335–346. https://doi.org/10.1093/biomet/75.2.335*

33 *Zivot, E. & Andrews, D.W.K. (2002) 'Further evidence on the great crash, the oil-price shock, and the unit-root hypothesis', Journal of Business & Economic Statistics, 20(1), pp. 25–44. https://doi.org/10.1198/073500102753410372*

Table A 1: Variable Structural Break Tests

Variable	Structural break	Underlying factors
lEXR	2016q1	The Zambian Kwacha's severe exchange rate volatility in early 2016 was caused by a convergence of acute external and domestic shocks. Externally, the collapse in global copper prices drastically reduced the country's primary source of foreign exchange earnings. This was compounded domestically by a severe energy crisis driven by low rainfall, which forced major copper mines to scale down production, thus further depleting the already diminished supply of US Dollars. These fundamental supply shortages led to rampant inflation, which peaked at 23%, compelling the Bank of Zambia to maintain a tight monetary policy stance of 15.5% to stabilise the currency. Adding to this instability was a general loss of investor confidence fueled by concerns over external debt servicing and a history of volatile mining tax policies, collectively driving significant downward pressure and uncertainty in the exchange rate market.
lMNR	2021q3	The mineral royalty environment in Zambia at the end of 2021 was defined by a looming structural pivot: the newly elected government announced that the Mineral Royalty Tax (MRT) would become deductible for corporate income tax purposes starting in January 2022, a major policy reform intended to correct the "double taxation" effect and signal a renewed commitment to attracting large-scale mining investment. This crucial policy shift occurred immediately following a period where the existing, non-deductible royalty regime had generated record revenue for the treasury, largely driven by soaring global copper prices, which pushed the sliding-scale royalty rates to their highest tiers, making 2021 a high-tax, high-revenue year just before the announced fiscal concessions took effect.
MVA	2013q3	The Zambian manufacturing sector at the end of 2013 achieved moderate growth, contributing positively to the overall 6.5% GDP expansion, with the agro-processing cluster consistently dominating the sector's output and providing crucial Non-Traditional Exports (NTEs) to regional markets. However, this growth potential was significantly constrained by severe structural issues, with access to finance reported as the most critical obstacle to business operations, followed closely by deficiencies in infrastructure, particularly electricity supply, and pervasive competition from the informal sector, all of which contributed to low global market integration and widespread underutilization of production capacity among small and medium-scale manufacturing firms.
AVA	2019q1; 2015q4	Agricultural Value Added (AVA) in the 2015 Quarter 4 faced intense pressure stemming primarily from the severe drought that characterised the preceding 2014/2015 agricultural season. This widespread dry spell led to a substantial decline in key crop production, particularly maize, causing a direct contraction in the AVA that significantly dampened overall GDP growth. The resulting weak harvest quickly translated into high domestic food prices and heightened concerns over national food security as the year drew to a close. In contrast, 2019 Quarter 4 also saw the AVA contract due to renewed climatic challenges from the unfavourable 2018/2019 rainy season, which produced lower-than-expected yields. However, this period's struggles were exacerbated by underlying policy inefficiencies; the sector was hampered by ongoing issues such as the late payment of farmers by the Food Reserve Agency (FRA), which constrained liquidity and discouraged production, alongside persistent difficulties in effectively managing the Farmer Input Support Programme (FISP). Thus, while both quarters dealt with weather-related output shortfalls, the 2019 Q4 challenges were compounded by fiscal strain and administrative constraints.

IENU	2017q1	The Zambian energy sector at the beginning of 2017 was defined by a necessary recovery phase as improved rainfall allowed major hydropower facilities like Kariba and Kafue Gorge to significantly increase generation, effectively ending the severe load shedding that had plagued the economy throughout 2015 and 2016. Although the sector remained heavily dependent on hydroelectric power with a generation capacity around 1,985 MW, the previous crisis had spurred greater reliance on the new Maamba Coal Power Plant and accelerated efforts toward diversification, including the ongoing construction of the massive Kafue Gorge Lower hydropower station, even as persistent challenges like poor rural access and the need for tariff reform continued to shape the regulatory landscape.
TRO	2016q2	The state of trade openness in Zambia in mid-2016 was formally high due to the country's commitment to regional integration within COMESA and SADC, benefiting from low external tariffs; however, this openness was significantly curtailed by persistent domestic challenges. The severe exchange rate volatility and high interest rates resulting from macroeconomic instability created crippling uncertainty and increased financing costs for both importers and exporters. Trade remained heavily unbalanced and concentrated, with foreign exchange earnings overwhelmingly reliant on copper exports, making the trade balance highly vulnerable to global commodity price swings. Furthermore, the growth of Non-Traditional Exports (NTEs) was hampered by high domestic production and transport costs associated with the country's landlocked status, alongside persistent inefficiencies in customs procedures and trade facilitation infrastructure.

ii. ARDL Bounds Test

After carrying out the unit root test and finding out the order of integration of the variables, that being I(0) and I(1), the Autoregressive Distributive Lag (ARDL) Bounds Test is used because it is capable of running estimation for time series on variables which have the order of integration such as I(0) and I(1) or even a mixture of both but strictly not of a higher order I(2)[34] [35] [36] [37]. This procedure goes beyond the limitations of Engle and Granger (1987)[38], and Johansen and Juselius (2009)[39], which constrain the cointegration steps only to variables with the same order of integration as the ARDL Bounds Test can run a regression with variables of order I(0), I(1), or a combination of both and hence making it superior. Another superiority of the ARDL Bound test is its ability to detect both the impact of direction of the regressor on the exchange rate in both the short–run and in the long-run, as well as its ability to determine its speed and time of convergence to the long–run effect on the dependent variable.

34 *Baniata, A., Alnawasreh, A. & Nsairat, F. (2023) 'Macroeconomic determinants of Jordan's external debt in the period 1980–2022 using ARDL', Investment Management and Financial Innovations, 20(3), pp. 152–165. https://doi.org/10.21511/imfi.20(3).2023.13*

35 *Saungwem, T., Maluleke, G. & Odhiambo, N.M. (2023) 'The impact of public debt on economic growth in Côte d'Ivoire: New evidence from linear and non-linear ARDL approaches', Croatian Review of Economic, Business and Social Statistics, 9, pp. 61–77. https://doi.org/10.2478/crebss-2023-0005*

36 *Serin, Ş.C. & Demir, M. (2023) 'Does Public Debt and Investments Create Crowding-out Effect in Turkey? Evidence from ARDL Approach', Sosyoekonomi, 31(55), pp. 151–172. https://doi.org/10.17233/sosyoekonomi.2023.01.08*

37 *Sharaf, M.F. & Shahen, A.M. (2023) 'Does external debt drive inflation in Sudan: evidence from symmetric and asymmetric ARDL approaches', JBSED, 3(3), pp. 293–307. https://doi.org/10.1108/JBSED-03-2023-0023*

38 *Engle, R.F. & Granger, C.W.J. (1987) 'Co-integration and error correction: Representation, estimation, and testing', Econometrica, 55(2), pp. 251–276. https://doi.org/10.2307/1913236*

39 *Johansen, S. & Juselius, K. (2009) 'Maximum likelihood estimation and inference on cointegration—with applications to the demand for money', Oxford Bulletin of Economics and Statistics, 52(2), pp. 169–210. https://doi.org/10.1111/j.1468-0084.1990.mp52002003.x*

The optimal lag determination criteria adopted for each of the variables were computed automatically using the Akaike Information Criterion (AIC) (Liew, 2006; Wooldridge, 2018)[40] [41] because it can suit the small sample sizes and also reduce any chances of underestimating the lags in the sample, as it improves the chances of determining the correct lag length. This is contrary to the other methods, such as the Sequential modified LR test statistic, Final prediction error, Schwarz information criterion, and Hannan-quinn information criterion (Liew, 2006; Wooldridge, 2018).

The procedure for the cointegration test for ARDL Bounds Test follows the F-test with a decision to reject the null hypothesis that cointegration is not present if the F-statistic is higher than the upper critical value or above the upper bound I(1) and lower bound I(0) and fail to reject the null hypothesis if the F-statistic is smaller than the lower critical value or below the lower bound I(0), with the cointegration, results inconclusive if the cointegration test entails that the F-statistic value lies between I(0) and I(1) bounds (Pesaran et al., 2001; Wooldridge, 2018).

iii. Diagnostic Tests

The post-estimation tests carried out in the study include the test for heteroscedasticity, autocorrelation, model stability, and normality. The preferred null hypothesis is no autocorrelation, heteroskedasticity, and the presence of normality (Wooldridge, 2018), with the acceptance having a lower F-statistic and a higher corresponding probability value, greater than 5 per cent. The CUSUM test and CUSUM of squares tests for model stability and stability without the effect of breaks, respectively, were also conducted (Wooldridge, 2018)[42]. The descriptive statistics of the variables of interest follow in the next section, which also contains the results and discussion.

APPENDIX B - Pre-estimation Test Results

Table B 1: Lag Selection Criteria

Lag	AIC	HQIC	SBIC
1	-2.38768	-1.79877	-.86867*
2	-3.34135	-2.24764	-.520321
3	-3.84146	-2.24297	.281577
4	-4.52912*	-2.42584*	.895927

Table B 2: Augmented Dickey Fuller Test

Augmented Dickey Fuller (P-value)			
	Levels	**First Difference**	**Order of Integration**
lEXR	0.956	0.0000***	I(1)
lENU	0.981	0.0000***	I(1)
lMNR	0.926	0.0000***	I(1)
MVA	0.077	0.0000***	I(1)
AVA	0.022**	0.0000***	I(0)

*Notes: *** p<.01, ** p<.05 & *p<.1 (Stationarity at the 1, 5 and 10 per cent significance levels)*

40 *Liew, V.K.-S. (2006) 'Which lag length selection criteria should we employ?', Economics Bulletin, 3(33), pp. 1–9. Available at: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=885505*

41 *Wooldridge, J.M. (2018) Introductory Econometrics: A Modern Approach. 7th edn. Cengage Learning.*

42 *Wooldridge, J.M. (2018) Introductory Econometrics: A Modern Approach. 7th edn. Cengage Learning.*

Table B 3: Zivot-Andrews Test

Zivot-Andrews (t-statistic)					
Variable	**Levels t-statistic**	**Critical value**	**First Difference statistic**	**Critical value**	**Order of Integration**
lEXR	-3.67	-5.08	-6.69***	-5.80	I(1)
lMNR	-4.27	-5.08	-7.10***	-5.08	I(1)
lENU	-3.32	5.08	-16.57***	-5.08	I(1)
MVA	-3.17	5.08	-9.07***	-5.08	I(1)
AVA	-5.08**	-5.08	15.29***	-5.08	I(0)
TRO	-4.463	-5.08	-6.694***	-5.08	I(1)

APPENDIX C- Post-estimation Tests

Table C 1: Bounds Test for Cointegration

Test	Result	I(0): lower bound	I(1): Upper bound
F-statistic	5.07	2.26	4.68
t-statistic	-4.08	-2.57	-4.79

Table C 2: Breusch-Godfrey LM Test

Lags	Chi2	df	Prob > chi2
4	3.006	4	0.55

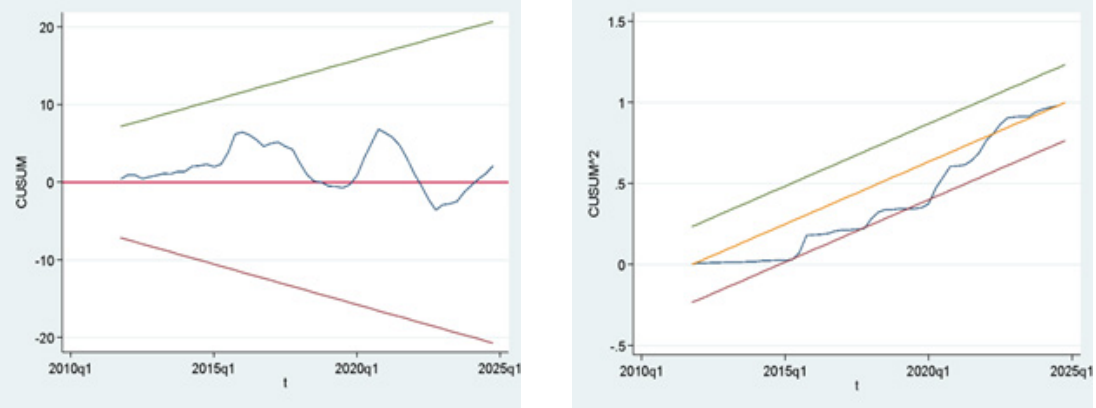
Table C 3: Information Matrix Test

Source	Chi2	df	p-value
Heteroscedasticity	56.00	55	0.43
skewness	12.85	10	0.23
kurtosis	0.94	1	0.33
Total	69.79	66	0.35

Table C 4: Cumulative Sum Test for Parameter Stability

Type	Test statistic	Critical value		
		1%	5%	10%
Recursive	0.41	1.14	0.94	0.84

Figure C 1: CUSUM Plot for Stability



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