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The Nexus Between Macroeconomic Instability and Clove Export Performance in Zanzibar

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Abstract

Agricultural exports remain the vital source of foreign exchange for small economies that heavily depend on traditional cash crops. In Zanzibar, clove exports contribute significantly to export earnings, employment generation, and rural household incomes. However, the performance of the clove export sector is strongly influenced by prevailing macroeconomic conditions. This study examines the relationship between selected macroeconomic variables and clove export values in Zanzibar, using annual time-series data from 1991 to 2023. The study draws on two frameworks: the macroeconomic theory, and the comparative advantage theory. It used the ridge quantile regression to analyse the influence of gross domestic product, population, exchange rate, inflation rate, interest rate, and world clove prices on clove export values. The results reveal that economic growth, population growth, inflation, and world clove prices are positively and significantly associated with clove export values. In contrast, interest rates are negatively associated with export performance; while exchange rate has varying impacts: positive and significant at lower quantiles, and negative and significant at higher quantiles. Based on these findings, the study recommends that the Zanzibar government pursue stable macroeconomic policies to maintain low and stable interest rates, and a competitive exchange rate. It further recommends improving access to affordable credit for clove farmers, strengthening domestic clove production capacity through better farming practices and inputs, and developing stronger international market linkages to stabilise and raise world clove prices. These measures are essential for enhancing the resilience and long-term competitiveness of Zanzibar's clove export sector.

Keywords: *macroeconomic instability, export value, cloves, ridge quantile regression, Zanzibar*

1. Introduction

Cloves are among the most valuable spices in the global market, with widespread applications in the food, pharmaceutical, and cosmetic industries. In 2023, Madagascar, Indonesia, Singapore, Sri Lanka, United Arab Emirates, and Tanzania dominated global exports of cloves (whole fruit, cloves, and stems). Madagascar led with exports valued at approximately USD248.43m (40,008,300kg), followed by Indonesia at USD99.61m (13,934,600kg), Singapore at USD65.89m (7,691,480kg), Sri Lanka at USD45.65m (5,841,750kg), and the United Arab Emirates at USD43.37m (6,118,010kg). Tanzania ranked sixth, contributing only 4.31% of the global clove trade value, with exports worth approximately

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USD25.13m (4,562,110kg) (WITS, 2025). This relatively small share is evidence to Tanzania's limited competitiveness in the international clove market despite the crop's long-standing economic importance.

A growing body of recent global literature attributes weak export performance in many developing economies to macroeconomic instability. Fluctuations in exchange rates, inflation, interest rates, and uneven gross domestic product (GDP) growth: all these create uncertainty for producers and exporters, increase transaction and input costs, and distort market signals. These conditions ultimately weaken international competitiveness, and can lead to declining export volumes and market share (Ocran & Abor, 2024; Mukherjee et al., 2023; Kamoche & Wood, 2023). In commodity-dependent economies, such macroeconomic pressures often interact with structural constraints—including limited access to finance, weak infrastructure, and institutional inefficiencies—to further undermine export sector performance.

In Tanzania, these challenges are particularly pronounced in Zanzibar, where most clove production is done. The crop has historically been the backbone of Zanzibar's economy, at times contributing up to 40% of foreign-exchange earnings (Chami, 2020). Beyond its macroeconomic significance, the sector supports the livelihoods of thousands of smallholder farmers, linking its performance directly to household welfare. Empirical evidence also suggests that favourable global clove prices can stimulate employment, increase incomes, and enhance the agricultural contribution to Zanzibar's GDP (Juma et al., 2010; Kingu & No, 2014). This underscores the strong connection between global market dynamics and local economic outcomes.

Despite this importance, the clove sector faces persistent structural and institutional challenges that limit its productivity and export potential. These include shrinking farm sizes, inefficient marketing systems, inadequate extension services, and restricted access to finance. Moreover, the dominance of the Zanzibar State Trading Corporation (ZSTC) as a state monopoly reduces private-sector participation, and limits responsiveness to international market signals (Moh'd et al., 2017; Kabote & Tunguhole, 2022). When combined with external pressures, such as global price volatility and increasing competition from more efficient producers, these factors weaken Zanzibar's position in the global clove trade.

Macroeconomic conditions further shape the performance of clove exports through multiple transmission channels. Economic growth influences investment in agricultural production, while exchange rate movements affect export competitiveness. Inflation and interest rates determine production costs and access to credit, thereby influencing farmers' output decisions. Trade policies, including tariffs and export incentives, also play a role in shaping export outcomes (Ocran &

Abor, 2024; Mukherjee et al., 2023; Kamoche & Wood, 2023). Although recent indicators show moderate economic growth in Zanzibar, these improvements have not consistently translated into sustained growth in clove exports.

This disconnect becomes more evident when viewed against the long-term performance of the sector. Traditional agricultural exports in Zanzibar have declined significantly over time, and the clove industry has experienced substantial reductions in both production and export volumes. For instance, production declined sharply from the 1970s to the 2000s, while export volumes have continued to fall in subsequent decades (Moh'd et al., 2017; Lwesya, 2018). More recent data indicate a further drop in production between 2022 and 2023, which is attributed to ageing trees, disease outbreaks, and increased global competition (ZiBi, 2025). These trends raise concerns about the sustainability of the sector, and its ability to support livelihoods in Zanzibar.

Taken together, the persistence of declining export performance despite periods of favourable macroeconomic conditions suggests a critical gap in understanding the interaction between macroeconomic factors and sector-specific constraints. Existing studies have largely focused on aggregate agricultural exports, emphasizing overall trade performance rather than commodity-specific dynamics (Abdullahi et al., 2022; Abdi & Mohamed, 2025; Nthebe & Mosikari, 2025; Seti, 2023; Tariq & Ahmad 2006; Kandiero & Randa 2004). Consequently, they provide limited insight into the unique challenges facing the clove sector. To address this gap, the present study adopts a sector-specific approach by analysing time series data to examine how key macroeconomic variables—such as GDP growth, inflation, exchange rates, and interest rates—affect the performance of clove exports. Such an approach allows for a more detailed understanding of the factors shaping export performance, and provides a stronger basis for policy recommendations aimed at revitalizing the industry and enhancing Zanzibar's competitiveness in the global spice market.

The remainder of the article is structured as follows. Section two reviews the relevant literature; section three outlines the methodology, including data sources and model specification; section four presents and discusses the empirical findings; and the final section concludes with policy implications.

2. Literature Review

2.1 Theoretical Background

The macroeconomic theory provides a vital framework for understanding how broad economic conditions shape export performance in agriculture-dependent economies such as Zanzibar. The theory stipulates that exchange rate fluctuations affect trade through both demand and supply channels. Currency appreciation makes exports, such as cloves, more expensive in foreign markets,

reducing demand, while simultaneously lowering the cost of imported inputs and potentially boosting domestic supply (Kandil, 2004; Dincer & Kandil, 2011). Other key macroeconomic variables—including inflation, money supply, interest rates, and government spending—also shape export outcomes. High inflation raises production costs and erodes competitiveness, whereas expansionary monetary policy may stimulate investment in the clove sector. However, excessive money growth can trigger inflation that undermines real export earnings (Ackah & Morrissey, 2005). Sustained real GDP growth, in turn, signals improved productive capacity, and creates favourable conditions for agricultural investment and trade (Hussain et al., 2025, Singh & Karol 2024; Tuyen et al., 2025).

Complementing this perspective, the comparative advantage theory (Ricardo, 1817) explains why Zanzibar specializes in clove exports. The theory argues that countries gain from specializing in goods they can produce at a lower opportunity cost. Zanzibar's favourable climate, fertile soils, and historical expertise give it a natural comparative advantage in clove production, enabling higher efficiency than many competitors, and hence potential gains from trade.

Although both theories provide useful insights, each has limitations that the other can partially overcome in the context of Zanzibar's clove sector. The macroeconomic theory effectively captures the short-term transmission mechanisms of instability, such as how exchange rate volatility and inflation increase costs and reduce export competitiveness, but it treats shocks as largely exogenous and underestimates the structural factors that keep Zanzibar heavily dependent on cloves despite persistent instabilities (Urgessa, 2024; Gold & Yusufu, 2025). This creates an incomplete picture of why volatility continues to damage export performance without prompting diversification.

On the other hand, the comparative advantage theory addresses this gap by explaining the structural foundation of Zanzibar's specialization in cloves based on natural endowments and lower opportunity costs (Siddiqui, 2018). However, its static assumptions of constant cost, full employment, and smooth resource adjustment prove unrealistic in Zanzibar, where macroeconomic instability raises input costs, discourages long-term investment in plantations, and prevents the reallocation predicted by the theory.

In this setting, the dynamic transmission channels emphasized by the macroeconomic theory help overcome the static nature of the comparative advantage theory by demonstrating how repeated shocks actively erode the gains from specialization. Conversely, the comparative advantage theory strengthens the macroeconomic theory by clarifying why Zanzibar does not easily shift away from cloves despite the instability its underlying cost advantages create. This

creates path dependence that macroeconomic policies must actively address rather than assume away. Hence, together, the two theories offer a balanced lens: the macroeconomic theory explains the volatile channels undermining clove exports; while at the same time the comparative advantage theory accounts for the persistent structural reliance on cloves, thereby providing a more comprehensive understanding of the nexus between macroeconomic instability and clove export performance in Zanzibar.

2.2 Empirical Literature

Macroeconomic factors have been widely studied worldwide as critical determinants of export performance in the agricultural and commodity sectors. For instance, Islam et al. (2024) applied the gravity model to explore how GDP, exchange rate, and inflation affect India's agricultural exports to SAARC countries. The study found that most variables behaved as expected and were statistically significant, supporting the gravity model's theoretical framework. Furthermore, the study used convergence rate calculations and discovered that India's agricultural exports are converging with five SAARC members, such as Bangladesh, Bhutan, Nepal, Pakistan, and Sri Lanka; while diverging with the Maldives, indicating a potential for expanded trade within the region. Similarly, in Indonesia, Siswanto et al. (2022) employed multiple linear regression on annual time-series data from 1990 to 2019 to investigate the influence of export prices, the exchange rate, and US GDP on Central Java's essential oil exports. The simultaneous test (F-test) revealed that these variables collectively significantly affect export volume, though only the importing country's GDP had a statistically significant individual effect; thereby underscoring the importance of demand-side factors in export performance.

In Indonesia, several studies have focused on clove exports with mixed results on the influence of macroeconomic variables. Hidayati (2023) analysed panel data from 2005 to 2020 and found that export prices, clove production, and GDP per capita of destination countries positively influence export volumes; while economic distance negatively affects trade. Rhezamayye and Amir (2020) reported that production, domestic consumption, domestic and export prices, and exchange rates explain more than half of the variations in Indonesia's clove exports. Lestari and Rahmanta (2018) similarly confirmed that production, and destination country GDP, positively impact clove export value, with distance negatively affecting it; however, the effects of population and exchange rates were mixed or insignificant. During the COVID-19 pandemic, Wahdiana and Tinaprilla (2023) observed that Indonesia's GDP, destination country GDP, population, and production continued to positively influence clove export performance; indicating resilience amid global disruptions. Also, Nurhayati et al. (2018) identified GDP per capita, export price, economic distance, and tariffs as key factors affecting Indonesia's clove exports.

In African countries, macroeconomic instability has also been linked to fluctuations in export volumes, particularly of agricultural commodities. In Nigeria, Oyetade et al. (2020) used the Autoregressive Distributed Lag (ARDL) bounds testing approach to analyse how exchange rate fluctuations, inflation, and other macroeconomic variables influence agricultural exports. Their results showed significant impacts of exchange rate volatility and inflation on export performance in both the short- and long-run, consistent with the notion that currency instability hinders trade by increasing uncertainty. Supporting this, Akinbode and Ojo (2018) also employed an ARDL model to show that exchange rate volatility negatively and significantly affects Nigeria's agricultural exports, confirming that macroeconomic stability is crucial for export growth. In Ethiopia, Eshetu and Goshu (2021) adopted a dynamic gravity model to examine coffee exports to key trading partners; and found that both Ethiopia's GDP and its partners' GDPs, along with exchange rate movements, significantly affect export volumes. Complementing this, Echobu et al. (2024) applied the vector error correction (VEC) model to explore the long- and short-run relationships of imports and exports in Nigeria, and found comparative advantage indices showing that global prices, foreign income, and domestic production are important determinants of Nigeria's export competitiveness.

In Zanzibar, Kabote and Tunguhole (2022) examined the decline in clove exports using time-series data from 1980 to 2020. They applied a VEC model, alongside qualitative insights from 39 key informants. Their findings revealed that, in the long-run, clove production, producer price, world price, GDP, and exchange rate had significant positive effects on exports. In contrast, foreign direct investment, population growth, and gross capital formation had significant negative effects. Inflation was found to have an insignificant negative impact. The qualitative evidence pointed to production-related issues and price fluctuations as the major determinants. The study emphasized that macroeconomic factors affect clove exports both directly and indirectly through production, and called for integrated policy interventions to boost production and stabilize prices, thereby reversing the export decline.

Despite the contributions of previous studies on export performance, significant research gaps remain in both methodological approaches and commodity-specific analyses. Most existing studies have relied on conventional econometric techniques such as Ordinary Least Squares (OLS), VEC models, and traditional gravity models (Kabote & Tunguhole, 2022; Islam et al., 2024). These approaches assume that constant parameter effects across the distribution are sensitive to outliers and multicollinearity; and often fail to capture heterogeneity, non-linear relationships, or varying impacts at different levels of export performance. Furthermore, empirical evidence shows that agricultural export studies predominantly adopt broad aggregate frameworks focusing on overall trade openness and general macroeconomic determinants, rather than examining individual commodities in depth.

While Kabote and Tunguhole (2022) specifically analysed the determinants of clove exports in Zanzibar, the study adopts a broad modelling strategy that simultaneously incorporates environmental, institutional, and macroeconomic factors. Such an approach introduces the risk of model overgeneralization and potential multicollinearity, which can obscure the individual contributions of each variable category. In particular, the inclusion of diverse determinants within a single framework limits the precision with which macroeconomic effects can be identified and interpreted. Consequently, the study pays insufficient attention to key macroeconomic variables such as exchange rate volatility, inflation, interest rates, and world clove prices, thereby constraining a clear understanding of how macroeconomic instability influences clove export performance. To address these methodological and commodity-specific gaps, the current study applies ridge quantile regression, which allows for a more detailed examination of how macroeconomic factors affect clove export performance across different quantiles of the conditional distribution.

3. Methodology

3.1 Data Source

The study used annual time-series data spanning from 1991 to 2023, based on data availability. Clove export value data were obtained from the Zanzibar State Trading Corporation (ZSTC). Macroeconomic variables—including gross domestic product (GDP), inflation rate, population, and labour force statistics—were sourced from the Office of the Chief Government Statistician, Zanzibar (OCGS). In addition, interest rate and exchange rate data were collected from the Bank of Tanzania (BoT). The study relied on secondary data because the analysis focused on long-term macroeconomic trends and export performance that require consistent, reliable, and historically comparable data over an extended period.

3.2 Description of Study Variables

The study categorizes both dependent and independent variables within a macroeconomic framework to examine clove export performance in Zanzibar. It focuses on how key macroeconomic conditions and external market forces jointly influence export outcomes over time. This classification allows for a systematic analysis of the relationship between economic stability and export performance in the clove sector.

3.2.1 Dependent Variable

The dependent variable in this study is clove export value, measured in United States dollars (USD). It represents the total earnings from clove exports and serves as a proxy for the performance of Zanzibar's clove export sector. This variable captures the overall competitiveness and revenue-generating capacity of cloves in international markets. Changes in clove export value reflect both domestic supply conditions and external market forces, making it an appropriate indicator for assessing export performance over time.

3.2.2 Independent Variables

The study includes several independent variables hypothesized to influence clove export performance, based on the theoretical and empirical literature, as summarised in Table 1. The exchange rate (USD/TZS) is included as a key macroeconomic determinant of export performance, reflecting the relative value of the Tanzanian shilling against the US dollar, and directly influencing export competitiveness. Depreciation is expected to enhance export earnings (Farahane & Heshmati, 2020; Kandil, 2008). Real GDP, measured in constant 2015 Tanzanian shillings, reflects domestic economic activity and production capacity, with higher GDP expected to improve export performance by boosting output, investment, and infrastructure development (Iyoha & Oriakhi, 2002). The inflation rate captures macroeconomic instability as rising prices increase production and transportation costs, thereby reducing competitiveness (Kumarnarayan & Narayan, 2005; Kandiero & Randa, 2004). The interest rate reflects the cost of borrowing and influences access to credit, with higher rates expected to constrain investment and export expansion (Odhiambo, 2010; Acaravci, 2012).

Table 1: Description of the Study Variables

Variable	Definition/Measurement	Type	Expected Sign
Clove Export Value	Total value of clove exports (USD)	Dependent	NA
Exchange Rate (USD/TZS)	Units of Tanzanian shilling per USD	Independent	+/-
Real GDP	Real GDP at constant 2015 prices (TZS)	Independent	+/-
Inflation Rate	Annual percentage change in consumer prices	Independent	+/-
Interest Rate	Lending/monetary policy rate (%)	Independent	+/-
World Clove Price	International price of cloves (USD/kg)	Independent	+/-
Population	Total population (persons)	Independent	+/-
Labour Force	Economically active population	Independent	+/-

World clove price (USD per kg) is included to capture external market conditions, as fluctuations in global prices directly affect export revenues and production incentives (Deaton & Miller, 1995). Population is incorporated as a demographic factor influencing both labour supply and domestic consumption, which may either increase production capacity or reduce the exportable surplus (Basu et al., 2013). Finally, labour force represents productive capacity in agriculture, and a larger labour force is expected to enhance clove production by increasing the availability of workers for cultivation and processing (Timmer, 2002; Todaro et al., 2015). Other relevant macroeconomic variables were excluded to avoid overestimation and misspecification, thereby ensuring the robustness and interpretability of the estimated results (Akyoo & Lazaro, 2007; Allaro, 2011).

3.3 Model Specification

This study models the nexus between macroeconomic instability and clove export performance in Zanzibar. The clove export value (CEV) serves as the dependent variable, while the independent variables include exchange rate (ER), inflation rate (IFR), gross domestic product (GDP), interest rate (IR), world clove price (WCP), and population (POP). The model's general functional form is linear, assuming that macroeconomic indicators influence cloves' export value. The general model can be expressed in equation 1 as:

$$CEV = f(ER, INF, GDP, IR, WCP, POP) \qquad (1)$$

To enhance interpretability and reduce heteroskedasticity, all variables are log-transformed. The resulting log-log model captures the elasticity of clove export value with respect to each macroeconomic factor, enabling the estimation of the percentage impact of changes in each explanatory variable. The log-transformed specification is presented in equation 2 as:

$$\begin{aligned} logCEV_t = \beta_0 + \beta_1 logER_t + \beta_2 logINF_t + \beta_3 logGDP_t + \beta_4 logIR_t \\ +\beta_5 logWCP_t + \beta_6 logPOP_t + \beta_7 logLF_t + \varepsilon_t \end{aligned} \qquad (2)$$

Recognizing the potential heterogeneity in how macroeconomic conditions influence clove export performance at different levels, the study applies the ridge quantile regression model proposed by Li and Zhu (2008). This analytical model enables the estimation of conditional quantiles, rather than only the conditional mean, of the clove export value. The ridge quantile regression model is specified as:

$$\begin{aligned} Q_\tau(log(CEV_t)|X_t) = \beta_0(\tau) + \beta_1(\tau) logER_t + \beta_2(\tau) logINF_t \\ +\beta_3(\tau) logGDP_t + \beta_4(\tau) logIR_t + \beta_5(\tau) logWCP_t \\ +\beta_6(\tau) logPOP_t + \beta_7(\tau) logLF_t \end{aligned} \qquad (3)$$

Where: $Q_\tau(.)$ represents the conditional quantile function of $logCEV_t$ at quantile $\tau\epsilon[0,1]$, such that $\tau = 0.25, 0.5, 0.75$; and $\beta_j(.)$ represents the quantile-specific effect of the explanatory variable.

Unlike Ordinary Least Squares (OLS), which estimates average effects, ridge quantile regression captures differences across the outcome spectrum, providing a more refined view of how explanatory variables interact with export values under different economic circumstances. For this reason, it is especially helpful in exposing patterns that traditional models may obscure (Li & Zhu, 2008). The method enhances estimation precision by regularizing the regression coefficients, making it suitable for situations where predictor variables are correlated; and the goal is to identify consistent macroeconomic influences on clove export outcomes in Zanzibar. It is particularly advantageous in policy-oriented research as it uncovers how effects differ across low, median, and high levels of export performance (Damette & Delacote 2012). In contrast, conventional linear models

may obscure these nuances by averaging effects across the entire sample. Therefore, adopting the ridge quantile regression framework in this study offers a deeper and more precise assessment of how macroeconomic instability shapes Zanzibar's clove export outcomes.

3.4 Stationarity Test

Before applying the ridge quantile regression model, the study first examined whether the variables were stationary by conducting a series of unit root tests. Specifically, the Augmented Dickey-Fuller (ADF) test, a widely used method for detecting the presence of a unit root, was employed to assess the time-series properties of the variables, and to determine whether long-run and dynamic causal relationships could be meaningfully estimated. To ensure robustness, the ADF test was performed individually for each variable. The test is generally specified in equation 4 as:

$$\Delta X_t = \gamma X_t + 1 \sum_{j=1}^{p} \vartheta_j \Delta_{t-j} + Z_t' \delta + \varepsilon_t \qquad (4)$$

Where: ΔX_t is the first difference of the variable; γ is the coefficient tested for a unit root; ϑ_j are coefficients of the lagged differenced terms; $Z_t' \delta$ represents deterministic components (such as a constant or trend); p is the number of lags; and ε_t is the error term.

The null hypothesis $H_0: \gamma = 0$ suggests that the series has a unit root (i.e., it is non-stationary); while the alternative hypothesis $H_1: \gamma < 0$ implies stationarity.

4. Results and Discussion

4.1 Descriptive Statistics

The descriptive statistics presented in Table 2 show several important characteristics of the macroeconomic variables and clove export performance over the period 1991–2023. The average GDP stands at TZS1,665.8bn, with a high standard deviation of 877.30bn, and a moderate positive skewness (0.57). This indicates substantial variability in economic growth over time, with occasional years of significantly higher GDP. Population (POP) shows a mean of 1,158.97 thousand with very low dispersion (standard deviation = 0.28), suggesting relative demographic stability during the study period.

Exchange rate exhibits high volatility (standard deviation = 667.31) and a moderate skewness, reflecting considerable fluctuations that may have affected the competitiveness of clove exports. Inflation has a mean of 10.3% with notable dispersion and a positive skewness (0.98), implying occasional sharp price spikes rather than steady increases. Clove export value (CEV) and export tax both display very high variation (coefficient of variation = 1.22), and a strong positive skewness

(1.44), indicating that export earnings were generally modest in most years, but experienced extreme high values in certain periods; a pattern typical of agricultural export sectors driven by external price shocks or good harvest years.

Table 2: Descriptive Statistics

Statistic	GDP (TZS Bill)	Pop. (000)	ER	INF	CEV (USD)	IR	WCP (USD/kg)	Export Tax (USD)
Mean	1665.8	1159.0	1289.8	10.3	15700000.0	8.6	4.7	313302.6
Max	3499.0	1890.0	2315.0	29.4	62500000.0	26.5	7.9	1249269.0
Min	567.0	706.0	230.0	0.7	10400.0	1.6	2.2	208.0
Standard Deviation	877.3	325.7	667.3	8.1	19000000.0	5.1	1.9	380925.2
Skewness	0.6	0.5	0.2	1.0	1.4	1.3	0.4	1.4
Kurtosis	2.2	2.2	1.8	2.8	3.7	5.9	1.5	3.7
Coefficient of Variation	0.5	0.3	0.5	0.8	1.2	0.6	0.4	1.2

Interest rates and world clove prices show moderate variability; however, interest rate has a high kurtosis (5.90), suggesting infrequent but extreme fluctuations. In the context of this study, these features point to the presence of outliers and non-normal distributions among the key variables. Such characteristics justify the use of ridge quantile regression, as it effectively handles multicollinearity and allows for a more robust analysis of the influence of these macroeconomic variables across different levels (quantiles) of clove export performance, rather than relying solely on average effects.

Moreover, the correlation results in Figure 1 indicate that GDP has a very strong positive relationship with exchange rate (0.9821), world clove price (0.9662), and population (0.9321); suggesting that economic growth in Zanzibar is closely linked to currency movements, global market conditions, and demographic trends. Population also shows strong positive correlations with both exchange rate (0.9236) and world clove price (0.8990); suggesting that demographic expansion is associated with greater economic exposure and stronger trade performance. Exchange rate exhibits a strong negative correlation with inflation (–0.6199), while inflation is moderately and negatively correlated with GDP (–0.5842) and interest rate (–0.5692), indicating that rising inflation may hinder growth and influence monetary policy. Clove export value (CEV) is moderately correlated with GDP (0.5971) and world clove price (0.6516), highlighting the sector's significance in the economy, and its sensitivity to global price changes. Interest rates show weak correlations with most variables, except for a moderate negative link with inflation. These high correlations among explanatory variables provide strong justification for applying ridge quantile regression in the subsequent analysis, as it helps mitigate multicollinearity while capturing heterogeneous effects across the conditional distribution of clove export performance.

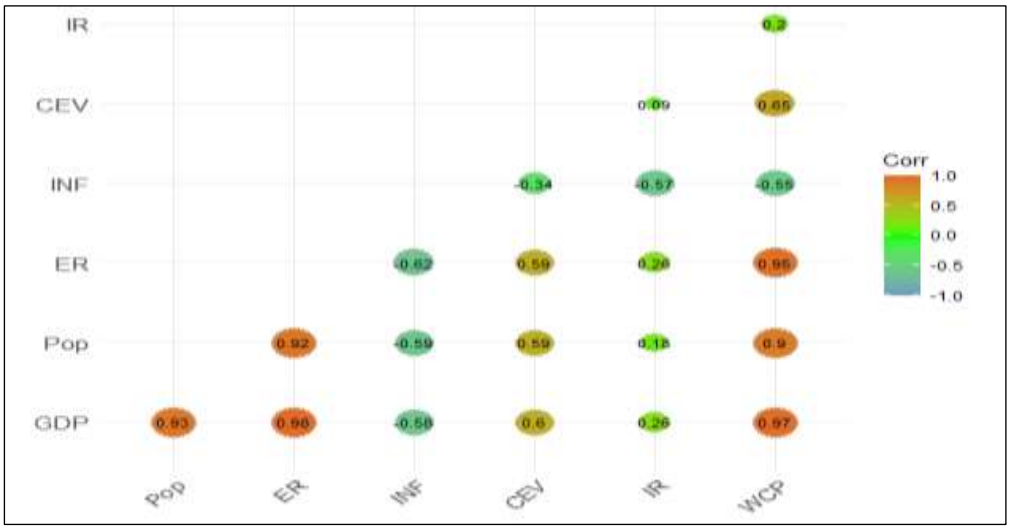

Figure 1: Correlation Heatmap

4.2 Trend Analysis

The results in Figure 2 show clear upward trends and fluctuations across all macroeconomic variables in this study. Over the period 1991–2022, GDP increased steadily from TZS567bn to ZS3,499bn, indicating sustained economic growth; while the population rose from 706,000 to 1.89m, reflecting demographic expansion.

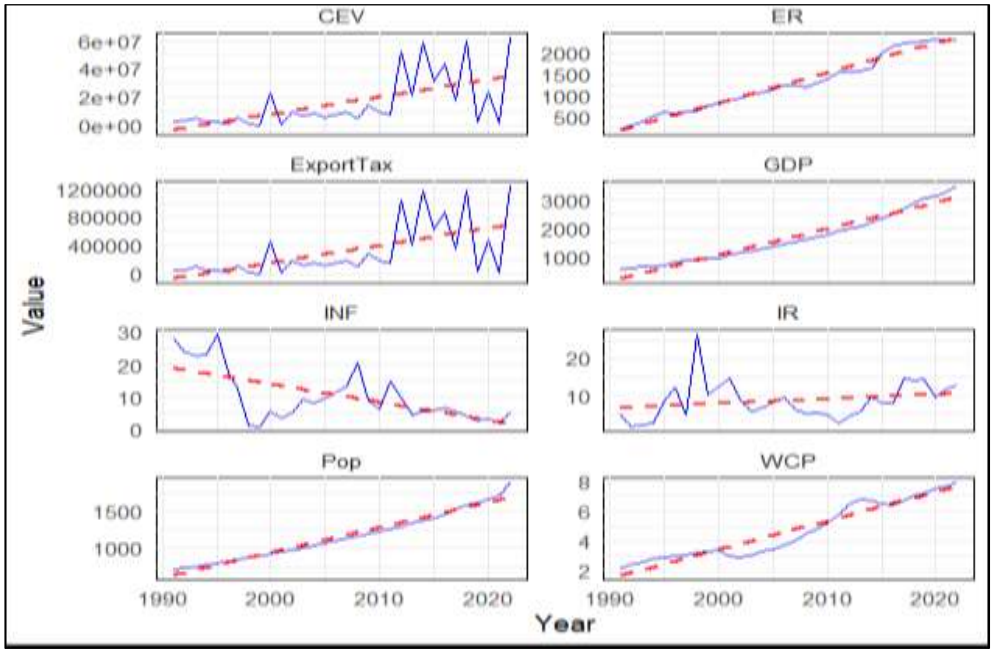

Figure 2: Trends of the Study Variables

The exchange rate depreciated significantly, moving from TZS230 to over TZS2,300 per USD, highlighting the weakening of the local currency over time. Inflation was highly volatile, with extreme rates in the early 1990s, such as 28% and 29.4%; followed by more stable figures in recent years. Clove export value (CEV) experienced considerable fluctuations, with low values in the early years and sharp increases in 2012 and 2022, influenced by global price shifts. Interest rates peaked at 26.5% in 1998 but generally declined to more moderate levels, though still showing year-to-year variations. The world clove price rose gradually from USD2.2/kg to USD7.9/kg, reflecting increasing international market demand. Export tax also varied widely, ranging from as low as USD208 in 1999 to over USD1.2m in 2022, driven by changes in export earnings, pricing, and taxation policy.

4.3 Stationarity Test

The Dickey-Fuller unit root test results in Table 3 reveal that most variables are non-stationary at the level but become stationary after first differencing, indicating they are integrated of order one, I(1). Specifically, variables such as population (LnPop), inflation (LnINF), interest rate (LnIR), and world cloves price (LnWCP): all have p-values above the 5% significance level, suggesting the presence of unit roots. However, after first differencing, their p-values drop below 0.05, confirming stationarity. On the other hand, variables like exchange rate (LnER) and cloves export values (LnCEV) are already stationary at the level, as indicated by highly significant test statistics and p-values less than 0.05. Addressing stationarity is important to avoid spurious regression results that can lead to misleading inferences about relationships among variables.

Table 3: Dickey-Fuller Unit Root Test Results

Variable	Z(t) at Level	p-value	Z(t) at 1st Difference	p-value
LnPop	-1.745	0.9982	-2.371	0.0311
LnER	-4.935	0.0000	-3.446	0.0095
LnINF	-2.658	0.0816	-5.573	0.0000
LnCEV	-4.593	0.0001	-12.232	0.0000
LnIR	-2.819	0.0556	-8.485	0.0000
LnWCP	-0.764	0.8294	-2.938	0.0411
LnExportTax	-4.593	0.0001	-12.232	0.0000

4.4 Ridge Quantile Regression Results

The results of the ridge quantile regression analysis in Table 4 reveal important insights into how various macroeconomic variables influence clove export performance in Zanzibar. Among these, GDP (LnGDP) shows a strong, growing positive impact, with its coefficient increasing to nearly 0.97 as the regularization penalty is reduced. This indicates that economic expansion significantly boosts

clove exports, likely due to improved infrastructure, increased investment flows, and enhanced institutional capacity that support production and trade. These findings are consistent with Suleiman (2018), who reported a positive relationship between economic growth and clove export performance in Zanzibar. Similarly, Tang et al. (2015) found a long-term relationship between exports and GDP across the four Asian Little Dragons, although the Export-Led Growth (ELG) hypothesis was not uniformly supported. Ahmad et al. (2018) confirmed the ELG hypothesis in both the short- and long-run for ASEAN economies; and highlighted the importance of foreign direct investment (FDI)-led growth. Conversely, some studies argue that economic growth does not always translate into improved export outcomes, especially in contexts where growth is uneven or accompanied by structural constraints (Zhu et al., 2022).

Table 4: Ridge Quantile Regression Coefficients

Variable	L1 Q (0.1)	L2 Q (0.25)	L3 (0.5)	L4 Q (0.75	L5 Q (0.95)
Intercept	15.7987	6.2024**	1.7271**	1.2242**	1.1878**
LnGDP	0.0	0.3287**	0.8421	0.9287	0.9664
LnPop	0.0	0.7813***	0.8621***	0.8799***	0.8877***
LnER	0.0	0.1738**	0.0093**	-0.0469*	-0.1126*
LnINF	0.0	0.0	0.3796**	0.4035**	0.4131**
LnIR	0.0	0.0	-0.2419***	-0.2233**	-0.2001**
LnWCP	0.0	0.4688**	1.1439**	1.1946**	1.265**

Diagnostic Test Results

Test/Statistic	Value
Breusch-Pagan-Godfrey Test	0.562
White Test	31.76
Ramsey Reset Test	0.35
Jarque-Bera Normality Test	1.114
Durbin Watson Test	1.871

Note: *The ate quick *, **, and *** represent the significance at 10%, 5%, and 1%*

Likewise, population (LnPop) displays a consistently positive effect, with coefficients rising from 0.78 to 0.89 across quantiles. This trend suggests that a growing population may boost the labour supply essential to clove farming and support increased production, thereby reinforcing the sector's contribution to the local economy. These results align with several empirical studies. In Iran, Karimi and Saadat (2021) found that the secondary education group and the average age of people between 20–40 and 41–65 years: all had a positive and significant effect on exports; indicating that human capital in more experienced and productive age groups improves job skills, and leads to comparative advantage and export growth. Similarly, recent evidence from African contexts shows that population growth enhances labour availability and supports agricultural export performance (Johnson et al., 2022; Aragie et al., 2023). In Sub-Saharan Africa,

rapid population growth, particularly through increased labour supply and urbanization, has been linked to higher potential for agricultural output and trade opportunities (Johnson et al., 2023). These findings reinforce the positive role of population dynamics in labour-intensive cash crop sectors such as the cloves sector in Zanzibar. However, contrasting evidence is found in the study by Wu et al. (2022) in China, which discovered that population ageing hurt exports compared to the elementary and highly educated groups.

Exchange rate (LnER) shows a varying impact on clove export values in Zanzibar. The ridge quantile regression results indicate that LnER has a positive, statistically significant effect at the lower quantiles (Q0.25 and Q0.50), suggesting that depreciation of the Tanzanian shilling enhances the competitiveness of clove exports when export values are relatively low. However, the coefficient turns negative and statistically significant at the upper quantiles (Q0.75: -0.0469 and Q0.95: 0.1126), implying that exchange rate depreciation becomes harmful to clove export performance during periods of higher export values. This non-linear effect highlights the complex influence of exchange rate movements on clove export performance in Zanzibar. While moderate depreciation may improve price competitiveness in international markets, a weaker shilling significantly increases the cost of imported inputs such as fertilizers, pesticides, and farming equipment; thereby squeezing profit margins and constraining production capacity at higher export levels. These findings are consistent with Akinbode and Ojo (2017), who reported that exchange rate misalignment reduces agricultural export volumes in Nigeria. Likewise, Eshetu and Goshu (2021) found that exchange rate volatility negatively affects agricultural exports in Ethiopia. Similarly, Nthebe and Mosikari (2025) noted that although currency depreciation can boost short-term competitiveness in South Africa, persistent volatility and rising input costs often offset gains in the agricultural export sectors.

Meanwhile, inflation (LnINF) shows a steadily positive association with clove export values, with the coefficient rising to approximately 0.41 at higher quantiles. This suggests that moderate inflation may align with rising export values, potentially reflecting higher producer prices and a generally expanding economic environment, provided inflation remains within manageable levels. Supporting this view, Ali et al. (2024) found a positive effect of inflation on exports in Pakistan. Recent studies have also reported a positive or non-negative relationship under moderate inflation conditions. For example, Okpe and Ikpesu (2021) showed that moderate inflation can support agricultural trade dynamics in developing economies, while Nnoli et al. (2023) found that low to moderate inflation (below certain thresholds) can have a slightly positive or non-negative effect on agricultural exports in Nigeria. In contrast, Akalpler (2013) reported that in Turkey, neither higher inflation rates between 1970 and 2000, nor lower rates between 2000 and 2010, significantly contributed to increasing trade capacity,

even though the Turkish export capacity grew steadily between 1980 and 2010. These findings indicate that the relationship between inflation and export growth remains complex and highly context-dependent.

Moreover, interest rates (LnIR) consistently exhibit a negative effect, with coefficients ranging from -0.24 to -0.20. This suggests that elevated borrowing costs reduce export performance by limiting access to affordable credit for farmers and traders in the clove value chain. Such financing constraints undermine productivity and operational scale in Zanzibar's clove sector. Empirical evidence aligns with this outcome. Daudi and Muba (2025) found significant negative impacts of interest rates on agricultural sector growth in Tanzania; while a panel study by Kim and Choi (2019) in Korea and Japan reported a strong negative effect of monetary policy interest rates on agricultural performance. Together, these findings underline the importance of ensuring access to low-cost financing to support export growth.

Among all variables, world clove prices (LnWCP) stand out with the highest and most robust positive coefficients, increasing from 0.47 to 1.26 across the quantiles. This indicates a highly elastic response of clove export values to changes in global market prices, with a 1% increase in world clove prices resulting in a more than 1% rise in export values. Such a strong relationship underscores Zanzibar's heavy reliance on favourable international price conditions for the performance of its clove export sector. It also highlights the sector's vulnerability to global price volatility, which can lead to sharp fluctuations in export earnings. These findings are consistent with Agyei-Holmes et al. (2023), who found that world commodity prices have a positive and statistically significant impact on agricultural export performance in Ghana. Similarly, studies on agricultural commodities in developing countries show that export values are highly sensitive to international price movements due to limited domestic market absorption and heavy dependence on export revenue (Emediegwu & Rogn, 2024; Chowdhury, 2023).

However, recent experiences in Zanzibar demonstrate the risks of this dependence, as global oversupply and falling world prices contributed to a dramatic 76% collapse in clove export values in 2025 (BoT, 2025). To mitigate such volatility and ensure long-term sustainability, policies should focus on promoting value-addition (e.g., clove oil and other derivatives), enhancing product quality standards, and pursuing market diversification to reduce reliance on a few traditional buyers. These measures would help stabilize earnings and strengthen the resilience of Zanzibar's clove export sector in the global marketplace.

Furthermore, the empirical findings of this study provide strong support for both the macroeconomic theory and the comparative advantage theory in explaining clove export performance in Zanzibar. Consistent with the macroeconomic

theory, the results demonstrate that key macroeconomic variables—particularly GDP growth, population, inflation, interest rates, and exchange rate movements—significantly influence clove export values, with their effects varying across different quantiles of the export distribution. This confirms that domestic macroeconomic stability and conditions play a critical role in shaping export outcomes. At the same time, the highly elastic and robust positive response of clove exports to world clove prices strongly supports the comparative advantage theory, underscoring Zanzibar's continued reliance on its traditional comparative advantage in clove production to participate in global trade. However, the negative effects of high interest rates and adverse exchange rate movements at higher quantiles reveal important limitations; that is, while Zanzibar possesses a comparative advantage in cloves, this advantage is not automatically translated into sustained export growth due to macroeconomic constraints and structural weaknesses. Generally, the study concludes that both theories are relevant. Still, their explanatory power is enhanced when applied together. Macroeconomic stability is essential for realizing and sustaining Zanzibar's comparative advantage in the global clove market.

Additionally, the diagnostic tests in Table 4 indicate that the model performs well overall. The Breusch-Pagan-Godfrey test shows no evidence of heteroscedasticity, with a p-value of 0.562. The White test statistic of 17.76 suggests homoscedasticity, but this should be interpreted alongside other tests. The Ramsey Reset test, with a p-value of 0.35, indicates that the analytical model is not mis-specified. The Jarque-Bera test value of 1.114 suggests that the residuals are approximately normally distributed. Lastly, the Durbin-Watson statistic of 1.871 indicates that there is no significant autocorrelation in the residuals.

4.5 Robustness Check

As part of the robustness check using the cross-validation stability check, the Elastic Net coefficient path plot presented in Figure 3 illustrates how the coefficients of the explanatory variables in the clove export value evolve as the penalty parameter (lambda) varies. At high lambda values, strong regularization forces all coefficients toward zero, minimizing the impact of less relevant predictors. As lambda decreases, the coefficients grow in magnitude, revealing the relative importance of each variable. Wholesale clove price emerges as the most influential factor, with its coefficient increasing earliest and exceeding 1. GDP and population also show strong, positive effects, with coefficients approaching 1, indicating delayed but meaningful contributions. Inflation exhibits a moderate positive influence early in the path, while interest rates and exchange rates exhibit a moderate negative influence. A consistent display of negative coefficients across the sample suggests a negative effect on clove exports. These results are consistent with the findings presented in Table 3, thereby verifying the robustness of the findings.

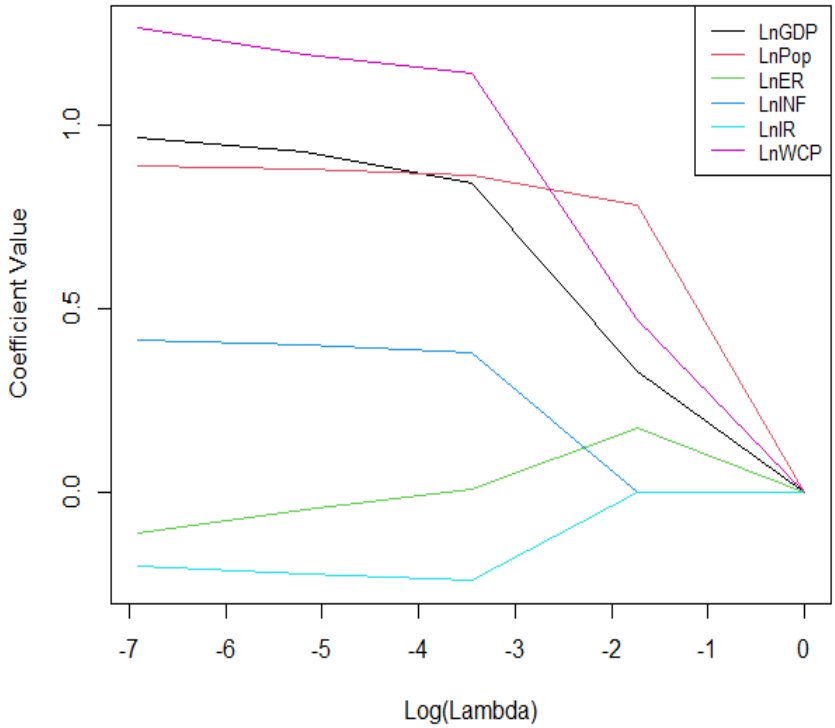

Figure 3: Elastic Net Coefficient Path

5. Conclusion and Recommendations

This study examined the influence of key macroeconomic variables on clove export performance in Zanzibar using annual time-series data from 1991 to 2023, analysed through ridge quantile regression. The results reveal that world clove prices exert a strong, positive, and statistically significant impact across all quantiles, underscoring the sector's heavy dependence on international market conditions. GDP growth and population growth also demonstrate robust positive effects, indicating that stronger economic expansion and increased labour availability enhance production capacity and export volumes. Inflation exhibits a moderately positive association with clove exports, while interest rates and exchange rate movements exert significant negative effects, with the adverse impact of the latter becoming particularly pronounced at higher quantiles. These findings illustrate the clove sector's pronounced sensitivity to global price dynamics, as well as the critical role of domestic macroeconomic stability; revealing that while global prices, economic growth, and population growth serve as key drivers of export performance, rising interest rates and exchange rate volatility act as major constraints undermining Zanzibar's competitiveness in the global clove trade.

The study contributes to the existing body of knowledge by focusing specifically on the clove export sector in Zanzibar. This traditional cash crop has received relatively limited scholarly attention despite its critical importance for export earnings, rural livelihoods, and government revenue. Through applying ridge quantile regression on long-term time-series data, the study provides robust empirical evidence on the heterogeneous effects of macroeconomic variables across different levels of export performance, offering information that can guide both academic understanding and practical policy-making in small island economies.

Policy recommendations arising from this study should focus on both price stabilization and macroeconomic management. The government should provide clove farmers with timely market information, storage facilities, and price forecasting tools to enable better responses to global price signals. Promoting value addition through processing and branding, coupled with investment in rural infrastructure and youth involvement in agriculture, will help enhance competitiveness and sustainability. Furthermore, subsidized agricultural credit schemes and measures to maintain moderate inflation and exchange rate stability are essential to reduce borrowing costs and create a more predictable environment for producers and exporters.

Despite its contributions, this study has limitations. It relies mainly on aggregate macroeconomic data, which may overlook micro-level factors such as farmer behaviour and institutional challenges. The analysis also does not fully capture the impact of external shocks such as climate variability or geopolitical events. Future research could address these gaps by incorporating more disaggregated data, and examining additional contextual factors affecting clove export performance in Zanzibar.

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