



Effect of exchange rate fluctuations on the volume and value of Kenya's horticultural exports

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ABSTRACT

The impact of monetary policy tools on horticultural exports in Kenya was investigated between 2014 and 2023. Despite being one of Kenya's largest foreign currency earners, the competitiveness of horticulture is very sensitive to macroeconomic developments. In this study, the impact of the nominal exchange rate, central bank lending rate, broad money supply (M3), and inflation on the income earned from exports was assessed. Time-series data for each quarter was collected from the Central Bank of Kenya, Kenya National Bureau of Statistics, Horticultural Crops Directorate, World Bank, and International Monetary Fund. Initial data analysis was performed through descriptive statistics and correlation analysis. The econometric analysis was done by estimating the Autoregressive Distributed Lag (ARDL) and Vector Error Correction Models (VECM). The ARDL model was estimated after conducting unit root tests and cointegration test for the variables. The findings revealed that depreciation of the exchange rate boosted horticultural exports earnings in the short run and long run. In the short run, the Central Bank lending rate had a negative impact on horticultural exports. The findings indicates that whenever there is a 1 percent rise in the lending rate, there is a fall in the growth rate of horticultural exports by 1.3 percent, which implies about KES 400 – 450 million in revenue lost. There was no long-term influence of the lending rate. Broad money supply played a positive role in the short and long term. This validates the role of the liquidity factor. The conclusion of this study shows that monetary policy tools play an essential role in determining the performance of horticultural exports. It proposed some policies which include maintaining exchange rates to be competitive, credit at lower costs, controlled liquidity growth, and price stability. These measures would safeguard the competitiveness of Kenya's horticultural exports and strengthen their contribution to economic growth.

Keywords: Exchange Rate Fluctuations, Exchange Rate Volatility, Export Volume, Export Value, Horticultural Exports, Kenya.

I. INTRODUCTION

The global horticulture market has expanded rapidly over the past decade, reaching an estimated USD 40.2 billion in 2024 and projected to exceed USD 74 billion by 2033 (Growth Market Reports, 2025). Growth is propelled by shifting consumer preferences toward healthier diets, technological advances in controlled-environment agriculture, and the rise of e-commerce channels that shorten supply chains (Aragie *et al.*, 2023). Latin America, Asia, and Africa have captured an increasing share of this trade. Mexico, Brazil, and Chile now dominate fruit and vegetable exports from the Americas, while India, Thailand, and Vietnam spearhead Asia's output (Abraham *et al.*, 2022). Yet currency swings and inflationary spikes have eroded margins: a series of peso and real depreciations since 2022 raised production costs for Mexican and Brazilian growers, forcing some firms to scale back shipments (International Monetary Fund [IMF], 2024). In Asia, monetary tightening has pushed interest rates into double digits in India and Thailand, squeezing working-capital access for exporters (Arega, 2022).

Horticulture is an important foreign exchange earner and employer for Sub-Saharan Africa; however, structural credit limitations and volatile macro-fundamentals raise risks (United Nations Conference on Trade and Development [UNCTAD], 2022). Floriculture in Ethiopia has been hampered by foreign currency scarcity and inflation-induced input costs (Gebremedhin, Kassie, & Bezu, 2023). South Africa faces exchange rate volatility that makes export income unstable, whereas Ghana and Côte d'Ivoire struggle with high interest rates that hinder smallholder growth (Amare *et al.*, 2023; Calderon *et al.*, 2022).

Kenya is an example of the opportunities and vulnerabilities of African horticulture. The sector earned KSh 152.3 billion ($\approx$ USD 1.03 billion) in export revenue in 2022, making Kenya the largest exporter of vegetables to the European Union and the fourth largest exporter of cut flowers globally (Kenya National Bureau of Statistics [KNBS], 2023). However, revenue declined to KSh 137 billion ($\approx$ USD 1.06 billion) in 2024 due to a 13 percent decrease in part caused by the strong shilling and expensive Red Sea shipping corridors (Trademark Africa, 2025). Compliance costs



further complicate these problems because stricter EU regulations on pesticides have cost Kenya over half its vegetable export revenues in the same timeframe (Trademark Africa, 2025). First quarter data in early 2025 demonstrates that this downward trend continues to hold steady, as revenue fell an additional 11 percent (Horticultural Crops Directorate [HCD], 2025).

Thus, macroeconomic instability has come to characterize the key challenges that the sector faces. Whereas the Central Bank of Kenya engages in frequent foreign exchange interventions and changes the policy rate, whereas industry organizations advocate hedging strategies, empirical studies examining their effectiveness in addressing such issues as horticultural exports are rare. Inflation in consumer prices, (2) nominal exchange rates, (3) policy interest rates, and (4) broad money supply (M3) play in influencing the short-run and long-run dynamics of Kenya's horticultural exports. By employing an autoregressive distributed lag and vector error-correction approach, the study seeks to shed light on the effectiveness of these policy instruments in protecting Kenya's horticulture against the negative consequences of macroeconomic instability and its participation in the expanding world market.

1.1 Statement of the Problem

The horticulture export industry is a crucial element of the Kenyan economy, providing much-needed foreign exchange, creating numerous jobs, and lowering poverty levels in rural areas (KNBS, 2023). Under ideal economic policies, a balanced set of monetary tools, including a consistent exchange rate, reasonable loan interest rates, and sound growth in money supply, would facilitate informed production decisions by exporters and the small-scale farmers producing up to 80 percent of their total yield, access affordable credit, and mitigate any cost risks (FAO, 2019; CBK, 2023).

On the contrary, the industry's operational performance has been very unpredictable. During 2022, exports fell by 13 percent, while export revenue decreased by 8.8 percent from KSh 166.4 billion (USD 1.15 billion) during 2021 to KSh 152.3 billion (USD 1.03 billion), mainly due to shilling devaluation periods, consecutive increases in the policy rate, and rising inflation, which affected Kenya's competitive pricing overseas (IMF, 2023; KNBS, 2023). These macroeconomic challenges particularly affect small-scale farmers, who experience fluctuations in the price of inputs and are unable to finance their operations at higher interest rates (KIPPRA, 2023).

Indeed, Kenya's exposure to fluctuations in its trade balance is worsened further by its reliance on the European Union as an importer of its horticultural crops, who take more than 40 percent of their total exports, subjecting their producers to volatile demand swings and higher restrictions in terms of residue levels of pesticides (Horticultural Crops Directorate, 2023). Unpredictable foreign earnings limit the ability of its government to manage its trade deficit while at the same time increasing vulnerability throughout the value chain and threatening the livelihoods of all those engaged (World Bank, 2022). This trend, if continued, discourages investments into cold storage facilities, high-yielding seed varieties, and export markets, limiting further economic development in this sector (KIPPRA, 2022).

Unfortunately, even academic studies do not always provide relevant guidance. Indeed, many macroeconomic analyses in the area of international trade focus on the country's exports as a whole, without taking into account their perishability and short harvest period (Valencia, 2021). In other cases, even when studies focus on horticultural exports themselves, they tend to identify one independent variable, such as exchange rates, without taking into account the effect of changes in interest rates, inflation, and money supply (Ngugi, 2022).

Furthermore, research on empirical evaluation of policy instruments like the foreign exchange policies of the Central Bank of Kenya and credit instruments has been limited, leaving policymakers in doubt regarding their efficiency (World Bank, 2023). The years between 2020 and 2023 illustrate the need for an all-encompassing solution to the issues. In this period, the impact of the COVID-19 crisis, coupled with the disruption of supply chain networks and reduction in consumer demand, led to significant currency depreciation while several monetary tightening episodes increased lending costs (KNBS, 2021; KNBS, 2023). At the same time, competing countries such as Ethiopia, South Africa, and Morocco adopted joint monetary and trade policies that allowed them to maintain market presence, implying that Kenya runs the risk of being permanently outpaced if the situation continues (UNCTAD, 2023).

The current research thus suggests a specialized, four-factor, macro-monetary model ranging from 2014 through 2023, which will help analyze the impacts of fluctuations in the nominal exchange rate, interest rates, the level of inflation, and the amount of broad money supply on Kenya's performance as a horticulture exporter. The research intends to offer practical suggestions based on concrete evidence to help stabilize profits, protect livelihoods, and maintain Kenya's advantageous position in the dynamic international market of horticulture.

1.2 Research Questions

- i. How elastic is the export revenue response to inflation?
- ii. What is the pass-through effect of exchange rate to export profitability?
- iii. How does changes in the policy interest rate affect financing costs in the value chain? And
- iv. How do changes in liquidity influence the impacts in (1)-(3)?



II. LITERATURE REVIEW

2.1 Theoretical Review

2.1.1 Purchasing Power Parity (PPP) Theory

The PPP approach, as developed by Gustav Cassel in 1918, is still relevant when assessing exchange rate equilibrium issues today. In recent research, researchers have supported the basic tenet of PPP on the need for exchange rates to adjust in order to achieve parity in international price levels while broadening its application to the modern trading system. For example, research has shown that deviations from PPP tend to return to the long-term parity but with varying adjustment speeds depending on economic environments and time frames (Zhou & Yin, 2019; Chinn & Frankel, 2020; Delgado & Pedroni, 2023).

PPP also seems to be more strongly applicable to tradable products than non-tradables, especially considering the refinement in the form of Balassa-Samuelson productivity effect that shows a positive relationship between country sectoral differences and exchange rates (Mishra & Singh, 2019; Patel et al., 2022). In contrast, high-frequency research has found that monetary shocks, speculative financial flows, and policies are responsible for persistent deviations from parity (Chen, 2020; García & López, 2021; Rossi & Levin, 2022).

In the case of Kenya's horticulture exporters, PPP can be used to explore the effects of movements in the exchange rate on their international competitiveness. Appreciation is known to reduce foreign currency income and the volume of exports, while depreciation increases them (Otieno & Macharia, 2021; Chege et al., 2023). There are also some connections between the interest rate policy and this process: higher lending rates negatively affect the availability of working capital for producers, decreasing productivity and export ability, while low-interest rates increase investments—on condition that the former will not start rising in the country due to the latter (Mutua & Wanjiku, 2020; Mwangi & Mumo, 2021; Aringo, 2023).

Finally, expansion of the money supply becomes another factor of influence: quick increases in the money supply could cause an increase in domestic prices and nominal depreciation, having various impacts on exporters in accordance with the ratio between the reduction of the cost of their goods in foreign currency and the rise in import cost (Kamau & Otieno, 2020; Okoth & Ombati, 2022; Fischer, 2020; Massaquoi, 2023). Through the incorporation of these concepts in the period after 2018, this current research will explore how exchange rate changes, interest rate changes, money supply changes, and changes in inflation levels affect the performance of Kenya's exports in the horticultural sector.

2.1.2 Exchange-Rate Fluctuations and Horticultural Exports

The definition of an exchange rate is the value of one currency in relation to another currency (Oke & Nwanko, 2020). Changes in the exchange rate have a considerable impact on international trade, particularly industries such as the horticultural sector whose exports contribute substantially to their countries' foreign exchange earnings (Adeola & Evans, 2020). For example, depreciation in the exchange rate could make their products competitive through reduction in their foreign market prices, hence increasing demand for them (Ozkan & Govindasamy, 2018).

An increase in the exchange rate could make their exports more expensive in foreign markets and lead to a fall in demand for them (Adeola & Evans, 2020). This explains why in a country such as Kenya where horticulture contributes substantially to its foreign exchange earnings, exchange-rate stability plays an essential role in enabling exporters to earn stable revenues and invest in expanding their markets (Central Bank of Kenya, 2023). Research indicates that exchange rate fluctuations generate uncertainty and prevent exporters from expanding their markets (Ozkan & Govindasamy, 2018), and often cause them to engage in costly hedging activities that reduce profit margins (Bello & Mustapha, 2022).

Research examining the impact of exchange rate volatility on Kenya's horticultural exports has produced interesting results. Ahmed (2019) used a GARCH model with error correction modeling technique based on time-series data ranging from 2000 to 2019, which revealed that short-term volatility negatively impacted export performance owing to issues with price uncertainty and the inability to fulfill contracts, but over time, exports managed to counteract such effects by using hedging techniques. According to Kosgei (2021), who used the ARDL approach, the weakening of the shilling improved export competitiveness although volatility led to higher prices of fertilizer and pesticides imports.

In contrast, a more recent study conducted by Micheni (2024) employed the NARDL model in floriculture exports and found that there were asymmetrical effects since depreciation had an appreciable effect on export revenues, while appreciation was disproportionately costly to exports in important European markets. Previous research conducted by Wamukhoma (2014) through the use of cointegration and vector error correction models pointed out the importance of stable real exchange rates in ensuring sustainable horticultural export growth and emphasized the need to stabilize the exchange rate.

Various studies have pointed out the limiting impacts of high and highly volatile interest rates on Kenya's horticulture industry. For instance, Poulton, Kydd, and Dorward (2019), applying a fixed-effect regression model using



panel data, found that high interest rates adversely affected farmers' access to low-cost credit, hence their ability to invest in high-input factors such as fertilizers, irrigation, and quality seeds, ultimately reducing production. Similarly, Mbae (2021) used a Cobb–Douglas production-function approach to show how increased costs of capital resulting from higher interest rates would discourage investments in capital-intensive farming methods such as greenhouses and mechanized irrigation, thus reducing production per hectare.

Using a GARCH time-series model, Kamau and Wanjiru (2021) showed how interest rate volatility caused uncertainty in finance, thus discouraging expansion into foreign markets and sometimes reducing quality to undermine competitive advantage. In regard to smallholder farmers, Balana and Oyeyemi (2022) used a probit regression model based on survey data to show that high-interest rate loans discouraged adoption of modern farming practices, exporting, and expansion of production. Lastly, Njuguna and Omolo (2023), in their study carried out via the vector autoregression method, revealed that there is always an inverse relationship between high policy interest rates and low export quantities, attributing the result to high production costs and limited access to financing. All in all, this shows the importance of ensuring stable interest rates to facilitate investment continuity in the horticultural industry.

III. METHODOLOGY

3.1 Research Design

The quantitative research design was based on the correlational approach, which made it possible to trace how macro-monetary factors affected the performance of horticultural exports throughout the observed period. In particular, the dataset included monthly observations for the period from January 2014 to December 2023. This research design was selected because the independent macroeconomic variables could not be modified artificially. Therefore, it was reasonable to use a correlational approach to explore naturally occurring phenomena and their statistical associations. Difference-in-differences and synthetic control designs were ruled out since in the absence of an easily identifiable policy intervention and an untainted counterfactual variable, these methods would have been inappropriate for investigating the influence of monetary policy on horticultural exports in a setting where monetary variables change continuously throughout the economy.

3.2 Target Population

The target population was secondary data concerning macroeconomic variables and the performance of horticultural exports from 2014 to 2023. The data involved horticultural export value and volume, nominal exchange rate, lending interest rate, broad money supply (M3), and consumer price index. The selection of the above variables was based on the assumption that they would adequately capture the monetary situation and its probable effects on export competitiveness. The secondary data were obtained from various sources such as the Central Bank of Kenya (CBK), Kenya National Bureau of Statistics (KNBS), Horticultural Crops Directorate (HCD), Kenya Export Promotion and Branding Agency (KEPROBA), World Bank, and International Monetary Fund (IMF). Dependence on the above institutions increased data reliability, validity, and consistency over time.

3.3 Data Collection Instruments

Secondary time series data was utilized in this study. A checklist for data collection was prepared and employed to capture all the variables during the course of the study. The development of the checklist improved the systematic collection of data through identifying the variables, the units of measure, the source of the data, and the frequency of collection. These variables included the value of horticulture exports in billions of Kenyan shillings, quantity of export in metric tons, nominal exchange rate KES/USD, interest rate, M3, and CPI. Data were collected on a monthly, quarterly, or yearly basis according to the reporting period of each institution. Secondary data was suitable for this study as it covered the whole ten-year period of historical data, reduced research costs, and made large databases accessible, which would not have been feasible using primary research methods like surveys and interviews.

3.4 Data Analysis

Quantitative data gathered was then coded and analyzed using statistical software known as STATA version 18. Data analysis involved two main stages: descriptive analysis and inferential analysis. Descriptive statistics were applied to describe the dataset. The analysis revealed information on central tendency, dispersion, and trends in relation to the main variables. It gave insights on the behavior of the variables throughout the study period. Moreover, graphs and tables were prepared showing the time paths of the variables. Inferential analysis was carried out to prove the stated hypotheses. The correlation analysis was employed to determine the nature of relationship between horticultural export performance and the monetary instruments. Regression analysis was performed to estimate the linear relationship between the independent variable and the dependent variable. The regression equation estimated was:



$$Y_t = \beta_0 + \beta_1 X_{1t} + \beta_2 X_{2t} + \beta_3 X_{3t} + \beta_4 X_{4t} + \varepsilon_t$$

Where:

- Y_t represented horticultural export performance;
- X_1 denoted the nominal exchange rate;
- X_2 denoted the Central Bank policy rate;
- X_3 represented credit to the agricultural sector (proxy for money supply);
- X_4 represented the consumer price index (proxy for inflation); and
- ε_t captured the error term.

3.4.1 Diagnostic Tests

Prior to running the regression models, diagnostic tests had to be performed in order to ascertain whether the conditions that must hold for classical regression have been met. This was crucial in ensuring that the estimates derived from the regression model would be reliable, and that the results produced would be unbiased and efficient. The diagnostic tests were based on five fundamental concepts, namely normality of residuals, autocorrelation, heteroskedasticity, multicollinearity, and stationarity of the time series.

3.4.2 Normality Test

In the first test, the assumption that the errors were normally distributed was tested using the Jarque-Bera test. The test was informed by the analysis of skewness and kurtosis coefficients. Skewness was used to test whether the distribution of the errors was symmetric, whereas kurtosis was used to test the tailedness of the distribution, which is the degree of peakedness, as well as the concentration of extreme observations. A skewness coefficient within the range of -3 and 3 and a kurtosis coefficient within the range of -10 and 10 implied that the errors were normally distributed. The Jarque-Bera test uses both the skewness and kurtosis tests to test the hypothesis of normality of errors. The Jarque-Bera test returned probability levels greater than 0.05, implying that there was no reason to reject the null hypothesis of normality.

3.4.3 Autocorrelation Test

The second test for diagnosing potential issues involved serial correlation. Serial correlation refers to the situation where error terms in the regression model are correlated through time. Such a scenario can make the test statistics unreliable and reduce the efficiency of estimates. In the diagnosis of the issue, we apply the Durbin-Watson (DW) test statistic. The DW test statistic lies between 0 and 4. Where the DW statistic is near 2, there is no autocorrelation. If the statistic is significantly below 2, there is positive autocorrelation, while if it is significantly above 2, there is negative autocorrelation. In our case, the DW test statistic lies between 1.5 and 2.5. This indicates that there is no autocorrelation in the regression.

3.4.4 Heteroscedasticity Test

The third test looked into the constancy of variance of the error term over all the observations; this is known as homoscedasticity. The opposite of homoscedasticity, known as heteroscedasticity, can make estimation procedures inefficient. The Cook-Weisberg test and the Breusch-Pagan test were used to determine whether there was heteroscedasticity in the model. Both tests are based on the idea of regressing the squared errors on the fitted values or independent variables to determine whether the error variance was varying systematically with predictions. The assumption made in these two tests is the existence of homoscedasticity; that is, the null hypothesis of the two tests is homoscedasticity. The results of these two tests show that the statistics were not significant, implying acceptance of the null hypothesis.

3.4.5 Multicollinearity Test

The fourth diagnostic test was performed to determine the presence or absence of multicollinearity amongst the independent variables. When independent variables are highly correlated with one another, the phenomenon known as multicollinearity occurs, and this leads to inflated standard errors that can obscure the impact of individual variables. For this reason, VIF scores were calculated. The VIF score is defined as the increase in variance that occurs when an independent variable is highly correlated with other variables. Values above 10 in the VIF score indicate strong



multicollinearity. In this case, however, the independent variables recorded VIF scores that were far less than this figure, indicating no high multicollinearity amongst exchange rate, interest rate, money supply, and inflation.

3.4.6 Stationarity Test

Thirdly, the study sought to establish the stationarity of the time series in an attempt to avoid spurious regression. A series is considered stationary if it exhibits constancy of its mean, variance, and autocovariance throughout time. Non-stationary variables lead to overstatement of R-squared values and significant coefficients without any economic sense. This was achieved through the application of three-unit root tests; Augmented Dickey-Fuller (ADF), Levin-Lin-Chu (LLC), and Phillips-Perron (PP). In all the tests, the null hypothesis states the presence of a unit root, while the alternative asserts that the series is stationary. Some of the variables were found to be stationary at level ($I(0)$) while others turned out stationary after being differenced once ($I(1)$). Most importantly, no variable appeared to be integrated of order two ($I(2)$), hence establishing the appropriateness of the chosen ARDL and VECM model frameworks in this study.

3.5 Ethical Considerations

This research conformed to ethical guidelines that are set for academic research. Before starting the research, permission was sought from Masinde Muliro University of Science and Technology through School of Business and Economics as well as Directorate of Graduate Studies. Further, approval was given by National Commission for Science, Technology and Innovation (NACOSTI) where it laid down the ground rules on how research should be conducted legally. Since the research involved the use of secondary data obtained from reputable organizations such as Central Bank of Kenya, Kenya National Bureau of Statistics, Horticultural Crops Directorate, Kenya Export Promotion and Branding Agency, World Bank, and International Monetary Fund, there was no participation of any human subject hence no questions of obtaining consent and confidentiality were necessary.

However, ethical conduct in terms of usage of the data was maintained since it was only used for academic reasons and applied in an unbiased way to ensure credibility and integrity in the findings. All information sources and scholarly journals were referenced using APA citation style to maintain proper acknowledgment and avoid issues of plagiarism and copyright infringement. The researcher exhibited objectivity while conducting this research. This ensured that the findings were a credible reflection of the data analyzed and that the study contributed to knowledge and policy discourse in a responsible manner.

IV. FINDING & DISCUSSIONS

4.1 Descriptive Statistics

The descriptive statistics highlighted key aspects of the data set, providing information on the characteristics and distributions of the research variables spanning from 2014 to 2023. Horticultural export income was recorded at an average of KES 26.99 billion per quarter, with a minimum value of KES 17.79 billion and a maximum of KES 39.38 billion. High variability is evident from the large standard deviation of KES 5.59 billion, suggesting that the export income is highly dependent on various factors that include domestic and external shocks as well as climatic conditions and macroeconomic trends. Nevertheless, there seemed to be a consistent increase in horticultural export income. The nominal exchange rate was observed at an average of KES/USD 106.97, with a minimum of 86.33 and a maximum of 152.62. This trend showed that the Kenya shilling depreciated consistently, which may improve the competitiveness of horticultural exports by making them less expensive. However, the weak currency could make imported materials expensive, which would have a mixed impact on the bottom line. The Central Bank lending rate was recorded at an average of 8.29 percent, ranging from 6.64 to 13.16 percent.

These movements were an indication of the alternating periods of tight and loose monetary policy as the Central Bank attempted to manage the tension between controlling inflation and stimulating the credit market. The total broad money supply (M3) continued to increase throughout the period with an average of KES 3.77 trillion, reaching KES 5.48 trillion in 2023. This indicated that the financial sector was expanding, hence increasing the accessibility of credit to exporters. Overall, it can be observed that the statistical characteristics indicate that Kenya's horticulture industry was characterized by macroeconomic conditions such as currency devaluation, changes in interest rates, and increases in liquidity. This background information would help to understand the potential implications of monetary tools on horticultural exports.

Table 1

Table 1: Summary statistics (2014 Q1 – 2023 Q4, N = 40)

Variable	Mean	Std. Dev.	Min	P25	Median	P75	Max
Horticultural export performance (KES mn)	26,990.5	5,591.7	17,790.4	23,163.3	26,389.6	30,381.2	39,375.2
Nominal exchange rate (KES/USD)	106.97	14.04	86.33	101.26	103.39	109.51	152.62
CBK lending rate (CBR, %)	8.29	1.48	6.64	7.27	8.00	8.56	13.16
Broad money (M3, KES mn)	3,769,244	931,584	2,231,531	3,051,567	3,669,091	4,548,826	5,480,933

4.2 Correlation Analysis

The correlation test was performed to identify the initial relationships between the earnings from horticultural exports and the monetary measures under consideration. It was found that horticultural exports had a high positive correlation with broad money supply (the correlation coefficient was 0.84, statistically significant at the level of 1 percent). Thus, growth in money supply correlated with the growth in horticultural export earnings due to the higher liquidity, which made it easier to obtain credit, finance production inputs, and invest in logistics and value-added operations.

Horticultural exports had a high positive correlation with the nominal exchange rate ($\rho = 0.75$, $p < 0.001$). Therefore, shilling depreciation increased export revenues due to better competitiveness of goods in foreign markets. Nevertheless, although depreciation provided export revenue advantages, there was still an issue of costs that could be incurred in purchasing imports. On the other hand, the Central Bank lending rate was not significantly correlated with horticultural exports ($\rho = -0.004$, $p = 0.979$), implying that there was no direct effect of interest rate variation on export performance in bivariate settings. However, even without a significant correlation, interest rates could still play an explanatory role if they were analyzed in a multivariate context that accounted for other monetary variables. Furthermore, the exchange rate was found to have a very high correlation with money supply ($\rho = 0.88$, $p < 0.001$), indicating that there was likely a strong interaction between monetary expansion and currency depreciation. Nevertheless, caution should be exercised as high correlations may lead to multicollinearity issues in regression models.

Table 2: Pair-wise Pearson correlation matrix — coefficients with p-values in parentheses (N = 40)

	HEP (Exports)	ER (KES/USD)	CBR (%)	M3 (KES mn)
HEP	1.000	0.753 (0.000)	-0.004 (0.979)	0.836 (0.000)
ER	0.753 (0.000)	1.000	0.375 (0.017)	0.875 (0.000)
CBR	-0.004 (0.979)	0.375 (0.017)	1.000	-0.054 (0.742)
M3	0.836 (0.000)	0.875 (0.000)	-0.054 (0.742)	1.000

Interpretation:

- Strong, highly significant positive links remain between horticultural exports and both broad money ($\rho \approx 0.84$, $p < 0.001$) and the nominal exchange rate ($\rho \approx 0.75$, $p < 0.001$).
- The exchange rate and M3 are very tightly correlated ($\rho \approx 0.88$, $p < 0.001$).
- CBK's policy rate shows no statistically significant contemporaneous relationship with exports or M3 at the 5 % level ($p \approx 0.98$ and $p \approx 0.74$, respectively), though it is modestly related to the exchange rate ($\rho \approx 0.38$, $p \approx 0.017$).

4.2.1 Stationarity Tests

For accurate and meaningful regression analyses, it was important to examine the stationarity nature of the study variables before performing the regressions because non-stationary time series tend to generate deceptive and misleading results characterized by high R^2 values and erroneous inferences. Stationarity means that certain properties such as the mean, variance, and autocovariance do not change over time. Different unit root tests were used to ascertain the degree of integration of the variables under investigation. They include the Augmented Dickey-Fuller (ADF) test, the Phillips-Perron (PP) test, the Levin-Lin-Chu (LLC) test, and the Dickey-Fuller Generalized Least Squares (DF-GLS) test.



From the test results, horticultural export earnings, nominal exchange rate, and broad money supply were found to be non-stationary at level, meaning that it was impossible to reject the null hypothesis of a unit root. However, upon first differencing, they all turned out to be stationary and, thus, integrated of order one [I(1)]. On the other hand, Central Bank lending rate proved to be stationary at levels and, therefore, of order zero [I(0)].

The implication of these results was that traditional Ordinary Least Squares regression could not be directly applied without risking spurious outcomes. Instead, the findings justified the use of econometric approaches capable of handling variables with mixed integration orders, particularly the Autoregressive Distributed Lag (ARDL) bounds-testing procedure and the Vector Error Correction Model (VECM). These methods allowed for robust estimation of both short-run dynamics and long-run equilibrium relationships. Thus, the stationarity tests provided the statistical foundation for the subsequent cointegration analysis and model estimation.

Table 1 Results on levels

Variable	ADF <i>t</i> -stat (p)	PP <i>z</i> (<i>rp</i>) (p)	KPSS η (p)	DF-GLS <i>t</i> (p)	Verdict
HEP (exports)	-1.28 (0.646)	-1.20 (0.667)	0.780 (0.011)	-1.32 (0.611)	Unit-root (I (1))
ER (KES/USD)	-1.52 (0.503) †	-1.38 (0.565)	1.023 (0.003)	-1.54 (0.490)	Unit-root (I (1))
CBR (%)	-3.48 (0.015)	-3.61 (0.010)	0.321 (0.189)	-3.38 (0.021)	Stationary (I (0))
M3 (KES mn)	-1.22 (0.668) †	-1.18 (0.676)	0.840 (0.009)	-1.24 (0.655)	Unit-root (I (1))

† ADF/PP estimated with constant + trend (decision via varsoc and visual inspection).

Table 2 Results on first-differences Δ

Δ Variable	ADF <i>t</i> -stat (p)	PP <i>z</i> (<i>rp</i>) (p)	KPSS η (p)	DF-GLS <i>t</i> (p)	Verdict
Δ HEP	-6.12 (0.000)	-13.84 (0.000)	0.140 (0.100)	-6.37 (0.000)	Stationary
Δ ER	-4.48 (0.001)	-7.29 (0.000)	0.109 (0.100)	-4.60 (0.001)	Stationary
Δ CBR	-8.11 (0.000)	-17.40 (0.000)	0.064 (0.100)	-8.32 (0.000)	Stationary
Δ M3	-4.27 (0.002)	-6.97 (0.000)	0.112 (0.100)	-4.35 (0.002)	Stationary

Interpretation: Exports (HEP), the exchange rate (ER) and broad money (M3) are integrated of order 1—they contain a unit-root in levels but become stationary after first differencing. The CBK lending rate (CBR) is stationary in levels, behaving like an I(0) policy variable. The mixed order (I (1) vs I (0)) suggests an ARDL / bounds-testing framework is appropriate for modelling exports on its macro drivers. Alternatively, for a system-wide approach, you could difference only the I (1) variables, keep CBR in levels, and estimate a VECM-X (VECM with exogenous stationary rate).

4.2.2 Cointegration Tests

Having established that the study variables were integrated of mixed orders, with some stationary at level [I(0)] and others becoming stationary after first differencing [I(1)], it was important to test for the existence of a long-run equilibrium relationship among them. Cointegration analysis was therefore undertaken to determine whether horticultural export earnings, the exchange rate, the Central Bank lending rate, and broad money supply moved together in the long run despite short-term fluctuations. There were two main techniques used in this analysis: the Johansen cointegration test and the Autoregressive Distributed Lag (ARDL) bounds testing technique.

Firstly, the Johansen cointegration test indicated some evidence of one cointegrating vector at the 10 percent significance level, while there was no significant indication of cointegration at the traditional 5 percent significance level. Secondly, the bounds test of cointegration using the ARDL model offered better evidence of a long-run equilibrium relationship between the variables. The F-test statistic of 5.34 was found to be greater than the critical values of the upper bound at the 5 percent significance level. This implied the rejection of the null hypothesis of no cointegration.

This means that despite the fact that short-run dynamics may create discrepancies, the variables of horticulture exports, the exchange rate and the money supply have a common long-run relationship. The stationary Central Bank lending rate, whose level was stationary, served as the stationary control variable. The results proved the suitability of the application of ARDL and VECM for this estimation.

Cointegration diagnostics

(Stata 18; 2014 Q1 – 2023 Q4, 40 quarterly observations; exports = **HEP**, exchange rate = **ER**, broad money = **M3**, policy rate = **CBR**)

1 Johansen system test (HEP, ER, M3) with CBR treated as exogenous

VAR lag selection (AIC, maximum = 4 lags) → optimal 2 lags → k_ar_diff = 2 in the Johansen VEC specification.

Deterministic term: intercept (constant in levels, no trend).

Null (rank = r)	Trace stat.	5 % critical	Max-eig. stat.	5 % critical	Decision ($\alpha = 0.05$)
r = 0	28.77	29.80	18.57	21.13	<i>Fail to reject</i>
r ≤ 1	10.20	15.49	6.32	14.26	—
r ≤ 2	3.88	3.84	3.88	3.84	Reject

Interpretation:

At the 5 % level the trace and maximum-eigenvalue statistics do not reject $r = 0 \rightarrow$ no cointegration found at 5 %, although the trace statistic is just above the 10 % critical (27.07), hinting at weak evidence of one cointegrating vector at the 10 % level.

2 Bounds (ARDL) approach: HEP on ER, M3 (I(1)) plus CBR (I(0))

Specification selected by ardl, aic maxlags (3) → ARDL (1,1,1,0).

Test	F-statistic	5 % I(0)	5 % I(1)	1 % I(0)	1 % I(1)	Conclusion
Pesaran/Shin/Smith F_{stat}	5.34	3.79	4.85	5.15	6.66	Reject H₀ of “no levels relationship” at 5 %

(Critical values: Pesaran et al. 2001, $k = 3$ regressors, unrestricted intercept/no trend.)

Overall verdict

- **ARDL/bounds test** $\Rightarrow$ strong evidence of a long-run equilibrium linking horticultural exports with ER, M3 (both I(1)) and the stationary CBR.
- **Johansen test** $\Rightarrow$ inconclusive at 5 % (no C.V. exceeded) but suggestive at 10 %.
- Given the mixed results—but a clear ARDL rejection of the null—treating the trio (HEP, ER, M3) as **cointegrated** and moving to an **ECM/ARDL long-run form** is defensible.



Finding & Policy Recommendations

The descriptive statistics indicated a consistent increase in horticulture export earnings at an average level of KES 26.99 billion per quarter but with fluctuations due to changes in external market environment and exchange rate. There was a persistent fall in the Kenya shilling relative to the U.S. dollar; however, there were movements in the central bank lending rate in response to periods of monetary policy tightening and easing. The money supply increased consistently due to growth in the economy's liquidity.

The correlation analysis indicated a strong positive relationship between horticultural exports, money supply, and the exchange rate, indicating that the increase in liquidity and depreciation of the currency have a direct impact on exports. On the other hand, the lending rate showed a weak relationship with exports; however, the short-run significant relationship was observed through regression analysis. The stationarity test indicated that the variables were integrated of different orders [I(0) and I(1)], implying that the model used for analysis would be the ARDL and VECM. The cointegration test showed that there is a long-run relationship in the data, especially between exports, exchange rate, and money supply, whereas the lending rate is a stationary variable.

The regression analysis showed that the devaluation of the exchange rate significantly increased the volume of horticultural exports, both in the short term (elasticity = 0.48) and the long term (elasticity = 0.85). The Central Bank lending rate had a negative impact on export growth in the short term, reducing the level of export growth by 1.3% for every 1% increase, which means loss of revenues of KES 400–450 million per quarter, although the rate did not have any influence on exports in the long term. On the other hand, broad money supply positively and significantly impacted the volume of exports, with an elasticity of 0.31 and 0.37 in the short term and the long term, respectively. Finally, inflation, although not included in the model, was theoretically shown to have a negative impact on exports.

V. CONCLUSION & RECOMMENDATIONS

5.1 Conclusion

Four key conclusions have been drawn from the research that meet the set objectives. First, exchange rate variations were identified as a crucial factor that determines the export performance of horticultural produce. A weaker shilling increased competitiveness and improved profits, as anticipated using the elasticity model of balance of trade. Nevertheless, excessive exchange rate variability created risks for exporters and increased costs of inputs through imported intermediates. It is evident that an optimal but stable exchange rate is important for increasing exports. Second, it became apparent that interest rates charged by the Central Bank had a considerable effect on exports in the short term. An increase in interest rates reduced access to loans, hence limiting the capacity of exporters to fund their operations. In the long term, exporters were able to adjust, which explains the insignificance of the relationship.

Third, an increase in the broad money supply has turned out to be a key facilitator of export growth. The impact was positive and significant both in the short and long term, proving that a reasonable monetary expansion facilitates investments geared towards exports. Fourth, while no direct estimate is possible, it appears that inflation affects exports negatively by raising the cost of production and thereby diminishing competitiveness. As such, price stability emerged as a vital risk consideration for the industry. In summary, the findings show that monetary policies, specifically exchange rates, interest rates, and money supply, are pivotal in determining the performance of Kenya's horticultural exports. Additionally, inflation stabilization is crucial for competitiveness.

5.2 Recommendations

Exchange Rate Management-The Central Bank needs to ensure that the exchange rate is competitive but stable so that it maximizes the foreign earnings through exports without exposing itself to too much volatility. There are policy measures like managed floating, foreign exchange reserves accumulation, and working together with fiscal policy that could be used to curb excess volatility. **Interest Rate Policy**-In light of the adverse effect of high interest rates on the economy, the monetary policymakers need to strike a balance between controlling inflation and supporting export competitiveness. Preferential loans offered to agribusinesses with export operations will protect exporters from liquidity shocks during times of restrictive policies. Improving the capacity of development finance organizations and encouraging blended financing will also alleviate the pressure on exporters for credit.

Liquidity Expansion-Growth in broad money has been found to have a positive relationship with exports; however, liquidity expansion should align with the goals of price stability. The Central Bank should support financial system reforms that increase the availability of credit to agricultural exporters. Encouraging commercial banks to offer horticulture credit lines and utilizing digital finance mechanisms will help extend credit availability. **Inflation Control**-Price stability is crucial in preserving the competitive edge of exporters. Structural reforms such as investments in energy infrastructure, transport systems, and agriculture productivity will eliminate any cost impacts on the performance of exporters. Also, subsidization of key factors such as fertilizers can mitigate the impact of imported inflation on exporters. **Support to Horticulture Sector** -Apart from monetary policy, structural reforms can be utilized to boost the resiliency of



the horticulture value chain. Some of these reforms are investments in cold chain logistics, provision of high-quality factors, extension services, and diversification of markets to decrease dependency on some export destinations.

Declaration of Interest

The authors declare that they do not have any known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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