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Article

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Impact of exchange rate volatility on coffee export in Kenya

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ABSTRACT

Ninety-five percent of Kenyan coffee is exported as green coffee in the international market in Europe. As a spot market, this presents a problem in that the currency of the foreign market differs from that of the domestic country (Kenya), resulting in an exchange rate problem. Kenya has a floating exchange rate system, which means that the country's exchange rate is decided by the forces of demand and supply for domestic currency. This means that there is a comovement of domestic currencies against other global currencies; in this case, the currencies of Kenya's key coffee market. Therefore, this study examines the influence of currency volatility on Kenyan coffee exports. According to recent figures from the Central Bank of Kenya, Kenya's real exchange rate fluctuated from 2001 to 2020 and the country recorded a negative trend in coffee exports during the same period. This begs the question of whether real exchange rate volatility had an impact on coffee exports during this period. Data was sourced from the Coffee Directorate, the International Coffee Exchange, and the Central Bank of Kenya and was analyzed using the gravity model. The exchange rate volatility was estimated using Purée and Steinherr's model. The findings show that exchange rate volatility hurts Kenyan coffee exports. Similar results were obtained through robustness checks by quantile regression. Consequently, this study advises that monetary and fiscal policy measures should be tailored to reduce exchange rate volatility, while still promoting agricultural exports and overall macroeconomic stability.

IMPACT STATEMENT

One of the most contentious issues in international trade today is the impact of exchange rate volatility on imports and exports. Thus, it is important to understand how Kenya's coffee exports are impacted by changes in exchange rates. For example, there are studies that report positive or negative effects, but there is a dearth of research on coffee exports from Sub-Saharan Africa, particularly from Kenya. The study's conclusions suggest that Kenyan coffee exports are negatively impacted by fluctuations in exchange rates. This finding may be helpful in reevaluating macroeconomic strategies to boost agricultural exports in nations with economies that are comparable to Kenya's.

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1. Introduction

The exchange rate can be considered a barometer for a country's economic health, which influences several facets of the economy, including agricultural commodity exports (Urgessa, 2024). Since the implementation of the floating exchange rate system in 1973, the nominal value of foreign currencies has fluctuated daily, with researchers and policymakers assessing if exchange rate volatility (ERV) has a significant impact on the international trade of commodities and services. Some studies have indicated that ERV present a significant risk to the world's trade interactions by raising the expense of goods that are manufactured locally, raising expenses for transactions, high inflation, reduced prices for export competitiveness, and wages that are lower (Umoru et al., 2023). This may reduce trade interests, leading to de-internationalization. Exchange rate

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volatility is caused by fluctuations in the value of a country's currency relative to others, which can be triggered by a variety of factors including poor economic performance, political stability, higher inflation rates, and interest rate changes (Zahir et al., 2023; Ouattara, 2023). Kenya has experienced fluctuations in exchange rates in several decades since the demise of the Bretton Woods system, which has caused concern among stakeholders. In comparison to other developing countries, the Kenyan shilling (KShs) has become more volatile in recent years. Understanding how exchange rate volatility affects agricultural commodity exports is critical because it has a significant impact on global trade. In light of an expanding repository of research evidence on agricultural exports that lacks a comprehensive and up-to-date review, particularly for coffee exports, this study looks into the impact of exchange rate volatility on coffee exports in Kenya. Furthermore, given that only 5% of Kenyan coffee is consumed locally, and 95% is exported as green coffee, an in-depth investigation of the impact of ERV on coffee exports in Kenya is required.

Exports are a key part of the Economic Recovery Strategy for Wealth and Employment Creation and Vision 2030, which aims to offer a roadmap for Kenya to achieve its economic objectives. This involves expanding the amount of trade exports, particularly agricultural commodities exports, by 6% per year by 2030 (KNBS, 2022). The exchange rate volatility (ERV) present in the bifurcated global coffee markets, on the other hand, has been a defining issue that has provided a significant challenge to coffee exporters. The ERV has been related to a negative impact on coffee price competitiveness in international auction markets, resulting in reduced economic efficiency (Hoai et al., 2023). Volatility has increased the risk and uncertainty of agricultural commodity exporters by lowering expected export income and diminishing trade incentives (Heriqbaldi et al., 2023). The typical price risk in international auction markets not only hurts the Kenyan economy but also makes it difficult for farmers to invest in and develop the crop.

A substantial number of theoretical and empirical studies have recently been published on the impact of ERV on various export commodities. According to the findings of these studies (both theoretical and empirical), the influence of ERV on exports is equivocal. Bahmani-Oskooee et al. (2023) proposed that the impact of ERV on trade can be analyzed through the lens of uncertainty or risk. As a result, exporters' risk attitudes (risk-averse, risk-neutral, or risk-taking) would govern their response to ERV. The other theoretical argument advanced by Chege et al. (2014) is that ERV can be viewed from either traditional or portfolio risk perspectives. According to the old paradigm, ERV generally dampens exports because it implies income uncertainty and imposes expenses on exporters based on their risk tolerance (Dada, 2022; Jamal & Bhat, 2023). The portfolio risk paradigm departs from the standard paradigm in that it hypothesizes that increased volatility provides more options for generating larger returns, thereby stimulating higher exports (income effect). This is especially true for risk-averse merchants, who find it appealing to boost exports if ERV causes the expected marginal utility of export returns to rise (Handoyo et al., 2022). As a result, currency volatility may increase, rather than decrease, exports.

Developing economies are typically associated with less economic development and poor financial system reform and hence experience more severe ERV (Afonso & Blanco-Arana, 2022). Perhaps this is why an assessment of Kenya's export performance since 1963 reveals that the RER has a considerable impact on export performance (Yabu & Kimolo, 2020). However, prior to the exchange rate liberalization in 1993 to reduce the difficulty of RER unpredictable alignment, coffee was the most important agricultural export in the 1980s, accounting for almost 40% of the total export value. Kenya has been marked by large exchange rate volatility since the liberalization of the exchange rate (Kiptarus et al., 2022). Coincidentally, coffee exports declined to less than 6% of the agricultural exports. According to the recent Central Bank of Kenya figures, Kenya's RER fluctuated between 2001 and 2020 (Figure 1). Similarly, Kenya reported a negative trend in coffee output and exports over the same period (Figure 2). This raises the question of whether genuine ERV has an influence, particularly on coffee exports, between 2001 and 2020. Furthermore, detailed data on the relationship between true ERV and coffee exports are scarce, particularly in Kenya. Previous research on the ERV-cash crop export nexus in Kenya has concentrated on tea, horticulture, and French beans. This report departs from previous research and focuses on the influence of ERV on coffee exports.

The remainder of the paper is structured as follows: Section 2 focuses on the literature review, which is separated into theoretical and empirical reviews in Subsections 2.1 and 2.2. The methodology is discussed in Section 3 and separated into four subsections: data source, measure of ERV, diagnostic tests, and estimation strategy. Sections 4 and 5 describe the results and the commentary, respectively. Section

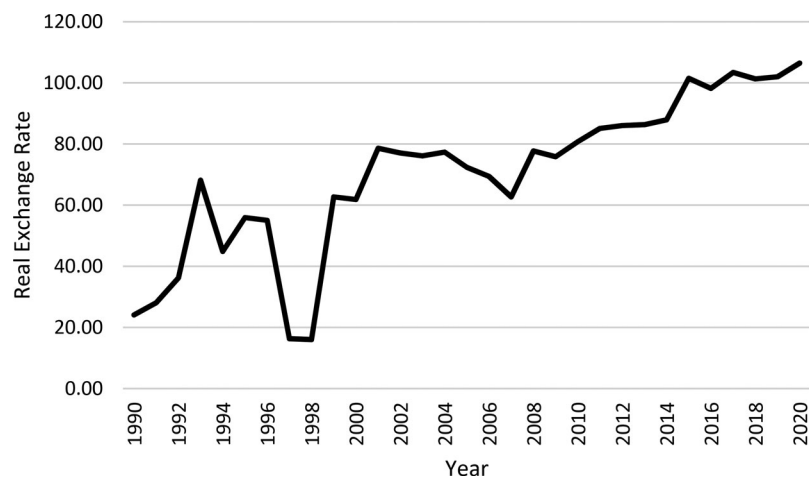


Figure 1. The USD/KSHS real exchange rate from 1990 to 2020.

Source: Central Bank of Kenya (2021).

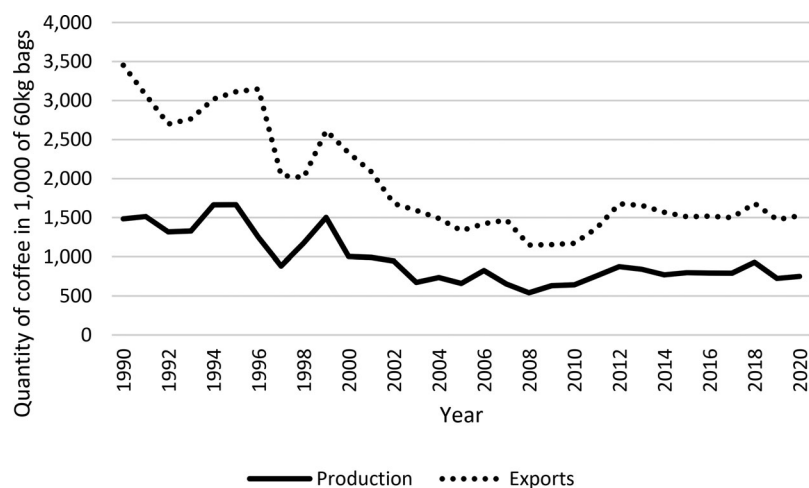


Figure 2. Trend analysis of Kenyan coffee production and exports from 1990 to 2020.

Source: International Coffee Organization (ICO, 2021).

6 discusses the implications for coffee cultivation and processing and the rural economy. Finally, Sections 7 and 8 include a robustness check and conclusion.

2. Literature review

2.1. Theoretical review

Several ideas explain the *RER* movement and its effects on exports and the economy as a whole. This study focuses on five of them: the Mundell-Fleming Model (MFM), the Purchasing Power Parity theorem (PPP), the Balassa-Samuelson Model (BSM), balance of payments (BOP) theory and monetary approach (MA) theory. MFM was developed in the early 1960s by Marcus Fleming and Robert Mundell as an expansion of the IS-LM model. The model predicts that a country's economic behavior is determined by its exchange rate system used (Hsing, 2020). In Kenya's floating exchange rate system, the central bank has no influence on the foreign exchange market; therefore, the net export of coffee is determined by either the prevailing exchange rate or the price of the foreign currency in relation to the domestic currency. Because the MFM assumes fixed pricing levels in both foreign and domestic markets, the nominal and *RER* are similar. As a result, *RER* volatility reduces net coffee exports, causing a domino effect that reduces planned expenditures and, as a result, returns.

Although the Purchasing Power Parity (PPP) concept was introduced in the 16th century, it was modernized in 1918 by Gustav Cassel's work (Zhang, 2024). Absolute PPP is the simplest and strongest form

of PPP, which predicts that altering the exchange rate is required to match the prices of commodities between countries (Zhang, 2024). The absolute PPP presupposes that the actual exchange rate is constant, which does not hold true in practice due to transaction expenses as well as asset and money market shocks. Furthermore, the aggregate pricing levels are stubborn. As a result, relative PPP, a weaker version of PPP, proposes that the exchange rate be adjusted to account for the varying inflation rates between domestic and foreign countries. In this case, the domestic country is coffee exporting country Kenya and the foreign market is European. Thus, relative PPP becomes useful for understanding exchange rate movements in nations where monetary shocks, rather than real shocks, predominate.

The BSM was proposed by economists Paul Samuelson and Bela Balassa in 1964, posits the 'Penn effect', which states that consumer goods prices are systematically higher in more developed economies than in less developed economies (Erokhin et al., 2023). The price variation can be explained by differences in productivity levels between domestic and foreign countries, particularly coffee exports in this case, which affect prices and wages in the coffee sector. As a result, an increase in coffee productivity raises real wages not only in the coffee sector but also in the non-coffee sectors, resulting in an overall increase in price levels in the economy and an appreciation of the real exchange rate. According to the BOP theory, exchange rates in a foreign market are essentially reliant on a country's BOP, which is influenced by demand and supply of its currency (Blecker, 2022). When a country's BOP is positive, its currency gains value on the international market. The BOP theory has limitations, including the difficulty of determining the precise level of natural unemployment or a reliable currency that corresponds to a global account equilibrium. The MA theory states that currency exchange rates are determined by demand and supply between two countries (Espinosa, 2024). This model assumes that by applying the principles of money demand and supply, the PPP relationship can be used to direct or strengthen the exchange rate. The MA hypothesis builds on the PPP theory, delineating the nominal exchange rate and connecting it to monetary principles. Even though empirical studies on the model have been not conclusive, the monetary method appears to be acceptable. Therefore, this study embraced MA theory.

2.2. Empirical review

The impact of ERV on exports has been debated in various empirical works, as evidenced by studies conducted to determine the causal connection between the two variables. The findings of these studies are wide-ranging and divergent depending on the model design, sample period, proxies for *ERV*, and the degree of development of the countries in question (Kang & Dagli, 2018). Some studies (Ekanayake & Dissanayake, 2022; Musa et al., 2023; Safuan, 2017; Upadhyaya et al., 2020) show a negative relationship between the *ERV* and the number of commodities exported, while other studies (Sugiharti et al., 2020) show a positive relationship. Furthermore, results from several empirical studies show that there is either no relationship at all or a hazy one between *ERV* and exports (Aslan & Akpiliç, 2023). For example, using quarterly data covering the period from 1993Q1 to 2021Q2, Ekanayake and Dissanayake (2022) investigated the effects of real *ERV* on the United States on the top 20 export products to BRICS. According to panel regression and ARDL analysis results, they concluded that *ERV* has a long-term negative impact on exports in all five countries (Brazil, Russia, India, China, and South Africa). Nevertheless, regardless of the *ERV* measure employed, their effects on exchange volatility are found to produce inconsistent results in the short term.

Similarly, Handoyo et al. (2022) investigated impact of the *ERV* on four main commodities exported from Indonesia to six member countries (Pakistan, Saudi Arabia, Malaysia, Turkey, United Arab Emirates, and Bangladesh). The study employed monthly data spanning from January 2007 to December 2019 and the EGARCH method to obtain *ERV*, while the ARDL method was used to model both the short-run and long-run impact of *ERV* on exports. In both the short and long-term, findings revealed that exchange rate volatility has a significant negative effect on five main commodity exports to OIC countries. On the other hand, Aslan and Akpiliç (2023) examined panel data spanning 58 countries and 48 quarters from 2010Q1 to 2021Q4, to determine the effect of exchange rate and exchange rate volatility on export performance. According to their study's findings, there is insufficient data to conclude that shocks to exchange rates and their volatility have an impact on overall export volumes. Nonetheless,

their research suggests that nations with more accommodating exchange rate policies that rely heavily on imported raw materials to create export goods tend to be more volatile in terms of exchange rates.

Using the ARDL model, Rathnayaka and Dunusinghe (2023) looked into the connection between Sri Lankan exports and exchange rate volatility from 2001 to 2019. According to their research, there is a positive correlation between Sri Lankan export revenue and exchange rate volatility. A study was conducted in 2020 by Sugiharti, Miguel, and Bektı to examine the effects of exchange rate volatility on Indonesia's export markets, which include China, India, South Korea, Japan, and the United States. The GARCH and ARDL models were applied, and data from 2006 to 2018 were used in the study. Overall, the data indicated that exports and industrial production are positively correlated for South Korea, China, and India, but not significantly for the United States or Japan. Furthermore, the results indicated that only exports to Japan benefited from the Rupiah's depreciation, while exports to China, South Korea, and the USA have been discouraged. Long-term estimates indicated that while exchange rate volatility promoted exports to China, it discouraged exports to South Korea, Japan, India, and the United States. At the commodity level, however, the effects of exchange rate volatility are not uniform.

Kiptarus et al. (2022) and Titus et al. (2022) investigated the effect of ERV on trade performance for exports in Kenya. Kiptarus et al. (2022) only investigated how to measure ERV. Using an error correction model and data from 1966 to 2018, Titus et al. (2022) discovered a significant and positive relationship between foreign ERV and global trade in Kenya. Muhia (2018) investigated the impact of ERV on imports and exports, discovering that ERV had a long-term negative impact on exports though no impact on imports. However, these studies relied on country-level aggregated data, producing debatable results that are unsuitable to offer policy direction and also falling short of demonstrating whether fluctuations in exchange rates affect specific exports in any way. Unlike these studies, this study employs de-aggregated data from eight major Kenyan coffee exporting companies spanning the years 2001–2020. As far as we are aware, not many Kenyan academics have looked into how the ERV affects coffee exports using disaggregated data. As a result, this study attempted to add to the existing body of literature by investigating the effects of exchange rate volatility on coffee exports in Kenya.

3. Methodology

3.1. Data source

The data used in this study were obtained from various sources. The firm-level panel data for coffee from 2001 to 2020 were obtained from the Nairobi Coffee Exchange and the International Coffee Organization. Annual firm-level data from eight main coffee exporters who control about 80% of the market share were obtained from the Coffee Directorate. Similarly, data on four main trade destinations (foreign importing countries) that control about 61% of coffee imported for the period under study were obtained from the Coffee Directorate. These countries include Germany, Belgium, the United States, and South Korea. Finally, the *RER* data were obtained from the Central Bank of Kenya.

3.2. Exchange rate volatility measurement

ERV represents the risk exporters face as a result of irregular exchange rate changes (Heriqbaldi et al., 2023). In international trade-flow studies, *ERV* was determined using a variety of metrics like standard deviation, vector autoregression, generalized autogressive conditional heteroscedasticity (GARCH), exponential generalized autogressive conditional heteroscedasticity (EGARCH) model and ordinary least squares. However, selection of the most appropriate *ERV* metric remains highly contentious (Upadhyaya et al., 2020). Studies that used the GARCH model include Urgessa (2024), Ouattara (2023), Kiptarus et al. (2023), and Kayani et al. (2023). Handoyo et al. (2022), Heriqbaldi et al. (2023), and Hadebe & Msomi (2023) are three additional studies that used EGARCH models.

Nonetheless, the model provided by Perée and Steinherr (1989) has been increasingly used in the recent literature because it provides a valid evaluation of the influence of long-run *ERV* on agricultural commodity trading. Moreover, it can capture long-term changes in *RER* volatility and risk and does not ignore information about the stochastic processes that cause *ERV*. As a result, this model is used in

this investigation, given that, among other factors, trade between two nations is dependent on their respective exchange rates and relative price levels (Todani & Munyama, 2005). The *RER* was estimated as follows:

$$RER_t = \Psi_t = RP_t = NER_t \left(\frac{P_{ft}}{P_{dt}} \right) \quad (1)$$

Where RER_t is the real exchange rate at time t , which equals the relative price (RP_t) at time t of coffee for the foreign importing firm to the Kenyan exporting firm. P_{ft} and P_{dt} are the prices of foreign importing and Kenyan exporting firms, respectively. The *ERV* is estimated using Perée and Steinherr's (1989) model as follows:

$$v_{xkt} = \left[\frac{\max \Psi_{xkt}^t + \min \Psi_{xkt-20}^t}{\min \Psi_{xkt-20}^t} \right] + \left[1 + \frac{|\Psi_{xkt} + \Psi_{xkt}^\sigma|}{\Psi_{xkt}^\sigma} \right] \quad (2)$$

where $\max \Psi_{xkt-20}^t$ is the maximum value of *RER* over the last 20 years and $\min \Psi_{xkt-20}^t$ is the minimum value of *RER* in the previous 20 years. The *RER* is between Kenya (exporting country x) and importing country (k). $\left[\frac{\max \Psi_{xkt}^t + \min \Psi_{xkt-20}^t}{\min \Psi_{xkt-20}^t} \right]$ represents the cumulative volatility, but not just *ERV*. $\left[1 + \frac{|\Psi_{xkt} + \Psi_{xkt}^\sigma|}{\Psi_{xkt}^\sigma} \right]$ represents the period and magnitude of erratic alignment from equipose exchange rates (Ψ_{xkt}^σ), which may signify a new signal. Ψ_{xkt}^σ is the average exchange rate for the study period (20 years). In developing *ERV* measures, some level of uncertainty is embraced. This equation illustrates that *ERV* for the 2021 study period relies on *RER* from 2001 to 2020. Finally, v_{xkt} was computed for each year (Figure 3).

3.3. Diagnostic tests

The diagnostic tests involved examining the time-series properties of the data. These tests include stationarity, multicollinearity, autocorrelation, and heteroscedasticity. The test for stationarity was estimated using the augmented Dickey–Fuller test and the data were stationary at a 5% level of significance. Using the Variance Inflation Factor, collinearity was not detected, and results from the Breusch–Godfrey Serial Correlation LM test showed that there was no serial correlation in the data at a 5% level of significance. Finally, the test of the null hypothesis of no heteroskedasticity using the Breusch–Pagan–Godfrey test was accepted at a 5% level of significance. To focus on the objective of the study, neither an empirical process nor theoretical underpinnings of this implementation are provided, but can be availed on request.

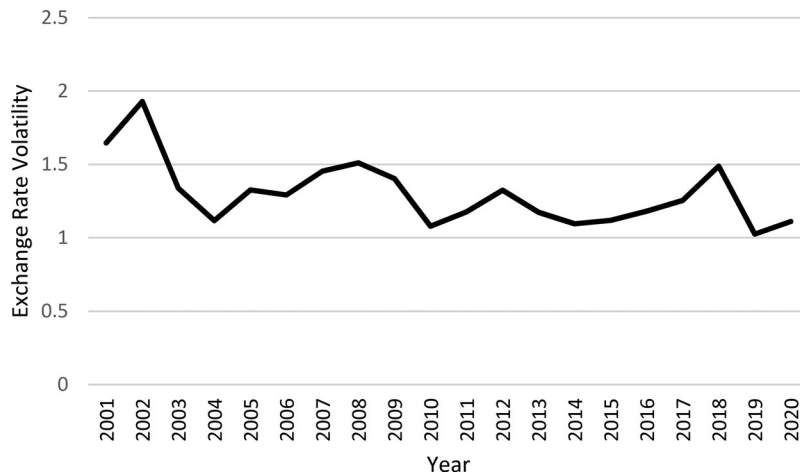


Figure 3. The exchange-rate volatility between USD/KShs from 2001 to 2020 estimated by Purée & Steinherr model.
Source: Central Bank of Kenya (2021).

3.4. Estimation strategy

A gravity model was used to assess the impact of *ERV* on coffee export volumes. This empirical model has been widely utilized in international trade as an empirical model (Jadhav & Ghosh, 2024). Gravity models have been employed to explain trade flows for more than four decades owing to their explanatory capacity and strong empirical robustness (Sadeh, 2024). The ability of the model to explain a significant fraction of the discrepancies in any observed trade dataset or patterns makes it empirically effective (Lei et al., 2022). The model's foundation in international trade theories has also been acknowledged (Upadhyaya et al., 2020). These theories range from those based on country variances in factor endowments or technology to models of monopolistic competition and increasing returns to scale. As a result, the empirical model for this study was a gravity model.

According to the gravity model, bilateral commerce between the two countries is proportionate to economic size but inversely related to topographical proximity. Industrialized countries frequently participate in bilateral commerce in absolute terms, but transaction costs increase in a log-linear fashion with distance (Luckstead et al., 2024). Consequently, distance is generally regarded as having a negative impact on trade flows. Furthermore, population is commonly used as a measure of a country's size (Heriqbaldi et al., 2023). This model can also be used to estimate firm- and industry-specific data (Az-zakiyah et al., 2024). As a result, *ERV* is added to the gravity equation to determine its impact on exports:

$$T_{xkt} = \delta_o \frac{(T_{xkt})^{\delta_1} (GDP_{xkt})^{\delta_2}}{(d_{xkt})^{\delta_3} (v_{xkt})^{\delta_4}} \quad (3)$$

Where T_{xkt} signifies bilateral trade or export flows among two countries (x and k) in year t . x and k stand for Kenya and destination country respectively. T_{xkt} , GDP_{xkt} , d_{xkt} and v_{xkt} are populations, Gross Domestic Product (GDP), the geographical distance and *ERV* of the two currencies. ϕ_{xt} is an economic mass of Kenya in year t that incorporates other measures such as topographical position (for neighboring countries) and cultural juxtaposition (such as sharing a similar language, colonial affiliation, cultural, or historical ties).

$$Q_{xkt} = \exp(\alpha_o) \cdot \frac{(\phi_{xt})^{\alpha_1} (\phi_{kt})^{\alpha_2}}{\exp(\alpha_3 v_{xkt}) (d_{xkt})^{\alpha_4}} \cdot Lang_{xk}^{\alpha_5} \cdot Border_{xk}^{\alpha_6} \quad (4)$$

When logarithms are applied to functional Eq. (4) becomes:

$$\ln Q_{xkt} = \beta_o + \beta_2 \ln KEM + \beta_3 \ln \phi_{kt} + \beta_3 v_{xkt} + \beta_3 RER_{xkt} + \varepsilon_{xkt} \quad (5)$$

Equation (5) is used for firm-level estimation (Kashi & Kennedy, 2013) where Q_{xkt} is the quantity of coffee exported from Kenya to country k in year t , β_o is defined as $\alpha_o + \eta_{xk}$. ϕ_{xt} is replaced by *KEM* in Equation (5). The firm-country pair fixed effects are denoted by η_{xk} . The time-invariant variables d_{xkt} , $Lang_{xk}^{\alpha_5}$, $Border_{xk}^{\alpha_6}$ are removed from Equation (5) using a fixed-effect model. Hence, $\ln \phi_{it}$ at time t is equivalent to $\sum \ln GDP$ and the country's population i at time t . However, when the interaction term of firm performance is included in Equation (5), the economic mass regressors (*KEM* and ϕ_{kt}) were removed from this equation to obtain Equation (6). Exporting firm performance is denoted by its total factor productivity (*TPF*), which was estimated using a semi-parametric approach (Olley & Pakes, 1996). Most extant theoretical frameworks are consistent with Equation (6); that is, the firm-level application of the gravity model (Berman et al., 2012).

$$\ln Q_{xkt} = \lambda_o + \lambda_1 v_{xkt} + \lambda_2 RER_{xkt} + \lambda_3 \ln(\omega_{xt}) + \lambda_4 \ln(\psi_{xt}) + \lambda_5 \ln(\omega_{kt}) + \ln(v_{xt}) + \lambda_6 \ln(\psi_{xt}) + \ln(v_{kt}) + \varepsilon_{xkt} + \theta_t \quad (6)$$

4. Results

Table 1 summarizes the results of the impact of exchange rate volatility and coffee as estimated by the gravity model. Baseline estimation is presented the baseline estimation. The second column presents the fixed effects model, which indicates that a 10% increase in *ERV* decreases coffee exports by

Table 1. Summary results of *ERV* and coffee exported using gravity model.

	Baseline	Fixed effect	Random effect	OLS
$\ln(v)$	−0.0127*** (0.00634)	−0.00712** (0.00457)	−0.0131*** (0.00411)	−0.00324*** (0.00438)
$\ln(RER)$	0.490*** (0.0402)	0.183*** (0.0373)	−0.0762*** (0.00398)	−0.0538*** (0.00253)
$\ln(\phi_{kt})$	–	0.469*** (0.0196)	0.124*** (0.00185)	0.152*** (0.00403)
$\ln(KEM)$	–	0.317*** (0.0419)	0.374*** (0.0401)	0.245*** (0.0385)
Constant	−7.435*** (3.010)	−2.429*** (1.341)	3.747** (0.516)	4.170*** (1.857)
Observations	160	160	160	160
R-squared	0.007	0.010		0.048
Firm FE	Yes	Yes	Yes	–
Year FE	Yes	Yes	Yes	

Source: Result estimates.

Note. *, **, and *** denote significance at the 10, 5, and 1% levels, respectively.
Standard error in parenthesis.

Table 2. Summary results of *ERV* and coffee exported with interaction term using gravity model.

	Fixed effect	Random effect
$\ln(v)$	−0.0431*** (0.00311)	−0.0723*** (0.00164)
$\ln(RER)$	0.0842*** (0.0437)	0.0212*** (0.00628)
$SD(\ln TPF)$	0.0320*** (0.00213)	0.0465*** (0.00144)
$SD(\ln \psi)$	0.271*** (0.00432)	0.0346*** (0.00275)
$\ln(v)*SD(\ln TPF)$	0.0170*** (0.00740)	−0.00367** (0.00541)
$\ln(v)*SD(\ln \psi)$	−0.0146*** (0.00567)	0.0190*** (0.00318)
Constant	9.84*** (0.00756)	0.634*** (0.00321)
Observations	160	160
R-squared	0.009	
Firm fixed effect	Yes	Yes
Year fixed effect	Yes	Yes

Source: Result estimates.

Note. *, **, and *** denote significance at the 10, 5, and 1% levels, respectively.
Standard error in parenthesis.

approximately 1.27% (baseline), 0.712% (fixed effect), 1.31% (random effect), and 0.324% (OLS) at the 1% level of significance. Thus, it can be deduced from the results that *ERV* has a significant and negative impact on coffee exports. This means that Kenyan coffee-exporting companies may cut back the quantities of coffee they export in light of an increase in *ERV*. The *ERV* has a direct impact on price and, therefore, determines the profit margin that coffee producers realize.

The third and fourth columns present the OLS and random effects models, respectively. The fixed model was deemed a fit after the Hausman test.

The interaction term, $\ln TPF$ is included in Equation (6) to provide the output, as summarized in Table 2. The first column shows that the coefficient of the interaction term of the volatility measure and $\ln TPF$ is positive, whereas the interaction term of the volatility measure and $\ln \psi$ is negative. Further, a one standard deviation increase in $\ln TPF$ and a 10% increase in *ERV* would lead coffee exports to increase by 0.01% from 0.16 to 0.17%. A rise in *TPF* would reduce the negative impact on the quantity of coffee exported. Exporting companies with elevated levels of *TPF* can decrease coffee prices with the advent of persistent *ERV*. If this happens, this will predispose larger exporting firms to a position that has more market share in comparison to companies characterized by a small market share. Hence, larger firms would have an incentive to acquire and export as much coffee as possible and realize more returns. Firms with higher performance can decrease the price in the case of persistent *ERV*, which may lead to a comparatively higher market share from those firms with low *TPF*, producing as many goods as possible and realizing more returns.

5. Discussion

Coffee exports are significantly harmed by *ERV*, according to Table 1's results. This finding is in line with earlier research (Ekanayake & Dissanayake, 2022; Musa et al., 2023; Upadhyaya et al., 2020) that shows that *ERV* has a significant negative impact on commodities exported at any given time. For example, Urgessa (2024) investigated the effects of real effective *ERV* on Ethiopian export earnings using quarterly data from 2007 to 2021. The study used GARCH model to measure *ERV*. Employing nonparametric ARDL (NARDL) and parametric autoregressive distributed lag (ARDL) models, the study discovered that *ERV* decreases the overall revenue from exports as well as revenues from coffee, vegetables, and meat products. Similarly, Musa et al. (2023) used the ARDL-Error Correction Model and the Bound Test to investigate the effects of *ERV* on exports in Nigeria from 2008 to 2021. The findings demonstrated that all of the *ERV* measures were statistically significant over the long term and displayed an expected negative sign. Kayani et al. (2023) examined the impact of asymmetric exchange rates on trade flows in selected Asian countries and finds that the effects of increased exchange rate volatility on exports and imports differ among Pakistan, Malaysia, Japan, and Korea. The quarterly data from the period 1980–2018 is collected from the International Financial Statistics database. This study employed GARCH model to estimate *ERV* and both parametric and non-parametric ARDL models for estimation. The results of the study suggest that increased exchange rate volatility adversely affects exports and imports, while decreased volatility enhances both.

This study contradicts Hadebe & Msomi (2023), Okogor et al. (2023), and Zahir et al. (2023). For example, Hadebe & Msomi (2023) used quarterly data from 2000 to 2021 to investigate how *ERV* affects South African export demand. *ERV* was estimated using the EGARCH Model. Their results from the ARDL model show a positive relationship between exchange rate volatility and exports. Okogor et al. (2023) used an ARDL model to examine the impact of exchange rate volatility on Nigeria's exports to the top five export destinations between 1995 and 2020. This study used the GARCH model to estimate *ERV*. The empirical findings show that *ERV*, GDP, and population have a positive impact on real exports in Nigeria, both in the short and long run. Zahir et al. (2023) investigated empirically the impact of the *ERV* on foreign trade in eight MENA countries from 1988 to 2022. The study used the Panel ARDL/PMG technique and the GARCH model to estimate *ERV*. The results show that *ERV* has a significant and positive effect on export demand, but a negative and significant effect on import demand in MENA countries.

From an empirical perspective, differing proxies for *ERV*, the duration of the sample period, and the size of the economies under consideration (developed vs. developing) could lead to inconsistent results. First, measurement error issues can arise when utilizing Okogor et al. (2023) method of creating a proxy for *RER* uncertainty. This is due to the technique's assumption of knowledge about the random processes that produce *RER*, which could result in a biased estimate. Additionally, information about the random processes that produce exchange rates may be disregarded by this method. Second, while long-run *ERV* is difficult and costly to hedge against, short-run *ERV* can be addressed with credit availability and hedging (Čechura & Jaghdani, 2021). Therefore, temporary *ERV* might not have a significant impact on exports. Lastly, developing nations like Kenya have fewer hedging options than developed nations, which could have unintended consequences (Kayani et al., 2023).

Table 2's findings demonstrate that *ERV* is negatively related to *TPF* growth. Stated differently, a higher *TPF* would mitigate the adverse effect of *ERV* on the volume of coffee exported (Bosworth et al., 1996; Dollar, 1992; Kandil, 2004). For example, Bosworth et al. (1996) examined the experiences of 88 developed and developing nations concerning economic growth over three years (1960–1992). According to Bosworth et al. (1996), real *ERV* lowers total factor productivity (*TPF*), which in turn slows growth. Larger companies, therefore, might be more vulnerable to this volatility because of their larger market share. As a result, bigger businesses would export less coffee than smaller businesses by a greater margin. In a similar vein, Kandil (2004) carefully examined how *ERV* affected *TPF* growth in 22 emerging economies. Their findings suggest that *ERV* inhibits *TPF* growth in the short and long terms, which has a detrimental effect on economic development. Conversely, Vieira et al. (2013) evaluated the impact of real *ERV* over 40 years on long-run growth in developed and developing nations, and they concluded that high *ERV* positively affects *TPF* growth. Thus, by promoting trade uncertainty, raising price volatility, impeding competitiveness, and decreasing *TPF* and gross margins, ongoing *ERV* has a detrimental effect on coffee exports.

Therefore, it is important to customize fiscal and monetary policy interventions to reduce *ERV*, support agricultural exports, and uphold macroeconomic stability in general.

This result, however, conflicts with the findings of the following researchers: Sugiharti et al., 2020; McKenzie & Brooks, 1997; Sercu & Vanhulle, 1992; Houndoga & Gabriel 2023; Rathnayaka & Dunusinghe, 2023. For instance, Rathnayaka and Dunusinghe (2023) used the ARDL model to examine the relationship between Sri Lankan exports and exchange rate volatility from 2001 to 2019 and discovered a positive correlation between *ERV* and export earnings. According to De Grauwe (1987), there may be a positive correlation between *ERV* and exports due to the dominance of income effects over substitution effects. Because an increase in *ERV* raises the expected marginal utility of export revenue, dealers are compelled to increase exports if their level of risk aversion is high enough. De Grauwe contends that the impact of *ERV* on exports ought to be commensurate with risk aversion. However, other research, like that done by Aslan and Akpiliç (2023), showed that exports were unaffected by fluctuations in exchange rates. Aslan and Akpiliç (2023) examined panel data spanning 58 countries from 2010Q1 to 2021Q4, examining the effects of exchange rate and *ERV* shocks on export performance. They concluded that there was insufficient evidence to support the notion that these factors affect overall export volumes.

6. Implications on coffee production, processing and rural economy

Agriculture is the main driver of Kenya's rural economy. Essentially, agriculture contributes 3.6% of the national GDP, 65% of national exports, 22.2% of government revenue, 70% of informal employment in rural Kenya, and a source of income for about 80% of people in rural areas (KNBS, 2022). It is against this backdrop that Kenya formulated both the Kenya Rural Development Strategy and the Poverty Reduction Strategy Paper in 2002 to reduce poverty and spur economic development in rural areas (Jacobsen et al., 2023). Among the key factors that have been identified as hampering the growth of the rural economy is the lack of competitiveness in cash crop production for the export market. For instance, coffee is a cash crop whose level of export and production has been fluctuating on a downward trend (Figure 2) to the extent that its contribution to national GDP has dropped from 40% in the 80's to currently 0.5% (ICO, 2019). Several factors have been linked to this morbid performance, including drought, poor access to credit, a lack of extension services, price, and *RER* volatilities. This study eliminated the impact of real *ERV* on coffee exports.

The results in Table 1 indicate that *ERV* decreases coffee exports, which may have various economic implications. First, *ERV* shocks directly magnify costs to the domestic economy and indirectly affect consumption smoothing in rural households and firms negatively way (Luckstead et al., 2024). As a result, the income generated from coffee and other agricultural production meant for rural economic growth is limited. Worldwide coffee production has been linked to infrastructure development. In Brazil, coffee production led to the construction of a 7,000 km railroad between 1860 and 1885. In Kenya, coffee production is closely linked to various developments such as the construction of rural infrastructure (storage facilities, rural access roads, electrification, production, and marketing facilities), hospitals, schools, and the emergence of small towns among others (Wanzala et al., 2022). Therefore, the adulteration of cash flows from coffee production will hurt rural infrastructural development. Moreover, the lower adoption of value addition and inferior quality coffee by cooperatives, most of which use obsolete processing facilities, has been attributed to the uncertainty of returns from coffee (ICO, 2019). Likewise, forward and backward linkages are also impaired in rural areas in the wake of persistent *ERV*. The impact of *ERV* on rural economic performance also influences the productivity or performance (*TPF*) of a firm's *TPF* (Table 2). In the table, exporting large firms have elevated levels of performance (*TPF*) and, therefore, can decrease coffee prices in the advent of persistent *ERV*. This is consistent with Bosworth et al. (1996), who empirically demonstrated that real *ERV* hurts economic performance by lowering *TPF*.

Globally, coffee provides livelihoods to over 25 million smallholder farmers and 125 million people working along the coffee value chain (Wanzala et al., 2024). In Kenya, it is estimated that coffee is a source of livelihood for over 600,000 households, and employs approximately 5 million people (30%) in the agricultural sector (Wanzala et al., 2021; ICO, 2019). The results in Table 1 show that real *ERV* has a negative impact on exports. Thus, it can also be inferred from these results that real *ERV* has a negative effect on the revenues received by coffee producers at various levels of production and the number of

people employed in the sector. For exporters, their profit margin is dictated by the real *ERV* of Kenya shilling (*KShs*) against the United States dollar (*USD*) because their transactions are purely executed in *USD*. Hence, if the *KShs* are weak, exporters will get equal or higher returns, and vice versa. For smallholder farmers, Lukanima and Swaray (2013) submit that the revenues they receive from coffee are very uncertain, given that exporters' prices are more volatile than global prices. Therefore, in the absence of a binding contract (hedging), short-run *ERV* will immediately have a negative impact on smallholder coffee farmers and coffee processing firms. Unfortunately, it is difficult to hedge in rural areas because their financial institutions are still underdeveloped, which makes access to credit a major challenge (Okogor et al., 2023). In the past, farmers have always responded to poor returns due to various factors such as scaling down production, uprooting coffee trees, or abandoning coffee for other seemingly profitable enterprises (Wanzala et al., 2022). In 2010 and 2011, for example, the production and export of coffee decreased by 22.22 and 13.57%, respectively, owing to *ERV* among other factors (ICO, 2019).

The *ERV* also influences aggregate supply through the cost of imported inputs (Obstfeld & Rogoff, 1998). Unfortunately, more than 85% of Kenyan agricultural inputs (fertilizers, agrochemicals, raw materials, and farm implements) and coffee processing machinery are imported. Therefore, if *KShs* depreciate, the prices of imported agricultural inputs will be very expensive and will reduce the gross margins received by farmers. For example, in 2007/2008, the *KShs* hit a record low of just 62.68 to the US dollar, which pushed the import value of fertilizer by 92.5% during this period (KNBS, 2009). Thus, the depreciation of *KShs* against the *USD* lowers exports and rural demand, and requires an expansionary monetary policy. The implication of the findings is that given *ERV* is virtually self-driven, uninhibited interventions may not only intensify fluctuations in coffee exports and production, but may also be expensive in terms of productivity. Therefore, there is a need for the Central Bank of Kenya and other economic policy institutions to reengineer exchange rate modeling and forecasting to incorporate the impact of real *ERV* on coffee exports, which should be in sync with minimizing inflation. Furthermore, the Kenyan coffee revitalization program may be reviewed to provide policy directions concerning ways to address the impact of *ERV* on coffee exports to improve the rural economy.

7. Robustness check

After empirical estimations using the gravity model, quantile regression was used to determine the robustness of the results' performance measures. Because the exporting firms have different performance (*TPF*) based on their different market shares, the sample is divided into three mini-sample clusters. The division of *TPF* is by tri-sectional quantile: low (<33%), median (34–66%), and high (>67%). This is followed by the application of Equation (6) for each subsample to determine the consistency of the results in Section 4. The results of the robustness check using quantile regression are summarized in Table 3. The second, third, and fourth columns provide an analysis of exporters with low (0–33%), median (34–67%), and high (67–100%) clusters of *TPF*. The absolute value of the *ERV* coefficient in the 0–33% cluster was less than the 34–67% cluster. Furthermore, the *ERV* coefficients in both the 0–33% cluster and 34–67% cluster are both significant and negative. However, the interaction term coefficients for the 0–33% and 34–67% clusters were 0.0676 and –0.000459. This indicated that they were significant. The absolute value in the first column for all samples was 0.031 at a 1% level of significance. This value is less than that in the *TPF* cluster (0.0700), which is also significant at the 1% level. Hence, this finding is consistent with that in Section 3, that is, a higher *TPF* would increase the negative impact of *ERV* on the quantity of coffee exported.

8. Conclusion and policy recommendation

This study focuses on the impact of *ERV* on coffee exports from a firm-level perspective, from 2001 to 2020. Using the gravity model, the research findings indicate that *ERV* has a significantly negative impact on exports due to revenue uncertainty. The return uncertainty stemming from the high-risk premium linked with *ERV* is seen from the downward trajectory of coffee exports. The *ERV* was estimated using Perée and Steinherr's (1989) model. After empirical estimations using the gravity model, quantile regression was used to determine the robustness of the results performance measures. The robustness check

Table 3. Summary results for robustness check using quantile regression.

	<i>ln</i> (Coffee exports) All sample	Percentiles of ψ		
		Low	Median	High
<i>ln(v)</i>	−0.0265*** (0.00391)	−0.00867** (0.0432)	−0.0242** (0.00678)	−0.0205 (0.0345)
<i>lnTFP</i>	0.0676*** (0.0214)	0.0745*** (0.0650)	0.0967*** (0.0126)	0.0745*** (0.0320)
<i>lnψ</i>	0.0544*** (0.00395)			
<i>ln(v)*ln(all)</i>	−0.0312*** (0.00136)			
<i>lnψ(Low 0 – 33%)</i>		0.0453* (0.0185)		
<i>ln(v)*lnψ(low)</i>		0.0676 (0.0204)		
<i>lnψ(Low 34 – 67%)</i>			0.332*** (0.0102)	
<i>ln(v)*lnψ(medium)</i>			−0.000459 (0.0274)	
<i>lnψ(Low 67 – 100%)</i>				0.680*** (0.0431)
<i>lnv*lnψ(high)</i>				0.0700*** (0.0284)
Constant	11.12*** (0.0416)	11.35*** (0.0654)	10.716*** (0.182)	10.514*** (0.119)
Observations	160	55	52	53
Fixed effects	Yes	Yes	Yes	Yes

Source: Result estimates.

Note. *, **, and *** denote significance at the 10, 5, and 1% levels, respectively.
Standard error in parenthesis.

finding is consistent with that of the gravity model; that is, a higher *TPF* would increase the negative impact of *ERV* on the quantity of coffee exported.

Consequently, both monetary and fiscal policy interventions should be periodically reviewed to minimize *ERV* and promote agricultural exports by stabilizing of exchange rate and general macroeconomic environment. Furthermore, the government can protect exporters from short-term *ERV* by developing policies that promote hedging through derivative instruments; that is, forward and futures markets. Similarly, exploring niche markets to increase the export of specialty coffee that offers premium prices in the international market will cushion farmers from the effects of *ERV*.

The scope of the investigation (Kenya) and the use of the disaggregate model to assess how coffee exports are empirically impacted by *ERV* constitute the study's limitations. Therefore, going forward, studies should consider using the aggregated model to determine the impact of *ERV* on coffee exports and broaden the scope of study to include all other coffee-producing East African nations. As a result, cross-national comparisons may offer concrete means of illustrating how *ERV* affects coffee exports and may also precipitate a broad range of suggestions for policy reforms. Furthermore, studying how the exchange rate is sensitive to import expenses and export revenues is also necessary. This is because not every sector of the economy absorbs changes in exchange rates equally, effectively, or efficiently. After economic sensitivities are established, efforts should be directed at correcting imbalances or mitigating their impacts. This study also recommends further research on demand-side factors, such as income elasticity, which seems to have received little attention in the extant literature on *ERV*.

Author contributions

Richard W. Wanzala: conception and design; analysis and interpretation of the data; the drafting of the paper; Nyankomo Marwa: revising the manuscript critically for intellectual content; and the final approval of the version to be published; Lwanga E. Nanziri: revising the manuscript critically for intellectual content.

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Data availability statement

The data is available at the Mendeley data platform using either doi or URL below: Mendeley Data: doi: [10.17632/wkyp73j7z.1](https://doi.org/10.17632/wkyp73j7z.1); Data URL: <https://data.mendeley.com/datasets/wkyp73j7z/1>.

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