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Analysis of the Factors Affecting Coffee Export in Cameroon: A Gravity Model Approach

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ABSTRACT

This study investigates the factors affecting coffee exports in Cameroon. For this purpose, we employed the gravity model. Considering the sample characteristics, the model is estimated with the Poisson pseudo-maximum likelihood (PPML) method. The main material of the study is a panel data set covering the years 2001-2021 for ten countries, Cameroon's main coffee export partners. The findings show that the GDP of importing countries, coffee export prices, and bilateral investment treaties (BITs) positively influence exports, whereas distance, exchange rates, and Cameroon's GDP have negative impacts. The results highlight Cameroon's logistics infrastructure deficiencies and the significance of stable, high-quality production. The Cameroonian government should implement policies to improve production quality and efficiency by expanding agricultural extension services and offering farmers input and investment incentives to address these challenges. Additionally, improving port efficiency will necessitate the digitalization of operations, implementation of data-driven planning, and strategic infrastructure investments.

Keywords: Gravity Model, Exchange Rate, Export Price, FTAs, BITs.

INTRODUCTION

The agricultural sector plays a crucial role in the economy of Sub-Saharan African countries (Senbet and Simbanegavi, 2017). It has a predominant place in the supply of food, employment for rural populations, raw materials, and foreign income and mainly contributes to the formation of the Gross Domestic Product (GDP). The contribution of agriculture to Cameroon's GDP was approximately 16.97% in 2021. In the same year, it was the leading employer, employing 42.82% of the total workforce, and served as one of the primary sources of foreign currency, contributing 18.63% to merchandise exports. (World Bank, 2024).

Coffee, along with cocoa and cotton, has played a decisive role in Cameroon's national economy (Kufa, 2010; René *et al.*, 2023). The coffee industry in Cameroon is an essential

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source of income for many households from various aspects, including production, marketing, and distribution. An historical analysis of coffee production in Cameroon reveals that the past decade marked the lowest levels of production. Between 2011 and 2021, coffee production amounted to 33,527 tons on average, with approximately 1.5% of the arable land allocated for cultivation. In contrast, the peak of coffee production was observed in the 1980s, with production reaching 137,900 tons in 1984. During this peak, 5.7% of the arable land was allocated to coffee, making it the fourth largest agricultural product by land area (FAOSTAT, 2024). Despite the decline in production, coffee continues to play a significant role in the Cameroonian economy due to its substantial contribution to exports. According to TRADEMAP (2024), coffee, tea, maté, and spices (code: 09) were Cameroon's 8th major export commodity category in 2001-2021. Coffee (code: 0901) constitutes 99.66% of this category. Cameroon directs 93% of its total coffee exports to its top ten coffee importers. Figure 1 illustrates the share of these countries in Cameroon’s coffee exports.

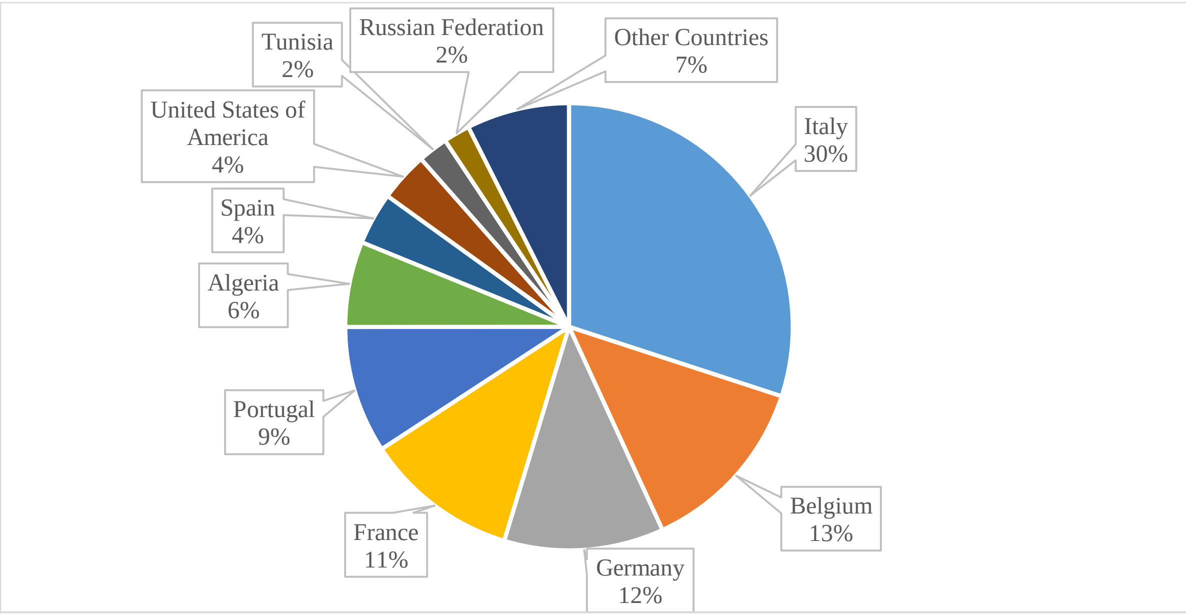

Fig. 1. Main Coffee Export Partners of Cameroon in 2001-2021 (TRADEMAP, 2024).

Figure 2 presents the data for Cameroon's coffee production, exports, and export-to-production ratio spanning from 2001 to 2021. The figure illustrates that Cameroon's ratio of production to exports was generally above 80% during this period. Nevertheless, there is a noticeable decrease in both the ratio of coffee exports to production and the amount of coffee exports.

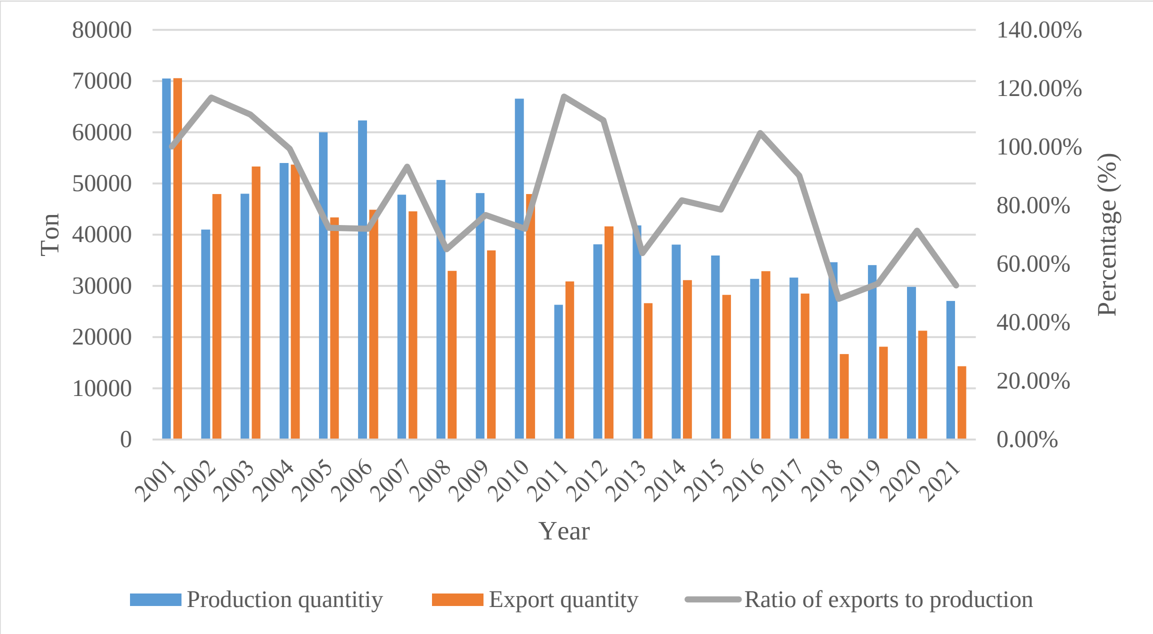

Fig. 2. Cameroon's coffee production, export, and export-to-production ratio between 2001 to 2021 (FAOSTAT, 2024).

The simultaneous decline in production and exports can be attributed to a combination of many structural and cyclical problems. One of the most important is that coffee provides lower returns than substitute crops, such as cocoa, for the farmers. A significant factor contributing to the decline in farmers' revenue is the decrease in coffee export prices. Cameroon's real coffee export price has declined by 24.53% over the past five years (2016-2021) compared with the preceding sixteen-year period. Moreover, Cameroon's real coffee export price was 30% below the world price in 2001-2021 (FAOSTAT, 2024; original calculations). The loss of income leads producers to switch from coffee to cocoa cultivation or to forego the renewal of their aging coffee trees (Shillie and Egwu, 2020). This change in production patterns may seem suitable, given that opting for a more profitable alternative is likely to result in a favorable impact on the total agricultural production value. Nonetheless, limiting the diversity within a country's production and export portfolio raises risks due to factors such as plant diseases and sector-specific global crises. Moreover, it renders investments made in established industries ineffective for processing abandoned products. The income loss in coffee production stems from export-related issues. Factors such as the limited popularity of Cameroonian origin in the international market, the absence of a strategic marketing approach, fluctuating production, concerns about product quality, high export taxes, and the insufficiency of dynamic promotional initiatives collectively erode the competitiveness in exports (MINADER, 2009; GCP, 2016). The low survival rate of export relationships could also be included among these factors. In

Cameroon, the probability of new exporters continuing their activities stands at 30 percent for the following year, decreasing to approximately 12 percent by the third year (World Bank, 2016).

To alleviate the prevailing crisis within the coffee sector, the Cameroonian government is concentrating its efforts on increasing domestic consumption (VOA, 2019). Improving local consumption is crucial, not only to ensure access to essential consumer goods within society but also to safeguard producers against potential export crises. Although enhancing local consumption might boost supply through increased demand, the main driver of Cameroon's coffee industry development is the prioritization of exports. This is primarily because the price level incentivizing producers to engage in coffee production can be attained through exports. Besides, international trade is essential for economic growth (Karambakuwa and Ncwadi, 2020). It enhances productivity by driving firms to improve efficiency, while supporting economic development through the expansion of exports and imports (Kircicek and Ozparlak, 2023).

Exports play a critical role in propelling the development of developing countries (Sanjuán-López & Dawson, 2010). Therefore, it is crucial to undertake more studies to identify the determinants exports in developing countries and to provide recommendations within this framework. The gravity model has been widely used in trade economics to elucidate the bilateral trade flows between countries. This model has been refined over the years, and scholars across the globe have extensively explored the various factors affecting the export of commodities. Among these factors, the exchange rate is frequently mentioned. Studies have shown that the impact of exchange rates on agricultural export flows can vary significantly depending on the country and sector in question (Abdullahi et al., 2021; Abdullahi et al., 2022; Yadav and Chattopadhyay, 2024). The effects of free trade agreements on exports have also been discussed in the literature, demonstrating that Free Trade Agreements (FTAs) facilitate increased export volumes by reducing trade barriers and fostering market access (Nsabimana and Tirkaso, 2020; Jagdambe and Kannan, 2020). Price is one of the key factors that shape demand for goods within a country. A decline in export prices typically leads to increased demand in importing countries, stimulating higher export volumes. Multiple works in the literature have reached similar conclusions (Yusiana et al., 2022, Phung and Nguyen, 2022). Recent researchs has investigated the effects of Bilateral Investment Agreements (BITs) on exports, demonstrating that these agreements significantly boost exports (Heid and Vozzo, 2020; Xiong, 2022).

Despite the growing body of literature, research on sub-Saharan Africa remains limited. Further research is needed to understand the factors driving strategic product exports and develop strategies in this area. This study assists in filling this gap by employing the gravity model to analyze factors affecting coffee exports in Cameroon. In its basic form, the gravity model provides ideas about the impact of transportation costs and trade partners' income on exports. However, this research extends the model by incorporating variables related to the impact of international agreements and export price elasticity. These factors have received limited attention in the literature regarding their impact on exports, particularly in developing countries. This versatile framework enables us to conduct a comprehensive foreign trade analysis for Cameroon, providing actionable findings to support policymakers in crafting and refining strategies for more effective trade planning and development.

MATERIAL AND METHODS

Material

The main material of this study consisted of data obtained from international bodies. The data set covers the period 2001-2021 and includes the ten countries to which Cameroon exports the most in the relevant period. These countries are Italy, Belgium, Germany France, Portugal, Algeria, Spain, the USA, Tunisia and Russian Federation, respectively. Information on the variables included in the model is given in Table 1.

Table 1. Description of the Variables.

Variable*	Description*	Unit	Source	Expected Sign
EX_{ij}	The value of coffee** exports from Cameroon to country *j*	US$, in 2015 Prices	TRADEMAP (2024), original calculations	N/A
GDP_i	Gross domestic product of Cameroon	US$ per capita, in 2015 Prices	FAOSTAT (2024)	+
GDP_j	Gross domestic product of importing country *j*	US$ per capita, in 2015 Prices	FAOSTAT (2024)	-/+
$DIST_{ij}$	The geographical distance between Cameroon and the importing country *j*	km	CEPII (2024)	-
RXP_i	The coffee export price of Cameroon	US$, in 2015 Prices	TRADEMAP (2024), original calculations	-
ER_{ij}	Exchange Rate. This indicates how much of the Central African CFA Franc is required to purchase one unit importing countries' own money.	Central African CFA franc	FXTOP (2024)	-/+
FTA_{ij}	Free Trade Agreements between Cameroon and the importing country j	Dummy	CEPII (2024)	+
BIT_{ij}	Bilateral Investment Treaties between Cameroon and the importing country j	Dummy	UNCTAD (2024)	+

* Here *i* represents Cameroon and *j* represents one of Cameroon's top ten trading partners.
** "Product: 0901 Coffee, whether or not roasted or decaffeinated; coffee husks and skins; coffee substitutes containing coffee in any proportion" (TRADEMAP, 2024).

Methods

This study analyzes the factors affecting coffee export in Cameroon. The gravity model is used for this purpose. In recent decades, this model has become a widely used tool for elucidating international trade determinants (Sharma *et al.*, 2023). The primary reason for this is the model's ability to offer a comprehensive analysis of revealed trade data (Jadhav and Ghosh, 2023). The gravity model of international trade elucidates bilateral trade flows by incorporating the economic scale of the trading partners and the geographical distance that separates them (Golovko and Sahin, 2021). Tinbergen's (1962) pioneering work established the framework for this model, and subsequent early studies further developed and applied its principles.

The gravity model in the logarithmic transformation of the variables, as commonly used in the literature, can be expressed as follows:

$$lnEX_{ij} = \beta_0 + \beta_1 lnGDP_i + \beta_2 lnGDP_j + \beta_3 DIST_{ij} + e_{ij}$$

where, i represents Cameroon, j represents trading partners, EX_{ij} represents the value of bilateral coffee exports from Cameroon to its trading partners, GDP_i represents the gross domestic product of country i, GDP_j represents the gross domestic product of the country j, and $DIST_{ij}$ represents the geographical distance between Cameroon and its trading partners.

The basic structure of the gravity model has evolved in multiple ways to accommodate the needs of researchers (Nawrot, 2023). In country- and product-specific studies, such modifications yield empirical insights that not only enrich the literature but also assist policymakers in formulating effective strategies. Therefore, we modified our model by integrating variables linked to the primary factors behind the decline in Cameroon’s coffee exports, as outlined in the introduction. We tackled the problem of low export prices by including variables such as the real export price and exchange rates. To address the issue of low survival rates in export relationships, we included dummy variables related to free trade agreements and bilateral investment treaties. The modified model is formulated as follows:

$$lnEX_{ij} = \beta_0 + \beta_1 lnGDP_i + \beta_2 lnGDP_j + \beta_3 DIST_{ij} + \beta_4 lnRXP_i + \beta_5 lnER_{ij} + \beta_6 FTA_{ij} + \beta_7 BIT_{ij} + e_{ij}$$

where, RXP_i is the coffee export price of Cameroon, ER_j is the exchange rate between Cameroon and its trading partners, FTA_{ij} is the Free Trade Agreements between Cameroon and its trading partners, and BIT_{ij} is the Bilateral Investment Treaties between Cameroon and its trading partners.

Estimation of the gravity model is a problematic issue in most cases and has long been debated by researchers. The primary cause behind this is the fluctuating nature of the bilateral trade flows. Economic and political circumstances have the potential to either excessively boost trade or entirely impede its occurrence. This phenomenon is especially evident in developing economies or emerging sectors of a country. An example of this is Cameroon, which has not traded with major coffee export partners for some years.

Zero trade flows create substantial econometric challenges, as the loss of observations in log-linear transformations leads to information loss and biased results (Gómez-Herrera, 2013; Borojo *et al.*, 2022). To simply solve the zero trade problem, removing these observations from the data set (Bikker, 1987) and formulating the dependent variable as ln(Export+1) (Eichengreen and Irwin, 1995; Guo, 2004) are commonly used. However, Santos Silva and Tenreyro (2006) showed that these traditional methods lead to inconsistent estimates, especially in cases where the heteroscedasticity problem exists, and suggested the Poisson Pseudo-Maximum Likelihood (PPML) model for estimating gravity models. The use of the PPML estimator in the gravity model has been criticized on the grounds that it may yield biased results in situations where zero trade flows predominate and there is overdispersion (Burger *et al.*, 2009; Martínez-Zarzoso, 2013). Nevertheless, a substantial amount of research has shown that PPML maintains its robustness, even in situations of frequent zero trade flows or overdispersion (Santos Silva and Tenreyro, 2011, 2022; Ghazalian, 2019).

Due to its advantages, we used the PPML method for estimation. This model can be estimated only when the dependent variable consists of integer count data. Hence, we rounded the data in our dependent variable, which included fractional observations, to integer values. Our gravity model to be estimated with PPML can be formulated as an exponential function as follows:

$$EX_{ij} = exp\big[\beta_0 + \beta_1 lnGDP_i + \beta_2 lnGDP_j + \beta_3 DIST_{ij} + \beta_4 lnRXP_i + \beta_5 lnER_{ij} + \beta_6 FTA_{ij} + \beta_7 BIT_{ij}\big] + e_{ij}$$

Given that the model is in exponential form, dummy variables are interpreted similarly to semi-logarithmic models. In this study, the approach proposed by Halvorsen and Palmquist (1980) was employed for interpreting dummy variables. Accordingly, whereas g represents the relative effect, the percentage effect is calculated using the following formula:

$$100 * g = 100 * (e^{\beta} - 1)$$

To test the robustness of the estimation methodology, we employed alternative commonly used estimators. These are the negative binomial maximum likelihood (NBML) model proposed by Burger (2009) and the OLS with ln(Export+1) modification. Since the negative binomial model is categorized as an integer count model, we used same rounding modification as the PPML for the dependent variable. In the findings section, we presented the outcomes derived from these estimators along with PPML.

RESULTS AND DISCUSSION

Table 2 presents descriptive statistics of the variables included in the model. As FTA and BIT are dummy variables, their means reflect their respective frequencies. FTAs, for instance, account for 20% of the observations. Cameroon's sole FTA with the countries in the dataset is the agreement with the EU, which came into effect on August 14, 2014. However, as the CEPII database registers agreements that take effect after July 1st in the following year, FTAs are recorded from 2015 onwards. BITs account for 39% of the observations. Cameroon has BIT agreements only with Italy, the USA, Belgium, and Germany, among the countries included in the dataset for this study. Of these, only the BIT with Italy occurred during the observation period, on April 1, 2004. The agreements with other countries came into force prior to the observation period.

Table 2. Descriptive Statistics.

Variables	Mean	Std. Dev.	Maximum	Minimum
EX_{ij}	5857.27	7658.47	52590.00	0.00
$lnGDP_i$	7.18	0.07	7.28	7.05
$lnGDP_j$	9.85	0.95	11.03	7.91
$lnDIST_{ij}$	8.51	0.27	9.17	8.20
$lnRXP_i$	0.52	0.20	0.91	0.17
$lnER_{ij}$	5.55	1.69	6.60	1.41
FTA_{ij}	0.20	0.40	1.00	0.00
BIT_{ij}	0.39	0.49	1.00	0.00

Table 3 shows the estimation results of the gravity model. Here, the PPML model is employed as the base model for interpretation, while NBML and OLS models are added for robustness check. Examination of the estimation results indicates that the estimators produce largely consistent outcomes regarding both the direction and significance levels of the relationships. The only difference is that the OLS method yields statistically significant results for the FTA_{ij}.

Table 3. Estimation Results for Gravity Model.

Variables	PPML[a]	NBML[a]	OLS $ln(EX_{ij}+1)$
Constant	69.41878*** (11.59736)	58.74402*** (10.81458)	75.23906*** (15.07565)
$lnGDP_i$	-5.624733*** (1.430220)	-4.627639*** (1.523776)	-10.56881*** (2.059889)
$lnGDP_j$	1.497604*** (0.260985)	1.191910*** (0.152143)	2.016000*** (0.239863)
$lnDIST_{ij}$	-3.994570*** (0.542036)	-3.325517*** (0.359847)	-4.170305*** (0.585373)
$lnRXP_i$	0.629975* (0.337856)	1.087721*** (0.379283)	2.429299*** (0.606308)
$lnER_{ij}$	-0.355475*** (0.098317)	-0.241735*** (0.065761)	-0.568053*** (0.104096)
FTA_{ij}	-0.170373 (0.228515)	-0.029155 (0.259557)	0.826028** (0.405091)
BIT_{ij}	0.430819*** (0.145855)	0.416284*** (0.131776)	0.605192** (0.291410)
Adjusted R^2	0.61	0.50	0.43
N	210	210	210

[a]Robust standard errors are in parenthesis.
*, **, ***P < 0.1, P < 0.05, and P < 0.01, respectively.

The estimation results for our base model show that all variables, with the exception of FTA, are statistically significant. The GDP of importing countries has the highest positive impact of 1.50%, followed by Cameroon's real coffee export price at 0.63%. Additionally, the percentage impact of BITs is measured at 54%. The variable with the most substantial negative effect is Cameroon's GDP, with -5.62%. This is followed by distance and exchange rates with -3.99% and -0.35%, respectively.

The negative correlation between Cameroon's GDP per capita growth and coffee exports can be attributed to the increase in domestic purchasing power. This growth enables higher internal consumption, potentially reducing the volume of coffee available for export. Concrete signs of this relationship are evident in Cameroon. The per capita GDP increased by 24% during the study period, indicating growing domestic demand. This is further supported by the rise in coffee processing facilities, with 104 active plants reported by the National Cocoa and Coffee Board (NCCB, 2020). Since 99% of Cameroon's coffee exports are unroasted and only 5% of production is processed domestically (AFCA, 2024), these facilities predominantly serve the local market. Moreover, the negative relationship between income growth and agricultural product exports has also been previously documented (Abdullahi et al., 2022). This shift in demand aligns with the broader mechanism of income elasticity, which suggests that as incomes grow, domestic consumption can compete with exports. If managed well, this mechanism can produce positive results for coffee exports in the long term. Because sustainable production is a prerequisite for sustainable exports, and sustainable production is possible with alternative sales channels. Establishing a vibrant domestic market is essential, enabling producers to engage in sales even when confronted with conditions detrimental to exports, such as international crises. Therefore, to safeguard against a potential decline in exports due to increased demand, it is essential to support producers with productivity-enhancing policies, such as facilitating access to agricultural credit, offering incentives for input use, and promoting mechanization.

Another variable that has a negative effect is distance. Each one percent increase in distance reduces export value by 3.99%. Although past studies reached results consistent with ours regarding the direction of the distance-export relationship, they differ in the magnitude of the effect. In the majority of the studies surveyed, the distance elasticity for coffee exports falls below the level estimated for Cameroon (Sadeghi et al., 2019; Abafita and Tadesse, 2021; Nguyen, 2022). Considering that the distance variable reflects the costs and risks in transportation, this finding may indicate Cameroon's logistical inefficiency in coffee. The inefficiency in the port of Douala, Cameroon's largest port, confirms our explanation. Douala's average dwell time for containers (19 days) differs negatively from other African ports such as Dar es Salam (12 days), Mombasa (11 days), and Durban (4 days) (Raballand *et al.*, 2012; Diarra and Tchapa, 2014; World Bank, 2016). Even more concerning, recent studies have demonstrated that Douala's container dwell time has exceeded 21 days (Awah *et al.*, 2021), placing it 340th out of 370 ports in the 2021 Container Port Performance Index (Worldbank, 2022). The World Bank (2016) pointed to the sector's lack of proper regulation as the explanation for this situation. Furthermore, if we accept that this variable also indirectly expresses cultural distances like language differences and varying institutional frameworks between countries (Van Bergeijk and Brakman, 2010; Golovko and Sahin, 2021), the obtained coefficient can also be associated with marketing failure. The Cameroonian government must invest in intercity transportation infrastructure and enhance port efficiency to address logistics shortcomings. This requires digitalizing port operations, data-driven planning, and infrastructure upgrades. Additionally, expanding the network of asphalt roads is essential, not only to increase the efficiency of coffee transport but also to enhance the movement of goods and improve domestic mobility across the country.

Our estimation results show that every 1% decrease in the value of the Central African CFA franc reduces coffee exports by 0.35%. The effect of exchange rates on exports is quite controversial, both theoretically and empirically. The appreciation of a country's currency can weaken that country's competitiveness in the international market. Generally, an increase in the exchange rate reduces the comparative price of exports and increases foreign demand by reducing the prices of domestic goods (Nugroho and Lakner, 2022). In reality, various factors tied to both the country and the sector play a role in determining the correlation between the exchange rate and export dynamics. Examining the case of Cameroon, we observe that its export price is approximately half of the global price, as previously noted. Given Cameroon's already highly competitive pricing, an appreciation of its currency may still yield a positive impact on the value of its exports. The literature also reflects on the relative nature of this situation. While a substantial body of evidence supports our study's conclusions (Irshad *et al.*, 2018; Yadav and Chattopadhyay, 2024; Eshetu, 2024), there is also a significant volume of evidence with contradictory outcomes (Abdullahi *et al.*, 2021; Abafita and Tadesse, 2021; Nugroho and Lakner, 2022). The estimation results further indicate a positive and significant relationship between coffee export prices and export value. While this finding diverges from the literature (Phung and Nguyen, 2022), it aligns with our results for the exchange rate. Similar to the exchange rate, the general assumption is that competitive pricing boosts total exports. However, this no longer holds for Cameroon, which already offers highly competitive prices compared to the global market. Therefore, Cameroonian policymakers should prioritize quality-enhancing production policies that increase prices rather than focus on selling more products at competitive prices to boost income from coffee exports. This can be achieved by expanding agricultural extension and advisory services. In this way, the necessary technical support is provided to help traditional producers improve the quality of their products. Additionally, producers are informed about certified production techniques, such as organic farming, which offers high-price premiums. In this context, it is crucial to financially support and motivate producers who engage in certified production.

Our estimation results for international agreements revealed that FTAs have no statistically significant effect on coffee exports, whereas BITs have shown a positive effect. This finding is consistent with the literature, which provides evidence of positive relationships between exports and BITs (Heid and Vozzo, 2020; Xiong, 2022). However, this study represents the first documented case in the context of a developing country. It is not surprising that, irrespective of the development level of the countries, BITs and exports display similar effects. One of the most significant advantages of BITs is their capacity to facilitate foreign direct investment, which, as studies have demonstrated (Samantha and Haiyun, 2018; Sahoo and Dash, 2022), enhances exports in both developing and developed countries. Furthermore, BITs offer several additional benefits that can boost export volumes, including promoting trade in specialized intermediate inputs and mitigating risks through enhanced legal protections (Heid and Vozzo, 2020). Contrary to the widely held assumption that FTAs boost exports, recent research on coffee by Abafita and Tadesse (2021) has found no statistically significant relationship, as in our study. They explain this by noting that coffee trade primarily flows from least developed countries to more developed countries, while most regional trade agreements (RTAs) in their study are intra-regional, which may diminish the impact of inter-regional RTAs on coffee trade. In the Cameroonian case, the most plausible explanation for the lack of a significant relationship is the steady decline in coffee production since the FTAs came into force. Despite the facilitation of bilateral trade, the continuous drop in production has prevented the Cameroonian coffee sector from benefiting from these agreements. These findings imply that, the cornerstone of increasing Cameroon's exports through international agreements is ensuring a steady and consistent production flow. Additionally, the Cameroonian government should analyze existing agreements and suggest strategic adjustments explicitly tailored to the coffee sector to maximize the impact of FTAs.

CONCLUSIONS

Our study uncovered key insights into the underlying dynamics of Cameroon's coffee exports. The most significant challenge is the negative impact of rising domestic demand for coffee, driven by income growth, on export levels. However, if adequately managed through policies aimed at increasing productivity, such as better access to credit and mechanization, this demand could support domestic consumption and sustainable exports. Cameroon's logistical inefficiencies, particularly when compared to its competitors, further constrain exports. On the positive side, international agreements and focus on quality rather than price competition can influence exports positively. To fully realize its potential, the Cameroonian government must provide technical and financial support to producers, enhance efficiency at the Douala port, and critically assess its international agreements to develop strategies that maximize their benefits.

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