Market and non-market determinants of roundwood exports from Cameroon: Implications of global trade on sustainable forest management

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Abstract
Africa south of the Sahara is endowed with forest assets which give the continent a comparative advantage in the trading of timber and other forest products. Countries at the 26th COP of the UNFCCC pledged to take steps to secure tropical forest assets against deforestation in countries on the frontiers of the Congo Basin such as Cameroon which are strategically positioned to optimise forest land-use for its global good imperative. However, comprehensive information is absent on the market and non-market drivers of roundwood timber exports. This study examines the economic determinants of roundwood exports from an archetypical African economy of Cameroon, and ascertains whether the reliance on few species for the export market has some implications on the environment and in the overall process of sustainable development. Secondary data is employed covering the period 1960-2020, to estimate an Error Correction Model (ECM) relating timber export value and economic factors. The results reveal that high timber prices may increase the quantity of exports. Similarly, better infrastructure, higher relative demand from Asian countries led by China, increase in area harvested of major species and incomes in importing countries in the European Union (EU) and United States of America (USA) may stimulate increased exports. On the contrary, however, increase in the prices of substitutes, higher exchange rates, higher export taxes, higher domestic consumption levels, and increased illegal exports may have a negative correlation with export receipts. Geographic diversification of roundwood to the EU and non-EU markets is shown to be significantly determined by market access factors. These findings are argued to have profound implications on the management of forest assets for sustainable development.

Keywords: Timber markets, Roundwood exports, Trade facilitation, Environment, Error-correction model

1. Introduction

At the twenty-sixth session of the United Nations Conference of the Parties (COP 26) to the UN Framework Convention on Climate Change (UNFCCC), world leaders pledged to eliminate the significant environmental issue of deforestation by 2030, in other to preserve the tropical rainforest, especially that of the Congo Basin. The milestone at COP26 in Glasgow not only highlights the essentiality of forests for human survival but also x-rays the critical role of forests in sustainable development. Forests' role in life on land is undisputed in nourishing the world, halting and reversing land degradation, combating desertification, protecting biodiversity, promoting sustainable terrestrial ecosystems and maintaining life's ecological balance. While natural resources can drive sustainable growth, ensuring that timber extraction is environmentally friendly for sustainable growth is an important Sustainable Development Goal (SDG) (IPBES, 2019; UN, 2015). However, the soaring demand for timber and other wood products is putting pressure on tropical forests. The supplies from tropical forests to meet demands for industrial and small-scale wood-use, not only drives the shrinking of forests but it is also associated with increasing forest cover loss, loss of biodiversity, even spread of zoonotic diseases which come with consequences for indigenous communities, local and global commons.

The rising demand for tropical timber both on international and domestic markets creates valuable opportunities for developing countries. Trade in forest commodities is the source of wealth for developing countries in Africa such as Cameroon (Scudder et al 2019; Schwerhoff and Wehkamp, 2018; Parajuli et al 2016; van Kooten, 2014; Lundmark 2010). Forest with its diverse functions (Acharya et al., 2021; Fouqueray and Frascaria-Lacoste, 2020), provide a nexus for the seventeen United Nations SDGs, and a pervasive conduit of goods and services which address poverty alleviation, hunger, health, water, energy, economic growth, and climate change as well as accounting for responsible production and consumption, enhancing equity, peace and justice for communities and nation states. Some studies have highlighted the global importance of the central African Congo Basin for which Cameroon is part (ITTO, 2011; de Wasseige et al., 2008; Ndoye and Tieguhong, 2004).

While diverse stakeholders also acknowledge that forests especially in the Congo Basin play an important in regulating the global climate, preserving biodiversity and are important for livelihoods, however, there is dearth of information on the economics related to the supply, demand and trade of commodities from these forests. An investigation to better understand the market costs and benefits associated with timber exploited from these forests is worthwhile, particularly factors that facilitate export trade, mindful that competitive markets may generate economic gains (Duan et al., 2022; Krugman, 2009; Barbier, 2000). This is so because while renewable natural resources are important for further wealth creation for developing countries such as Cameroon, however market-based barriers continue to be significant (Hansen and Lund, 2011; Tumaneng-Diete et al. 2005; UNCTAD, 2005). This paper thus seeks to close the knowledge gap using an archetypical African economy such as Cameroon endowed with forest resources on the frontiers of the Congo Basin by examining the factors facilitating timber extraction for lucrative foreign markets.

Sustainable development on its own is beyond a publicity mantra. It is an inherent wisdom to guide growth efforts towards environmental, social and economic sustainability. No other sector than the forest mandates such consciousness, especially with Cameroon's increasing levels of deforestation (MINFOF 2014; 2013). The exploitation of the countries forest for timber has significant environmental dimension with important implications for biodiversity conservation and sustainable development (Scudder et al., 2019; Eisenbarth, 2017; Lundmark, 2010). Global institutions promoting trade such as the WTO are cautious in their treatment of natural resources as trade goods. For instance, the General Agreement on Trade and Tariffs (GATTS) which is the foundation to the WTO in its Paragraph 1(a) of Article XVII (Annex I) which refers to "national natural resources" recognized the need for countries to take steps towards conservation of plant-based natural resources such as standing timber. The role of forests as a nexus and conduit for sustainable development is, therefore, tested in developing countries such as Cameroon that have an over-reliance on forest exploitation for revenue generation..

This study enriches the literature by examining the situation of raw-logs.[1] Mindful of the importance of wood exports to Cameroon's economy, especially lacking are quantitative studies suitable for forecasting and policy analysis. It is therefore important, particularly for policy imperatives, that we evaluate and quantify the factors that motivate exports from the sector. If export revenue from timber is important, what then are the policy options available to support the interaction of markets, institutional and environmental factors required to promote its trade? Therefore, in the context of an empirical analysis, it is important to address some important questions. What factors statistically account for production and export trends of roundwood from Cameroon? How does geographic export diversification between EU and non-EU markets respond to bio-economic determinants? What are the implications of exporting timber on the environment? This paper thus sets as its goal to examine the economic determinants of roundwood timber exports from Cameroon, compares market diversification for timber between EU and non-EU destinations, and ascertains whether the reliance on few species for the export market has some implications on forest management. To achieve this, this paper is divided into five sections. Section two of this paper examines the forest sector of the case study. Section three presents the estimation method complete with the analytical framework, the empirical model as well as the nature and source of data. In section four the results are presented for the key factors that drive timber exports both in the long-run and short-run periods. The paper concludes in the fifth section some policy implications and recommendations for action.

2. Timber Production and Exports from Cameroon

Historically, Cameroon has been a roundwood exporter, recouping increased share of foreign exchange revenue (Oyono et al, 2005). For instance, De Wasseige et al. (2008) note that the trade of timber and other forest commodities earn significant foreign exchange for Cameroon. As shown in figure 1, Cameroon's wood exports have doubled since the 1990s representing almost 60 % of roundwood timber. In early 1990s

[1] Here we examine crude materials of wood in the rough or roughly squared in the aggregated data (short-term and long-term indicators) as defined by the Standard International Trade Classification (SITC) of UNCTAD's revision 4 of 2006.

the country earned on average US$ 200 million from timber trade, and this grew slightly then declined tremendously in the early 2000s following measures to regulate the sector. The sector has since picked up in 2010 recovering more than US$ 300 million.

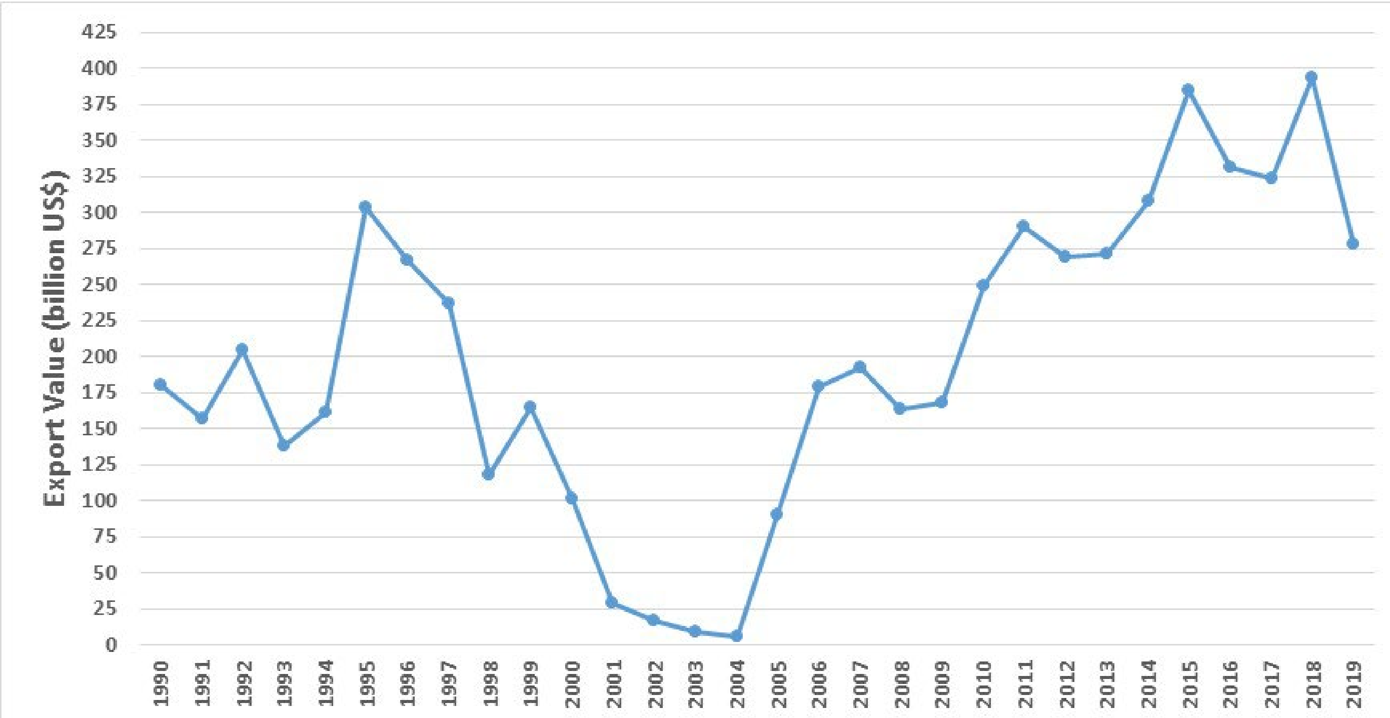

Figure 1: Cameroon's Industrial roundwood (non-coniferous tropical) exports
(Source: computed with Data from FAOSTAT, 2021)

While trade enhances economic efficiency particularly when production costs are low for commodities destined to both foreign and domestic markets (Dunn, 2022; Moyo, 2022; Atyi et al., 2013; Amoah et al 2009), however, the exploitation of Cameroon's forests and export of timber may be challenged by a plethora of factors. These relate to inadequate processing technologies (ITTO, 2005, Eba'a Atyi, 1998), barriers to foreign markets, increasing trade diversion to new markets in the Far East, corruption and subterranean trade (Cerruti and Tacconi, 2006), institutional weaknesses (Alison, 2015; Buttoud et al., 2002), uncertainty surrounding liberal macroeconomic initiatives, timber 'mining' and attendant environmental effects of the overexploitation of few major species that makeup the trade basket (Alison, 2015; Benhin and Barbier, 1999; Ndoye, 1995). These factors are reinforced by a regulatory scenario in which the government is the primary 'owner' and source of natural resources (Ndoye and Tieguhong, 2004).

Excessive selective logging of few species threatens the integrity of forests, degrades and hampers forest ecosystem services. The most logged species in the formal Sector include Ayous/Obéché, Sapelli, Tali, Azobé/Bongossi, Iroko, Okan/Adoum, Fraké/Limba, Movingui, Kossipo/Kosipo, Red padouk (MINFOF, 2015). The ITTO (2020) notes that, "of the 300 tree species found in the country, approximately 80 are logged commercially." "Of these 80 species, 5 account for more than half of all wood exports, and two species (e.g. Ayous and Sapelli) account for over a third of exports" (ibid.). Ayous and Sapelli are commonly used in furniture production and housing construction. Effective trade policy is required to correct for the anomaly of over-exploitation of forest resources (Scudder et al 2019; Eisenbarth, 2017; Merry and Carter, 2001. For example, Merry and Carter (2001) demonstrated the possibility of correcting for inter-temporal declines in mahogany stocks with trade policy change. Since the export supply is highly price sensitive, policy measures to control price may be more important than instruments that regulate forest concessions. There is increasing attraction of these hardwood species to foreign markets. As shown in Figure 2, the major destination of the exports are in the European Union (EU), particularly to Germany, France, Belgium, Netherlands and Greece. Recently, the Far East received about 30 %, followed by Italy and France, harvested from a few species of commercial value (ITTO, 2017; ITTO, 2011). Since the beginning of the 21st century China has emerged as the dominant market destination for coniferous tropical timber exports from Cameroon. As shown in Figure 2, exports to China have grown steadily, averaging US$ 5.8 billion in 1997 and doubled to almost US$ 10 billion by 2017.

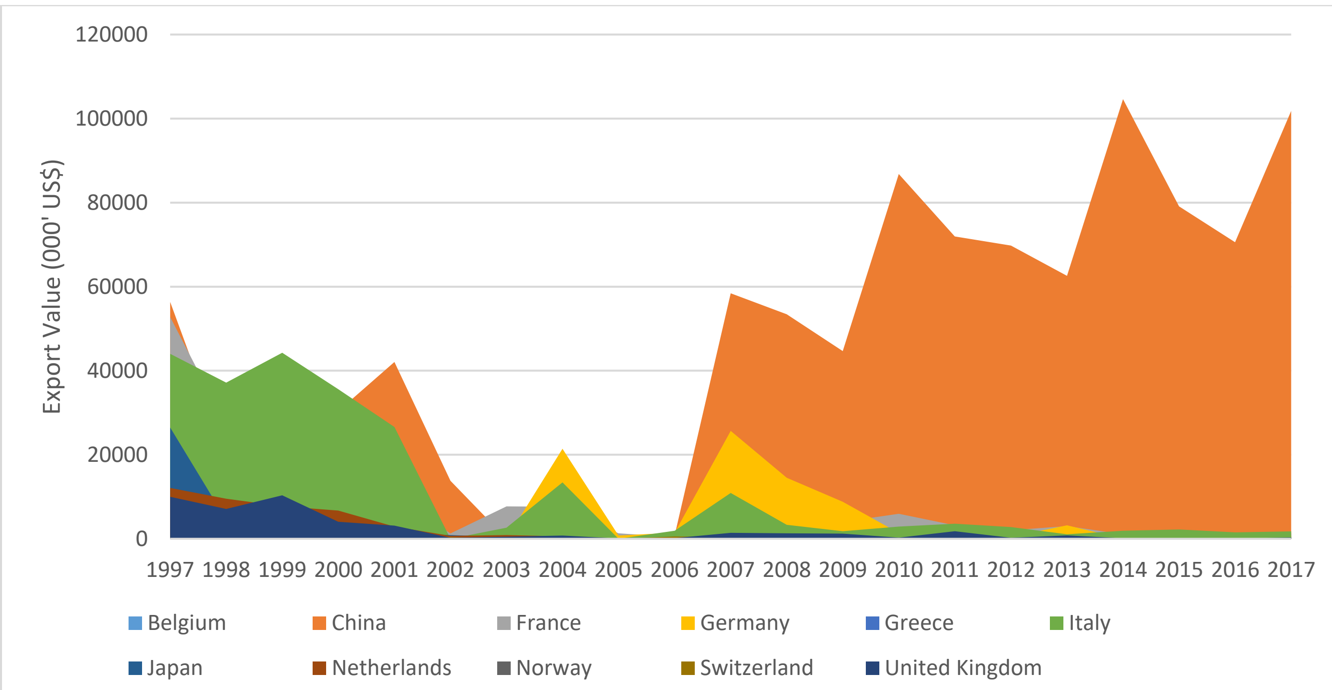

Figure 2: Export flow of industrial roundwood (non-coniferous tropical wood) from Cameroon (Source: computed with Data from FAOSTAT, 2021)

The challenge of overexploitation is surmounted by worries associated to legal timber trade, export facilitation and diversification for effective revenue mobilization. For instance, as shown in figure 3, recent policy efforts have encouraged market diversification, with the country emerging as a global player in wood exports to industrialized and emerging countries. The export production share to Argentina is 100% and a host of other countries for which the principal commodity Cameroon ships to their market is raw timber logs.

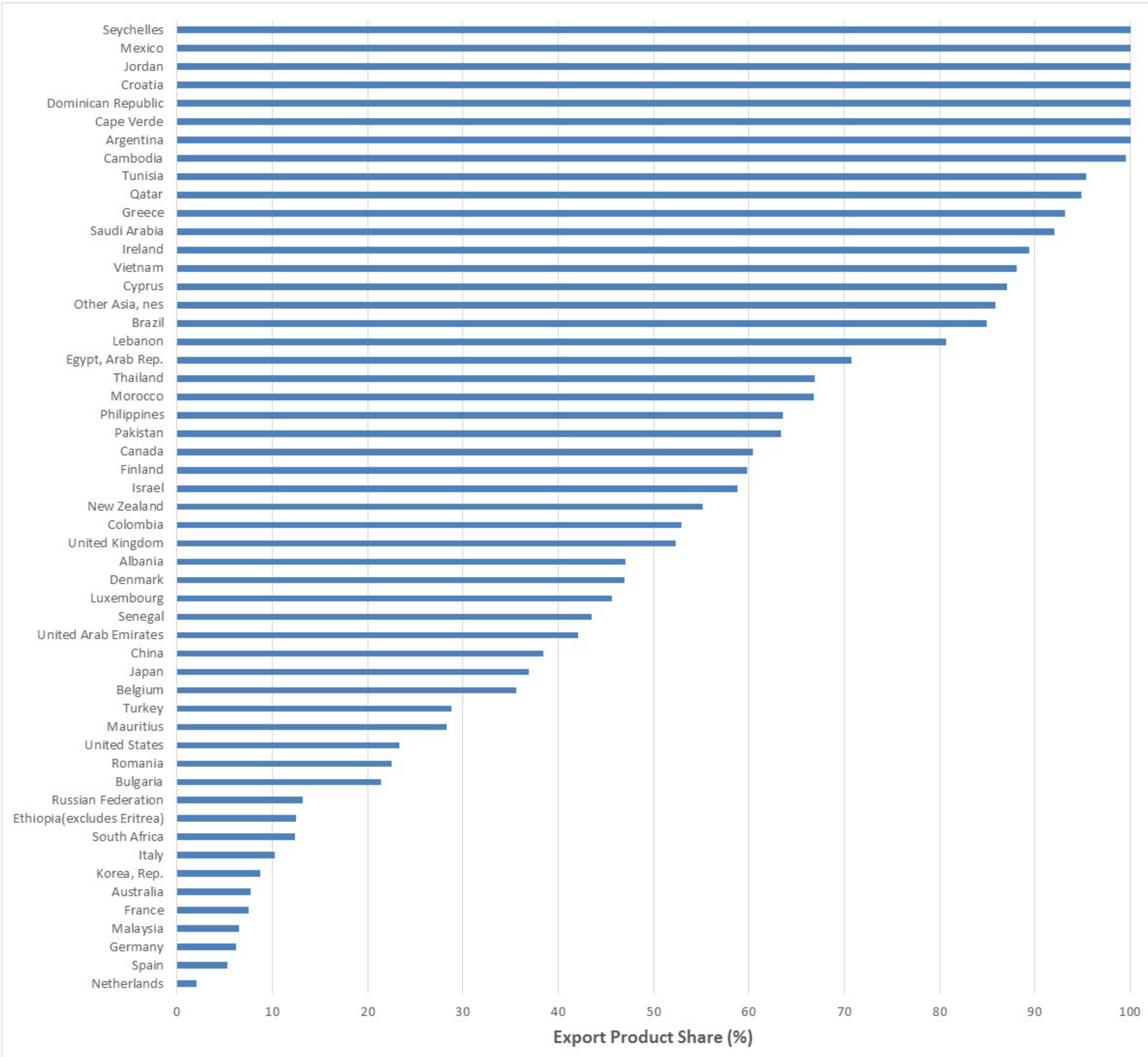

Figure 3: Wood Trade Flow Export (2017) for Cameroon
(Source: computed with Data from WITs)

Figure 4 shows the share of market diversification of wood exports from Cameroon for 2020, where Asian markets in Vietnam and China appear more strategically important, despite the institutionally guaranteed market access to the EU. The EU, however, seemed to have raised barriers using non-tariff based impediments. Market access for sustainably produced timber should assist export countries such as Cameroon to pursue the SDGs by providing employment opportunities, and encourage sustainable forest management. Hence, market access and non-discriminatory trade practices would be important to derive gains from timber trade. This may nonetheless without astute management promote increased exploitation of forest assets. Such logging if excessive may have dire environmental consequences for would suppliers from the Congo Basin and Cameroon. . This may include the opening of huge tracts of roads in the forests thus permitting the expansion of agricultural land through shifting slash-and-burn farming system which encourages deforestation and poses significant problem for regeneration (Karsenty et al 2008; Mertens et al., 2000). According to FAO, about 90% of logging in Cameroon takes place in primary forests, promoting agricultural encroachment and human settlements. Recent assessment which identifies hotspot areas for which tropical deforestation poses threat, revealed that four of these areas were in Cameroon.

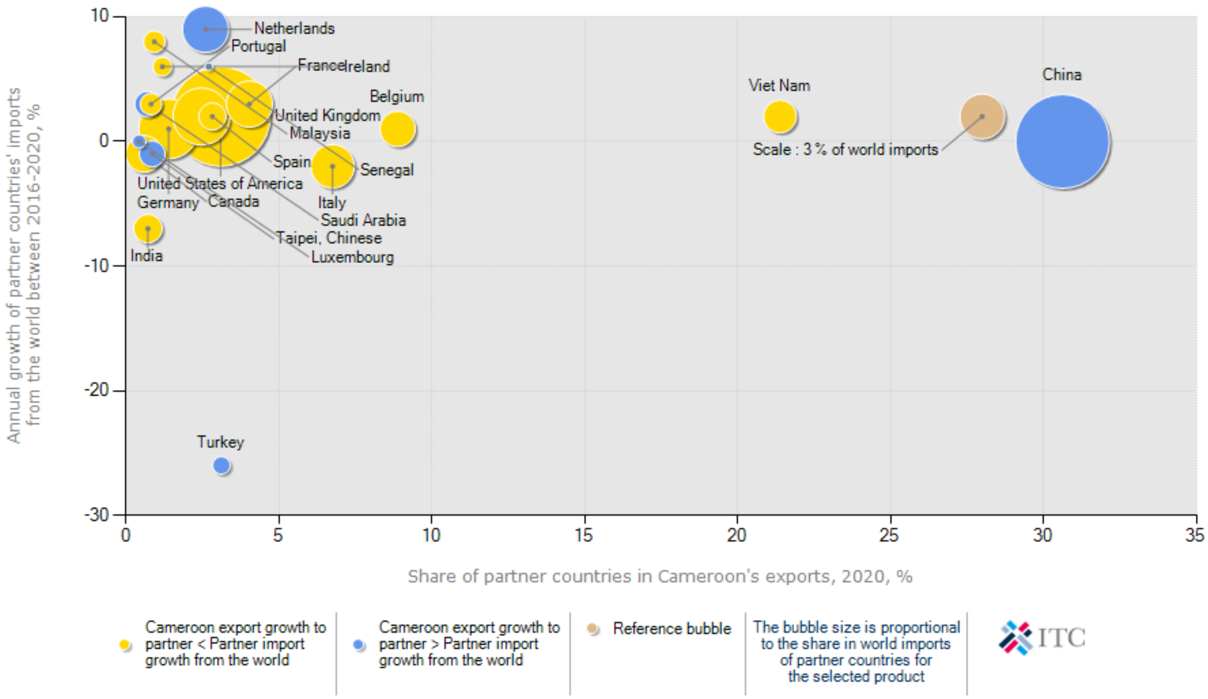

Figure 4: Share of Market Diversification of Wood Exports from Cameroon for 2020
(Source: computed with Data from International Trade Centre, 2021)

3. Estimation Methodology

3.1 Conceptual Framework

Being a natural resource, the trade of timber submits to the foundational tenets of the neoclassical trade theories, such as the Ricardian theory of comparative advantage (Dunn, 2022; Moyo, 2022). The patterns of the export of tropical timber hardwood are predetermined by differences in factor endowments, and between destination countries. The declining transaction costs and access to technologies as well as the enhancement of the Ricardian gains accruing to a natural resource such as timber means that trade may still take place even when countries have similar resource endowment and technology. As predicted in the Heckscher-Ohlin-Samuelson theorem, countries may gain from exporting natural resources such as timber since it is about intensive use of locally abundant factors (Atyi et al., 2013; Amoah et al 2009; Burgess, 1993; Vincent, 1992). However, in the competitive market of tropical timber, developing countries in recent times experience increased domestic and foreign direct investments in the sector, which accounts for gains of leading exporters. This promotes competition and substitution. According to Rybczynski such investments may not only upgrade the technological and transportation needs of the timber sector, but the increasing substitution of modern technology over the years would shift the resource-mix away from labour-intensive rudimentary systems to technology-driven production (Štěrbová et al., 2019; Trømborg et al., 2000; Barbier et al., 1994; Cubbage et al., 1988; Bullard & Watson, 1986).

Competition, substitution and technology driven investments cause pervasive market movements with consequences for smaller developing economies reliant on natural resource exports. As highlighted in the Stolper-Samuelson theorem, the predominant exportation of raw timber logs which is relatively cheap compared to processed wood, reduces domestic availability for the burgeoning construction industry in the country. A rise in demand for the abundant resource leads to a corresponding rise increase in its price and possibly an augmenting of its income. However, the unfolding dynamics is that, there is a simultaneous response in the market for substitutes. The income of the resource used intensively in the import-competing product decreases as its demand falls, causing market perturbations and influencing revenue mobilization. For developing countries with established trade links, an abundant resource such as wood that has comparative advantage would typically realize gains in income. This income nonetheless is impeded in recent times by growing environmentalism and pressures to conform to international agreements on ecosystem and biodiversity protection (Ituarte-Lima et al., 2019; Freeman and Xu, 2015; Barbier, 2000; Vogel, 1997; Kasimbazi, 1996). Curbing deforestation and environmental stress with the possibility of declining availability of timber and hence income, reinforces the market dynamics whereby some sectors of the economy may incur losses from timber trade particularly in the long-term. The emergence of new trade poles and the juxtaposition of trade partners under rising globalization of timber trade, raises a Krugman possibility in which patterns of timber trade is driven by the interaction of consumer preferences for different wood products, a home market effect reinforcing specialization and concentration on few important species shipped to emerging economies (Chandra, 2022; Gaspar, 2020; Krugman, 2009, 1995).

Despite these myriad of challenges, developing countries continue to aspire to the Ricardian gains from natural resource trade. Their promotion of timber exports which is associated with national factor endowment may cause them to take advantage of economies of scale. However, the accruing economies and the distribution of benefits to the rest of the economy over time from such trade orientation will depend on the market model and access to the lucrative overseas destination. The global market arena being defined by the WTO arrangements, the United Nations Conference on Trade and Development (UNCTAD) dictates as well as by bilateral programs, such as the U.S. Africa Growth and Opportunity Act (AGOA) and the European Everything but Arms (EBA) initiative, may facilitate or hinder not only gains from trading efforts but also development aspirations, as well. For instance, though the WTO does not directly regulate renewable and non-renewable resources before they are extracted or harvested, its legal and institutional framework contributes to the expansion of global trade in natural resources (WTO, 2010).[2] This will mean that governmental efforts on export promotion notwithstanding, the market model

[2] In addition, "the extraction and distribution of natural resources may involve services activities that fall within the ambit of the General Agreement on Trade in Services (GATS)."The Agreement on Trade-Related Aspects of Intellectual Property Rights

remains important in guaranteeing the volume of timber exports with or without incentives. The dictates of the market imply that the demand, supply and consumption of timber may depend not only on the level of activity in the consumer sector but also on the market share of forest products, which results from their competitiveness (on price, convenience, performance), as well as perceptions of the environmental issues associated with forest exploitation.

Therefore, the nature of natural resource trade flows, when examined in the context of differentiated markets, may provide interesting insight into the underlying bases of timber market and trade. A tractable market model captures patterns of trade, particularly via domestic and international policy. Market characteristics may influence the pattern of trade, which also tends to influence the selection of heterogeneous export markets. Trade volumes, income and cooperative arrangements, for instance, respond to both the size of a market and the extent of its integration through trade. Figure 5 thus summarizes three interrelated pillars of timber management, viz environmental considerations, market-driven forces and institutional factors. Sustainable timber trade is anchored on these foundations with a clear symmetrical distribution of impacts. For instance, while trade, forest management and overall environmental policy interact to control for production, harvest and marketing of timber, the prevailing infrastructure, exchange rate and prices at the market provide an incentive for the subsector to respond. Wunder (2005) notes that the long-run macroeconomic fluctuations may affect timber production levels, with competiveness having a significant impact on logging.

Market destination therefore matters, especially for primary commodities (Cadot et al., 2011; Al-Marhubi, 2000). The extent of export diversification may depend upon the type and number of commodities derived from forests and included in the export mix. While export diversification can be vertical, horizontal or cross-sectoral , recent developments of increased trade with China and Asian tigers on the backdrop of historical economic and political relationship between African states and the EU would mean more geographic diversification. Geographical diversification is aimed at stabilizing exports, spread out risks and opportunities so as to cushion against demand and supply fluctuations in foreign markets (Agosin et al 2012; Mejía, 2011; Shepherd, 2010). More importantly, diversification of timber exports between geographically distinct markets is expected to contribute to better export revenues.

Government policies and strategies on investment, taxation, and trade may similarly influence timber exploitation and management. The existing forest policy is thus as important as the trade policy. The depletion of forest and the noticeable effects of deforestation are likely to affect agricultural activities (Gbetnkom, 2005). Given its historical and contemporary importance, trade volumes have been studied in recent past by examining economic theories relating to market competitiveness, price convergence and trade facilitation. Market based factors are important determinants of export performance of developing countries (Kolo and Tzanova 2017; Jordaan and Hinaunye. 2011; UNCTAD 2005). UNCTAD (2005), for instance, highlight the importance of both demand and supply-side factors, and note that trade barriers continue to be of significance to effectively exploit export opportunities.

provides a legal basis to promote innovation and the transfer of technology, both of which are particularly relevant to natural resources as new technologies open frontiers for exploration and promote more efficient use of natural resources" (WTO, 2010).

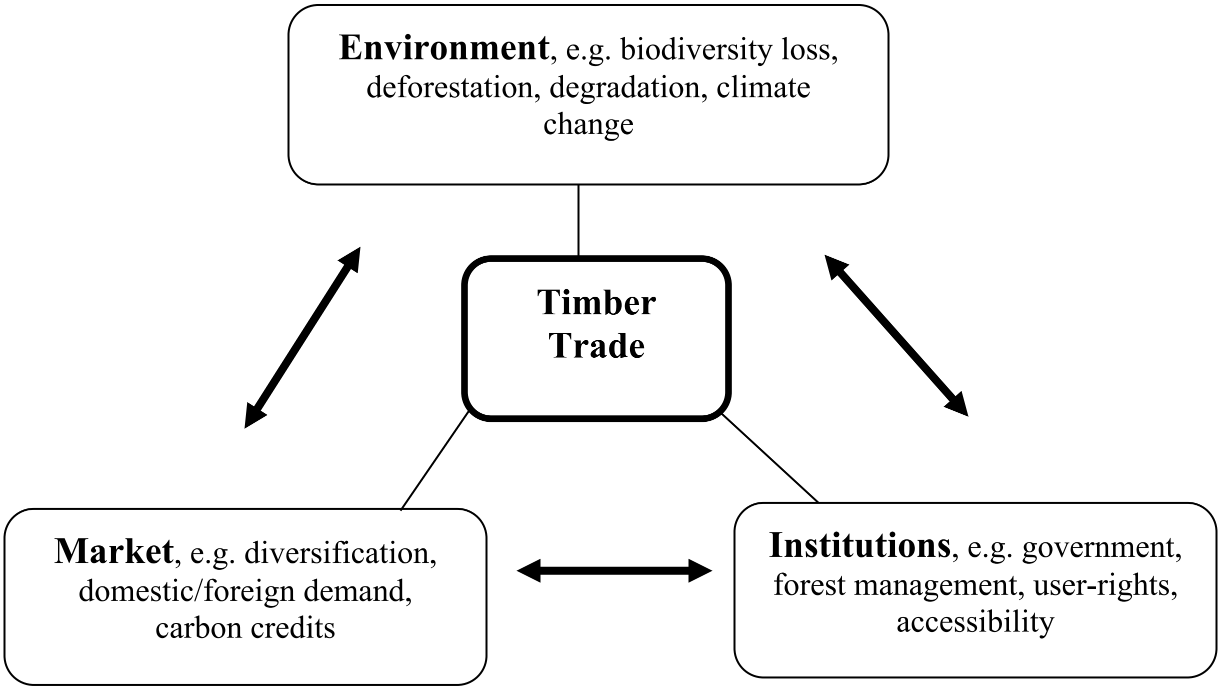

Figure 5: Simplified depiction of interactive factors influencing timber trade management

Trade in timber is complicated further since it has no specific treatment under the WTO. A range of self-reinforcing factors would therefore delineate the volume of timber trade and the response of the subsector (Alison, 2015; Alemagi and Kozak, 2010; Gbetnkom 2009; Wunder, 2005). Cameroon like Nigeria and Ghana has traditionally depended on a few primary export products including timber and mineral resources as the mainstays of its economy. On analyzing the factors influencing the exports of timber in Nigeria, Yusuf and Edom (2007) find that changes in export quantities can be determined by domestic-international price ratio, and domestic output-consumption ratio, amongst other factors. These findings are similar to Kolo and Tzanova (2017), Song et al, (2011), Hansen and Lund (2011), Nanang (2010) and Wunder (2005).

The interaction of environment, market and institutions to influence the terms of export would require properly managing taxes and fees, royalties or other terms of payment for timber as well as policies for alternative uses and marketing of products e.g. export taxes, incentive for domestic processing and rebates on royalties. Forest conservation as an environmental goal can therefore be achieved through trade barriers (Schwerhoff and Wehkamp, 2018; Barbier, 2000; Kasimbazi, 1996). These economic instruments will condition the access to forest resources and exert controls over the allocation for specific uses thus influencing decisions on the levels of production and the markets served (Alemagi and Kozak, 2010; ITTO, 2005; Benhin and Barbier, 1999).

3.2 Modeling Timber Export Supply

This study adopts a partial equilibrium analysis to examine Cameroon's roundwood export determinants, with the variable selection supported by previous studies (Schwerhoff and Wehkamp, 2018; Nanang, 2010; Solberg et al 2010; Alemagi and Kozak, 2010; Karsenty et al 2008; Gbetnkom, 2005; Mertens, 2000). Some studies on trade patterns have employed the gravity model to predict bilateral trade flows based on the distance between countries and the interaction of the countries' economic sizes (Duan et al., 2022; Egger et al., 2022; Anderson and van Wincoop, 2003). Its strengths, notwithstanding, the model is not used in this study because of inherent limitations to the capacity to capture the long-term dynamics in trade creation. Colonial trade relations are possibly endogenous to trade flows, with endogeneity having effects on the gravity-based estimates. While the gravity model explains the increase or decrease in bilateral trade flows, however, it is limited in explaining the substitutions between flows that may characterize timber commodity trade. In other words, the intuitive gravity model may not efficiently account for multilateral trade diversion and the associated structural dynamics in the transaction and trade costs in the timber subsector.[3] In this study, we employ an expedient modelling approach that uses historical data points to generate accurate results, efficient for analysis and sufficient for forecasting and predicting the future.

Assuming timber exports are represented in terms of the end product market, the model accounts for a complex set of interactions, including production capacity, a derived demand function and a log supply function. The timber supply function (Q_{RWt}) is represented by:

$$Q_{RWt} = g(P_{st}, Inv_t) \tag{1}$$

Where P_{st} is the price of stumpage and Inv_t is the total timber inventory. The objective of the timber supply is to determine the path of timber prices and harvests that maximize the net present value of net surplus:

$$Max \sum_{0}^{T} \rho^t \left\{ \int_0^{Q_{RWt}} D_t(n)dn - C_t \right\} \tag{2}$$

where Dt (Q_{RWt}) is the derived demand function for industrial wood volume Q_{RWt} harvested in period t, and C_t is the cost involved with harvesting and transporting timber to markets in each period. The dynamic optimization model endogenously determines forest management. However, the current analysis seeks to consider policy questions, rather than to simply predict market behaviour, so we undertake a partial equilibrium analysis and estimate separately the timber supply recognizing that the total timber supply in any period must equal to the derived demand. The following general model of timber roundwood exports therefore represents the aggregate implicit supply function for this study:

[3] The GM takes no account of comparative advantage, close ties may be by accident rather than direct causation, and in the advent of globalization and economic integration, geographical distance to export timber tend to matter less due to improvements in transport and communications. More importantly African states such as Cameroon tend to have more trade with South East Asia which offer more scope for growing trade than Europe and USA of comparative distances. In other words, while the GM successfully reproduces the volume of trade between connected countries, it only predicts the interaction with homogeneous topology, thus failing to reproduce the highly heterogeneous structure in modern day international trade network (see Almog et al., 2019).

(3) $$E_{RWt} = \mathrm{f}(\mathrm{Q}_{RWt}, \mathrm{P}_{RWt}, \mathrm{LAE}_t, Z_t)$$

where f is a functional form that relates roundwood export (E_{RWt}) in a particular time period, the roundwood export price (P_{RWt}), LAE_t is the forest area, and other factors (Z_t) that may influence supply. Z_t may include trade relate infrastructure and other economic variables, as well as government policies so that Eq. 1 now includes:

(4) $$E_{RWt} = \mathrm{f}(\mathrm{Q}_{RW\,t}, \mathrm{C}_{RW\,t}, \mathrm{P}_{RW\,t}, \mathrm{Ps}_{t,} \mathrm{DV}_t, \mathrm{LAE}_t, \mathrm{R}_t, \mathrm{T}_t, \mathrm{F}_t, \mathrm{Y}_t, \mathrm{U}_t, \mathrm{G}_t, \mathrm{V}_t)$$

where E_{RWt} represents annual export supply of roundwood in cm^3 in year t, Q_{RWt} is output of roundwood in cm^3, C_{RWt} is domestic consumption in cm^3, P_{RWt} is the export price in US$ in year t, Ps_t is the world price in US$ of substitute product in year t, DV_t captures trade diversion measured as the ratio of volume of exports to Asia to that of the European Union, LAE_t is the land area for major tree species harvested, R_t is the average exchange rate against the US$ in year t, T_t is export taxes for timber in year t, F_t is the infrastructure (e.g. road – km tarred), Y_t is the trade weighted income of the country's six main timber trading partners, U_t captures illegal timber exports[4], G is dummy for forest management regulations,[5] V may represent a dummy for policy which takes a value of 0 from 1961–2000 and 1 from 2000.[6] It is expected that the price of substitutes P_{st} will also influence exports. Hence, the price of substitutes e.g. metals (steel, aluminum, etc.) may influence the level of roundwood exports. The signs of the first-order partial derivatives may take the form:

$$\frac{\partial E_{RWt}}{\partial Q_{RWt}} > 0; \frac{\partial E_{RWt}}{\partial C_{RWt}} < 0; \frac{\partial E_{RWt}}{\partial P_{RWt}} > 0; \frac{\partial E_{RWt}}{\partial P_{st}} < 0; \frac{\partial E_{RWt}}{\partial DV_t} > 0; \frac{\partial E_{RWt}}{\partial LAE_t} > 0; \frac{\partial E_{RWt}}{\partial R_t} < 0; \frac{\partial E_{RWt}}{\partial T_t} < 0, \frac{\partial E_{RWt}}{\partial F_t} > 0; \frac{\partial E_{RWt}}{\partial Y_t} > 0; \frac{\partial E_{RWt}}{\partial U_t} < 0$$

Economic theory suggests a positive correlation between the supply for a commodity and its price. For example, high timber prices increase the quantities that would be exported from Cameroon. Similarly, better infrastructure, higher relative demand from Asian countries, increase in area harvested of major species and incomes in importing countries may stimulate increased exports. On the contrary, increase in the prices of substitutes, higher exchange rates, higher export taxes, higher domestic consumption levels, and increased illegal exports may have a negative correlation with export receipts. The higher the inventory level, the higher the growth and the lower the harvest cost, which implies a positive effect on timber production (Brännlund et al. 1985, Binkley 1987, Bolkesjø et al. 2010; Wunder, 2005). We may expect a positive effect of the interest rate on supply since increasing interest rate increases the opportunity cost of holding trees (Bolkesjø et al. 2010). The implicit empirical model for Eq. 2 is assumed to be log-linear as follows:

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[4] A proxy for illegal harvest and trade deals is generated by comparing information from the COMTRADE database of reported timber imports from Cameroon by the country's trading partners and computing the difference from the declared exports from Cameroon.

[5] The dummy variable takes 0 for 1960 – 1994 accounting for old forest regime and 1 for 1995 – 2020 when the forest law came into force.

[6] The dummy is used for the impacts of policy initiatives, i.e., currency devaluation, changes in timber pricing and taxation, and partial log export ban.

(5) $$\ln E_{RW\,it} = \beta_0 + \beta_1 \ln Q_{RW\,it} + \beta_2 \ln C_{RW\,it} + \beta_3 \ln P_{RW\,it} + \beta_4 \ln Ps_{it} + \beta_5 \ln DV_{it} + \beta_6 \ln LAE_{it} + \beta_7 \ln R_{it} + \beta_8 \ln T_{it} + \beta_9 \ln F_{it} + \beta_{10} \ln Y_{it} + \beta_{11} \ln U_{it} + \beta_{12} G_t + \beta_{13} V_t + u_{it}$$

where ln indicates the natural logarithm of the variables, so that β_1 to β_{13} are the partial elasticities of exports with respect to the explanatory variables.

The data used for this study is time series in nature, we therefore subject it to time series econometric analysis. This gives opportunity to use past observations and make predictions about future patterns. Time series cointegration econometric methods are employed, in line with Zhang et al (2017), Song et al (2011); Nanang (2010), and Tambi (1998) to review and evaluate which factors better explain roundwood export volumes. Cointegration naturally arises in time series economic data, and is most often associated with input-output models that imply equilibrium relationships between time series variables. For instance, a timber harvest model implies cointegration between volume of harvests, the effort and forest density, with volume of harvest being the common trend. The error correction model (ECM) representation of the levels VAR(p) is then employed to test for cointegration and to estimate cointegrating vectors as described by Kolo and Tzanova (2017) and in the seminal proceedings of Johansen (1988). The ECM of eq. (5) allows for a drift term μ in the VAR process (see e.g. Song et al, 2011; Nanang, 2010; Baillie and Bollerslev, 1994).

The equation of the nonlinear error correction model for roundwood is specified as follows:

(6) $$\Delta \ln E_{RW_t} = \alpha_0 + \sum_{t=1}^{m} \alpha_1 \Delta \ln E_{RWt-m} + \sum_{t=1}^{n} \alpha_2 \Delta \ln Q_{RWt-n} + \sum_{t=1}^{p} \beta_1 \Delta \ln C_{RWt-p} + \sum_{t=1}^{s} \beta_2 \Delta \ln LAE_{t-s} + \sum_{t=1}^{q} \beta_3 \Delta \ln \frac{P_{RW_{t-q}}}{Ps_{t-q}} + \sum_{t=1}^{r} \beta_4 \Delta \ln R_{t-r} + \sum_{t=1}^{s} \beta_5 \Delta \ln Y_{t-1} + \delta ECM_{t-1} + \mu_t$$

The ECM in eq. (6) links the long-run equilibrium relationship implied by cointegration with the short-run dynamic adjustment mechanism thus making the concept of cointegration useful for modeling bio-economic time series.

3.3 Source of Data and Trends in Roundwood Exports

Secondary data is employed covering the period 1960-2020. Information for Cameroon on timber harvest as well as Land use Area (e.g. Forest area), Forest stock, Annual harvest, domestic consumption as well as annual change in forest stock per hectare is obtained from the Food and Agriculture Organisation (FAO) database (FAOSTAT) and statistical accounts of the Ministry of Forestry and Wildlife. Information on Forest density and unit export value are computed from the International Tropical Timber Organisation (FAOSTAT and ITTO).[7] The world price is obtained from the ration of export value to the export quantity

[7] The data for raw-log exports are as defined by the Standard International Trade Classification (SITC) which the United Nations uses in the compilation and comparison of trade statistics, for commodity

(export unit value, \$/m3). Information on Income per capita (GDP_{ct}), exchange rate and rate of discount are obtained from the PENN World Tables. Information for Cameroon on Road infrastructure and income of trading partners are obtained from the World Bank database. Information on timber export taxes are obtained from the Ministry of Finance. Table 1 shows the summary statistics of forest related variables studied. On average over a 60-year period the forests covered 22.6 million ha, the total volume of wood in forests 130 m^3 ha, timber production 2.5 billion cubic metres with roundwood production almost 2 billion cubic metres. Of these, 1.42 billion cubic metres worth of roundwood was exported. Summarily, the roundwood exports have steadily trended upwards following the adoption of the tenets of sustainable forest management. It is evident that the positive growth in production is affected by difficulties in exports since the early 2000s. Policy improvements since 2010 has contributed to the revival of the export market, as captured in figures 1 and 2, respectively.

Table 1. Summary statistics for forest related variables 1960 - 2020

Variable	**Mean**
Forests covered (10^6 ha)	22.6
Total volume of wood in forests (m^3/Ha)	130.0
Timber production ($10^6 m^3$)	2.52
Roundwood production ($10^6 m^3$)	3.56
Roundwood exports of ($10^6 m^3$)	1.42
Roundwood imports of ($10^6 m^3$)	0.77
Wood-based panels export production ($10^3 m^3$)	83.0
Wood-fuel consumption ($10^3 m^3$)	8.23
Domestic consumption of roundwood ($10^6 m^3$)	2.23

Note: Main commercial species include Ayous (*Triplochiton scleroxylon*), sapelli (*Etandrophragma cylindricum*) and azobe (*Lophira alata*), frake (*Terminalia superba*) and iroko (*Milicia/Chlorophora excelsa*, *Milicia/Chlorophora regia*) they represent 75% of Cameroon's timber production.

4. Results and Discussion

On testing the extent to which prices, exchange rate and transport infrastructure have positive response to timber export supply they are shown to be significant. The land area for major tree species harvested, export taxes for timber, the economic conditions in importing countries as well as government forest management regulations are similarly revealed to be important in the long-run. These factors adjust to balance roundwood export. , possibly having both a long-term and a short-term element. Our challenge is to identify what element of a change in these factors is part of the long-term pattern, and which part is a short-term change. We therefore present the long-run and short-run results from the econometric experiment.

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groupings which reflect the materials used in production, the processing stage, market practices and uses of the products, the importance of the commodities in terms of world trade, and technological changes.

Long Run Effects for Roundwood Exports

The determinants of roundwood exports examined included production levels, domestic consumption, world price of roundwood, price of substitutes, trade diversion volumes, land area for major tree species, exchange rate, taxes for timber, road infrastructure, income of trading partners, illegal timber exports, forest regulations and some policy measures. First, we test the potential long-run effects in the long-run equilibrium relationships implied in equation (6). As noted in table 2 from Ordinary Least Squares (OLS) regressions, there are significant correlations between export of roundwood and these explanatory variables. The dynamic OLS estimators of roundwood export quantities are observed to have the expected signs in conformity with economic theory. The results show that market forces do influence Cameroon's roundwood export. Prices have a significant positive effect on timber export supply. The quantity of roundwood harvests, infrastructure and incomes of importing countries have the expected positive signs. In accordance with *a priori* expectation, the price of roundwood is positively signed, while domestic policy reform is not negatively signed as expected. There is a positive relationship between forest area and volume of roundwood exports, as well as an expected negative relationship from illegal exports.

The land area worth of major wood species harvested is a positive and significant driver of long-term roundwood exports. This is employed as a proxy to capture the reliance on important yet fewer species of trees in the export basket from Cameroon to its trading partners. This would imply significant pressure on the forests and threats to biodiversity (Laurance and Arrea, 2017; Hooper, et al., 2012). Such intensive logging is a serious issue, requiring government policies and actions that better regulate timber exploitation for its ecosystem services of carbon sinks, storm protection, and biodiversity and water filtration. Cameroon and its trading partners are Parties to the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). While some species have been listed as protected under CITES Appendix II, there is need to be proactive and avoid endangerment (Albrecht et al., 2021; Hooper et al., 2012). The positive sign associated with LAE would therefore require adequate policy response, which limits timber exploitation from fewer species.

Table 2: Long Run Regression of Roundwood Exports

Variables	Coefficients	t-statistics	Probabilities
Constant	0.7091	3.5451**	0.0002
$\ln Q_{RW\,t}$	0.4211	1.7432*	0.0015
$\ln C_{RW\,t}$	-0.3612	-2.6371**	0.0009
$\ln P_{RW\,t}$	0.0693	1.4829*	0.0013
$\ln Ps_t$	0.2702	1.1993	0.0016
$\ln DV_t$	0.3214	1.7601*	0.0008
$\ln LAE_t$	0.0732	1.9325**	0.0006
$\ln R_t$	0.1805	1.5991*	0.0003
$\ln T_t$	-0.0287	-1.3519*	0.0000

$\ln F_t$	0.0420	1.8731**	0.0001
$\ln Y_t$	0.1359	2.3091*	0.0000
$\ln U_t$	-0.0046	-1.1972	0.0001
G_t	-0.0097	-1.6368*	0.0000
V_t	0.0083	1.7710*	0.0000
Diagnostic tests: Adj. R^2 = 0.6731 F-stats = 209.131; DW = 1.9372; χ^2_{auto} (B-G) = 0.7714 (0.5791); χ^2_{norm} (JB) =1.5172 (0.8625); χ^2_{RESET} = 1.3411 (0.2643); χ^2_{white} white = (2.7315) 0.056			
Notes: χ^2_{RESET} is the Ramsey test for omitted variables; χ^2_{auto} is the Breusch-Godfrey LM test for autocorrelation; χ^2_{white} is the white test for heteroskedaticity; χ^2_{norm} is the Jarque-Bera normality test; * and ** indicate statistical significance at the 5% and 1% level, respectively.			

With regards to government's role on roundwood exports, the elasticity of supply with respect to forestry regulation and government policy were both statistically and economically significant. This finding indicates that government could thus play a significant role by improving the investment climate. These observations highlight the elastic response of government's market and non-market based regulatory measures. For example, the challenges associated with timber exploitation have driven Cameroon and other countries in the central Africa sub-region to ban export of the raw timber logs, commencing with a transitional period for more studies on the opportunities associated with wood processing. If the log ban takes effect, the economic and social gains may be far-reaching albeit with challenges, stimulating export markets for value-added timber products.

Short-run ECM for Roundwood Exports

Given the time series nature of the data employed to address the objectives of the paper, it is important that the data series have similar statistical properties and overall behavior over time, i.e. the mean, variance and autocorrelation structure do not change over time. Secondly, we therefore employ the Augmented Dickey Fuller (ADF) and Phillips-Peron (PP) unit root testing procedures on both level and first difference, to determine whether the individual series are stationary and exhibit similar statistical properties, without accounting for a structural break. As reported in table 3, in general, the ADF and PP tests confirm the obvious finding that the economic time series are not possibly I(0) (Banerjee et al., 1993). While land area for major tree species harvested (LAE_t) and the infrastructure (F_t) are level stationary at I(0), the price of substitute products (P_{st}), trade diversion (DV_t), export taxes (T_t) and illegal timber exports (U_t) achieved stationarity after second difference, that is, (I(2). However, output (Q_{RWt}), domestic consumption (C_{RWt}), export price (P_{RWt}), exchange rate (R_t) and trade income (Y_t) were only stationary after differencing implying they are integrated of the first order, I(1).[8] In nutshell the differenced series are found to be significant at the critical values, which allows their use in the estimation of the ECM.

Table 3: Augmented Dickey Fuller and Phillips-Peron Unit Root Test

Variables	ADF Test			PP Test		
	Test Statistic	P-Value	Remark	Test Statistic	P-Value	Remark
$\ln Q_{RW\,t}$	-6.3244	0.0021**	I(1)	-6.0152	0.0021**	I(1)
$\ln C_{RW\,t}$	-5.1631	0.0000*	I(1)	-5.0766	0.0000*	I(1)
$\ln P_{RWt}$	-4.2857	0.0001**	I(1)	-4.1963	0.0001**	I(1)
$\ln Ps_t$	-3.7422	0.0000*	I(2)	-3.1562	0.0000*	I(2)
$\ln DV_t$	-2. 9380	0.0000*	I(2)	-2.7291	0.0000*	I(2)
$\ln LAE_t$	-2.7165	0.0000*	I(0)	-2.5074	0.0000*	I(0)
$\ln R_t$	-3.1640	0.0000*	I(1)	-3.1182	0.0001*	I(1)
$\ln T_t$	-2.6781	0.0001*	I(2)	-2.4196	0.0000*	I(2)
$\ln F_t$	-2.5592	0.0000*	I(0)	-2.0471	0.0000*	I(0)
$\ln Y_t$	-6.1314	0.0012**	I(1)	-6.2536	0.0012**	I(1)
$\ln U_t$	-2.8273	0.0000*	I(2)	-2.6354	0.0001*	I(2)
**Significant at 1%. * Significant at 5%						

Furthermore, the Zivot–Andrews unit root tests with endogenous structural break detection is applied. Failure to allow for an existing break leads to a bias which may reduce the ability to reject a false unit root null hypothesis (Schmidt and Schweikert, 2021; Perron, 1989). We acknowledge the deficiency of the ADF and PP unit root tests in their potential confusion of structural breaks in the series as evidence of non-stationarity, whereby they may fail to reject the unit root hypothesis if the series have a structural break. We exploit the opportunity to either test for a known exogenous structural break in the ADF tests or an endogenous structural break with unknown date (Emirmahmutoglu et al 2021). In line with De Assis Paiva and Sáfadi (2021) and Waheed et al (2006), we pursue the Zivot and Andrews (1992) and Perron (1997) proposal to determine the break point endogenously. The Zivot and Andrew unit root test together with the break-date for each time series are presented in Table 4. According to the results we may reject the null of unit root for trade diversion (DV_t), species harvested (LAE_t), the infrastructure (F_t) and illegal timber exports (U_t) at significance levels of testing. However the test fails to reject the unit root hypothesis for export taxes (T_t), domestic consumption (CRW_t), exchange rate (R_t) and trade income (Y_t). The test similarly identifies endogenously the point of the single most significant structural break in the series

[8]The p-values of the ADF and PP test statistic show that all unit root test results are significant either at the 1% or 5% level.

examined. The results confirms a structural break in 1994. This establishes that the data may not remain the same throughout the period under study, and to estimate the interactive relationships of wood exports while accounting for structural stability we use a dummy variable for the break period (Narayan & Popp, 2013; Altinay & Karagol, 2004)). This then allows for the use of a single regression model fitted over the entire data set.

Table 4: Zivot and Andrews structural break test			
Variables	**Lag length**	**t-statistics**	**Break year**
$\ln Q_{RW\,t}$	[3]	-6.2371 ***	1994
$\ln C_{RW\,t}$	[1]	-4.8397*	1994
$\ln P_{RWt}$	[3]	-5.0254*	1994
$\ln Ps_t$	[3]	-5.3721**	1994
$\ln DV_t$	[1]	-2.6801	1994
$\ln LAE_t$	[2]	-3.8143	1994
$\ln R_t$	[5]	-6.2581***	1994
$\ln T_t$	[1]	-4.8326*	1994
$\ln F_t$	[0]	-3.2285	1994
$\ln Y_t$	[2]	-7.0914***	1994
$\ln U_t$	[1]	-3.0925	1994
The critical values for Zivot and Andrews test are -5.57, -5.08 and -4.82 at 1 %, 5 % and 10% levels of significance respectively. *** denotes statistical significance at 1% level. ** denotes statistical significance at 5% level. * denotes statistical significance at 10% level.			

The Johansen (1988) procedure is then used to determine the number of possible cointegrating relationships among roundwood timber exports. This is important to establish if there is a correlation between the factor series in equations (3) and (4), and whether any two or more non-stationary series are integrated. We use this test to identify the degree of sensitivity of any two variables to the same average conditions over a specified period of time. Table 5 reports the maximal eigenvalue test statistics for the hypothesis of k = 0 against the alternative of k+1 cointegrating vectors. The maximal eigenvalues show that there is one cointegrating equation at the 5% critical levels. It therefore means that the null hypothesis (k = 0) of not having a co-integrating equation is rejected and the alternative hypothesis of having at least one (k = 1) is accepted. Engle and Granger (1987) showed that cointegration implies the existence of an error correction model (ECM) that describes the dynamic behavior of the input-output variables under study.

Table 5: Number of co-integrating Vectors				
Hypothesis		Eigenvalue	Test statistics	5% critical value
Null	Alternative			
$K = 0$	$K \leq 1$	0.93	78.67*	75.45
$K \leq 1$	$K \leq 2$	0.41	46.28	53.72
$K \leq 2$	$K \leq 3$	0.33	35.19	42.85
$K \leq 3$	$K \leq 4$	0.14	18.36	29.46
$K \leq 4$	$K \leq 5$	0.07	6.19	13.29
*Significant at 5% critical level				

We undertake the granger causality analysis to gain an understanding of causal linkages between the principal variables influencing roundwood timber exports. This allows us to determine whether past values of the variables help to predict changes in other variables. Table 7 indicates the pairwise Granger Causality between the selected variables, together with the F-statistics and p-values. The results suggest that there exists a causal relation between the lagged values of timber exports and the other factors, thus increasing our ability to predict future response of timber exports. The test reveals that wood harvest, wood consumption, species harvested and price of timber can Granger cause timber exports and vice versa, thus indicating that there is a bidirectional causality in the case of Cameroon's tropical timber exports. On testing the directions of causality between timber exports and exchange rate no causality is found.

Table 7: Granger Causality Analysis		
Null Hypotheses	**F-statistics**	**P-value**
Wood Harvest does not Granger cause Timber Export	5.0162	0.0053***
Timber Export does not Granger cause Wood Harvest	4.3759	0.0016***
Wood Consumption does not Granger cause Timber Export	2.6893	0.0432*
Timber Export does not Granger cause Wood Consumption	3.2867	0.0189*
Species Harvested does not Granger cause Timber Export	4.3625	0.0074***
Timber Export does not Granger cause Species Harvested	2.7562	0.0243**
Price of Timber does not Granger cause Timber Export	4.8546	0.0037***
Timber Export does not Granger cause Price of Timber	3.6721	0.0401**
Exchange Rate does not Granger cause Timber Export	0.9438	0.8852
Timber Export does not Granger cause Exchange Rate	1.3629	0.5836
Superscripts ***,** and * indicate rejection of null hypothesis at 1%, 5% & 10% level of significance.		

We therefore proceed finally to estimate the short-term interactive effectives on roundwood exports, given that there are at least one cointegrating equation. Table 5 provides the details of short run results estimated from the nonlinear ECM by seemingly unrelated regressions (SUR). The lag-length were estimated using the Akaike information criterion. Supplementary tests with the Schwartz Bayesian Information Criterion also confirms the lag length. To avoid the problem of multicolinearity, the world price of timber and that of its substitute are replaced by a relative price ratio. The ratio captures the income effect, for the change in export of timber with respect to the change in the relative price compared to that of its substitute. This gives an indication if the supply for timber may be affected as it becomes either more or less lucrative relative to other goods in the market. The results demonstrate that change in roundwood supply in Cameroon is positively influenced by stocks of export, produced quantities, domestic consumption, relative price[9], exchange rate and income of the country's trading partners. For instance, the positive coefficients of 0.1703, 0.2507 and 0.0938 for lagged export volumes, production quota and for ratio of prices indicate that a 1 % change would increase roundwood exports by about 0.1703, 0.2507 and 0.0938%, respectively. The positive coefficients of 0.0305 and 0.0459 for lagged exchange rates and income of importing countries, indicating that a 1% change would increase roundwood exports by about 0.0305 and 0.0459%, respectively. On the other hand, the results show that a 0.0175% decline in roundwood exports in the current period is significantly linked with a 1% rise in domestic consumption of the previous periods.

The land area worth of major wood species harvested is similarly positive and appears to be a significant driver of short-term roundwood exports. This finding is instructive of the short-term effects of the use of sophisticated methods of harvest contributing to overharvesting and overexploitation to meet the expanding markets and increasing demand. The elasticity response value of 16.15% seems high indicting that overharvesting of timber for extended periods of time may grow revenue yet deplete this resource and prevent recovery in the short-term. This brings with it associated challenges such as threats to biodiversity, habitat fragmentation, and habitat destruction.

When the interaction of factors were studied to gauge the response of timber exports, the results as shown in table 6 reveal stronger and significant response. The findings of the current study are robust, corroborating similar experiences. These results bring to fore the broad issues of environmental management, for countries like Cameroon with precarious economy yet specialized in primary commodity exports. With weak political institutions, such countries do face difficulties combatting deforestation. There is, however, a silver lining for better policy directives. For instance, Eisenbarth (2017) reveal that trade measures can supplement environmental policy. For example, tax rates could be set to discourage export of raw timber logs. While recognizing government's stewardship for the economy and the environment, Tumaneng-Diete (2005) established that trade policy via log export restrictions can control for sustainable forest management. For instance, a partial ban on log exports as well as trade policies directed at the exportation of logs may mitigate deforestation problems. Some studies assert that log export ban may be used to enhance the efficiency and competitiveness of the wood processing industry . This lends support to the prescriptions to ban or limit the export of raw logs from the sub-region. The

[9] The removal of price distortions, promotion of market incentives, and relaxation of other constraints generally are expected to contribute to both economic and environmental gains. Unintended adverse side effects may occur, however, when economy-wide reforms are undertaken while other neglected policy, market or institutional imperfections persist. According to Brandon et al (1993), "the expansionary impacts of currency devaluations, tariff liberalization, and reduction of real interest rates may be most directly and adversely felt in natural resource use, especially in the forestry and fishery sectors."

dummy for 1994 is significant, thus indicating that timber export growth may have been constrained partly by the implementation of structural adjustment since the mid-1990s.

Overall, the results reported in table 6 are therefore robust, as indicated by the primary and secondary diagnostic tests. The ECM parameter (μ_{t-1}) for the lagged error term is found to be negative yet significant, indicating the existence of a long-run relationship between the variables. The results indicate that about 53.272% of the change in Cameroon's timber supply is attributed to disequilibrium. Importantly, the ECM of -0.5327 enters with a small correct sign (negative and tending to -1) indicating that the speed of adjustment to equilibrium is high, concluding that, *ceteris paribus* , Cameroon's roundwood export indicators do not cointegrate and the ECM pushes the timber economy back to equilibrium at a high rate. According to the tests for normality of residuals, serial correlation, heteroskedaticity, and misspecification of functional form applied to the ECM, there is non-significant evidence of departure from standard assumptions, thus the empirical validity of the model is confirmed.

Table 6: Short-run Results for Cameroon's Roundwood Export (Dependent Variable = $\Delta \ln E_{RW_t}$)

Variables	Coefficients	t-statistics	Prob-value
Constant	0.1531	1.9505**	0.0001
$\Delta \ln E_{RWt-2}$	0.1703	2.1783**	0.0001
$\Delta \ln Q_{RW\,t-3}$	0.2507	3.8263**	0.0000
$\Delta \ln C_{RW\,t-1}$	-0.0175	-1.3892	0.0001
$\Delta \ln LAE_{t-2}$	0.1615	3.3421**	0.0000
$\Delta \ln P_{RWt-3} / P_{s_{RWt-3}}$	0.0938	1.8133*	0.0002
$\Delta \ln R_{t-5}$	0.0305	1.5963*	0.0004
$\Delta \ln Y_{t-2}$	0.0459	2.5726**	0.0002
$\Delta \ln E_{RWt-2} \ln Q_{RWt-3}$	0.1942	3. 2161**	0.0000
$\Delta \ln Q_{RW\,t-3} \ln R_{t-5}$	0.4001	2.9152**	0.0000
$\Delta \ln Y_{t-2} \ln P_{RWt-3} / P_{s_{RWt-3}}$	0.1630	3.0863**	0.0001
D_{1994}	1.3491	2.1559**	0.0001
ECM (μ_{t-1})	-0.5327	-4.4013**	0.0005

Diagnostic tests:
Adj. $R^2 = 0.5939$; F-stats = 99.6643; DW = 1.953;
χ^2_{auto} (B-G) = 1.8861 (0.1804); χ^2_{norm} (J-B) = 0.3771 (0.92155);
χ^2_{RESET} = 0.0006 (0.5732); χ^2_{white} white = 0.3175 (0.8391)

Notes:

χ^2_{RESET} is the Ramsey test for omitted variables;
χ^2_{auto} is the Breusch-Godfrey LM test for autocorrelation;
χ^2_{white} is the white test for heteroskedaticity;
χ^2_{norm} is the Jarque-Bera normality test;
* and ** indicate statistical significance at the 5% and 1% level, respectively.

Export Geographic Diversification and Market Access

Roundwood timber exports to EU and Non-EU country markets may be associated with efforts to manage volatility of export earnings, productivity growth and the terms of trade (ToT). Export diversification is expected to lower ToT volatility and shocks. Diversification proxied by export volume to geographic destination of partner countries is tested in this study to establish the relationship for timber export performance by destination market. In table 7 we disaggregate the data and compare the roundwood timber exports to EU and non-EU destinations. Since the UNCTAD (2020) trade figures demonstrate that Europe is Africa's largest export market followed by China, the USA and India. This may be so since most African countries enjoy duty-free and quota-free access to the EU market, due to the Economic Partnership Agreements (EPAs) or the Everything-But-Arms (EBA) scheme. The comparative estimates in table 6 show that export diversification to EU is positive and significantly determined by previous exports, timber prices, and income. On the contrary, non-EU exports is more significantly driven by volume of timber production and the interaction of production and export volumes in previous years. The ECM parameter indicates that the change in Cameroon’s timber supply to EU is attributed to lower disequilibrium (39.10%) as compared to non-EU markets (64.25%).

The land area for major wood species harvested is positively significant for roundwood exports destined for both EU and non-EU markets. However, the results in table 7 show a stronger response is observed for the non-EU market. This may be capturing the burgeoning market of timber into the Far East, particularly to China. There are trepidations that China’s glut for primary materials such as timber from Africa may be unhealthy to biodiversity and ecological stability (Yang et al., 2021; Ascensão et al, 2017). The results call for proactive policy measures. The CITES timber listings of threatened species include some of the wood occurring in the international trade of tropical timber species from Cameroon, e.g. *Diospyros spp, Prunus africana,* and *Pterocarpus* spp. Managers of the forest sector would therefore have to be vigilant, since overexploiting such resources not only threatens the resource being harvested but can directly impact the growing population in the domestic market that depend on these forests for life sustaining goods and services.

The analysis of key drivers of export diversification are informative, particularly as export supply for wood products are projected to increase at a steady rate in most of Europe, especially as Eastern European countries and emerging economies may have a more substantial impact in terms of developments in international timber markets. The non-EU market for timber export is dominated by the Asian market led by China. The development of the Chinese economy positions China as one of the world’s major wood importers. These factors thus examined may plausibly affect future trade flows, and encourage diversification to different destinations. If the barriers are significant enough in these markets, exporters may attempt to switch supplies to alternative markets, and importers would in turn be forced to switch to alternative sources of supply to meet their requirements. Overall, government intervention in trade – through tariffs, subsidy schemes, or phytosanitary measures, for example – can have the effect of disrupting the link between exports in the different regions. While income and non-income determinants e.g. market access proxied by bilateral and multilateral trading arrangement, are shown as drivers for diversification, unilateral trade reforms as in domestic policies can be positive on timber exports.

Table 7: Estimation results for export diversification
(Dependent Variable = $\Delta \ln E_{RW_t}$)

	Exports to EU			Exports to non-EU		
Variables	**Coefficients**	**t-statistics**	**Prob-value**	**Coefficients**	**t-statistics**	**Prob-value**
Constant	0.2661	1.9832*	0.0000	0.2735	1.8889*	0.0001
$\Delta \ln E_{RWt-2}$	0.1057	3.0947**	0.0000	0.1840	2.1577*	0.0000
$\Delta \ln Q_{RW\,t-3}$	0.2815	2.9065*	0.0000	0.3023	3.7246**	0.0000
$\Delta \ln C_{RW\,t-1}$	-0.3042	-1.4005	0.0002	-0.2615	-1.5873	0.0001
$\Delta \ln LAE_{t-2}$	0.1464	2.5703*	0.0000	0.2377	2.7631*	0.0000
$\Delta \ln P_{RWt-3} / P_{s_{RWt-3}}$	0.2352	3.7263**	0.0001	0.1806	1.6945*	0.0000
$\Delta \ln R_{t-5}$	0.0461	1.6801*	0.0002	0.0574	1.6539*	0.0001
$\Delta \ln Y_{t-2}$	0.0527	3.6803**	0.0001	0.0606	2.4152*	0.0001
$\Delta \ln E_{RWt-2} \ln Q_{RWt-3}$	0.2581	2. 9741*	0.0000	0.2933	2. 6351**	0.0000
$\Delta \ln Q_{RW\,t-3} \ln R_{t-5}$	0.5304	2.8786*	0.0000	0.3201	2.3489*	0.0001
$\Delta \ln Y_{t-2} \ln P_{RWt-3} / P_{s_{RWt-3}}$	0.2071	2.9980*	0.0000	0.1658	2.5631*	0.0000
D_{1994}	1.1652	2.2684**	0.0001	1.0387	1.9999**	0.0001
ECM (μ_{t-1})	-0.3910	-3.5724**	0.0006	-0.6425	-2.9347**	0.0004
Diagnostic tests:	Adj. R^2 = 0.5327; F-stats = 111.0251; DW = 1.8420; χ^2_{auto} (B-G) = 1.9365 (0.1726); χ^2_{norm} (J-B) = 0.4255 (0.8341); χ^2_{RESET} = 0.0007 (0.5954); χ^2_{white} white = 0.4609 (0.9582)			Adj. R^2 = 0.6125; F-stats = 99.3720; DW = 1.9743; χ^2_{auto} (B-G) = 1.87443 (0.1905); χ^2_{norm} (J-B) = 0.4762 (0.9624); χ^2_{RESET} = 0.00075 (0.6108); χ^2_{white} white = 0.4957 (0.8863)		

Notes:
χ^2_{RESET} is the Ramsey test for omitted variables;

χ^2_{auto} is the Breusch-Godfrey LM test for autocorrelation;
χ^2_{white} is the white test for heteroskedaticity;
χ^2_{norm} is the Jarque-Bera normality test;
* and ** indicate statistical significance at the 5% and 1% level, respectively.

Overall, the results reveal that logging for economic gain should be coherent across a set of macroeconomic, trade, sectoral, and financial policies. The extent to which timber can freely be traded into export markets, is clearly influenced by some market and non-market factors. Broadly, the findings of the current study corroborate others on export research e.g. Schwerhoff and Wehkamp (2018), Eisenbarth (2017), Jordaan and Hinaunye (2010), Solberg et al (2010), Tumaneng-Diete (2005) and Wunder (2005). For instance, some studies including Jordaan and Hinaunye (2010) found that importer's GDP and population have a positive effect on exports of wood products, while exporters GDP has a negative impact on the exports of wood products.

The implications of the current results are therefore instructive for both forest and trade policies. This and previous studies thus confirm that forests are a possible two-way street in realizing the SDGs. Forests management can therefore enhance as well as mar the realization of the SDGS, with attendant losses. Forests are an overlooked and undervalued asset in the struggle to achieve these goals. Moving forward and ensuring that timber production continues to play an important role in the economic development of the state by tapping into its economic good, it will be imperative that policies support the ecologically-efficient use and transformation of such natural resources.

Cameroon's forests which are part of the Congo-basin commons, could play significant roles in avoiding emission of greenhouse gases (GHGs). Cameroon has the opportunity to global climate change abatement via different policy measures and strategies such as the Kyoto Protocol and decisions on reducing emissions from deforestation and forest degradation in developing countries (REDD+), the UN Convention on Biological Diversity and the Strategic Plan for Biodiversity 2011–2020, and the Global Partnership on Forest Landscape Restoration (IPBES 2019). More importantly, policy efforts should promote regulation which ensures that roundwood and their derivatives are used in commercial trade only if they are presented with a Protected Plant Permit or documentation from CITES, an Import or Export Permit or Re-Export Certificate, and imported or exported through designated ports.

5. Conclusion

This paper examines the determinants of roundwood exports from a Congo basin member country Cameroon, which allows for the plausibility of contributing to the debate in prescribing solutions to both export growth and sustainable development. The study addresses the timber trade portfolio which caters for environmental factors as transformative action to conserve forests, promote sustainable trade and development policies, while increasing financial incentives towards sustainable land use transition. In selecting valuable hard-wood, timber exploiters in the country rely on few species. With this type of selective exploitation, much of the timber is limited to less than six species, although nationally there are many species. Cameroon being party to the Convention on International Trade in Endangered Species, is mandated to monitor and restrict international trade in species that are threatened. However, institutional challenges for market regulations, particularly effective law enforcement have plagued sustainable forest management. Logging is mostly economic and less of environmental concerns.

With Cameroon being a price-taker in the global timber and related product trade, there is increased propensity to source for new better markets especially into Asia away from the traditional EU market. This trade diversion is itself characterised with facilitation, market entry and access challenges, but also receptive to illegal logging, smuggling and disrespectful to environmental conventions. Increase in primary forest produce, better investment in the forest sector, value addition and diversification in the species base could accompany increase in export volumes. However, challenges exist in terms of prices, market conditions and information asymmetry. This is reinforced by the constraints in roundwood export such as dearth of infrastructure (e.g. road transport, port handling and logistics, communication infrastructure), access to trade finance, market access (tariffs and quota arrangements of trading partner), custom procedures and associated institutions. These forces against supply and trade facilitation are strong enough to eclipse rising opportunities from the increasing demand for timber in the lucrative EU and non-EU markets. Overall, these results highlight the need for countries in the Congo basin such as Cameroon to take concrete steps to secure forest assets by engaging in economically-smart-exploitation which controls deforestation and combats the climate crisis in the spirit of COP26.

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The data used for this study shall be made available upon reasonable request.

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