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RESEARCH ARTICLE

Does Pesticide Regulation Impact the Export Competitiveness of Major Global Cocoa Producers?

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Abstract

Several methods are used to evaluate competitiveness, but the non-inclusion of quality measures, despite their importance in international product markets, gives less credence to such assessments. This study evaluates export competitiveness in the cocoa sector from the context of pesticide regulations. Such regulations are now increasingly common, due to their perceived benefits for humans, animals, and the environment. The results of our study show that cocoa-exporting countries stand to derive more earnings if standards are harmonized at the Codex level. Adherence to international standards, as reflected in large standard-scaled trade values, enhances competitiveness: yet compliance capacity must be matched with a sustainable increase in output for higher competitiveness. In addition to stepping up advocacy for the adoption of the Codex standard or its variants, cocoa-exporting countries need to diversify into different markets to balance quality and quantity requirements for improved earnings.

Keywords SPS measure · Competitiveness score · Cocoa producers · Public standards

JEL Classification C23 · F14 · Q17

1 Introduction

The successful reduction in tariffs championed by the World Trade Organization (WTO) has shifted the attention of food importers and agricultural producers to non-tariff measures (NTMs) to mitigate the influx of substandard products (Rickard & Lei, 2011). Sanitary and phytosanitary (SPS) measures, which include pesticide regulations, have witnessed increased usage over time, as seen by the exponential rise in notifications at the WTO over the last few decades (Maria de Almeida et al., 2012; Swinnen, 2016). The importance of such measures stems from increased usage, since they enhance trade through changes in consumer tastes and preferences in importing countries, in addition to their significance for protecting humans, animals, and the environment from food contamination (Kareem, 2013, 2014). Increased income levels and an associated high degree of social awareness

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are fueling demand for products that conform to certain standards (UNCTAD, 2007; Boza, 2013; Ferro et al., 2013).

Globally, there is increased awareness regarding the reduction or outright elimination of pesticide use, given its deleterious effects on health (Drogué & DeMaria, 2012; Wei et al., 2012). In response to this, cocoa-importing countries have implemented strict regulations on the chemical contaminants absorbed by cocoa beans, either during production or in storage. As such, these counties have stipulated levels of active ingredients (the maximum residue level, MRL) of pesticides found in the beans. This is also applicable to physical contaminants such as stones and dirt. Cocoa beans that do not meet the stated criteria are considered low in quality and are treated accordingly.

Cocoa (*Theobroma cacao*) is an important export crop native to South America. It is now produced in diverse humid regions around the world. Its significance stems from usage in beverages, confectionery, and pharmaceuticals (UNCTAD, 2016). At present, Africa is the leading cocoa-producing continent in the world (Fig. 1), with the West African subregion producing 70% of the world's cocoa and supplying 90% of the cocoa in the European Union (Crozier, 2013; Wessel & Quist-Wessel, 2015). Major world suppliers include Nigeria, Cote d'Ivoire, and Ghana (West Africa), as well as Cameroon (Central Africa). Indonesia is also a major player, ranking third in world production after Cote d'Ivoire and Ghana, and followed by Nigeria and Cameroon (see Figs. 2 and 3). Table 1 shows production and export volumes for the major exporters. Most cocoa from these major suppliers is exported as beans (whole or broken, raw or roasted) and usually ends up in European markets where it is processed, mainly into chocolate (CBI, 2016).

Pesticide application is the most common method of controlling pests and diseases on cocoa farms due to its efficacy (Asogwa & Dongo, 2009) and even during storage at the point of export. The need to maintain a balance between productivity and health concerns with pesticides usage (Afrane & Ntiamoah, 2011) has led governments in cocoa-exporting countries to institute regulatory frameworks for dealing with the issue of agrochemicals in their respective domains. The policies of exporting countries regarding pesticide use play an important role in product quality in the sector.

In Cote d'Ivoire, representatives from different ministries formed the Inter-departmental Committee on Pesticides (established through Decree 89–02). This committee is statutorily mandated to supervise the manufacturing, sale, and use of pesticides. The Pesticides Control and Management Act (Act 528) of 1996 is still in operation in Ghana to regulate agrochemical procurement and usage through the Cocoa Research Institute in Ghana (CRIG) (an arm of the Ghana Cocoa Board (COCOBOD), which is tasked with the responsibility of screening pesticides) and the National Pesticides Technical Committee (USAID/WCF, 2012; Akrofi et al., 2013). In Nigeria, the National Agency for Food and Drug Administration and Control (NAFDAC) oversees issues related to the regulation of pesticides and other chemicals, and is backed by the Drug and Related Products Act No. 19 of 1993. However, the Cocoa Research Institute of Nigeria (CRIN) approves pesticides for use on cocoa farms. In Cameroon, the National Commission on Certification of Plant Protection Products and Equipment Certification meets to approve agrochemicals for sale by registered outlets in the country (USAID/WCF, 2012).

Many works have been written on both SPS standards and competitiveness as these pertain to international agricultural trade, but there is a dearth of literature on the relation between pesticide regulation and competitiveness. This paper assesses competitiveness from food safety and quality perspectives by looking at major global cocoa producers in the context of global pesticide regulations. Specifically, we use trade values from individual importers' standard points and trade values under harmonized standards as a springboard

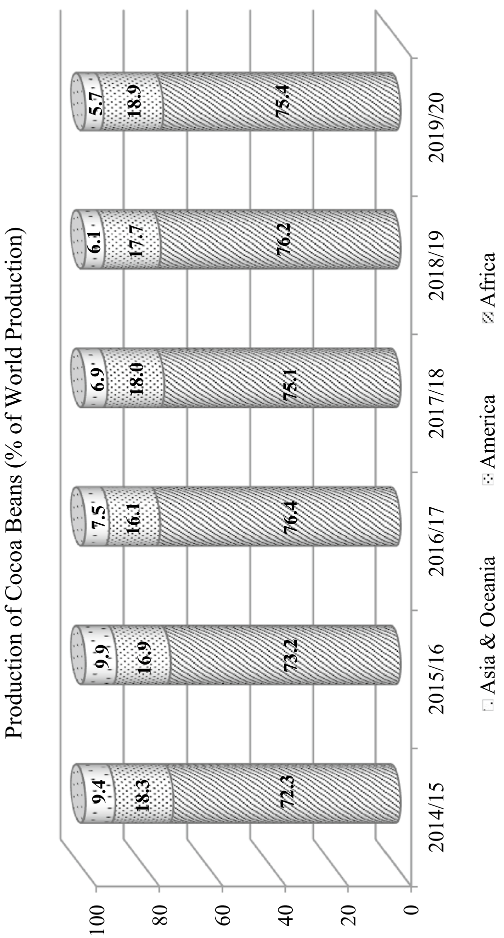


Fig. 1 Shares of cocoa exports from producing continents. Source: ICCO (2018–2021)

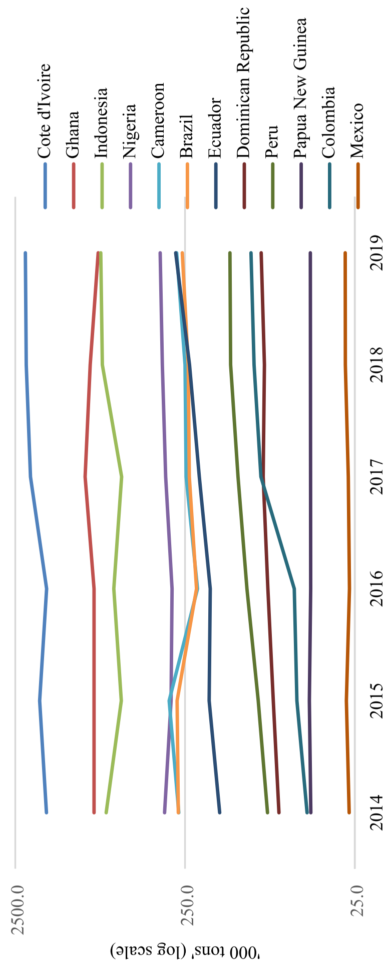


Fig. 2 Global cocoa production ranking. Source: FAOSTAT (2021)

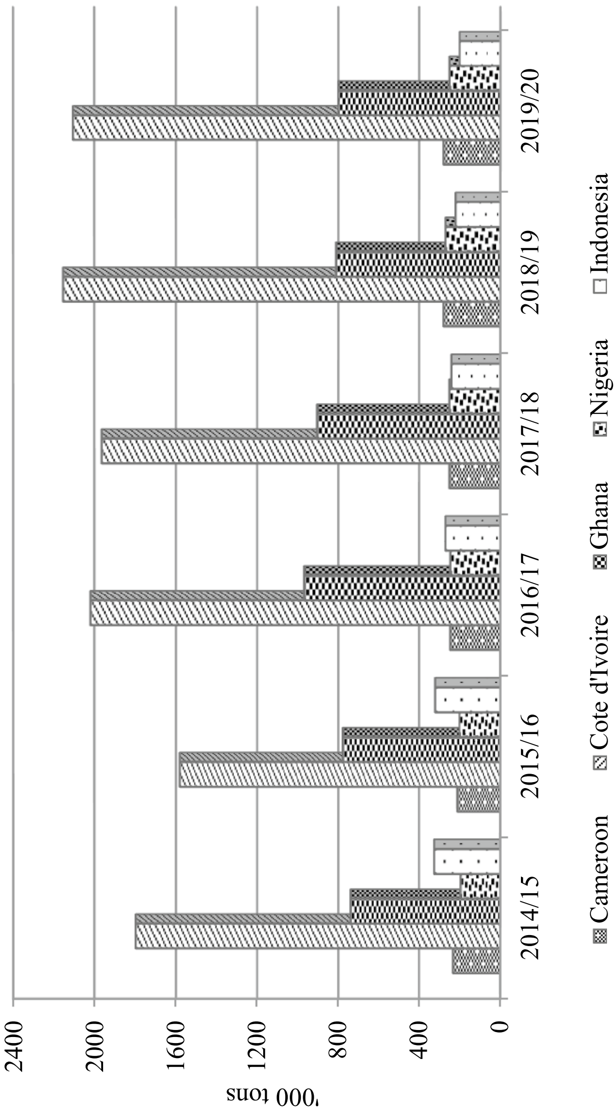


Fig. 3 Cocoa production volume from main exporting countries. Source: ICCO (2018–2021)

Table 1 Values of production and exports for major cocoa exporters (in thousands of US dollars); Source: FAOSTAT (2021)

	Cote d'Ivoire		Ghana		Indonesia		Nigeria		Cameroon	
	Production	Export	Production	Export	Production	Export	Production	Export	Production	Export
2005	1286.3	991.0	740.0	535.3	748.8	367.4	441.0	267.7	140.0	163.7
2006	1408.9	925.1	734.0	589.2	769.4	490.8	485.0	189.5	164.6	168.2
2007	1229.9	803.9	614.5	506.4	740.0	379.8	360.6	174.9	212.6	131.1
2008	1382.4	782.9	680.8	474.7	803.6	380.5	367.0	227.3	229.2	178.1
2009	1223.2	917.7	710.6	395.7	809.6	439.3	363.5	247.0	235.5	194.0
2010	1301.3	790.9	632.0	281.4	844.6	432.4	399.2	226.6	264.1	193.9
2011	1511.3	1073.3	700.0	697.4	712.2	210.1	391.0	219.0	240.0	190.2
2012	1485.9	1011.6	879.3	585.9	740.5	163.5	383.0	199.8	268.9	173.8
2013	1449.0	813.9	835.5	526.2	720.9	188.4	367.0	182.9	275.0	179.9
2014	1637.8	1117.0	858.7	747.6	728.4	63.3	329.9	190.0	272.0	192.6
2015	1796.0	1286.0	858.7	572.6	593.3	39.6	302.1	200.0	310.0	237.4
2016	1634.0	1055.6	858.7	581.4	656.8	28.3	298.0	227.5	211.0	263.7
2017	2034.0	1510.1	969.3	573.3	590.7	23.6	325.0	288.0	246.2	221.7
2018	2154.4	1525.6	904.7	843.6	767.3	27.8	340.0	294.7	249.9	236.1
2019	2180.0	1621.7	811.7	643.6	784.0	30.5	350.1	299.6	280.0	310.6

to assess the competitiveness of exporters, thus showcasing the importance of adhering to cocoa quality standards. Assessing competitiveness from the perspectives of safety and quality is important for several reasons. These two characteristics have a serious effect on product prices. Not adhering to the stipulated quality can lead to 'discounting,' whereby low prices are offered for cocoa beans. In some instances, cocoa can be outright rejected, with the attendant loss in revenue for the affected country. The level of safety of a product and its quality also drive consumer preferences in the international produce market. Furthermore, using a baseline (harmonized) standard as a major component to assess competitiveness puts exporters on an equal and appropriate footing for comparison. The study thus sets out to answer the following research question: What is the level of competitiveness of the cocoa sector in different major exporting countries based on trade scenarios with individual and harmonized standards?

We here establish that the effect of pesticide regulation on trade is positive. Harmonized standards were found to be largely desirable for major cocoa-exporting countries and should be advocated. Exporting countries stand to benefit from the high-end market if standards are harmonized at the Codex level, the internationally agreed limit. Furthermore, the high standard-devolved cocoa trade values obtained by playing in a premium market enhance competitiveness. The results also point to the fact that, although high supply capacity is desirable, this should be coupled with the ability to comply with quality requirements, and the focus should not be solely on the trade volume.

The rest of the paper is structured as follows: Sect. 2 gives the background to the key concepts, Sect. 3 states the theoretical and conceptual frameworks, Sect. 4 presents the methodology and describes the data, Sect. 5 discusses the results, and the paper ends with a conclusion in Sect. 6.

2 Harmonization of Standards and Export Competitiveness

Part of the effort made on the global scale to reduce complaints regarding product quality involves finding a common ground on the nature of standards that will apply to food and agricultural products. The Codex Alimentarius Commission (CODEX) was jointly established by the Food and Agriculture Organization (FAO) and the World Health Organization (WHO) to take care of standards, quality, and safety at a global level. However, the differences in production, technology, and demographics of individual countries dictate the type and nature of quality standards across countries, with the implication of unrestricted variation in the number and stringency of standards that developing countries must abide by when exporting commodities to developed nations (Chen et al., 2008; Wilson & Otsuki, 2001). Harmonizing export standards is crucial because it can foster regional and economic integration, in contrast to the complexity that heterogeneity brings for policy treatment in the export sector (Engler et al., 2012). Heterogeneous standards are costly considering their multi-faceted impact in terms of additional production and transaction costs, and they result in inefficient production because they cannot benefit economies of scale as a result of segregated markets. Heterogeneous standards are also costly to governments from the perspective of divided support for exporters producing for different markets (Foletti & Shingal, 2014). At the macro-level, the loss of efficiency associated with complying with varying importing countries' standards can be an impediment to trade that stands in the way of a true assessment of export competitiveness.

Economics is about the allocation of scarce resources among unlimited wants, a realization that guides researchers to focus on a sector of the economy that will bring maximum welfare benefits to people (Latruffe, 2010). The concept of competitiveness is practically similar. Although there is no agreed-upon definition of competitiveness owing to its expansiveness and multidimensional nature, it could be defined as the capability of a country to supply goods and services that meet local and international quality, quantity, and price requirements, ultimately leading to improved social welfare (Latruffe, 2010; Zmuda & Czarny, 2017).

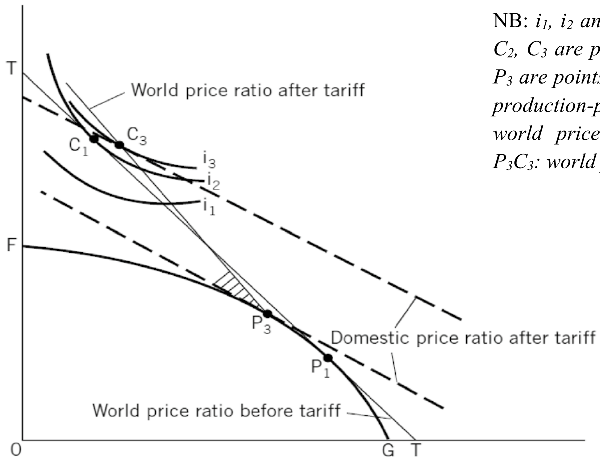
Competitiveness in international trade borders can be understood according to comparative advantage theory in which factor endowments, location, and scale effects determine how countries tap into dividends of integration, and this is reflected in product pricing (Latruffe, 2010; UNCTAD, 2008). Since competitiveness is here defined as the ability to meet with market requirements, competitiveness in terms of SPS measures then signifies the extent to which a country can better price its products based on its level of compliance to quality standards. Competitiveness in this context indicates the extent to which an exporting country conforms to the set of SPS rules governing international trade. The higher the competitiveness, the better the capacity for compliance. Applying this to the cocoa trade, competitiveness is built upon the ability of exporting countries to monitor quality requirements in cocoa production and storage.

Harmonization is much desired in the assessment of competitiveness in this regard. The variance in the number and stringency of standards that exporters need to deal with is associated with negative consequences, such as a poor assessment of competitiveness. With consideration given to harmonization, countries are better off if they are placed on an equal footing, because differing market conditions often preclude a true reflection of individual strengths. The ability to create competitively advantaged situations for primary exports, for example through investment in the extensive use of agricultural input and engagement in strong policy-making, quickens the pace towards development (OECD, 2013).

3 Theoretical and Conceptual Frameworks

This study is built upon the Heckscher–Ohlin theory of trade. The theory aptly explains a situation where the factor endowment of a country differs from a worldwide factor endowment pattern and provides a coherent framework upon which other approaches can be built (Dunn & Mutti, 2004). The theory is applicable to the trade of a primary product like cocoa between exporting countries, where weather conditions are suitable for its production, and importing countries, where it is not grown. Heckscher–Ohlin theory can be extended to analyze the effect of sanitary and phytosanitary (SPS) measures, such as pesticide regulations, through *tariffication*.

Figure 4 provides a theoretical example of the effect of tariffs imposed by an importing country when they are sufficiently large to influence world prices. The figure shows that the importing country enjoys improved terms of trade because the trading line changes from TT (whose slope gives the world price ratio) to P_3C_3 (the production–consumption line). Thus, welfare improves from free trade as the country produces at P_3 and consumes at C_3. This analysis is extended to the effect of SPS standards on cocoa trade thus: SPS measures drive a wedge between the price of cocoa in the supplier's market (the world price) and the higher domestic price paid by consumers in the global market occasioned by the introduction of the standard. The importing countries absorb a considerable amount of cocoa;



NB: *i_1, i_2 and i_3 represent indifference curves; C_1, C_2, C_3 are points on the consumption frontier; P_1, P_3 are points on the production frontier; FG is the production-possibility curve; TT is the line of world prices; P_1C_1: world price before tariff; P_3C_3: world price after tariff.*

Fig. 4 Effects of tariffs in a general equilibrium for a large (importing) country. Source: Dunn and Mutti (2004) therefore, any imposition of such a measure likely affects supply and price, which makes a large-country case applicable to the analysis.

Conceptually, this study focuses on the supply and demand sides of the cocoa trade. On the supply side, pesticide regulations and other government policies affect chemical usage in cocoa production and storage. Favorable policies without adequate regulation mean producers might use excess or unsanctioned pesticides, which can ultimately affect cocoa quality. Compliance with SPS standards through proper pesticide usage brings about market access. This, in turn, affects the competitiveness of exporters. Any cocoa-exporting country that abides by the requisite international regulations gets its product sold in the market and, moreover, at a premium price depending on the level of quality. Thus, the higher the revenue earnings borne out of the extent to which a country can meet with quality requirements, the higher the level of competitiveness. Furthermore, higher earnings give citizens improved welfare outcomes and the exporting country a better reputation (Kolavalli & Vigneri, 2011), which is one of the 'selling points' in the international produce market.

On the demand side, governments of importing countries issue regulations to safeguard humans, animals, and the environment, although sometimes with subtle protectionism. This protectionist intent might not be well pronounced in the case of cocoa, because the importers are mainly non-producers with unfavorable climates for growing cocoa in their respective countries. However, the key chocolate-making centers sometimes stock cocoa and engage in re-exporting. Apart from government action, consumers in importing countries are wary of foods being consumed because of their levels of nutritional awareness. They also have choices of disposition that are dictated by tastes and preferences and fueled by income levels. The actions of government and consumers directly or indirectly affect the stringency of standards in the international cocoa market because of the enormous power wielded by these two 'market agents'.

4 Methodology

4.1 Empirical Model

The gravity model was used to assess the effects of pesticide regulation on cocoa trade, since it remains the workhouse of empirical trade analysis, particularly with its theoretical backing that has been improved upon over the years (Bureau & Jean, 2013). Several models were tried within the gravity equation context, and Poisson fixed-effects regression was finally adopted for the study. This model takes care of over-dispersion issues related to zero trade, heterogeneity, and the small-sample problem, and it produces consistent estimates while at the same time aligning with results of the structural gravity model, especially in the presence of exporter and importer fixed effects (Westerlund & Wilhelmsson, 2009; Santos Silva et al., 2010; Philippidis et al., 2013; Fally, 2015; Honore & Kesina, 2015). Moreover, it was the best fit according to the results of regression specification (RESET) tests and other tests conducted on the models.

In its application to the estimation of the effect of NTMs (to which pesticide regulations belong), and adapting from Fugazza (2013), the gravity model can be specified as follows:

$$X_{sij,t} = \varnothing_{sij,t}\ln\left(1 + \mathrm{tar}_{sij,t}\right) + \gamma \mathrm{NTM}_{sj,t} + \beta' Z_{ij} + \rho' T_{ij} + fe_{si} + fe_j + fe_t + \varepsilon_{sij,t} \tag{1}$$

where $X_{sij,t}$ is the value of trade in product s between exporter i and importer j at time t; $\ln(1+\mathrm{tar}_{sij,t})$ is the log of tariff applied by country j on imports of product s from country i

at time t; $\mathrm{NTM}_{sj,t}$ is the NTM-related indicator applied by country j on product s at time t; Z_{ij} is the set of gravity variables for importers j and exporters i; T_{ij} is the set of other trade-related variables; Ø is the coefficient of tariff; γ is the coefficient from the NTM-related variable; β' is the vector of coefficients of gravity variables; ρ' is the vector of coefficients of other trade-related variables; fe_{si} is the exporting country fixed effect; fe_j is the importer fixed effect; fe_t is the time-specific fixed effect; and $\varepsilon_{sij,t}$ is the error term of the equation given product s traded between importer j and exporter i at time t.

The gravity model variables denoted by vector Z include exporter and importer GDPs, importer GDP per capita, distance, language, and colonial affinity. Other trade-related variables designated as T include productivity, exchange rate, trade openness, domestic stock, and relative prices. Stringency indices (STIs) are measures of pesticide regulations (SPS standards). They were generated based on the following equation from Ferro et al. (2013):

$$\mathrm{STI}_{ijct} = \frac{1}{N_{j(c)}} \sum_{n(c)=1}^{N(c)} \frac{\mathrm{MRL}_{\max.t} - \mathrm{MRL}_{jct}}{\mathrm{MRL}_{\max.t} - \mathrm{MRL}_{\min.t}}, \tag{2}$$

where STI_{ijct} is the stringency index for cocoa beans in importing country i concerning exporting country j in year t; $N_{j(c)}$ is the number of pesticides considered in exporting country j; MRL_{jct} is the exporting country j's MRL value for cocoa pesticides in year t; $\mathrm{MRL}_{\max.t}$ is the highest MRL value for cocoa in year t considering all importing countries in trading group, i.e., the least restrictive; and $\mathrm{MRL}_{\min.t}$ is the lowest MRL value for cocoa in year t considering all importing countries in trading group, i.e., the most restrictive.

The STI values were calculated for MRL values of regulated and commonly used pesticides, which were collected from the Homologa database for cocoa trade partners for each year. The calculated STI values were thereafter aggregated to generate the annual STI for each importing country concerning its exporting partner. This procedure was repeated for Codex MRL values to derive Codex stringency indices. The STI varies between 0 and 1, with 0 being the least restrictive and 1 being the most restrictive. The Codex STI values are common for all importing countries and were therefore used as the basis for harmonization.

The elasticities of standard variables (STIs) derived from the gravity equations were combined with values of trade to assess the cost effect of standards on exports in harmonized and non-harmonized scenarios. Following Wilson et al. (2003) and Chen et al. (2008), the cost effect is expressed as

$$\mathrm{dEX}_{ij}^{k} = \beta\left(\frac{EX_{ij}^{k}}{STI_{i}^{k}}\right)\left(\mathrm{STI}_{\mathrm{codex}}^{k} - \mathrm{STI}_{i}^{k}\right) \tag{3}$$

where dEX_{ij}^{k} is the change in the value of trade for cocoa beans from five exporting countries j to 19 importing countries i; β is estimated elasticity of standard for world trade, i.e., the coefficient of the stringency index variable; EX_{ij}^{k} is the value of trade between exporter j and importer i; STI_{i}^{k} is the importers' measure of the standard on cocoa; and $\mathrm{STI}_{\mathrm{codex}}^{k}$ is the baseline (international) measure of standard for cocoa.

Concerning the measure of export competitiveness, this study deviates from earlier methods by incorporating quality parameters into the variables of assessment and ranking the exporters through the variables. The countries were ranked based on three criteria: the export value at the level of individual importers' standards, the export value at the Codex level of standard, and the percentage change of individual values from Codex. Averages were taken to derive mean rank scores (Rs), which were then transformed into competitiveness scores (Cs). The relationship between Rs and Cs is given by

$$\mathrm{Cs} = 2\left[\frac{1}{(i + \mathrm{Rs})}\right], \tag{4}$$

where i is a discrete factor that takes values of 1 and above. It has the following two conditions: $\mathrm{Rs} > 0$ when $i = 1$; but if $\mathrm{Rs} < 0$, then $i > |\mathrm{Rs}|$. The second condition becomes necessary to be able to take the inverse of the rank score. The higher the Cs, the higher the level of competitiveness for any given exporting country. It is a relative measure with a maximum value of 1.

4.2 Data Type and Description

The data used in this study were sourced from local and foreign agencies. Data on cocoa trade values were collected from the International Trade Center (ITC) TradeMap; exporter GDP, importer GDP, GDP per capita, and tariffs were from the World Development Indicators of the World Bank; cocoa output, area harvested to cocoa, yield, domestic (producer) prices, and the exchange rate were from FAOSTAT; language, distance, and colonial relationship data were obtained from the Center for International Prospective Studies (CEPII); foreign prices of cocoa were from the Pink Sheet documents of the World Bank database, and trade openness values were from UNCTADStat. In addition, MRL values of regulated pesticides were from the Homologa database and the list of pesticides regulated in exporting countries was obtained from documents of national agencies in charge of cocoa regulation in the respective countries (e.g., the Cocoa Research Institute of Nigeria (CRIN) and the Cocoa Research Institute of Ghana (CRIG) and action documents of projects conducted by international agencies. An example of such an action document is the Pesticides Evaluation Report and Safer Use Action Plans (PERSUAP) by the United States Agency for International Development (USAID). Data from the various sources were harmonized in units of measurement with all datasets covering 2005–2016, as dictated by the available historical MRL data in the Homologa Agrobase-Logigram database. In addition, several tests were carried out on the variables to establish the nature of the relationships and to justify their suitability for inclusion. These included pairwise correlation tests, stationarity tests, and tests of the cointegration between trade values and stringency indices (STIs). Tables of the results are presented in the Appendix.

5 Results and Discussion

5.1 Effects of Pesticide Regulation on Cocoa Trade

The results of the analysis of the effects of standards on the value of cocoa trade are shown in Table 2. The results show that productivity, exporter GDP, importer GDP, the stringency index, and colonial affinity were positively related to the value of cocoa trade, while importer GDP per capita, tariff, distance, and language were negatively related to it. From the results, a 1% increase in the stringency index increased the trade value by 0.26%. The positive elasticity for the measure of the standard is in line with the findings of Crivelli and

Table 2 Parameter estimates of the determinants of the value of cocoa trade for different models

	Ordinary least square (OLS) regression		FGLS (homoscedastic panels; no auto-correlation)		Fixed-effects (FE) Poisson		FE negative binomial	
	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
Dep. var.: Value of trade	Coef. (Robust Std. Err.)	Coef. (Robust Std. Err.)	Coef. (Std. Err.)	Coef. (Std. Err.)	Coef. (Robust Std. Err.)	Coef. (Robust Std. Err.)	Coef (Std. Err.)	Coef (Std. Err.)
Productivity	1.980*** (0.510)	3.194*** (0.682)	1.980*** (0.508)	3.194*** (0.670)	1.282*** (0.339)	3.207*** (0.303)	0.791*** (0.158)	1.851*** (0.232)
Exporter GDP	1.509*** (0.509)	0.464 (0.566)	1.509*** (0.480)	0.464 (0.569)	0.678** (0.310)	0.446** (0.217)	0.669*** (0.155)	0.407** (0.186)
Importer GDP	2.910 (4.702)	6.850 (4.672)	2.910 (4.168)	6.850 (4.284)	3.197*** (0.505)	4.105*** (0.672)	−0.167 (1.301)	1.302 (1.359)
Importer GDP/capita	−3.583 (4.894)	−6.459 (4.818)	−3.583 (4.332)	−6.459 (4.375)	−3.587*** (0.585)	−4.340*** (0.704)	−0.111 (1.372)	−1.353 (1.407)
Stringency index	0.735 (0.578)	0.784 (0.618)	0.735 (0.600)	0.784 (0.624)	0.256* (0.147)	0.127 (0.200)	0.213 (0.193)	0.127 (0.195)
Tariff	0.477 (0.365)	−0.553 (0.456)	0.477 (0.379)	−0.553 (0.422)	−0.266*** (0.050)	−0.390*** (0.057)	0.164 (0.130)	−0.147 (0.139)
Distance	−2.641*** (0.188)	−2.641*** (0.183)	−2.641*** (0.216)	−2.641*** (0.214)	−1.187*** (0.070)	−1.202*** (0.070)	−1.177*** (0.060)	−1.204*** (0.059)
Language	−1.265*** (0.450)	−1.264*** (0.444)	−1.265*** (0.404)	−1.264*** (0.399)	−0.582*** (0.095)	−0.598*** (0.090)	−0.647*** (0.117)	−0.676*** (0.114)
Colonial affinity	2.127*** (0.546)	2.127*** (0.547)	2.127*** (0.584)	2.127*** (0.577)	0.313*** (0.111)	0.331*** (0.108)	0.188 (0.158)	0.179 (0.155)
Relative prices		−2.159*** (0.491)		−2.159*** (0.455)		−1.261*** (0.199)		−0.857*** (0.148)
Area harvested		1.593 (1.083)		1.593 (1.019)		2.364*** (0.193)		1.440*** (0.313)
Exchange rate		−0.880* (0.507)		−0.880 (0.542)		−1.153*** (0.235)		−0.516*** (0.169)

Table 2 (continued)

	Ordinary least square (OLS) regression		FGLS (homoscedastic panels; no auto-correlation)		Fixed-effects (FE) Poisson		FE negative binomial	
	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
Trade openness		0.836		0.836		0.251		0.007
		(0.759)		(0.731)		(0.346)		(0.259)
Domestic stock		−0.181		−0.181		−0.236***		−0.160***
		(0.123)		(0.128)		(0.031)		(0.036)
Exporter effects								
Cote d'Ivoire	7.747***	−0.263	7.747***	−0.263	3.775***	−2.550**	3.865***	0.220
	(1.678)	(2.332)	(1.565)	(2.355)	(0.980)	(1.131)	(0.510)	(0.787)
Ghana	7.896***	−3.595	7.896***	−3.595	3.295***	−7.900***	3.495***	−2.164
	(1.574)	(4.360)	(1.494)	(4.685)	(0.949)	(2.080)	(0.480)	(1.463)
Cameroon	4.474***	0.480	4.474***	0.480	2.922***	1.309	2.545***	1.663**
	(1.728)	(2.488)	(1.634)	(2.479)	(1.041)	(0.860)	(0.537)	(0.761)
Nigeria	2.306***	−3.123	2.306***	−3.123	1.585***	−3.280***	1.229***	−1.220*
	(0.520)	(2.171)	(0.560)	(2.273)	(0.550)	(1.092)	(0.189)	(0.699)
Importer effects								
Brazil	−6.642***	−2.209	−6.642***	−2.209	−1.800***	−1.036***	−3.816***	−2.603***
	(2.302)	(2.487)	(2.078)	(2.359)	(0.327)	(0.389)	(0.643)	(0.725)
Canada	3.085	11.960	3.085	11.960	5.080***	7.103***	−1.984	1.255
	(10.381)	(10.322)	(9.204)	(9.471)	(1.108)	(1.465)	(2.872)	(3.000)
China	−7.988	−10.265	−7.988	−10.265	−7.692***	−8.540***	−2.087	−3.475
	(7.459)	(7.296)	(6.645)	(6.628)	(0.987)	(1.092)	(2.106)	(2.138)
Estonia	10.358	33.069	10.358	33.069	14.654***	19.858***	−3.319	4.935
	(25.503)	(25.370)	(22.565)	(23.280)	(2.785)	(3.705)	(7.022)	(7.354)
France	0.214	6.619	0.214	6.619	2.407***	3.915***	−2.202	0.133
	(7.324)	(7.266)	(6.483)	(6.667)	(0.886)	(1.098)	(2.013)	(2.098)

Table 2 (continued)

	Ordinary least square (OLS) regression		FGLS (homoscedastic panels; no auto-correlation)		Fixed-effects (FE) Poisson		FE negative binomial	
	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
Germany	1.868	7.328	1.868	7.328	2.257***	3.570***	− 1.864	0.146
	(6.271)	(6.222)	(5.545)	(5.698)	(0.744)	(0.928)	(1.724)	(1.792)
Italy	− 0.419	6.499	− 0.419	6.499	2.178**	3.785***	− 2.889	− 0.417
	(7.724)	(7.682)	(6.849)	(7.059)	(0.896)	(1.136)	(2.127)	(2.220)
Japan	− 1.866	2.516	− 1.866	2.516	0.489	1.478**	− 2.481**	− 0.969
	(4.154)	(4.159)	(3.694)	(3.838)	(0.458)	(0.605)	(1.152)	(1.207)
Malaysia	5.845	16.795	5.845	16.795	5.911***	8.317***	-1.510	2.285
	(11.095)	(11.085)	(9.866)	(10.727)	(1.115)	(1.582)	(3.047)	(3.214)
Netherlands	7.844	19.404	7.844	19.40	9.081***	11.813***	− 0.713	3.649
	(13.751)	(13.639)	(12.166)	(12.490)	(1.520)	(1.948)	(3.791)	(3.950)
Poland	− 3.618	6.176	− 3.618	6.176	1.633	3.829***	− 4.582*	− 1.215
	(9.693)	(9.689)	(8.599)	(8.951)	(0.998)	(1.368)	(2.665)	(2.809)
Russian Fed	− 8.786**	− 3.261	− 8.786***	− 3.261	− 2.829***	− 1.795*	− 5.282***	− 3.642***
	(3.619)	(3.753)	(3.240)	(3.536)	(0.880)	(1.040)	(1.043)	(1.131)
Singapore	9.503	24.646	9.503	24.646	10.186***	13.778***	− 2.577	3.052
	(19.512)	(19.307)	(17.213)	(17.635)	(2.158)	(2.775)	(5.359)	(5.577)
Spain	1.755	9.837	1.755	9.837	2.994***	4.877***	− 2.719	0.188
	(8.874)	(8.822)	(2.484)	(8.115)	(1.023)	(1.318)	(2.438)	(2.548)
Switzerland	2.484	16.591	2.484	16.591	6.295***	9.605***	− 4.438	0.822
	(17.342)	(17.188)	(15.353)	(15.740)	(2.032)	(2.510)	(4.796)	(4.991)
Thailand	− 3.015	6.891	− 3.015	6.891	0.708	2.610**	− 3.703*	− 0.590
	(7.072)	(7.246)	(6.310)	(6.807)	(0.670)	(1.031)	(1.949)	(2.112)
United Kingdom	− 0.520	5.998	− 0.520	5.998	2.795***	4.346***	− 2.288	0.093
	(7.474)	(7.414)	(6.617)	(6.803)	(0.858)	(1.055)	(2.051)	(2.138)

Table 2 (continued)

	Ordinary least square (OLS) regression		FGLS (homoscedastic panels; no auto-correlation)		Fixed-effects (FE) Poisson		FE negative binomial	
	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
Belgium	7.549 (15.697)	20.888 (15.577)	7.549 (13.893)	20.888 (14.276)	9.386*** (1.753)	12.522*** (2.306)	−1.948 (4.332)	3.029 (4.517)
Constant	−57.049 (87.286)	−132.72 (85.69)	−57.049 (76.976)	−132.72* (77.89)			−0.985 (24.087)	−38.926 (24.887)
Log (pseudo-) likelihood			*−2966.01*	*−2952.81*	*−21,034.21*	*−18,716.82*	*−3816.70*	*−3787.83*
Wald chi^2			*1318.34*	*1375.95*	*6987.25*	*3548.04*	*2014.03*	*2239.74*
Prob > chi^2			*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*
RESET test								
Chi^2 Prob > chi^2			*1.56 0.2115*	*3.04 0.0813*	*0.60 0.4394*	*0.84 0.3585*	*14.34 0.0002*	*18.43 0.0000*

$N=1{,}140$, $n=12$, T = 19. Levels of significance: ***1%, **5%, *10%

Base variables: Indonesia (exporter) and the United States of America (importer)

The diagnostics for the OLS are as follows

Model (1): $F(31, 1108)=74.15$, Prob > $F=0.000$; R-squared = 0.5363; Ramsey RESET test $F(3,1105)=17.40$, Prob > $F=0.000$; Linktest = _hatsq, $t=0.98$, $P>|t|=0.325$; Mean vif = 522.92

Model (2): $F(36, 1103)=65.18$, Prob > $F=0.000$; R-squared = 0.5469; Ramsey RESET test $F(3,1100)=18.23$, Prob > $F=0.000$; Linktest = _hatsq, $t=1.39$, $P>|t|=0.166$; Mean vif = 510.90

Groschl (2012) and Shingal et al. (2017). Stringent market conditions acted as a catalyst rather than a clog in the wheel to trade because of gains attached to compliance with standards. In addition, trade values increased with increased productivity in exporting countries. This is intuitive since a higher yield means that more cocoa beans will be available for commercial exchange. However, an associated reality is that in most cocoa-exporting African countries, increased output has been linked to the loss of plant cover (Wessel & Quist-Wessel, 2015).

Furthermore, positive coefficients for both exporter and importer GDPs point to the fact that the bigger the trade partners, the more goods they are likely to exchange, cocoa beans inclusive. The imposition of tariffs and long distances are disincentives to trade. Consistent with this, the work of Philippidis et al. (2013) supports the negative elasticities of tariff and distance. Importer GDP per capita signifies the income level and implied ability of citizens in each country to pay for goods and services. The expectation is that increased GDP per capita in cocoa-importing countries should increase the value of cocoa for exporting countries. But this was not so in the results. A positive relationship might be found with respect to consumer goods that are taken directly by consumers. However, for a primary product like cocoa, which must undergo much processing and change hands multiple times before getting to the consumers, the relationship might not be direct.

Several models were tested for the gravity equation: random effects generalized least square (GLS) regression (which was picked with the Hausman test [chi2(6) = 8.63; Prob > chi^2 = 0.1956] but whose results were not significantly different from the OLS based on the Breusch–Pagan LM test [chibar^2(01) = 0.07; Prob > chibar^2 = 0.3983]); feasible GLS; fixed-effects (FE) Poisson regression; and FE negative binomial regression. For each of these models, two regressions were run. The first set of regressions involved only the traditional gravity model variables, while other variables were added for the second set of regressions. The FE Poisson regression model was ultimately selected based on the representativeness of the statistics, the fitness of the model, and the number of significant variables, among other reasons. Additionally, panel FE Poisson takes care of the overdispersion that is usually associated with disaggregated trade data. Great effort was made in the selection of appropriate model through tests and diagnostics to correctly determine the coefficient of the standard variable (STI) because of its importance for subsequent analyses.

5.2 Aggregate Trade Values and Standards Harmonization

Cocoa trade values at individual and harmonized standards, together with percentage changes from Codex, were estimated for each exporting country concerning the main cocoa-importing countries. This was done for the global cocoa trade using the coefficient of the STI variable from the gravity equation. The values were later aggregated for each exporting country. The results of this aggregation and the assessment of harmonization effects are presented in the following sub-sections. Summary statistics for the STIs and the changes from Codex are given in Annex 2.

5.2.1 Estimated Trade Values on Aggregate and Exporting Countries' Bases

Figure 5 shows aggregate trade values under different standard scenarios for the global cocoa trade and its sub-blocs of the EU and the rest of the world (RoW). This is disaggregated by exporting countries in Tables 3 and 4 to show the corresponding trade shares in the different market blocs. The dichotomization into the EU and RoW is a way

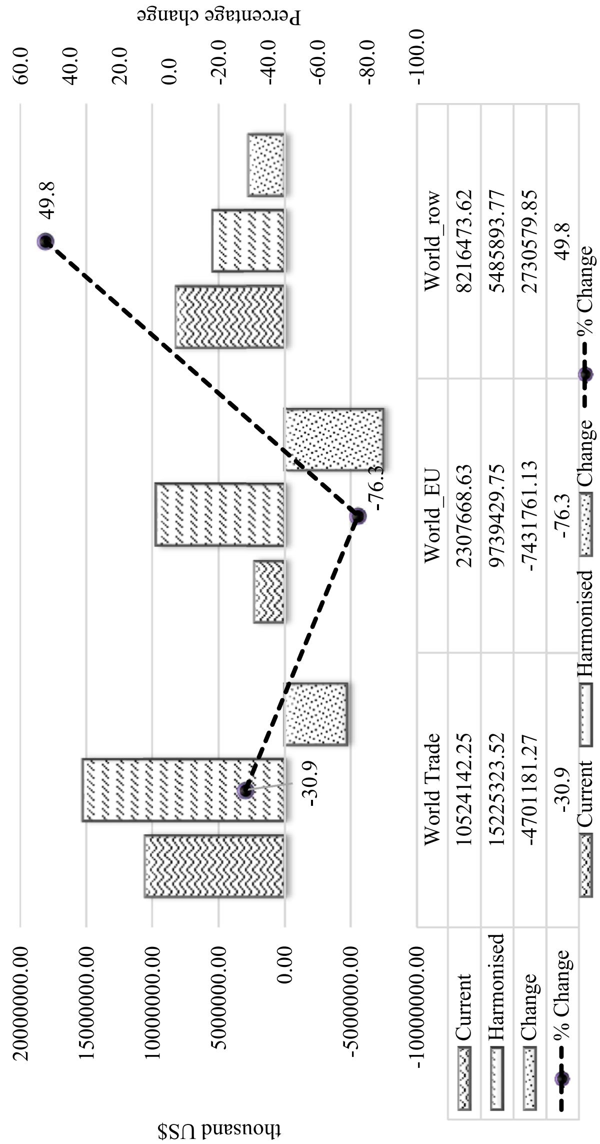


Fig. 5 Aggregate global trade values in different blocs

Table 3 Aggregate trade values in each market on the basis of an exporting country (2005–2016)

	Export value with importer standard ('000 US$)	Export value with Codex standard ('000 US$)	Change from Codex ('000 US$)	% change from Codex
World Trade				
Cameroon	260,545.61	1,407,641.17	−1,147,095.56	−81.5
Cote d'Ivoire	6,146,023.48	6,727,836.27	−581,812.79	−8.6
Ghana	2,131,786.81	3,570,622.44	−1,438,835.63	−40.3
Indonesia	1,084,897.63	1,674,947.18	−590,049.55	−35.2
Nigeria	900,888.72	1,844,276.46	−943,387.74	−51.2
i. EU bloc				
Cameroon	172,437.11	1,262,564.26	−1,090,127.15	−86.3
Cote d'Ivoire	1,130,833.51	4,402,916.99	−3,272,083.48	−74.3
Ghana	672,041.94	2,586,141.54	−1,914,099.60	−74.0
Indonesia	13,685.55	39,742.45	−26,056.90	−65.6
Nigeria	318,670.52	1,448,064.52	−1,129,394.00	−78.0
ii. RoW bloc				
Cameroon	88,108.50	145,076.91	−56,968.41	−39.3
Cote d'Ivoire	5,015,189.97	2,324,919.29	2,690,270.69	115.7
Ghana	1,459,744.87	984,480.90	475,263.97	48.3
Indonesia	1,071,212.08	1,635,204.73	−563,992.65	−34.5
Nigeria	582,218.20	396,211.94	186,006.26	46.9

Table 4 Share of cocoa trade in different markets for each exporter

	% of global cocoa trade (individual standards)	% of global cocoa trade (Codex standard)	Difference: Codex − individual
EU			
Cameroon	66.2	89.7	23.5
Cote d'Ivoire	18.4	65.4	47.0
Ghana	31.5	72.4	40.9
Indonesia	1.3	2.4	1.1
Nigeria	35.4	78.5	43.1
RoW			
Cameroon	33.8	10.3	−23.5
Cote d'Ivoire	81.6	34.6	−47.0
Ghana	68.5	27.6	−40.9
Indonesia	98.7	97.6	−1.1
Nigeria	64.6	21.5	−43.1
Total	**100.0**	**100.0**	

of examining the chances that the countries have if they intend to diversify into different markets in their export drives. The test of the difference of the mean was carried out on the major market variables to verify the justification of the division. The results of the test, presented in Annex 6 of the Appendix, are in the affirmative. The means of critical variables for the sub-sections were sufficiently different to warrant discussing each bloc separately.

i. Global trade: In Fig. 5, the estimated global cocoa trade value for the five major exporters within the period under review stood at $10.52 billion, with a projected increase to $15.23 billion had the standards been harmonized. The greater contribution to this increase was from the EU bloc, where, although the initial trade value was put at $2.31 billion, there was an expected four-fold increase in the trade value to $9.74 billion under the Codex regime. On the other hand, there was an expected decrease in the trade value from $8.22 billion to $5.49 billion for the RoW. These results suggest that a lowering of standards encouraged a shift of attention from lucrative to less-lucrative markets. Thus, far more gains were expected from the EU market (−76.3%) compared with a lower corresponding loss in earnings from the RoW (49.8%). When the global cocoa market was considered on the aggregate, there was a 30.9% gain under the Codex regime.

Disaggregating the global trade values by exporting countries (Table 3), Cote d'Ivoire had an estimated leading trade value of $6.15 billion between 2005 and 2016, considering the individual importers' standards. Harmonization at the Codex level would see this value jump to $6.73 billion, indicating a loss of 8.6% in revenue based on the existing standards. The existing deficit in trade earnings for Ghana stood at 40.3%. This is very significant concerning a higher percentage change in values for Cameroon and Nigeria, considering Ghana's initial trade value of $2.13 billion in the period under review. Comparing the percentage values for Cote d'Ivoire and Ghana, a lowering of standards from individual levels to the Codex level would have had a more positive effect on Ghana's earnings than on Cote d'Ivoire's earnings. Indonesia also had a projected earning deficit of 35.2%, yet with high initial trade earnings of $1.08 billion.

ii. EU section of world trade: Export values from Tables 3 and 4 revealed that Cameroon received approximately two-thirds of its total cocoa export revenue from the EU, for a total sum of $172.4 million, whereas Indonesia received only 1.3% of its export earnings, valued at $13.7 million, from the same market. This shows the very poor presence of Indonesia in the EU market. For other countries, Ghana exported approximately one-third of its produce, estimated at $672.0 million, to the EU, while Cote d'Ivoire exported less than one-fifth, though at a high value of $1.13 billion. This means that the cocoa sector in Cote d'Ivoire is strong in terms of quality standards compliance, since such presence would not have been possible without abiding by the stringent regulations in the EU. With harmonized standards, the trade shares in this market showed an increase for all importers (Table 4), with the highest value for Cote d'Ivoire at 47.0%. All exporters would want to take advantage of a lowering of standards in the lucrative EU cocoa market.

iii. RoW section of world trade: At individual importers' standards, Cote d'Ivoire's exports to non-EU regions were estimated at $5.02 billion for the period from 2005–2016. This was followed by Ghana, with an estimated cocoa export value of $1.46 billion, and by Indonesia at $1.07 billion. Nigeria's cocoa export earnings stood at $582.2 million. These high values reflect the fact that if major exporters could scale hurdles in the EU market, registering presence in other markets would be easy, since standards in non-EU countries are not as stringent as they are in the EU. Although additional transportation costs might be incurred for distant markets such as the USA and Canada, this should not constitute a hindrance, provided that the cocoa beans are sold at the right prices in those destination markets. Fortunately, cocoa beans from market leaders (Cote d'Ivoire and Ghana) can attract the highest price possible without discounting, since they are of high quality (Asante-Poku & Angelucci, 2013; El Makhloufi et al., 2018).

Looking at Indonesia, 98.7% of the estimated aggregate earnings based on individual standards were from the non-EU section of the global market. Cote d'Ivoire (81.6%), Ghana (68.5%), and Nigeria (64.5%) also received significant earnings from the non-EU market based on the attached values. The exporters might be taking advantage of the lower standard in the market. With harmonization, however, the estimated trade value for Indonesia remained high, in sharp contrast to other major exporters whose earnings from the market were reduced. They might have taken advantage of more lucrative markets consequent upon a lowering of standards. To understand this result better, Indonesia engages in bulk exports to countries such as the USA that require low-quality cocoa beans for blending. It also sells in neighboring markets such as Malaysia, a cocoa producer but a net importer, and to Singapore, which has a vibrant cocoa processing industry (ITC 2020). Under such a scenario, there is no advantage to changes in quality requirements. Indonesia merely focuses on its traditional and regular markets.

5.3 Exporters' Competitiveness

The results of competitiveness analyses are presented in Table 5 and Fig. 6. These show the major cocoa exporting countries in decreasing order of competitiveness: Cote d'Ivoire, Ghana/Indonesia, Nigeria, and Cameroon, with competitiveness scores of 1.00, 0.50, 0.46, and 0.35, respectively. Ghana and Indonesia have the same score: although Ghana has a quality advantage, Indonesia has a greater cocoa supply. Since the good quality of Ghanaian cocoa beans is recognized worldwide, Ghana needs to focus on increasing its supply capacity for higher competitiveness through improved earnings. The export competitiveness results for the major cocoa exporters could be explained in the light of policy thrusts in those countries. The reforms introduced in the Ivorian cocoa sector helped to keep Cote d'Ivoire as the leading cocoa producer in the world. This is reflected in an increase in the export of high-grade cocoa beans and guaranteed/stabilized producer/farm gate prices, which improved the welfare of the large number of smaller producers that dominate the sector. This led to the overall high competitiveness of Ivorian cocoa exports in comparison with other major producers. In addition, Cote d'Ivoire enjoys enormous support from private cocoa and chocolate companies through different projects (Hütz-Adams et al., 2016). Similarly, Ghana improved competitiveness and the overall development of its cocoa sector by introducing institutional and governance reforms that transfer a good portion of export prices to farmers, availing them of the opportunity to increase production through input-support-backed productivity enhancement, in addition to assistance in upgrading and maintaining export quality (Kolavalli & Vigneri, 2011, 2017). Indonesia is a bulk supplier, with

Table 5 Estimation of the competitiveness score

Exporter	Rankings			Rs	Cs
	Individual STI trade value	Codex STI trade value	% change from Codex		
Cameroon	5	5	4	4.67	0.35
Cote d'Ivoire	1	1	1	1.00	1.00
Ghana	2	2	5	3.00	0.50
Indonesia	3	4	2	3.00	0.50
Nigeria	4	3	3	3.33	0.46

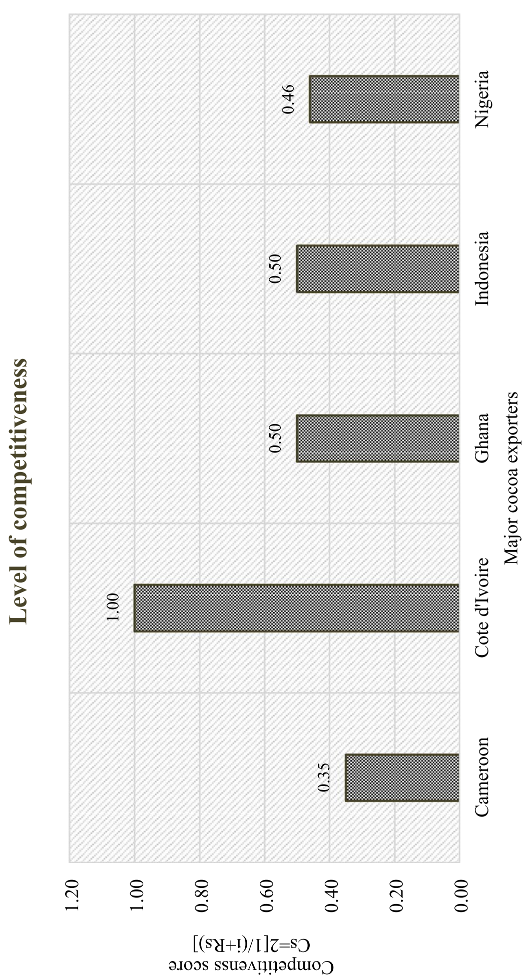


Fig. 6 Level of competitiveness of the main world cocoa exporters

its farmers mainly selling unfermented cocoa beans that are lower in quality. To correct this situation, amendments are being made to domestic regulations to ensure the marketing of fermented cocoa beans (Hütz-Adams et al., 2016).

In Nigeria, farm gate prices are less stable, and the export sector is dominated by a handful of companies. The cocoa transformation agenda under the Growth Enhancement Support Scheme (GESS) achieved some revitalization of the cocoa sector, but things have since returned to 'normal' with no coordinated effort on cocoa quality. Furthermore, with weak institutional support, some private companies engage farmers through projects aimed at improving productivity (Hütz-Adams et al., 2016), but these have not had an adequate impact. Like Nigeria's case, a lack of quality control has been identified as being responsible for the unstable competitiveness of the Cameroonian cocoa sector and, thus, its exports. Although efforts by the government to improve the competitiveness of the cocoa sector have shown appreciable results, Cameroon still lags behind other major cocoa-producing countries (Abei & Rooyen, 2018).

6 Conclusion

This study focused on competitiveness from the lens of harmonized pesticide regulation, an SPS standard. We analyzed competitiveness by considering the present and future strengths and weaknesses of major cocoa producers. The initial harmonization assessment revealed substantial losses for cocoa-exporting countries because importing countries have standards that are far stricter than the Codex standard. Countries that retained high export values after factoring in the level of stringency of standards in the global cocoa market had high competitiveness, save some differences brought by a deficient supply capacity.

There are important implications to the results for major cocoa exporters, especially those in Africa. Product quality still features prominently in their cocoa trade relationships with the outside world. Working on this seems to be one of the sure ways of getting appreciable foreign exchange earnings from the sector. Institutional capacity building to ensure quality compliance and monitoring pesticides usage from production to export will go a long way to achieving the desired results. The capacity of firms in exporting countries should also be enhanced through public–private partnership (PPP) efforts because experience in countries with high export competitiveness attests to the importance of such synergy. Alongside this, it is desirable to fashion a sustainable way to increase cocoa output. Although land seems to be in abundance in many of cocoa-producing and exporting African countries, unfettered deforestation for new cocoa plantations can exacerbate an already fragile climatic situation.

We also established that harmonized pesticide regulations at the Codex level are desirable for exporting countries at both aggregated and individual levels. They should, therefore, 'take the struggle' to the WTO by engaging in advocacy and diplomacy to rally support for the implementation of a Codex regime or regulation consistent with these levels. In the meantime, exporters should target different markets, such as countries heavily engaged in processing activities and emerging markets, and they should seek to strike a balance between quantity and quality requirements to generate better foreign exchange. Moving forward, the leading producers-cum-exporters should 'up their game' by venturing into traceability and other higher-level quality provisos for greater price gains and a sustainable market presence. Focusing on first-grade semi-finished products, which are precursors to chocolate production and are highly sought after in the EU market (CBI, 2020), will achieve similar results.

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Declarations

Competing Interests The authors declare no competing interests.

Ethical Approval Not applicable.

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