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Deep preferential trade agreements and export efficiency in Ghana: Do institutions matter?

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ABSTRACT

Preferential trade agreements with environmental provisions (Deep PTAs) have introduced a new layer of costs to bilateral trade. For a country seeking to grow its exports to generate sufficient foreign exchange for economic transformation, it is essential to investigate the effects of the expanded preferential trade area on its export efficiency. Therefore, this paper, employs the stochastic frontier gravity model to investigate Ghana's bilateral export efficiency using a panel of 44 of her export destination countries for the period 2007 to 2019. The paper finds that Ghana's bilateral export trade is inefficient, implying huge potential exists. It further reveals that PTAs with environmental provisions reduce Ghana's export efficiency. The reduction in export efficiency lessens with improvement in institutional quality. The paper recommends that the regulatory roles of Ghana Standards Authority and the Environmental Protection Agency should be strengthened to ensure that exporters meet target market regulations to continue to benefit from the bilateral PTAs. Given the negative effect of the exchange rate on export efficiency, the Bank of Ghana and the Ministry of Finance should urgently enhance macroeconomic stability to provide a stable platform which should promote the country's export value and volume.

Introduction

Governments enter into preferential trade agreements (PTAs) with trading partners to increase trade, promote economic growth and reduce poverty (Winters & Martuscelli, 2014). Traditionally, PTAs have focused on removing tariff and non-tariff barriers between trading partners. In recent times, however, the number of PTAs has ballooned. Their scope has expanded beyond the removal of tariffs and other trade-related frictions to include non-trade components such as investment, competition policy, labour standards and protection of the environment (Horn, Mavroidis, & Sapir, 2010). These add-ons are referred to as deep PTAs. Despite the prolific nature of such agreements, which are meant to increase trade, other hindrances remain and continue to impede the proportion of extractable trade potential existing in a country (efficiency) (Khan & Kalirajan, 2011). Therefore, with the increase in expanded PTAs, this paper focuses on bilateral export efficiency and argues that once a country gains knowledge of its export efficiency with a preferential trading partner, it will fashion policies to increase efficiency and enhance trade performance.

The issue of trade efficiency has become pertinent due to disparate evidence surrounding the adoption and implementation of deep PTAs. In this paper, deep PTAs refer to PTAs with environmental provisions. While deep PTAs are suggestively positive for environmental protection (Brandi, Bruhn, & Morin, 2019; Kolcava, Nguyen, & Bernauer, 2019), they can also reduce trade (Berger, Brandi, Morin, & Schwab, 2020). Moreover, evidence from Brandi, Schwab, Berger, and Morin (2020) suggests that although deep PTAs curtail dirty exports, they encourage export of green products. It has also been observed that many environmental provisions fall outside the World Trade Organisation (WTO) mandate (Morin, Dür, and Lechner, 2018), thus, raising concerns about their real intent. Arguably, these are augmenting trade requirement pressures faced by developing countries. To meet such demands, exporting countries would require a robust institutional framework to devise and implement a green production policy which safeguards the environment.

Extant literature argues that countries with institutions, which ensure that firm activities do not harm the environment and meet expected standards, can cope in the global export market when confronted

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with these environmental provisions in PTAs (Fiorini & Hoekman, 2018; Gómez-Mera & Varela, 2021). Therefore, regulatory quality, which we define as the “ability of the government and its agencies to formulate and implement sound policies and regulations that promote private sector development”, will ensure that firms obey environmental regulations and can extract more export potential in partner countries (Gómez-Mera & Varela, 2021, p. 614). Another critical factor is the institutional capability to enforce environmental provisions. Some provisions are also considered restrictive, which may limit a country’s ability to maximise its export capacity with a bilateral trading partner. Consequently, regulatory quality, enforcement and the effect of restrictive provisions are crucial factors in analysing deep PTAs and export efficiency. These require urgent attention and make the issue of deep PTAs, their supporting institutions, and their effect on export potential an empirical problem.

Ghana is well suited for this study because its trade was liberalised extensively during the 1980s economic reforms. It has since signed onto many trade agreements such as the interim Economic Partnership Agreement (iEPA) between the European Union (EU) and the African, Caribbean and Pacific (ACP) countries, the African Growth Opportunity Act (AGOA), and the African Continental Free Trade Area (AfCFTA) agreement. Despite the liberalisation, evidence suggests that such agreements may not yield the desired results. In the context of AfCFTA, Boakye et al. (2022) reveal that Ghana’s export efficiency was low from 2007 – 2019. Specifically, export inefficiency was highest in the European Union and the United States, which are identified as the nerve centres of PTAs with environmental provisions. To this effect, the aching question is, how have all these trade agreements affected Ghana’s bilateral export efficiency? Particularly, the role of expanded PTAs in ensuring optimal export efficiency.

This paper fills a vital gap in the empirical literature by answering the following research questions: First, what is the level of efficiency of Ghana’s bilateral exports? Second, what is the effect of deep PTA on export efficiency and is the number of PTAs in place relevant for trade efficiency? Third, to what extent do existing institutions affect the relationship between deep PTAs and export efficiency? This paper answers these questions using 44 of Ghana’s bilateral trade partners and disaggregated exports [Agricultural, Forestry & Fishery (AFoF), Minerals, and Manufactured products] for the period 2007 – 2018. To our best knowledge, no country-specific study has been conducted for Ghana, and for a more efficient analysis, we employ the Stochastic Frontier Gravity Model (SFGM). Related export efficiency studies identified include Kumah (2017) and, Adam and Tweneboah (2008). The former studied the level of trade integration among countries in the West African Monetary Zone (WAMZ), while the latter employed the usual traditional gravity model to predict the trade potential of Ghana’s trading partners.

The paper’s uniqueness is its focus on the effect of expanded PTAs on export efficiency in Ghana. Crucially, it examines the extent to which the quality of institutions promotes trade efficiency by interacting institutions (proxied by regulatory quality) with deep PTAs. It also examines the moderating effect of enforcement capability and the role of restrictive provisions in either improving efficiency by reducing inefficiencies or vice versa. The paper makes these important findings: First, Ghana’s export efficiency is low for the disaggregated exports to all trading partners, implying that considerable unexploited potential exist in these markets. Second, deep PTAs reduce Ghana’s export efficiency, and third, the extent of reduction lessens with improvement in institutions. The rest of the paper is organised as follows: Section two is devoted to a review of the literature. Section three presents the methodology. The results and discussion are provided in section four and section five concludes the paper.

Literature review

Theoretically, traditional PTAs remove tariffs to reduce trade costs

and offer free access to expanded markets with the aim of promoting trade among members. This results in overall trade benefits for participating countries due to increased trade created in response to PTAs, or, from trade diversion to such favourable agreements (Viner, 1950).

PTAs also ensure the survival of export firms, as encapsulated in the heterogeneous firm model of Melitz (2003) and espoused in Nkansah, Takyi, Sakyi, and Adusah-Poku (2022). The model argues that economic integration agreements (EIAs) remove trade barriers and reduce costs among member countries. The ensuing competition between firms leads to the more efficient firms surviving while the less profitable firms exit the export market. Survival of efficient export firms implies the ability of the country to extract more of the export potential existing in a particular market (enhance export efficiency). Another conduit by which firms, and hence, countries, enhance their export performance in a regional liberalisation environment is the formation of regional value chains. PTAs provide a product hub to which members contribute components as their comparative advantage dictates. This way, countries without the capacity to enter the global export market for whole products can participate through regional value chains (Razeq, 2022).

Another channel through which PTAs enhance export efficiency is through the attraction of foreign direct investment (FDI). Here, the expanded market derived from the creation of the PTA attracts FDIs that desire to take advantage of the large market created. The enhancement of the scope of modern PTAs to include investment, property rights, competition, labour laws, and environmental provisions serve as a further attraction to FDIs. This is because investors are sure member countries will be committed to implementing the requirements of the agreements, thereby, securing their investments and improving their confidence (Medvedev, 2012).

While increased trade is the ideal outcome for both parties of a PTA, the broadening of modern PTAs to include non-trade protocols such as, investment, labour, laws and environmental provisions have resulted in additional implications in terms of compliance and its attendant trade costs. This additional increase in trade costs has the potential to deter highly environmentally polluting firms from producing environmentally-dirty products for export, thereby reducing exports in line with the pollution haven hypothesis (Bommer, 1999; Brandi et al., 2020). From a positive perspective, the rising compliance cost will motivate innovative firms to explore more environmentally-friendly ways of production, and therefore, export more to increase exports in line with the Porter hypothesis (Porter & Van der Linde, 1995; Porter, 1991).

Most crucially, the literature suggests that a vital channel through which PTA impacts exports is the policy credibility that accrues as a country joins a PTA (Büthe & Milner, 2008). Thus, upon joining a PTA, a government commits to implementing all its requirements. This totemic support is vital for deep PTAs with environmental provisions which require robust domestic regulatory attention. Thus, domestic institutions with strong administrative, regulatory, and technical capacities are essential for implementing trade agreements (Chauffour & Kleimann, 2012; Chayes & Chayes, 1993; Cole, 2016; Guzman, 2002). Gray (2014) highlights the mediating role of quality domestic institutions in facilitating the capacity of PTAs to enhance export performance, and hence, export efficiency. The literature identifies two channels through which quality domestic institutions augment the impact of PTAs on export performance: the implementation channel and the enforcement mechanism.

First, comprehensive PTAs have numerous policy requirements that, when implemented, bestow the full benefits of an agreement on a country. Therefore, it takes stronger and quality domestic institutions to ensure that a country implements all these policy requirements. The second channel through which institutions moderate the effect of PTAs on export performance, and hence, export efficiency, is the enforcement of the agreement. When a country adopts the policy requirements of a PTA, it can only realise the full benefits if firms apply these requirements to their production activities. It takes only a strong and quality domestic

institution to enforce the policy requirements that have been agreed on (Bütthe & Milner, 2008; Gray, 2014).

The main drawback of PTAs on exports is the growing number that developing countries join, and the enormity of rules and regulations member countries have to commit to and comply with. This requires a huge state commitment, institutional capacity and effectiveness and appropriate infrastructure for a country to manage them successfully. Given that most developing countries do not have these capacities, they are often unable to implement the PTA requirements and do not accrue the best out of them. The inability of member countries to implement the fully required protocols of PTAs raises issues of policy credibility and institutional quality, which should improve the export efficiencies of participating countries (Bown, Lederman, Pienknagura, & Robertson, 2017).

Drivers of export inefficiency

Empirically, trade agreements and their modern variants have been widely studied due to their increasing relevance for trade performance. The Stochastic Frontier Gravity Model (SFGM) has been used in most studies, including those focused on individual nations, regions, trade agreements, bilateral relationships, and alternative scenarios. Some country-level research solely examined the factors that affect the efficiency and performance of exports. While these studies are useful for gauging how close a country is to its potential, they offer no evidence regarding the factors that contribute to inefficiency. For instance, Hassan (2017) examined the factors affecting Bangladesh's export performance and efficiency in its bilateral trade with 40 countries.

The author used the SFGM and likelihood estimation techniques on panel data from 2008–2011. He found that GDP, population, trade agreements, and exchange-rate depreciation all positively affect exports, while tariff levels and distance between Bangladesh and its partner countries adversely affect trade. The findings also demonstrated that customs procedures, port inefficiencies, and corruption are issues that impede trade. The results reveal a great deal of untapped export potential that may be harnessed by eliminating behind-the-border limitations to ensure a better integration with the world economy.

For the Philippines, Deluna and Cruz (2013), also employed the SFGM to assess the efficiency and potential of bilateral exports between the country and its trade partners from 2009 to 2012. Results of the research indicate that distance, partner's market size, and income all contribute to export performance. An additional intriguing conclusion from their research shows that the efficiency level varies from 38 % to 42 % between the Philippines and her trading partners, suggesting that inefficiency in the former's exports is relatively significant. The results also suggest that the Philippines' involvement in trading blocs like ASEAN, APEC, and the WTO, as well as the reduction of corruption, improvement in the importing country's labour market conditions, and a common language, all contribute to greater export efficiency.

It has also been observed that country-specific commodity/service studies that used SFGM are increasingly emerging (see Barma, 2017, Nasir & Kalirajan, 2014; Atif, Haiyun, & Mahmood, 2017). For instance, Barma (2017) examined the effectiveness of India's bilateral agricultural exports to 112 trading partners between 2000 and 2013. The study, which employed the SFGM and maximum likelihood estimation (MLE) on panel data, demonstrated that while GDP, population, and business freedom all positively affect India's bilateral agricultural exports, distance, being landlocked, the real exchange rate, trade freedom, and freedom from corruption all adversely affect India's exports. Finally, there were considerable variations in the efficiency levels of the country's agricultural exports with trading partners.

Accessing data from 1995 to 2014, Atif et al. (2017) employed SFGM and MLE to assess Pakistan's agricultural exports. The findings show that the factors driving agriculture exports were exchange rates, tariff rates, shared borders, shared cultures, colonial history and PTAs. They conclude that a huge untapped potential exists between Pakistan and its

neighbouring Middle Eastern and European countries. The aforementioned works, however, simply take into account the countries' capacity for trade; they say nothing about what causes the level of inefficiencies currently being experienced.

Within the context of the SFGM, studies on regional blocs have also surfaced. Stack, Pentecost, and Ravishankar (2018) analysed the efficiency of bilateral trade between 18 Western European countries and the 13 new EU member countries. The authors used the SFGM and MLE techniques to analyse a panel of current EU member-to-new member states' bilateral trade from 1995–2022. The researchers found that trade was positively affected by factors like income and per capita income differential, shared borders, languages, colonial ties, and regional integration, but negatively impacted by distance and landlocked status. The findings also demonstrated a significant increase in trade integration among new members. According to trade literature, a more effective logistics system lowers trade costs and promotes international trade. Recent studies have employed the World Bank logistic performance index to confirm the beneficial impact of logistics on trade flows. These include Martí, Puertas, and García (2014), Gani (2017), and Celebi (2017). Similarly, macroeconomic instability (inflation) lowers trade flows by making exports less competitive (Irshad, Xin, Hui, & Arshad, 2018).

Demir, Bilik, and Utkulu (2017) employed the stochastic frontier gravity model to estimate the effect of competitiveness on trade efficiency for a subset of Asian economies between 2006 and 2015. The disclosed comparative advantage index was standardised to serve as a surrogate for competitiveness. The findings highlighted the importance of factors like GDP per capita, distance, population, proximity, a shared official language, a common coloniser, free trade agreements, and the global financial crisis in determining export performance. They suggested that, to strengthen their comparative advantages, nations should invest more in research and development (R&D) and human resources to boost their production technology.

For developing countries, Kaushal (2022) used the SFGM to investigate how regional trade agreements impact India's export efficiency. The findings demonstrate that India's increased export efficiency is a direct effect of the country's participation in regional trade accords. Similarly, Hai and Thang (2017) examined ASEAN Free Trade Agreement on Vietnam's trade efficiency. The authors indicate that, ASEAN membership and trading partners' economic freedom induced trade efficiency by bridging the gap between actual and potential trade. Kumah (2017) also used SFGM and panel data on exports for 45 countries over the period 2000–2014 to examine the trade efficiency of the West African Monetary Zone (WAMZ). This study focused on trade integration among WAMZ member countries using the Battese and Coelli (1988), and Kumbhakar (1990) models. The author discovered that trade among monetary zone members is extremely low, suggesting that a significant trade potential currently exists.

There is also a more recent study by Boadu, Obeng, Dasmani, and Brafu-Insaidoo (2021). Employing the SFGM and a panel of 61 trading partners, the authors found that GDP and population had a positive effect, while distance had a negative effect on Ghana's bilateral exports. On drivers of export efficiency, the authors found that members of trade agreements, language, corruption, trade freedom and institutional quality enhance export efficiency. On the other hand, tax burden, electricity supply and financial development raised export inefficiency. Finally, the results revealed a huge unexploited export potential among Ghana's trading partners. To further investigate the reasons behind the considerable unexploited export capacity, it is vital to examine the role of trade agreements and how they impact export efficiency. These agreements have all been directed at liberalising trade to remove rigidities that might impede the potential for growth.

The existing literature on deep PTAs point to the role of institutions in attracting foreign direct investment (FDI) (Gómez-Mera & Varela, 2021) and promoting service trade (Fiorini & Hoekman, 2018). Gómez-Mera and Varela (2021) argued that stronger institutions signal to a

government’s commitment to protect and respect investment agreements, and enhance the country’s ability to attract more FDI. Additionally, Fiorini and Hoekman (2018), posit that the welfare benefits of service trade liberalisation are enhanced in countries with high regulatory quality. However, there is no study that has investigated how institutional quality moderates the effects of deep PTAs on export efficiency. Crucially, there is no study on the moderating role of institutions (regulatory quality) on the effect of environmental PTAs and export efficiency in Ghana, and the contributing effects of enforcement and restrictive provisions. This study, therefore, extends the extant literature by exploring the mediating role of regulatory quality on the effects of deep PTAs on export efficiency using Ghana as a case study.

Methodology

This part of the work presents the theoretical and empirical models, measurements, descriptions, and reasons for using certain variables and data sources.

Theoretical model

Three factors slow down the flow of exports from the country of origin to the destination country: (1) natural constraints, such as distance and transportation costs; (2) “behind-the-border” restrictions, such as the exporter’s rigid institutions and infrastructure; and (3) “beyond-the-border” constraints, such as the importer’s rigid institutions and infrastructure. Beyond the boarder restrictions manifest in two ways: explicit and implicit limitations. Tariffs and exchange rates are the most obvious cross-border constraints. Contrarily, implicit beyond-the-border restrictions resulting from the importer’s institutional and regulatory rigidities are particularly challenging to identify and quantify because they are typically not within the exporter’s control. Without these limitations, the exporter will achieve its full export potential (Bhattacharya & Das, 2014; Boadu et al., 2021; Khan & Kalirajan, 2011; Obeng, 2022).

Following Kalirajan (2007), the formal presentation of the aforementioned theoretical framework, which is a version of the SFGM created by Aigner, Lovell, and Schmidt (1977) and Meeusen and van Den Broeck (1977), is presented below:

$$\ln \text{Exp}_{ijt} = f(\ln Z_{ijt}; \gamma) \exp(-\omega_{ijt}, \eta_{ijt}) \tag{1}$$

where $\ln \text{Exp}_{ijt}$ is the log of bilateral exports from one country to another; $\ln Z_{ijt}$ is the augments of potential bilateral exports; γ is the estimated parameters; η_{ijt} is the stochastic error term and $-\omega_{ijt} = (0, 1)$ represents the bilateral exports inefficiency levels. It is presumed that $-\omega_{ijt}$ follows a truncated (at 0) normal distribution, with a mean “mu” and constant variance. If $-\omega_{ijt} = 0$, then bilateral exports reach its optimum level. When $-\omega_{ijt} > 0 < 1$, it signifies that the actual level of exports falls short of potential exports, implying that behind-the-border constraints limit the attainment of full export potential.

Using the notion of export efficiency as the ratio of realised to potential exports by Battese and Coelli (1988), we calculate efficiency as follows:

$$\text{Exportefficiency}_i = \frac{\ln f(\ln Z_{ijt}; \gamma) \exp(-\omega_{ijt}, \eta_{ijt})}{\ln f(\ln Z_{ijt}; \gamma) \exp(\eta_{ijt})} = \exp(-\omega_{ijt}) \tag{2}$$

where all variables are as defined earlier. Export efficiency estimates vary from zero to one. A value of zero for export efficiency means that real export levels need increase (i.e., inefficiency), while a value of one for export efficiency means that current export values and potential export values are the same. Following from that, the export inefficiency is expressed as:

$$\omega_{ijt} = f(\psi_{ijt}, \varphi) + \varpi_{ijt} \tag{3}$$

From Eq. (3), ω_{ijt} is export inefficiency; ψ_{ijt} represents plausible determinants; φ is the parameter to be predicted; ϖ_{ijt} represents the random error.

To test for the robustness of the stochastic frontier model, we estimated the gamma coefficient as specified in equation

$$\gamma = \frac{\sigma_e^2}{(\sigma_e^2 + \sigma_v^2)} \tag{4}$$

The gamma coefficient (γ) tests the robustness of the stochastic frontier gravity model in Eq. (1) and so provides insight into whether or not “beyond the border” limitations contribute to the inefficiency of Ghana’s bilateral exports. If γ is significant, then Ghana’s bilateral exports are heavily influenced by “behind the border” constraints. Put differently, the discrepancy between potential and actual export is attributable to the influence of behind-the-border limitations if gamma is significant. We also evaluated the likelihood ratio test statistics proposed by Kumbhakar, Wang, and Horncastle (2015) in addition to the gamma, which serves as a robustness test. Eq. (5) was used to calculate the likelihood ratio test.

$$\lambda = -2\{ \ln[L(H_0)] - \ln[L(H_1)] \} \tag{5}$$

where $L(H_0)$ is the restricted model computed from ordinary least squares (OLS) and $L(H_1)$ represents the unrestricted model estimated from the stochastic frontier. $L(H_0)$ and $L(H_1)$ are the values of the log-likelihood under the null and alternative hypotheses, H_0 ; there are no technical inefficiencies and H_1 : there are technical inefficiencies. The computed value of lambda (λ) was then compared with the mixed distribution of critical values obtained from Kodde and Palm (1986).

Empirical model

Implementation of specific objective one of the study required a simultaneous estimation of the frontier and the drivers of the inefficiency of bilateral exports. Following Simar, Lovell, and van den Eeckaut (1994) and Wang and Schmidt (2002) the empirical model for this exercise was specified as the Stochastic Frontier Gravity model below:

$$\ln \text{Export}_{ijt} = \alpha_0 + \alpha_1 \ln \text{GDP}_{it} + \alpha_2 \ln \text{GDP}_{jt} + \alpha_3 \ln \text{Population}_{jt} + \alpha_4 \ln \text{Distance}_{ijt} + \eta_{ijt} - \omega_{ijt} \tag{6}$$

$t = 1, \dots, 44$ & $t = 2007, \dots, 2019$; $i = \text{exporter}$; $j = \text{importer}$

Eq. (6.1) shows how the inefficiency effect model takes into account important factors that lead to Ghana’s bilateral export inefficiency.

$$\begin{aligned} \text{Exp.Ieff}_{ijt} = & \exp[\gamma_1 \text{PTAdummy}_{it} + \gamma_2 \text{PTAdepth}_{jt} + \gamma_3 \text{enforcementPTA}_{jt} \\ & + \gamma_4 \text{restrictiveprovisions}_{jt} + \gamma_5 \text{LANG}_{jt} + \gamma_6 \text{Landlocked}_{jt} \\ & + \gamma_7 \text{corruption}_{it} + \gamma_8 \text{corruption}_{jt} + \gamma_9 \text{Inflation}_{it} \\ & + \gamma_{10} \text{exchangerates}_{it} + \gamma_{11} \text{TradeFreedom}_{ijt} + \gamma_{12} \text{Logistics}_{it} \\ & + \gamma_{13} \text{Logistics}_{jt} + \gamma_{14} \text{RegulatoryQuality}_{it} \\ & + \gamma_{15} \text{PTAdepth} * \text{Regulatoryquality}_{ijt} + \epsilon_{ijt}] \end{aligned} \tag{6.1}$$

$t = 1, \dots, 44$ & $t = 2007, \dots, 2019$; $i = \text{exporter}$; $j = \text{importer}$

where Export_{ijt} represents disaggregated bilateral exports of Ghana to her trading partners (agricultural, forestry and fishery, mineral products and manufactured products); Exp.Ieff_{ijt} is export inefficiency; GDP_{it} is the GDP of Ghana while GDP_{jt} is the GDP for country j at time t ; Population_{jt} is the population of country j at time t ; Distance_{ijt} refers to geographical distance between the capital cities of country i and j measured in kilometres; PTA dummy, PTA depth, enforcement, and restrictive provisions indicates preferential trade agreements, depth of preferential trade agreements, enforcement of environmental provisions in preferential

Table 2
Descriptive Statistics.

Variable	Obs	Mean	Std. Dev.	Min	Max
Agriculture, forestry, and fishery (SIC 0)	585	30889.98	75157.2	0.044	1,070,000
Mineral commodities (SIC 1)	585	43903.32	221,000	0.002	4,300,000
Manufactured commodities (SIC 2)	585	23230.01	68289.28	0.016	833,000
GDP of exporter	585	317209**	207926**	498300**	655600**
GDP of importer	585	114507***	255670***	487000*	205000***
Population of importer	585	100057*	261322*	1320*	1393**
Distance	585	5864.057	3851.618	306.96	15472.97
Trade freedom of exporter	585	6.652491	0.1953403	6.25	6.92
Trade freedom of importer	585	7.155583	0.8752686	4.59	9.11
Freedom from corruption of exporter	585	39.469	4.677	33	48
Freedom from corruption of Importer	585	55.103	23.993	10	94
Inflation of exporter	585	13.08631	3.767191	7.12635	19.25072
Effective Exchange rate	585	86.48745	11.94544	68.3678	106.9446
Regulatory Quality	585	-0.0125304	0.1095471	-0.2325097	0.1281278
PTA dummy	585	0.6222222	0.4852466	0	1
PTA number	585	1.822	1.902	0	5
Depth of PTA	585	0.735	1.001	0	2.286
Enforcement environmental provisions in PTAs	585	0.244	0.43	0	1
Restrictive environmental provisions in PTAs	585	4.089	5.35	0	13
Logistics of exporter	585	2.505	0.149	2.16	2.66
Logistics of importer	585	4.373	0.608	2.96	5.5

Source: Authors' construct.

NB *, **, *** are in millions, billions, and trillions respectively.

trade agreements, and restrictive provisions in preferential trade agreements, respectively. LANG shows that importing country speaks the same official language as Ghana. Landlocked means importing country is landlocked; $Logistics_i$ and $Logistics_j$ are the logistic performance index of the exporter and the importer taken from the World Bank, corruption represents the freedom from corruption; $PTAdepth^*$ $Regulatoryquality$ is the interaction term between depth of preferential trade agreements and regulatory quality; $-w_{ijt}$ represents the inefficiency level of bilateral exports; η_{ijt} and ϵ_{ijt} is the random error term \ln denotes natural logarithm.

Definition and sources of data

The study utilised panel data consisting of 44 of Ghana's trading partners (see Appendix A for the list of countries) from 2007 to 2019. The selection of this sampling period was motivated by the availability of Ghana's bilateral export statistics and its trading partners around the world. Table A1 (see Appendix B) presents the variables used, measurements, a priori signs, and sources of data.

Estimation techniques

This study adopted the maximum likelihood estimation technique for the stochastic frontier analysis since it is distinct when the OLS residuals have the right skewness, as suggested by the works of Kalirajan and Paudel (2015), Ravishankar and Stack (2014), and Atif et al. (2017). It is a well-known statistical approach that is used to fit a mathematical model to real-world data. The maximum likelihood estimates of an unknown parameter are defined as the parameter value that optimises the chances of arbitrarily reflecting a certain sample of observations. The likelihood function is maximised via an iterative optimisation technique that entails selecting beginning values for the unknown parameters and extensively upgrading and amending them until the values that maximise the log-likelihood function are determined. Different from and superior to OLS estimates, a routine solution for the stochastic frontier emerges. The stochastic frontier gravity model's method of estimating efficiency is better than other methods because it can examine both the underlying export potential and changes in technical efficiency over time.

To determine the adequacy of the SFGM, the least square residuals were tested for negative skewness. The presence of negative skewness

subsequently validated the use of SFGM, and STATA was used for all estimations.

Results

In this section, the estimation results are presented. We first present the descriptive statistics, followed by presentation of the export inefficiency results, the frontier analysis estimates and export efficiency scores.

Descriptive statistics

The descriptive statistics of the variables used in this study are presented in Table 2.

Table 2 shows that Ghana exported agriculture, forestry, and fishery commodities worth an average of US \$30889.98 million, with a minimum of US \$ 0.044 million and a maximum of US \$1070000 million over the studied period. Ghana exported mineral products worth an average of \$43903.32 million USD. Ghana exports roughly \$ 23,230 million in manufactured products on average. This means that, on average, mineral commodities were Ghana's most exported items. The standard deviations of the goods shipped are larger than their means, which indicate that the data points are spread out over a wider range of values.

Furthermore, Ghana's average GDP for the period is around US \$31.7 billion, whereas its partner country's average GDP is about US \$1.1 trillion. Ghana's GDP has a minimum and maximum value of about US \$5 billion and US \$65.6 billion, respectively. The partner's GDP has a minimum and highest value of around US \$487 million and US \$ 20 trillion, respectively. Throughout the study period, the average population of the partner countries was around 100 million people. Likewise, the statistics show that the average distance between Ghana and all trading partners was around 5864.057 km. This means that Ghana's commodities travel an average distance of 5864.057 km to reach its trading partners. The mean logistic performance index for Ghana is 2.505 while the mean logistic index of its trading partners is 4.373. This implies that goods are easily and more efficiently moved to Ghana's partner trading countries. The minimum and maximum values for Ghana's logistic performance index are 2.16 and 2.66, while the minimum and maximum values of partner's logistic performance index are 2.96 and 5.50, respectively.

Table 3
Frontier and Export inefficiency estimates.

	(1)	(2)	(3)	(4)	(5)	(6)
	Agricultural, Forestry & Fishery	Agricultural, Forestry & Fishery	Mineral Products	Mineral Products	Manufactured Products	Manufactured Products
Frontier Estimates						
Log GDP of exporter	0.527*** (0.118)	0.650** (0.218)	0.0561*** (0.00505)	0.0561*** (0.00443)	3.392*** (0.598)	0.849** (0.307)
Log GDP of importer	0.831*** (0.0907)	0.863*** (0.167)	0.242*** (0.00161)	0.242*** (0.00144)	0.454*** (0.137)	0.150* (0.0531)
Log Population of importer	0.0202 (0.0957)	1.521*** (0.175)	0.585*** (0.00244)	0.585*** (0.00216)	1.178*** (0.153)	0.574*** (0.0812)
Log Distance	-0.576*** (0.161)	-0.584*** (0.214)	-1.461*** (0.00216)	-1.461*** (0.00193)	-2.428*** (0.169)	-1.312*** (0.145)
Constant	-19.57*** (5.205)	-17.094*** (4.092)	7.758*** (0.00131)	7.758*** (0.00116)	-56.78*** (14.11)	-14.02** (4.703)
Export Inefficiency Estimates						
PTA Dummy	-22.44*** (4.801)		1.266 (0.802)		-0.781** (0.283)	
Number of PTA		-1.699*** (0.181)		-0.742* (0.316)		-2.757*** (0.743)
Depth of PTA	-16.35*** (3.593)	-5.204*** (0.837)	-3.489* (1.714)	-2.268** (0.873)	-0.775** (0.260)	-4.027** (1.377)
Landlocked	5.210*** (1.070)	0.213* (0.101)	1.586 (1.115)	2.211 (1.138)	1.253*** (0.367)	6.116* (3.029)
Enforcement of Environmental Provisions in PTA	-66.72*** (12.92)	-18.66*** (1.541)	-7.831*** (1.171)	-7.745*** (2.043)	-6.412*** (1.179)	-13.18** (4.126)
Restrictive environmental provisions in PTA	8.877*** (1.829)	2.482*** (0.263)	0.847** (0.517)	0.461** (0.159)	0.668*** (0.194)	2.072** (0.683)
Trade Freedom of importer	-1.302*** (0.170)	1.507 (1.016)	-3.251*** (1.063)	-0.541** (0.184)	-1.754* (0.778)	-5.033* (2.277)
Trade Freedom of exporter	2.036*** (0.609)	0.543 (0.300)	1.740** (0.591)	1.928** (0.600)	-0.0436 (0.219)	1.504 (0.814)
Language	-2.066** (0.764)	0.164 (0.344)	-0.677 (0.714)	-0.886 (0.717)	-0.962*** (0.241)	-5.179** (1.892)
Corruption of exporter	0.211*** (0.0512)	0.0797** (0.0263)	0.100** (0.0341)	0.112* (0.0558)	-0.0115 (0.0176)	0.0455 (0.0453)
Corruption of importer	0.0371** (0.0127)	0.0115 (0.00895)	0.0636*** (0.0180)	0.0568** (0.0178)	-0.0196*** (0.00580)	-0.0477** (0.0174)
Exchange rate of exporter	0.473*** (0.0648)	0.178** (0.0599)	0.0723** (0.0242)	0.0930*** (0.0281)	0.0679** (0.0233)	0.121 (0.0693)
Inflation of exporter	0.114 (0.0732)	0.0326 (0.0366)	0.0122 (0.0755)	0.0185 (0.0758)	-0.0830** (0.0277)	-0.00708 (0.0681)
Logistics of exporter	-6.801*** (-2.013)	1.999*** (0.480)	-1.936** (0.649)	-2.141 (3.143)	10.40*** (1.516)	8.211*** (2.583)
Logistics of importer	-4.330*** (0.964)	-5.634*** (0.599)	-3.181*** (0.926)	-3.095*** (0.932)	-2.819*** (0.371)	-3.328** (1.197)
Regulatory Quality	-3.899*** (0.981)	-3.751*** (0.628)	-4.955** (1.671)	-0.500*** (0.135)	-2.548*** (0.337)	-0.636 (2.890)
PTA Dummy × Regulatory Quality	-70.29*** (18.64)		-17.15** (5.773)		2.074 (2.286)	
Depth of PTA × Regulatory Quality	-49.60*** (12.86)	-4.421** (1.517)	-11.03** (3.724)	-4.441 (14.04)	-0.477*** (0.0341)	-2.639*** (0.769)
Enforcement of Env. Prov. in PTA × Regulatory Quality	-192.4** (64.82)	-25.50* (11.68)	-61.83** (23.91)	-35.10* (14.77)	-9.179* (3.474)	-18.82* (7.301)
Restrictive Evn. Prov. × Regulatory Quality	-27.94** (9.47)	-3.252** (1.094)	-8.130*** (2.815)	-4.366* (2.124)	-2.823* (1.204)	-2.200 (3.201)
PTA Number × Regulatory Quality		2.920* (1.348)		1.315* (0.588)		1.752* (0.836)
Lgtgamma constant	1.389*** (0.266)	1.657*** (0.256)	34.68*** (0.942)	35.30*** (0.119)	2.533** (0.941)	0.532** (0.162)
Insigma2						
Insigma2 constant	2.387*** (0.151)	1.802*** (0.0738)	3.301*** (0.0455)	3.307*** (0.0489)	1.213*** (0.0662)	1.761*** (0.171)
Gamma	0.800	0.840	0.983	0.975	0.926	0.629
Likelihood ratio Test	311.721	341.247	136.311	139.651	145.701	338.269
Observation	585	585	585	585	585	585

Standard errors in parentheses.

NB: Enforcement of Env. Prov. in PTA is enforcement of environmental provisions in PTA.

* $p < 0.05$.

** $p < 0.01$.

*** $p < 0.001$.

Additionally, the statistics show that Ghana's trade freedom is roughly 6.7, while that of its trading partners is approximately 7.2. This suggests that, on average, Ghana's trading partners are more economically-free. Ghana's average inflation rate is 13.1 percent, with minimum and maximum readings of around 7.1 and 19.3 percent, respectively. Ghana's exchange rate is 86.48745 on average, with minimum and maximum values of 68.37 and 106.94, respectively. The mean for regulatory quality is -0.013 , with a minimum of -0.23 and a maximum of 0.13 . Finally, the average number of PTAs between Ghana and her trading partners at any particular time is 1.822, with a minimum and maximum values of 0 and 5, respectively. Furthermore, the average depth of PTA between Ghana and her partners is 0.735, with a minimum value of 0 and a maximum of 2.286. The average value for restrictive environmental provisions in PTAs is 4.089, with minimum and maximum values of 0 and 13, respectively.

Estimation results

The results in [Table 3](#) are in two parts. The first part presents the frontier estimates, which capture the traditional variables for a trade gravity model, and, the second part submits the inefficiency estimates, which capture the determinants of Ghana's export inefficiency. For the estimation of export inefficiency, four sets of variables were considered. The first set focuses on trade agreements, which comprises of preferential trade agreements (PTAs), the depth of preferential trade agreements, the enforcement of environmental provisions in PTAs, and environmental provisions in PTAs that are considered restrictive. On the principal variable, the absolute number of PTAs contracted between Ghana and her trading partners in a given year was used as a robustness check. This is to capture the membership of trade agreements on export efficiency. The second set of variables presents specific characteristics of trading partners, such as logistics, and, language and geographical location, which are natural barriers to export. For the third set, macro-economic and market freedom variables such as inflation, exchange rate, economic freedom, and corruption were also included to capture economic stability. The final covariate is the institutional variable proxied by regulatory quality. This crucial variable determines whether domestic institutions matter for a country to benefit from signing trade agreements with environmental provisions.

From [Table 3](#), Columns (1), (3) and (5), we present results of the export inefficiency estimates for the determinants of technical efficiency with a focus on the PTA dummy. We highlight those estimations of the models in Columns (2), (4) and (6) were conducted to improve the rigour of the analysis. In these estimations, we replace the PTA dummy with the absolute number of PTAs in place between Ghana and her trading partners at a particular time. This is to ascertain whether the number of PTAs in place actually matters for Ghana's export efficiency. For each variable discussed, parameter estimates are presented consecutively for all three disaggregated exports [Agricultural, Forestry & Fishery (AFoF), Mineral, and Manufactured products] to indicate the differential effects of a PTA on the three main export sectors. For the same variable, we present the statistically significant results for models (2), (4) and (6), to compare the differences between the results with the PTA dummy and those with the number of PTAs. This is followed by a discussion of the frontier estimates and efficiency scores.

Export inefficiency model

From our export inefficiency results in models (1), (3), and (5) of [Table 3](#), we find that Ghana's membership of a preferential trade agreement significantly reduces its inefficiency in the exports of agricultural, forestry, & fishery products (henceforth, AFoF) and exports of manufactured products. However, joining a preferential trade agreement has no effect on Ghana's export efficiency of mineral products. Specifically, at 1 per cent level, Ghana's membership of a PTA reduces its export inefficiency or increases export efficiency of AFoF and

manufactured products by 22.44 and 0.781 units respectively.

We replace the binary PTA with the number of PTAs in place [see models (2), (4), and (6)] to check that it is not just the existence of a PTA but also the total number of agreements in place can affect the extent of export inefficiency or efficiency. The results suggest that the number of PTAs significantly reduces inefficiencies in Ghana's exports of AFoF, mineral, and manufactured products. Precisely, the results show that an additional PTA will increase export efficiency of AFoF and manufactured products by 1.699 and 2.757 respectively, and they are statistically significant at 1 percent. Additionally, the number of PTAs in place increases Ghana's export efficiency of mineral products by 0.742, which is statistically significant at 10 percent. These findings reveal that, although belonging to a PTA has a greater effect on improving export efficiency of AFoF products, the total number of PTAs in place at a given period is also important for the performance of Ghana's exports in all product categories.

On the depth of PTAs, we find that it significantly reduces export inefficiencies in AFoF and manufactured products but the increase in efficiency for mineral exports is marginally significant. However, after considering the number of PTAs, the depth of trade agreements significantly reduces inefficiencies in all three product categories at 1 and 5 percent levels. It is important to note that the binary PTA has a greater effect on increasing Ghana's export efficiency in AFoF products relative to the depth of PTAs. For instance, the effect of the PTA dummy on AFoF products is 6.09 units higher than those with expanded provisions. This can be attributed to the fact that deep PTAs increase Ghana's obligations to fulfil its environmental provisions compared to simply signing on to any trade agreement. Consequently, deep PTAs will have a lower impact on increasing exports.

Environmental provisions with restrictive policies and their enforcement can also affect Ghana's disaggregated export performance. The results indicate that, consistent with common expectation, including restrictive provisions in preferential trade agreements significantly reduces export efficiency or increases export inefficiency for all three product categories. From models (1), (3), and (5), the results suggest that, restrictive environmental provisions in PTAs reduces efficiency levels of all categories of export products; however, inefficiencies are greater for AFoF products (8.877 units). We also find an increase in inefficiencies after controlling for the number of trade agreements. Therefore, for all models, having restrictive provisions in PTAs adversely affect export efficiency, which is consistent with earlier studies ([Blümer, Morin, Brandi, & Berger, 2020](#); [Brandi et al., 2020](#)). This implies that signing a PTA with restrictive environmental provisions hurts Ghana's overall export performance.

Following [Brandi et al. \(2020\)](#), we categorise PTAs based on whether they contain a generic or specific dispute resolution process for environmental provisions to measure enforcement of such provisions in PTAs. The results revealed that PTAs that contain enforceable provisions or those that have specific dispute settlement mechanisms reduce export inefficiencies in all three product categories. Particularly, enforceability of environmental provision reduces inefficiencies significantly for agricultural-related products with an effect of 66.72 units and the result is highly statistically significant at the 1 percent level.

The study also incorporated unique trading partner variables such as language and landlocked status. Language improves export efficiency of AFoF and manufactured products. From models (1), (3) and (5), the estimate's negative sign indicates that Ghana's exports to English-speaking countries increase efficiencies when compared to non-English-speaking countries. In other words, Ghana's export of agricultural-related and manufactured products to English-speaking countries boosts its export efficiency by 2.066 and 0.962 units, respectively. Language's negative and significant coefficient shows that it has some predictive power, which eliminates communication barriers between trading partners and boosts export efficiency. This is consistent with the findings of [Ravishankar and Stack \(2014\)](#) and [Boadu et al. \(2021\)](#), who concluded in their studies that common language improves

bilateral trade flows significantly. In contrast, [Deluna and Cruz \(2013\)](#), discovered that language had no effect on export efficiency in their analysis of the Philippines' trade potential and performance.

As expected, the coefficient of the landlocked dummy is positive for all the product categories, but significantly increases the export inefficiency of only AFoF and manufactured products [see Columns (1) and (5)]. Specifically, if the trading partner is a landlocked country, it reduces the export efficiency of the aforementioned products by 5.210 and 1.253 units, respectively. These coefficients are highly significant at 1 percent. The geographic feature of being landlocked lowers trade, primarily because lack of access to the sea tends to increase transportation costs. The results confirm the findings of [Ravishankar and Stack \(2014\)](#).

The study included trade freedom index to measure the openness of Ghana's trade. The result revealed that the trade freedom of the importer significantly reduces inefficiencies in Ghana's export of AFoF, mineral, and manufactured products [see Columns (1) to (6)]. Conversely, the exporter's trade freedom increases export inefficiencies of agricultural-related and mineral products [see Columns (1) and (3)], but it has no significant effect on the efficiency of Ghana's manufactured products. Additionally, in Columns (1) and (3), corruption in Ghana significantly increases inefficiency in the exports of AFoF and mineral products while results in Columns (1) to (6) suggest that corruption in partner countries limits the performance of Ghana's exports in all product categories.

Regarding the macroeconomic variables, we find that the exchange rate of the exporting country has a positive and significant effect on all three product categories [see Columns (1) to (5)]. However, the effect is greater on the exports of agricultural, forestry, & fishery products.

Regarding the macroeconomic stability variables, the results suggest that the exchange rate of the exporting country has a positive and significant effect on all three product categories. For every percentage increase in the value of the cedi, we see a 0.473, 0.0723, and 0.0679 percent increase in the inefficiency of AFoF products, mineral exports, and exports of manufactured products, respectively [see Columns (1) to (5)]. However, the effect is greater for the exports of AFoF products. This implies that Ghana's exchange rate appreciation vis-à-vis its partner economy increases export inefficiency of agricultural, forestry, & fishery products. After replacing the PTA dummy with the number of PTAs in place, we find that exchange rate appreciation only matter for Ghana's exports of agricultural-related and mineral products [see Columns (2) and (4)].

The inflation rate of the exporting country has a positive but insignificant effect on the exports of all product categories except for manufactured products. This variable is only responsive to the number of PTAs in place, which happens to be relevant for reducing inefficiencies for the exports of manufactured products [see Column (5)]. This implies that domestic inflation matter only for Ghana's exports of manufactured products. The results in Column (1) to (6) of [Table 3](#) further show that the logistics performance index of both exporter and trading partner has a statistically significant negative effect on export inefficiency of AFoF products, mineral products, and manufactured commodities. The statistically negative effect of the logistics performance index of both exporter and importer highlights logistics as an important determinant of export efficiency as improved trade-related logistics facilitate more trade and increase trade volume. This outcome corroborates the findings of [Martí et al. \(2014\)](#), [Gani \(2017\)](#) and [Celebi \(2017\)](#).

The role of institutions

We examined how institutional quality moderates the influence of the PTA dummy, depth of PTA, enforcement of environmental provisions and restrictive environmental conditions on Ghana's disaggregated export efficiency. Our findings show that, the quality of domestic regulations reduces export inefficiencies in Ghana's exports of AFoF, mineral, and manufactured products for both the PTA dummy and the number of PTAs in place [see Columns (1) to (5)]. However, we note

that the result is not significant for the exports of manufactured products when the number of PTAs is considered.

On PTA dummy and regulatory quality, we find that the interaction term is negative and statistically significant at 1 percent for agricultural, forestry, and fishery products in Column (1) and significant at 5 percent for mineral products in Column (3). This means that domestic regulatory quality is critical for Ghana to realise the potential impact of a PTA on its export efficiency in agricultural, forestry, and fisheries exports, as well as mineral products. When the effect of the PTA dummy and the interaction term between PTA and regulatory quality on AFoF exports are compared, it is clear that the interacting term has a greater effect on increasing efficiency in agricultural, forestry, and fishery exports the independent PTA dummy. This demonstrates the importance of regulatory quality in a country's ability to benefit from preferential trade deals.

Furthermore, the interaction term for the depth of PTA and regulatory quality is statistically significant and negative across models, indicating that the relationship between depth of PTA and all disaggregated exports is dependent on domestic regulatory quality. This means that strong domestic rules are essential for Ghana to boost its export efficiency in all product categories for PTAs with environmental provisions. The findings indicate that regulatory quality has a bigger impact on increasing the effect of depth of PTA on the export efficiency of manufactured goods, agricultural, forestry, and fishery products than on mineral products. When the interacted coefficients are compared to the depth of PTA coefficient, we discover that the interaction term has a stronger impact on enhancing Ghana's export efficiency. This implies that when domestic-level regulatory quality is effective, the full benefits of expanded PTAs on export efficiency can be realised.

Again, at the 5 percent level of significance, the interaction term for enforcement of environmental provisions in PTA and regulatory quality increases the export efficiency of agricultural, forestry, & fishery products, as well as mineral products, while only marginally increasing the export efficiency of manufactured products. As expected, interacting enforcement of environmental provisions in PTAs with regulatory quality has a bigger influence on boosting Ghana's disaggregated export efficiency, implying that domestic-level regulatory quality is crucial. Finally, when restrictive environmental provisions in PTAs are interacted with regulatory quality, we find that at 5 percent, regulatory quality is statistically significant in reducing inefficiencies in agricultural, forestry, & fishery products, as well as mineral products while at 10 percent, the interaction term for restrictive environmental provisions in PTAs and regulatory quality reduces exports inefficiency of manufacturing products.

Frontier estimates

Although our focus is on the inefficiency results, we also present results of the traditional gravity model. In all the six Columns of [Table 3](#), as expected, the GDP of both the exporting country and its trading partners have positive and significant impacts on the disaggregated exports of Ghana. The GDP of the exporting country has a significant effect on the exports of agriculture, forestry, & fishery products, mineral commodities, and manufactured commodities. In particular, in Column (1), (2), and (3), a percentage increase in Ghana's GDP increases its exports of agriculture, forestry, & fishery products, mineral products, and manufactured products by 0.527, 0.0561, and 3.392 percent, respectively. With respect to the GDP of the trading partner, a percentage rise increases Ghana's exports of agricultural, forestry, & fishery products, mineral products, and manufactured products by 0.831, 0.242, and 0.454 percent, respectively, and all the coefficients are highly significant at 1 percent. The outcome on GDP validates the findings of [Berma \(2017\)](#) and [Hassan \(2017\)](#).

Also, in Column (1), (2), and (3), the population of the partners, which measures the economic size of the partner country has a positive and significant effect on Ghana's disaggregated exports. Specifically, a

percentage increase in the population of the trading partner raises imports of agricultural-related exports, mineral exports, and manufactured exports of Ghana by 1.521, 0.585 and 1.178 percent, respectively. This finding confirms the results of Berma (2017) and Hassan (2017).

For the distance variable, the coefficients are expectedly negative across all three models and are statistically significant at the 1 per cent level, which is consistent with the gravity model. The distance variable has a highly significant negative coefficient, suggesting that greater distance reduces the likelihood of trade between countries. Trade with more distant countries is constrained by the distance variable, which stands for the high transportation costs associated with moving products and services across international borders. As can be seen in Table 3, the distance parameter has a significant impact on trade volumes for manufactured products and mineral commodities exported from Ghana, with more distant countries trading fewer of these items. There is less of a distance effect for products that come from agriculture, forestry, and fishery. Precisely, the exports of AFoF, mineral, and manufactured products all decrease by 0.576, 1.461, and 2.428 percent, respectively for every kilometer that separates Ghana from a trade partner. Berma (2017), Hassan (2017), and Stack et al. (2018) all had findings that led to the same conclusions.

Post-estimation test

The result in Table 3 shows that sigma-squared (σ^2), which measures the mean total variation over time in all the six (6) models, is statistically significant at the 1 percent level, suggesting that Ghana's exports of all the three (3) commodities changed over the period under study. The gamma coefficient for the export of the products is positive and highly significant, except for mineral commodities, which is insignificant. Therefore, the Stochastic Frontier analysis provides meaningful and valid results for models (1), (3), and (4), suggesting that behind-the-border restrictions have a massive impact and are causing a considerable fraction of the mean total variance in this scenario. This conclusion agrees with that of Ebaidalla and Ali (2022), who evaluated the potential and integration of intra-Arab trade, and found a positive and substantial sigma-square (σ^2) and gamma (γ) coefficient for the Arab countries. The result also agrees with the results of Hassan (2017), who used the SFGM to examine the primary drivers and bottlenecks of Bangladesh's export market. The sigma-square (σ^2) coefficient he calculated was positive and statistically significant, and the gamma (γ) coefficient also met the significance threshold, indicating that "behind-the-border" constraints play a major role in and are the primary drivers of the mean total variation of Bangladesh's bilateral exports. However, export models for mineral commodities have negligible gamma coefficients. This suggests that factors outside Ghana's control are making the export of mineral commodities less efficient.

However, Kumbhakar et al. (2015) argue that the gamma (γ) coefficient is not a particularly useful tool for evaluating SFGM's reliability. A likelihood ratio test is proposed, in which two models are estimated: the unrestricted model $L(H_1)$ and the restricted model $L(H_0)$, respectively representing the values of the log-likelihood function for the frontier model under the null and alternative hypotheses; H_0 : there are no technical inefficiencies and H_1 : there are technical inefficiencies, as stated in equation (9).

Results from the likelihood ratio test (LR test) for each of the six (6) models are compared to the 1 percent significance threshold (8.273) established by Kodde and Palm (1986). We reject the null hypothesis of no technical inefficiencies or inappropriate use of the SFGM if the estimated value of the LR test is larger than the critical value of Kodde and Palm (1986). Based on the findings, we reject the no-export-inefficiency hypothesis since the LR test () for all six (6) models is larger than the crucial value of 1 percent established by Kodde and Palm (1986). Consequently, we agree with the alternative hypothesis that there are inefficiencies in Ghana's exports of all three (3) commodities considered. Therefore, the stochastic frontier gravity model (SFGM) is

Table 4
Variance Inflation Factors.

Variable	VIF	1/VIF
Restrictive environmental provisions in PTAs	8.71	0.114811
PTA depth	2.44	0.409836
Enforcement of environmental provisions in PTA	2.62	0.381679
PTA binary	2.35	0.425532
Mean VIF	4.03	

NB: VIF denotes variance inflation factor.

Source: Authors construct, 2022

appropriate for this investigation.

There may also be a connection between the primary elements of PTAs, the depth of a PTA, the extent to which environmental laws are enforced, and the stringency of environmental provisions incorporated into PTAs. Since multicollinearity may be a cause for concern, Table 4 presents the Variance Inflation Factors (VIFs). There is no evidence of multicollinearity in the aforementioned estimates because no variable has a variance inflation factor greater than 10.

Export efficiency scores

The results for mean estimated technical efficiency (in percent) of Ghana's disaggregated bilateral exports for all the trading partners selected for the study are presented in Fig. 1. From the figure, the average technical efficiency score for the exports of Agriculture, Forestry, and Fishery products to all trading partners over the entire period under study is 14.37 percent, which is generally low. The result reveals that exports of Agriculture, Forestry, and Fishery products from Ghana to the Netherlands and Belgium are relatively efficient and closer to the frontier, with efficiency scores of 62.67 and 50.32 percent, respectively. This remarkable performance implies that Ghana is facing less resistance in terms of its exports of Agriculture, Forestry, and Fishery products to these two EU member countries compared to the rest of the partners. Despite the low efficiency score for the entire set, individual countries such as Togo, Cote d'Ivoire, Malaysia, Burkina Faso, South Africa, Ireland, Denmark, Spain, United Kingdom, France, Singapore, Italy, Turkey and Switzerland, respectively, have efficiency scores above the average score for the entire period. It also suggests that Ghana has a high unrealized export potential of Agricultural, Forestry, and fishery products to the selected trading partners.

On the exports of mineral commodities, Fig. 1 reveals relatively high technical efficiency scores and that most efficiency scores for individual countries are far above the average technical efficiency of 41.86 percent. Most countries recorded efficiency scores above 50 percent which is half of the frontier level. The countries with the highest efficiency scores are the Netherlands, United States, and Switzerland with efficiency scores of 65.40 and 63.45 and 62.73 percent, respectively. Others include Belgium (56.86), China (56.78), India (56.68), United Kingdom (55.59), and Singapore (50.37). This implies that Ghana's export of mineral commodities to these countries is relatively efficient compared to its export efficiency score of 41.86 percent for the entire period, suggesting that the constraining impact of country-specific effects on potential exports (i.e., behind-the-border) is declining due to bilateral negotiations with these countries. Also, other EU member countries such as Italy, France and Greece as well as ASEAN and East Asian (EA) member countries such as Indonesia, Hong Kong, Japan, Malaysia, and Ukraine have efficiency scores above the overall average score. South Africa and Kenya also maintained efficiency scores above the average score. It is interesting to note that ECOWAS countries-such as Burkina Faso, Senegal, Sierra Leone, and Togo -performed quite well by recording efficiency scores above the average score.

Regarding the technical efficiency scores for Ghana's exports of manufactured commodities, the average efficiency score is 27.62 percent, implying that there are inefficiencies in this trade. It is

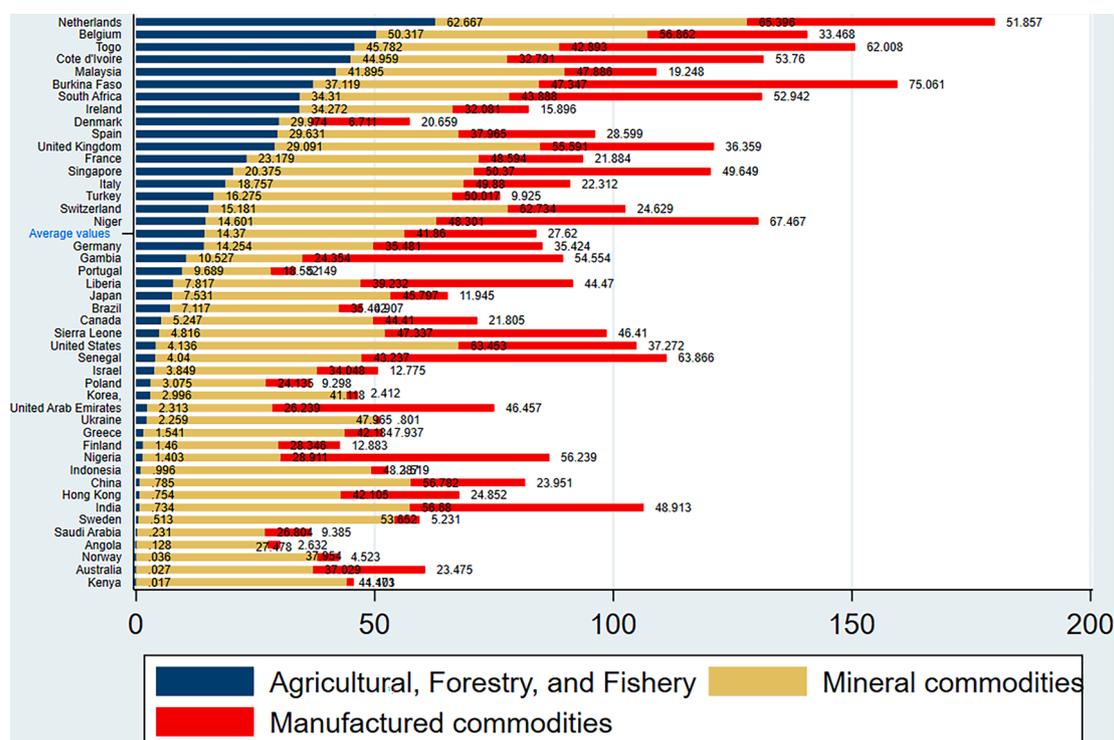


Fig. 1. Export efficiency (in percent) of Ghana's Disaggregated Exports to trading partners, 2007–2019 Source: Authors construct, 2022.

interesting to note that all the countries that recorded high efficiency scores above 50 percent are ECOWAS member countries, with the exception of South Africa and Netherlands. The highest efficiency score of 75.01 percent is registered by Burkina Faso. This is closely followed by Niger, Senegal, Togo, Gambia, and Côte d'Ivoire with efficiency scores of 67.47, 63.87, 62.00, 54.55, and 53.76 percent, respectively. This overwhelming performance can be attributed to shorter distance between Ghana and these countries especially Burkina Faso and also the fact that regional trade agreements among these countries has made it possible for members to trade in goods in which they are more or less endowed with.

On the other hand, the low efficiency scores registered by the other partners may be attributed to the fact that they are better producers of such commodities relative to Ghana. The other partners with high efficiency scores are South Africa and Netherlands, with each registering efficiency scores of 52.94 and 51.86 percent, respectively. Some trading partners such as United Arab Emirates, United Kingdom, United States, Spain, Singapore, India and two ECOWAS member countries, Liberia and Sierra Leone have efficiency scores above the average score of 27.62 percent. Generally, Ghana's exports of manufactured commodities to the ECOWAS member countries are relatively efficient compared to the rest of the partners.

Conclusions and policy recommendations

Deep PTAs with environmental provisions have become prolific in trade agreements with most developing countries. While these are undoubtedly positive for promoting exports of green products, they may also negatively affect the extractable trade potential of a country. As the first of its kind, this paper investigated the effect of deep PTAs with environmental provisions on export efficiency. It advances the traditional analysis of the drivers of trade efficiency by addressing the pertinent role that institutions play in such agreements and how they affect export efficiency.

For a deeper analysis, which fosters a comprehensive understanding of this issue, the study also investigates how institutions moderate

enforcement capability and deep PTAs with restrictive provisions in their contributions to export performance. The findings reveal that there is an unexplored export potential in the country; thereby, rendering the export potential inefficient. As expected, deep PTAs with environmental provisions reduce disaggregated bilateral exports. However, the study reveals that institutional quality ameliorates the extent to which deep PTAs affect bilateral exports. Furthermore, economic freedom enhances export efficiency while exchange rate and corruption reduce export efficiency.

To improve the efficiency of existing exports, the Ministry of Trade should continue to sustain Ghana's interest in trade blocs and strengthen negotiations to remove barriers to trade flows and thereby increase Ghana's exports to partner countries. In addition to negotiating tariff reductions, the government must strengthen environmental regulatory bodies like the Environmental Protection Agency (EPA) and the Food and Drugs Authority (FDA) to ensure that exporting firms produce goods to meet the requirements of the international export market, and preserve the integrity of the environment in their production activities. There is also the need for the Central Bank to ensure the stability of the local currency against the currencies of trading partners. Equally essential is the need for the country to improve upon its economic freedom, which includes upholding property rights; and most importantly, implementing an efficient legal system to reduce corruption.

CRedit authorship contribution statement

Camara K. Obeng: Conceptualization, Formal analysis, Writing – original draft. **Michael Tutu Boadu:** Methodology, Data curation, Formal analysis, Writing – original draft. **Ewura-Adwoa Ewusie:** Formal analysis, Writing – original draft, Writing – review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A

A. Selected countries.

United Kingdom, United States, France, Italy, Germany, Spain, Belgium, Japan, Nigeria, Malaysia, Ukraine, Turkey, China, India, Portugal, Australia, Benin, Burkina Faso, Cote d'Ivoire, Croatia, Mali,

Netherlands, Sierra Leone, Singapore, South Africa, Switzerland, Togo, Ukraine. Spain, Estonia, Denmark, Senegal, Ireland, Iran, United Arab Emirates, Brazil, Guinea-Bissau, Vietnam, Greece, Lebanon, Egypt, Niger.

B. Table A1.

Table A1

Definition and sources of data.

Identifier	Definition	Measurement	Expected sign	Data source
$BEXP_{ijt}$	Disaggregated bilateral exports	It measures the total value of nominal bilateral exports of Ghana in Million US dollars		World Integrated Trade Solution (WITS)
$BEXPineff_{ij}$	Bilateral export inefficiency	It measures the extent to which the actual export falls short of potential export	-	-
GDP_{it}/GDP_{jt}	Gross domestic product of exporter and importer	real GDP in US dollars	Positive	World Development Indicators
Pop_{it}/Pop_{jt}	Population of exporter ($lnPop_{it}$) and importer ($lnPop_{jt}$)	Total population measured in millions	Positive/negative	World Development Indicators
$Distance_{ijt}$	Distance	Geographical distance between the capital cities measured in kilometres (km)	Negative	Centre d'Études Prospective et d'Informations Internationales (CEPII)
$Landlocked_{jt}$	landlocked	1 if the partner country is landlocked and 0 otherwise	negative	Centre d'Études Prospective et d'Informations Internationales (CEPII)
$LANG_{jt}$	Language	dummy variable with a value 1 if the partner country is an English-speaking country and 0 otherwise	Negative	Centre d'Études Prospective et d'Informations Internationales (CEPII)
PTA_{dummy}_{jt}	Preferential Trade Agreements between country pairs	Measures preferential trade agreement and it is 1 if there is trade agreement between two countries at given time and 0 otherwise	negative	Trade and Environment Database (TREND)
PTA_{depth}_{jt}	Depth of Preferential Trade Agreements	Based on the DESTA depth index. It measures the maximum depth of any preferential trade agreement between country pairs	negative	Trade and Environment Database (TREND)
$EnforcementPTA_{jt}$	Enforcements of environmental provisions in PTAs	It is a dummy variable with value 1 if PTA contain a specific dispute resolution mechanism for environmental provisions and 0 if PTA contain generic one that applies to environmental provisions.	Negative	Trade and Environment Database (TREND)
$Restrictiveprovisions_{jt}$	Restrictive environmental provisions in Preferential trade agreements	It refers to environmental provisions embedded in trade agreements that can restrict or impede trade flow.	Positive	Trade and Environment Database (TREND)
$Corruption_{it}/Corruption_{jt}$	Freedom from corruption of exporter and importer	Freedom from corruption score of each partner country, i and j, is from 0 to 100, higher score shows little corruption	Positive	World Heritage Foundation
$Logistics_{ijt}$	Logistics performance index	Logistics Performance Index overall score reflects perceptions of a country's logistics based on efficiency of customs clearance process, quality of trade- and transport-related infrastructure, ease of arranging competitively priced shipments, quality of logistics services, ability to track and trace consignments, and frequency with which shipments reach the consignee within the scheduled time. The index ranges from 1 to 5, with a higher score representing better performance.	Negative	World Development Indicators
$RegulatoryQuality_{it}$	Regulatory quality of exporter	Proxy for institutional quality. Ranges from -2.5 to 2.5, with higher values corresponding to stronger performance	Negative	Worldwide Governance Indicators
$TradeFreedom_{ijt}$	Composite measure of the absence of tariff and non-tariff barriers that affect imports and exports of goods and services of both the exporter and importer	The trade freedom score of each partner country i and j is a number between 0 and 100. The higher the score implies lesser barriers of trade	Negative	The Heritage Foundation Heritage foundation (2020)
$Inflation_{it}$	Inflation rate of the exporter	Consumer price index reflects changes in the cost to the average consumer of acquiring a basket of goods and services that may be fixed or changed at specified intervals, such as yearly.		World Development Indicators
$ExchangeRate_{it}$	Real effective exchange rate of the exporter	Nominal effective exchange rate measure of the value of a currency against a weighted average of several foreign currencies divided by a price deflator or index of costs.	Positive/Negative	World Development Indicators

Source: Authors' construction.

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