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Determinants of Peruvian Export Efficiency: Poisson PML Estimation Approach

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Abstract: Given their increasing engagement with the global economy, emerging countries such as Peru depend on their export sector. This research evaluates the level of efficiency of Peruvian exports (EF) and the impact of four regional trade agreements (RTAs) (MERCOSUR, the EU, the European Free Trade Association (EFTA), and the Andean Community of Nations (CAN)), twelve bilateral agreements (BAs), the World Trade Organization (WTO), institutional distance (ID), cultural distance (CD), foreign direct investment (FDI), trade freedom (TF), and traditional (TX) and nontraditional exports (NTX) by sector on the export efficiency of Peru. This non-experimental study used a dataset of 38 countries from 1995 to 2019. An extended stochastic frontier gravity (SFGM) ten-variable model with the one-step estimation method was applied to estimate export efficiency. Poisson's PML estimator was used to investigate the factors that impact export efficiency (EF). The results showed that the export efficiency of Peru was moderate, ranging between 0.462 and 0.458, with a stationary trend, indicating considerable export potential between Peru and its trading partners. The major contributors to this efficiency are ID (voice and accountability, corruption control, nonadherence to the rule of law), NTX (chemicals and metal mechanics), and BA with American countries. On the other hand, CD (indulgence, long-term orientation, individualism, uncertainty, and lack of a culture of achievement), TF, agreements with MERCOSUR and the EU, FDI, and TX weakened the efficiency of exports. Finally, CAN, EFTA, BA with Asian countries, FDI, TX, and WTO did not have a significant effect on the EF. Recommendations to policy makers are presented.

Keywords: export efficiency; FTA; cultural; institutional distance; nontraditional exports; stochastic frontier model; PPML model

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1. Introduction

Economic sustainability in Peru depends in many ways on international trade, which applies to the world's emerging countries regarding the sustainability of their growth. To this end, the present study analyzes the impacts of several factors on Peruvian export efficiency. Exports of goods and services significantly and positively impact economic growth (Doanh et al. 2020). In the past 24 years, exports of Peruvian goods and services made significant progress. Between 1995 and 2019, they grew by an order of 3.82, going from 38.5 billion dollars in 1995 to 1470.38 billion dollars in 2019 (WITS 2021). In addition, the growth of exports in the first half of the study period (1995–2006) was 2.45-fold, while in the second half of the study (2007–2019), this figure was only 1.46-fold, even though it was the period during which 76% (16) of the 21 free trade agreements (FTAs) signed as of January 2021 entered into force (SICE 2022). Given this situation, to maintain the level of Peru's exports with the rest of the world, it is essential to study the efficiency of Peruvian exports.

Exports are key to promoting economic growth in developing and developed countries (Suleiman 2018). Their promotion is one of the main engines driving growth (Doanh et al.

2020). The increase in exports can give rise to new products, new technologies, greater productivity, and increased competitiveness (Md Reza et al. 2019). On the other hand, some authors consider that FTAs promote free trade and encourage countries to adopt multilateral free trade (Kumar 2021; Tinbergen 1962), while others believe that FTAs distort trade and generate negative trade balances (Shah et al. 2022; Levy 1997).

The literature review reveals knowledge gaps; studies have yet to be found on the influence of traditional and nontraditional exports by sector on trade efficiency (Doanh et al. 2020).

The Peruvian nontraditional sector represents 31% of the country's total exports. Peruvian nontraditional exports amounted to USD 1.242 billion in 2022, representing a 75% expansion compared to the same month in 2021 (BCRP 2022a). This study investigated for the first time the influence of nontraditional and traditional exports by their respective sectors on export efficiency. The most important findings were that some sectors of nontraditional exports have a positive impact on export efficiency; the industries that contribute the most are the chemical (0.233) and metal mechanical sectors (0.108). However, traditional exports (BCRP 2022b) have an inverse impact on export efficiency.

In the 1990s, several Latin American countries, including Peru, adopted economic reform based on a package of ten measures proposed and used by various Washington-based institutions, known as the Washington Consensus (Williamson 1990). The consensus promoted the idea of free trade and highlighted the need for a solid export sector, in addition to proposing an opening to international competition (Dingemans and Ross 2012).

Peru has six regional trade agreements (RTAs) as of December 2022 (SICE 2022): (a) Andean Community of Nations (CAN), the first regional integration agreement in South America (Fairlie et al. 2021), signed in 1969; (b) Southern Common Market (*Mercado Común del Sur*) (MERCOSUR [ACE 58]), signed 12 December 2005; (c) European Free Trade Association (EFTA), signed 14 July 2010; (d) European Union (EU), signed 26 June 2012; (e) Pacific Alliance, signed 1 May 2016; (f) Comprehensive and Progressive Agreement for Trans-Pacific Partnership (CPTPP), signed 19 September 2021. Peru also has 14 bilateral agreements (BAs) in force with Canada, the USA, Mexico, Honduras, Panama, Costa Rica, Chile, Singapore, Thailand, China, South Korea, Japan, Australia, and Venezuela (SICE 2022). However, the countries that are part of the trade agreements do not necessarily have the same level of development, which is why this research considers that cultural distance would provide greater scope to understand the trade flow between countries (Gharleghi and Shafighi 2020).

Studying the internal and external factors that affect export efficiency will make it possible to assess which factors positively affect export efficiency and which need to be adjusted to convert export potential into real export.

The following research questions are posed:

RQ1: What is the level of Peruvian export efficiency?

RQ2: What is the impact of four regional trade agreements (RTAs) (MERCOSUR, EU, EFTA, CAN), twelve bilateral agreements (BAs), the World Trade Organization (WTO), institutional distance (ID), cultural distance (CD), foreign direct investment (FDI), trade freedom (TF), and the traditional (TX) and nontraditional exports (NTX) by sector on the export efficiency of Peru?

The paper utilizes data between 1995 and 2019, providing a significant Peruvian export efficiency scenario. This study contributes to the scholarly literature in many respects. First, few studies include NTX and TX (per sector) in predicting export efficiency. Second, this study added the multiple dimensions of institutional distance (ID) and cultural distance (CD), allowing us to focus on specific internal and external variables. Third, the inclusion of 16 bilateral agreements and regional agreements provides us with a better picture of the impact of Peruvian Free Trade Agreements on export efficiency. This is a particularly important contribution of this study compared to all previous research in this field. The results have important policy implications, not only for policy makers but also for export/import companies and society in general.

In the following sections, we discuss the theoretical framework, data sources, and methodology. Finally, we present the results, discussion, and recommendations.

2. Theoretical Framework

Several authors quantified the factors affecting trade efficiency (Kaushal 2022; Abreo et al. 2021; Doanh et al. 2020; Doan and Xing 2018; Noviyani et al. 2019) (see Table 1). Findings show that certain agreements such as ASEAN, RTA, and BA can contribute effectively to export efficiency in the same way as having a common border and language. On the contrary, variables such as being landlocked, having institutional distances and cultural distances, firm size, and trade barriers contribute negatively to trade efficiency. More recently, Forgione and Migliardo (2023) conducted a study on firms and concluded that "profit efficiency decreases as the export intensity grows unless a firm achieves a medium scale".

Table 1. Selected studies on export efficiency.

Study	Data	Contributed Positively	Negative Contribution
Doan and Xing (2018)	They used the stochastic gravity model to estimate Vietnam's export efficiency levels to its principal main trading partners in the period 1995–2013	- ASEAN membership - FDI	- Rules of origin - Non-membership of the European Union - Non-membership of NAFTA
Noviyani et al. (2019)	They applied a stochastic border gravity model to estimate Indonesia's export efficiency levels to its 62 trading partners in the period 2011–2016	- Labor freedom - Financial freedom - Border - FTA	- Business freedom - Investment freedom - Landlocked
Doanh et al. (2020)	Analyzed the effects of institutional and cultural distances on trade efficiency in ASEAN using data from 65 countries from 2006 to 2017	- ASEAN trade efficiency	- Institutional and cultural distances - Trade barriers
Abreo et al. (2021)	Used a trade gravity model to examine the effect of governance on the evolution of Colombian exports using data from 136 countries in the period 2005–2018	- Corruption control	- Institutional quality - Institutional distance
Abdullahi et al. (2022)	Applied stochastic frontier analysis to examine the key determinants and China's agricultural export efficiency of 114 importing countries in the period 2000–2019	- China's GDP importing countries - Belt and Road Initiative (BRI) - The common border and common Chinese language	- China and its trading partners' GDP per capita - Currency depreciation - Distance - Landlocked
Kaushal (2022)	Analyzed the effects of RTAs on India's export efficiency using data from 167 countries in 2008–2018	- Accession to RTAs	

2.1. Nontraditional Exports (NTX) and Traditional Exports (TX)

Few studies discuss nontraditional exports (NTX) and traditional exports (TX). The term "nontraditional exports" is used in the literature to describe three distinct phenomena. (a) An export can be nontraditional because it involves a product that has not been in a particular country, such as snow peas in Guatemala. (b) The product was traditionally produced for domestic consumption but is now being exported, such as various tropical fruits. (c) The term can refer to the development of a new market for a traditional product, such as exporting bananas to the Soviet Union (Barham et al. 1992). However, Barham et al.

(1992) concluded that in the Central American region, agricultural exports predominate both in terms of traditional exports (bananas) and NTX (Gwynne 1996). Besides, each country defines its nontraditional exports. For example, gems and jewelry, marine products, chemical and allied products, machinery instruments, transport equipment, engineering goods, electric goods, cotton fabrics, readymade garments, and leather products have been selected in India (Kaur and Kapoor 2018); in Ghana, NTX are all export products except cocoa beans, lumber and logs, unprocessed gold and other minerals, and electricity (Appiah et al. 2019).

The contrast between traditional and nontraditional exports can be more sectoral—minerals constitute traditional exports, and agriculture and manufacturing products are nontraditional exports (Gwynne 1996).

In Peru, nontraditional exports are the other tariff items not indicated in the Supreme Decree 076-92-EF (BCRP 2022c) and are products that tend to have a higher added value. For presentation purposes, the BCRP groups them into agriculture, textiles, fishing, wood and paper, chemicals, metal mechanics, iron and steel and jewelry, non-metallic mining, and others. In 2020, Peru exported about 12.9 billion US dollars in nontraditional products, approximately 52.7 percent of which corresponded to agricultural products. That same year, the chemical industry generated 1.57 billion US dollars in exports, fishing 1.3 million, textiles 1.0 million, metallurgy and jewelry 981 million, industrial and metals 463 million, non-metallurgical minerals 447 million, and wood and paper 293 million (Statista 2022). Traditional exports in Peru include mining, agricultural, hydrocarbon, and fishmeal products determined by Supreme Decree 076-92-EF (BCRP 2022c).

2.2. Trade Agreement (TA)

TA includes regional trade agreements (RTAs) and bilateral agreements. Kaushal (2022) analyzed the effects of RTAs on the efficiency of India's exports and observed that accession to the RTAs considered in the study—such as bilateral agreements, the Association of Southeast Asian Nations (ASEAN), the South Asian Free Trade Area (SAFTA), and MERCOSUR, except for the Asia-Pacific Trade Agreement (APTA)—technically improved the efficiency of India's exports. Kaushal (2022) recommended that India sign RTAs keeping in mind two things: (a) mutually reciprocal terms with maximum trade liberalization and (b) a focus on products and services with maximum export potential, striving to channel FDI towards export-oriented manufacturing sectors to improve the export basket and global competitiveness.

Gharleghi and Shafighi (2020) used the augmented gravity model of international trade to test trade creation and diversion in the context of trade agreements in the Asia-Pacific region. The estimated model results indicated that trade between AFTA and APTA members has increased, but not between ASEAN-Australia-New Zealand Free Trade Area (AANZFTA) members. Gharleghi and Shafighi (2020) concluded that differences in levels of development appear to have a significant impact on trade flows, suggesting that there can be no blanket assumption about the degree of trade creation and trade diversion.

Hai and Thang (2017) stated that FTAs offer both advantages and disadvantages: as a benefit, there is the effect of trade creation by reducing trade barriers; a disadvantage is the effect of trade diversion due to the birth of some types of non-tariff accompaniment with the FTA that induce production and administrative costs. Hai and Thang (2017) recommended that to improve Vietnam's trade efficiency, Vietnam needs to join more regional FTAs, improve economic freedom, reduce tariffs, and enhance the competitiveness of its products to take advantage of currency devaluation.

Several economists have shown a positive and significant impact on trade flows between European community members and the impact of enlargement (Buch and Piazolo 2001; Brada and Mendez 1983; Aitken 1973). Bergstrand (1985) reported negligible effects, while Eicher and Henn (2011) found mixed results.

2.3. Cultural Distance (CD)

Doanh et al. (2020) argued that due to the degree to which shared norms and values differ between countries, cultural distance reduces trade efficiency because trade costs increase. Doanh et al. (2020) recommended analyzing ASEAN trade efficiency across sectors to ensure the narrow scope of the investigation. Various authors stated that exports are related to cultural distance (Zheng et al. 2020; Kristjánsdóttir et al. 2017) and some previous research analyzed the relationship between exports and cultural distance based on the dimensions of the national culture model from Hofstede (see Table 2). The authors found that cultural distance greatly impacts countries' international trade (Kristjánsdóttir et al. 2017). On the other hand, Outreville (2018) argued that empirical studies reveal that institutions prefer to invest in foreign places that minimize some dimensions of culture (p. 1050).

Table 2. Cultural distance dimensions.

Dimensions	Definition
Power Distance	Reflects the degree to which people accept unequally distributed power.
Individualism vs. Collectivism	Refers to a tightly knit framework in which the role of the group is emphasized. It also reflects the creative capability of a country.
Achievement Culture	Kristjánsdóttir et al. (2017) refers this to "Masculinity". This is defined as the degree to which a society emphasizes masculine values such as achievement, heroism, assertiveness, and material rewards for success, as opposed to feminine values such as cooperation, modesty, caring for the at-risk population, and quality of life. Authors have changed "masculinity" to achievement culture (to avoid using gender as a dimension).
Uncertainty Avoidance	Indicates the degree to which people feel uncomfortable with uncertainty and the unknown.
Long-Term Orientation	Refers to the degree to which a society prefers to maintain time-honored traditions and norms while viewing societal change with suspicion or taking a more pragmatic approach: encouraging thrift and efforts in modern education to prepare for the future.
Indulgence vs. Restraint	Indulgence is a society that allows relatively free gratification of basic and natural human drives related to enjoying life and having fun. Restraint stands for a society that suppresses gratification of needs and regulates it using strict social norms.

2.4. Institutional Distance (ID)

Institutional distance is "the degree of similarity or dissimilarity between the formal or regulatory aspects and the informal or normative and cognitive aspects of the institutions of two countries" (Gaur and Lu 2007, p. 34).

Institutional distance affects the efficiency of exports negatively since it involves the enforcement of contracts, property rights, and the rule of law between the countries involved in the export process (Doanh et al. 2020; Liu et al. 2020; Anderson and Marcouiller 2002; Zheng et al. 2020). There are six indicators in the worldwide governance indicator used to build the institutional distance index: (a) voice and accountability, (b) political stability and absence of violence, (c) government effectiveness, (d) quality of regulation, (e) the rule of law, and (f) control of corruption (see Table 3). There is a consensus from different sources that the control of corruption represents a long-term problem in Peru (Caistor and Villarán 2006; Pena-Mancillas 2011; WTO 2019), even though the country has an Anti-Corruption Plan (DL N° 30823-2018 (Diario Oficial El Peruano 2018)). Transparency International expresses its concern. Along the same lines, Narayan and Bui (2021) found that corruption in Vietnam discouraged bilateral export flows and that the negative effect of corruption was highly significant in the long run. Stringent, inefficient government regulations and other trade regulatory barriers can delay transactions or lead firms to bribery (Kumanayake 2022).

Table 3. Institutional distance dimensions.

Dimensions	Definition
Voice and Accountability	Reflects perceptions of the extent to which a country's citizens can participate in selecting their government, freedom of expression, freedom of association, and free media.
Political Stability and Absence of Violence/Terrorism	Measures perceptions of the likelihood of political instability and/or politically motivated violence, including terrorism.
Government Effectiveness	Reflects perceptions of the quality of public services, the quality of the civil service and the degree of its independence from political pressures, the quality of policy formulation and implementation, and the credibility of the government's commitment to such policies.
Regulatory Quality	Reflects perceptions of the ability of the government to formulate and implement sound policies and regulations that permit and promote private sector development.
Rule of Law	Reflects perceptions of the extent to which people have confidence in and abide by the rules of society, particularly the quality of contract enforcement, property rights, the police, and the courts.
Control of Corruption	Reflects perceptions of the extent to which public power is exercised for private gain, including petty and grand forms of corruption and "capture" of the state by elites and private interests. Stands for a society that suppresses gratification of needs and regulates it by employing strict social norms.

2.5. Foreign Direct Investment (FDI)

Doan and Xing (2018) found that FDI is positive and statistically significant at 1%, thus boosting Vietnam's trade efficiency. FDI also partly explains the divergence of trade efficiency among members of a free trade agreement. Mohanty and Sethi (2021) stated that there is a negative and significant impact of FDI on India's real exports in the long run, but a positive impact in the short run. Camacho and Bajaña (2020) concluded that GDP does not influence FDI in Ecuador, Peru, and Colombia. Additionally, both Ecuador and Peru have a low level of FDI over the GDP of Colombia.

2.6. Trade Freedom (TF)

Doanh et al. (2020) concluded that free trade is an essential factor positively affecting ASEAN trade efficiency. Tariffs and non-tariff barriers can undermine the efficiency of trade (Doan and Xing 2018).

2.7. The Stochastic Frontier Gravitational Model (SFGM) to Calculate Export Efficiency (EF)

Trade efficiency is the ratio between a country's actual exports and its maximum potential export volume, estimated by a stochastic gravity model (Hai and Thang 2017; Doan and Xing 2018). The measure of trade efficiency requires a hypothetical trade frontier, i.e., the maximum trade capacity when free trade is possible. The difference between potential and actual trade is known as untapped trade potential (Irshad et al. 2018). If it is high, there is low trade efficiency; if it is low, there is increased trade efficiency (Stack et al. 2018; Doan and Xing 2018). Then, trade efficiency can be calculated as the ratio of actual to potential trade (Tochkov 2018).

Armstrong's (2007) model proposes specifications for two estimation stages, one for the trading frontier and the other to measure trade resistance. It suggests that many variables normally included in gravity models would be better left to explain the gap between actual and potential trade rather than estimated. Here, the suggestion is that the estimation of the frontier, or potential trade, be made using only fundamental or basic determinants of trade, as the theoretical derivations suggest: the size of the economy (GDP), the relative distance, border, and other determinants that cannot be changed in the short and medium term, such as language and complementarity. These can be called the natural determinants of trade.

On the other hand, Wang and Schmidt (2002) and Schmidt (2011) explained theoretically why two-step procedures are biased and presented Monte Carlo evidence showing

that the bias can be very severe. This evidence argues strongly for one-step models whenever one is interested in the effects of a firm's characteristics on efficiency levels. Indeed, the estimated frontier is biased if x and z are correlated and z is significant. Kumar and Prabhakar (2017) state that the single-stage estimation procedure can also accommodate exogenous variables' non-monotonic trade efficiency effects. Hence, the present study employs a single-stage panel SF model for efficiency estimation.

To test endogeneity, we used the command xtsfkk (Karakaplan 2022) in this study. Karakaplan (2022) introduced xtsfkk as a new command for fitting panel stochastic frontier models with endogeneity. The advantage of xtsfkk is that it can control the endogenous variables in the frontier and the inefficiency term in a longitudinal setting. He demonstrated that xtsfkk performs better than standard panel frontier estimators such as xtfrontier that overlook endogeneity, the stochastic frontier (SF) model, and trading efficiency.

This study uses an extended stochastic gravity model to estimate export frontiers in one step. To overcome the inherent biases of the conventional time-varying gravity model that did not segregate individual heterogeneity from inefficiency, the study adopts the SF gravity model introduced by Kalirajan (1999) to estimate Peru's export efficiency. The trade potential of a country is defined as the maximum possible trade that can be achieved under free trade with only natural resistance. Armstrong (2007) defined a stochastic gravity equation as follows:

$$Y_{ji,t} = f(X_{it};\, \beta)\, \exp^{(\varepsilon it - uit)} \quad (1)$$

where X_{jt} is Peru's exports to country i in year t, $f(Y_{ij,t};\, \beta)$ captures the factors determining the potential trade only with natural resistances, and β represents a vector of unknown parameters to be estimated. Both ε_{it} and u_{it} are error terms. Since X_{it} represents actual exports and is always below the trade frontier due to objective trade resistances such as non-tariff barriers and other institutional frictions, the non-negative error term u_{it} is included to capture the lost efficiency, that is, technical inefficiency due to commercial resistance caused by man. The error term ε_{it} is assumed to follow a normal distribution with mean zero and variance ${\sigma_\varepsilon}^2$. This captures measurement and specification errors. If a country reaches its maximum commercial capacity, it can be said that the country's exports are 100% efficient (Doan and Xing 2018).

3. Data Sources and Methods

3.1. Data Sources

This study uses a panel dataset of 38 trading partners of Peru, representing 90.17% of Peru's exports. The data cover the period 1995–2019. Countries were selected based on their relative importance for Peru's exports and on having bilateral, regional, and multilateral free trade agreements in force with Peru. The research used data from the following sources: export data were taken from World Integrated Trade Solution (WITS), and GDP and population data were downloaded from the World Bank database (WBD). The data on distance, language, and area came from the Center d'Etudes Prospectives et d'Informations Internationales (CEPII 2022). Likewise, the data of the dimensions to construct the cultural distance of the Hofstede Model were obtained from the Hofstede database (Hofstede-Insights.com), and the data of the variables to construct the institutional distance were from the World Bank (WBD). Similarly, data for foreign direct investment and freedom of trade were also collected from the World Bank. Data on nontraditional and traditional exports were taken from the Central Reserve Bank of Peru.

The 1995–2019 study period was considered, given that Peru was a founding member of the WTO in 1995. The country had already begun its commercial opening in August 1990 with the reduction in the dispersion of nominal tariffs and the elimination of para-tariff barriers (Pasco-Font 2000), and 2019 was the last year before the COVID-19 pandemic. This study uses four of the six regional trade agreements (RTAs). The four regional trade agreements are the Southern Common Market (MERCOSUR), the European Union (EU), the European Free Trade Association (EFTA), and the Andean Community of Nations (CAN). The RTAs that were not included in the study are the Comprehensive and Progressive

Agreement for Trans-Pacific Partnership (CPTPP), which was signed in 2021, and the Pacific Alliance (several countries of this alliance already have bilateral agreements with Peru).

3.2. Methodology

The extended gravity stochastic frontier (SF) model was used to answer RQ1: What is the level of Peruvian export efficiency?

The exchange rate was introduced in addition to the term ε_{it}. Exports are affected by export supply (as the GDP of the exporting country), import demand (as the GDP of the importing country), and trade resistance (Doanh et al. 2020). Commercial resistances are divided into natural and artificial (Armstrong 2007). Natural resistances are objective and observable barriers (being landlocked, language difference, geographical distance, area of the importing country, the population of the importing country, the population of the exporting country, and having a border or not with the exporting country).

The study adopts the SF gravity model introduced by Kalirajan (1999) to estimate the country's export efficiency. The SF gravity model combines a gravity model with a stochastic frontier approach to efficaciously capture inefficiency or the unquantified multilateral resistances, the cause of time-invariant heteroscedasticity, and the distinct technical inefficiency term. The study employs Battese and Coelli's (1988) specification to estimate Peru's export efficiency using the single-stage SF gravity approach in panel data settings. It is a tool to estimate reliable efficiency scores and variation between actual and potential values. When a country achieves its maximum trade capacity, the exports are assumed to be 100% technically efficient. The error term (u_i) is the log difference between the maximum and the actual output; therefore, $u_i \times 100\%$ is the percentage by which actual output can be increased using the same inputs if production is fully efficient (Doan and Xing 2018). Explicitly, it relates to the percentage of output lost due to technical inefficiency. The estimated value of u_i is the output-oriented technical inefficiency, and the value nearing 0 suggests fully efficient production (Ahmadzai 2017).

To estimate the export function of the stochastic frontier, the following extended stochastic gravity equation was specified:

$$\begin{aligned} \boldsymbol{lnX_{it}} = \boldsymbol{\beta_0} + \boldsymbol{\beta_1 lnGDP_{it}} + \boldsymbol{\beta_2 lnGDP_{jt}} + \boldsymbol{\beta_3 Landlocked_i} + \boldsymbol{\beta_4 Language_i} + \boldsymbol{\beta_5 lnWDist_{ji}} + \boldsymbol{\beta_6 Area_i} \\ + \boldsymbol{\beta_7 POP_{it}} + \boldsymbol{\beta_8 POP_{jt}} + \boldsymbol{\beta_9 Border_i} + \boldsymbol{\beta_{10} ER_{ji,t}} + (\boldsymbol{v_{it}} - \boldsymbol{u_{it}}) \end{aligned} \quad (2)$$

where:

Dependents:

$\boldsymbol{lnX_{it}}$ is the natural logarithm of exports from country j (Peru) to each of the 38 trading partners i in year t measured in thousands of USD.

Independents:

(1) $\boldsymbol{GDP_{it}}$ is the gross domestic product of country i for year t.

(2) $\boldsymbol{GDP_{jt}}$ is the gross domestic product of country j for year t. GDP is considered an indicator of economic size.

(3) $\boldsymbol{Landlocked_i}$ is a dummy variable, taking the value 1 if the country is a landlocked country, and 0 otherwise.

(4) $\boldsymbol{Language_i}$ is equal to 1 if the trading partners speak Spanish, and 0 otherwise.

(5) $\boldsymbol{WDist_i}$ is the weighted distance in kilometers between country j and country i.

(6) $\boldsymbol{Area_i}$ is the land area of the importing country measured in km^2.

(7) $\boldsymbol{POP_{it}}$ is the population of importing country i.

(8) $\boldsymbol{POP_{jt}}$ is the population of j (Peru).

(9) $\boldsymbol{Border_i}$ is a dummy variable that is equal to 1 if the importing countries share a border with the exporting country and 0 otherwise.

(10) $\boldsymbol{ER_{ji,t}} = \frac{\boldsymbol{Exrate_{jt}}}{\boldsymbol{Exrate_{it}}}$ determines the average annual exchange rate of Peru per unit of the exchange rate of partner country i. $\boldsymbol{Exrate_{jt}}$ is the exchange rate of country j (LCU per US dollar) and $\boldsymbol{Exrate_{it}}$ is the exchange rate of country i (LCU per US dollar).

$\boldsymbol{v_{ij,t}} - \boldsymbol{u_{ij,t}} = \boldsymbol{\varepsilon_{ij,t}}$. $\boldsymbol{v_{ij,t}}$ is the conventional symmetric error term, which is purely random and follows the normal distribution, with mean 0 and variance σ_v^2. u_{it} captures trade

inefficiency due to manmade resistances that prevent Peru's actual exports to country *i* from reaching the potential level. It is a one-sided error term and follows a truncated normal distribution (Battese and Coelli 1988) with a mean μ and variance σ^2. If there is a difference between Peru's actual and potential exports, the error term value will be greater than 0 but less than 1. This implies that the impact of trade resistance exists and has a negative effect on the efficiency of exports. However, if the one-sided error takes a value of 0, it implies no difference between the actual and potential exports between Peru and its trade partners.

The equation above is the SF equation for Peru's exports. However, the inefficiency effect $\boldsymbol{u_{ij,t}}$ is assumed to be a function of a set of independent variables. Thus, the inefficiency effect of $\boldsymbol{u_{ij,t}}$ in the SF equation is stated below as:

$$\boldsymbol{u_{ij,t}} = \boldsymbol{z_{ij,t,}\delta} + \boldsymbol{w_{ij,t}} \quad (3)$$

where $z_{ij,t}$ would be the vector (1*m) of explanatory variables related to Peru's export inefficiency over time t, δ would be the vector (m*1) of unknown coefficients, and $\boldsymbol{w_{ij,t}}$ is "defined by the truncation of the normal distribution with zero mean and variance σ^2" (Kalirajan 1999).

$$\boldsymbol{Export\ efficiency_{ij,t}} = \boldsymbol{exp}\left(-\boldsymbol{u_{ij,t}}\right) \quad (4)$$

The parameters for the technical efficiency are estimated using Equation (4). The study employs a built-in function in Stata for estimating u_{it} based on the inefficiency model proposed by Battese and Coelli (1988). Estimating trade efficiency requires a hypothetical trade frontier representing the maximum trade capacity achievable under the free trade proposition. The one-step estimation, where both equations are executed simultaneously, is the proposed solution to the possibility of omitting unobservable resistances and the consequent heteroscedastic error through the one-sided error term and its possible determinants. This approach, the assumed relationship between "z" and the trade efficiency, is imposed on the frontier equation to estimate export inefficiency levels. Hence, the present study employs a single-stage panel SF model for efficiency estimation.

The SF analysis does not require prior knowledge of trade resistance variables' effects on exports. Moreover, the SF approach does not require prior knowledge of the direction and the magnitude of the effects that the explanatory variables included in the equation have on exports. These factors can be verified post-estimation to ensure the robustness of the resulting efficiency estimates.

The export efficiency score ranges from 0 (there is a need to raise actual exports nearer to the maximal level) to unity (actual exports coincide with potential exports). The study uses the extended stochastic gravity model that uses the exchange rate to explain the variation in bilateral trade (Bergstrand 1985; Dell'Ariccia 1999). The calculation used by Binh (2013) is $\boldsymbol{Exrate_{ji,t}} = \frac{\boldsymbol{Exrate_{jt}}}{\boldsymbol{Exrate_{it}}}$, where $\boldsymbol{Exrate_{ji,t}}$ is the annual mean of the national monetary unit of Peru per USD and $\boldsymbol{Exrate_{ji,t}}$ is the annual mean of the national monetary unit of country *i* per USD.

The Poisson pseudo maximum likelihood estimator (PPML) was used to answer RQ2: What is the impact of four regional trade agreements (RTAs) (MERCOSUR, EU, EFTA, CAN), twelve bilateral agreements (BAs), the World Trade Organization (WTO), institutional distance (ID), cultural distance (CD), foreign direct investment (FDI), trade freedom (TF), and the traditional (TX) and nontraditional exports (NTX) by sector on the export efficiency of Peru?

The goal was to overcome the autocorrelation problems of the variables considered in the study and to analyze the impact of bilateral agreements. Bilateral agreements (BAs) are divided into two groups: BAs with Asian countries (Singapore, Thailand, Japan, China, and South Korea) and BAs with American countries (Canada, USA, Mexico, Honduras, Panama, Costa Rica, and Chile). In addition to the BA, the impacts of regional and multilateral free trade agreements, cultural and institutional distances, foreign direct investment, trade

freedom, nontraditional exports, and traditional exports on the efficiency of Peru's exports with the 38 trading partners are evaluated.

$$EX_{jt} = exp\,(\,\alpha_0 + b_1 EFTA_{it} + b_2 CAN_{it} + b_3 EU_{it} + b_4 MERCOSUR_{it} + b_5 BA\_America_{it} + b_5 BA\_Asia_{it} + b_6 WTO_i + b_7 CD_{ij} + b_8 ID_{ij,t} + b_9 lnFDI_{it} + b_{10} lnTF_{it} + b_{11} lnXNT_{jt} + b_{12} lnXT_{jt}\,) \quad (5)$$

EX_{jt} is the export efficiency of Peru to its trading partner i in year t (found with Equation (4)).

(1) $EFTA_{it}$ is a dummy variable if the free trade agreement between Peru and the EFTA states is active during period t, and otherwise 0.

(2) CAN_{it} is a dummy variable of the CAN trade agreement with Peru, to which it assigns a value of 1 if the agreement is in force during period t, and otherwise 0.

(3) EU_{it} is a dummy variable of the trade agreement between Peru and the European Union, being 1 if it is active during period t and 0 otherwise.

(4) $MERCOSUR_{it}$ is a dummy variable of the free trade agreement between Peru and the member states of MERCOSUR, being 1 if it is active and 0 if it is not.

(5) $BA\_America_{it}$ is a dummy variable that is assigned a value of 1 if Peru has an FTA/PTA with a country i in America during period t.

(6) BA_Asia_{it} is a dummy variable that is assigned a value of 1 if Peru has an FTA/PTA with a country i in Asia during period t.

(7) WTO_i is a dummy variable that refers to whether the partner country is a member of the World Trade Organization. It is assigned a value of 1 if it is a member and 0 if it is not a member.

(8) CD_{ij} is the cultural distance between Peru and each trading partner country.

$$CD_{ij} = \frac{1}{6} \sum_{k=1}^{6} \frac{(\,C_{kj} - C_{ki}\,)2}{V_k} \quad (6)$$

C_{kP} and C_{ki} represent the kth cultural dimension of Peru and partner country i, respectively, and V_k is the variance of the kth dimension between Peru and its trading partners. The six dimensions of the national culture score were obtained from Hofstede Insights.

(9) $ID_{ij,t}$ is the institutional distance between Peru and each trading partner country.

$$ID_{ij,t} = \frac{1}{6} \sum_{k=1}^{6} \frac{(\,I_{kj,t} - I_{ki,t}\,)2}{V_{k,t}} \quad (7)$$

$ID_{kP,t}$ and $I_{ki,t}$ denote the kth institutional dimension of Peru and partner country i in year t, respectively. $V_{k,t}$ is the variance of the kth institutional dimension between countries in year t. There are six institutional dimensions, and the values range from −2.5 to 2.5.

(10) $lnFDI\_P_{it}$ is the natural logarithm of the Foreign Direct Investment that Peru receives from its trading partners i in year t.

(11) $lnTF_{ij,t}$ is the logarithm of the product of the trade freedom of Peru and trading partner i in year t.

$$lnTF_{ij,t} = ln\,(\,TF_{jt} \times TF_{it}\,) \quad (8)$$

where TF_{jt} and TF_{it} are the trade freedom indices of Peru and its partner country i in year t, respectively. A composite measure of the absence of tariff and non-tariff barriers affecting imports and exports of goods and services developed by the Heritage Foundation, the TF Index scores from 0 (repressed) to 100 (free trade).

(1) $lnNTX_{jt}$ is the natural logarithm of nontraditional exports of Peru considering its eight sectors in year t.

(2) $lnTX_{jt}$ is the natural logarithm of traditional exports of Peru considering its four sectors in year t.

Endogeneity test

Equation (2) can potentially suffer from an endogeneity problem. For example, GDP can affect exports (Zheng et al. 2020), and exports can affect GDP (Sakyi and Egyir 2017). To overcome this problem, the authors employed a command in Stata with Battese and Coelli's 1988 specification to estimate Peru's export efficiency using the single-stage SF gravity approach in panel data settings. The instrument for the GDP variable is estimated using the augmented Solow growth model (Solow 1956), whose independent variables are capital, labor, and technology. After that, we conducted the test for endogeneity specified in Karakaplan (2022). If the components of the η term are jointly significant, the model suffers from the problem of endogeneity, and a correction would be necessary, and vice versa.

4. Results

4.1. RQ1. Estimated Export Efficiency

Table 4 shows the significance level of each independent variable for estimating export efficiency scores using the extended stochastic gravity frontier model, and the endogeneity test is shown in Table 5. The basic variables of the gravity equation behave as the model predicts. All the estimated coefficients, except Peruvian population ($Population_j$), are statistically significant. The study found that the market size of Peru's trading partners has a positive impact on the total value of Peru's exports. The coefficient of Peru's GDP is also statistically significant despite its small market size. The signs of $lnGDP_{it}$, $lnGDP_{jt}$, $Landlocked_i$, $Languaje_{ij}$, $lnPopulation_j$, $Border_i$, $Exchange\ Rate_{ji,t}$ are positive, while the signs of $lnWDistance_i$ and $lnArea_j$ are negative. Table 4 also shows the endogeneity test ($X^2 = 4.43$, $p = 0.109$), which shows non-significance. This result means that Peru tends to export to countries that have larger incomes and markets or share a common border. On the contrary, Peru tends to trade less with trading partners that are distant. Besides, Peru maintains a regime of dirty floating of its exchange rate to avoid exchange rate volatility: the Central Reserve Bank of Peru tends to buy dollars when the exchange rate falls and tends to sell when the exchange rate rises that helps to boost Peru's exports (Mendoza 2017).

Table 4. Stochastic frontier gravity model results.

Variables	Coefficient	Coefficient Standardized	Std Error	Z Statistic	*p*-Value
Frontier Equation					
$lnGDP_{it}$	0.754	0.576	0.049	15.360	0.000
$lnGDP_{jt}$	0.740	0.179	0.098	7.540	0.000
$Landlocked_i$	0.721	0.094	0.175	4.120	0.000
$Language_{ij}$	0.639	0.123	0.208	3.070	0.002
$lnWDistance_{ij}$	−0.343	−0.113	0.141	−2.440	0.015
$lnArea_i$	−0.117	−0.094	0.037	−3.130	0.002
$lnPopulation_i$	0.311	0.188	0.063	4.920	0.000
$Border_{ij}$	1.380	0.196	0.188	7.330	0.000
$Exrate_{jt}/Exratei_{it}$	0.105	0.113	0.019	5.620	0.000
cons	−13.405	0.471	1.615	−8.300	0.000
Log Likelihood	−1636.161	-	-	-	-

Tables 6 and 7 summarize the estimated commercial efficiencies. Table 6 shows the estimates corresponding to the countries of America, firstly with the members of the regional blocs, i.e., the Southern Common Market (MERCOSUR) and the Andean Community of Nations (CAN), and secondly with the countries with which Peru has bilateral agreements. In general, the empirical results suggest that the efficiency of Peru's exports with almost all its trading partners improved from 1995 to 2019. However, even though the average efficiency of exports to MERCOSUR member countries went from 0.281 in the period 1995–1999 to 0.348 in the period 2015–2019, this was below 50%, which implies that exports from Peru to that bloc were less than half of the maximum capacity;

to the CAN countries, the average efficiency of exports went from 0.574 to 0.511 during those periods.

Table 5. Endogeneity Test.

	Model EX		**Model EN**	
Dependent Variable: $\ln Exports_{ij,t}$				
Dependent Variable: $\ln(\sigma^2\_u)$				
Constant	1.837 ***	(0.271)	1.820 ***	(0.267)
FTA	−0.065	(0.048)	−0.072	(0.051)
Dependent Variable: $\ln(\sigma^2\_v)$				
Constant	−1.122 ***	(0.052)		
Dependent Variable: $\ln(\sigma^2\_w)$				
Constant			−1.127 ***	(0.052)
η 1 $\ln GDP_{jt}$			−0.550 *	(0.268)
η 2 $\ln GDP_{it}$			0.000	(0.104)
η Endogeneity Test			$X^2 = 4.43$	$p = 0.109$
Log Likelihood	−750.76		−760.10	

Notes: Standard errors are in parentheses. Symbols indicate significance at the 0.1% (***), 5% (*) levels.

Table 6. Estimated efficiency of exports from Peru to the countries of America (%).

	1995–1999	**2000–2004**	**2005–2009**	**2010–2014**	**2015–2019**
Argentina	0.262	0.244	0.390	0.355	0.311
Brazil	0.265	0.336	0.349	0.306	0.332
Uruguay	0.365	0.469	0.470	0.497	0.484
Paraguay	0.232	0.115	0.101	0.260	0.264
MERCOSUR	**0.281**	**0.291**	**0.328**	**0.355**	**0.348**
Bolivia	0.615	0.605	0.611	0.585	0.554
Ecuador	0.598	0.543	0.565	0.558	0.487
Colombia	0.508	0.552	0.583	0.531	0.493
CAN	**0.574**	**0.567**	**0.586**	**0.558**	**0.511**
Canada	0.597	0.587	0.742	0.746	0.684
USA	0.544	0.573	0.614	0.576	0.528
Mexico	0.435	0.391	0.415	0.391	0.384
Honduras	0.444	0.552	0.572	0.562	0.546
Panama	0.653	0.742	0.756	0.742	0.715
Costa Rica	0.590	0.544	0.606	0.585	0.552
Chile	0.573	0.678	0.708	0.666	0.599
BA with American Countries	**0.548**	**0.581**	**0.630**	**0.610**	**0.573**

Bilateral agreements (BAs) with American countries (Canada, USA, Mexico, Honduras, Panama, Costa Rica, and Chile). Note: Own elaboration.

With bilateral agreements with American countries, the level of efficiency went from 0.548 in the 1995–1999 period to 0.573 in the 2015–2019 period. At a disaggregated level, the highest level of efficiency with MERCOSUR was with Uruguay, reaching 0.484, and with the CAN with Bolivia, reaching 0.554 in the 2015–2019 period. With countries with bilateral agreements, the highest level of efficiency was with Panama (0.715) and Canada (0.684) in the period 2015–2019; the lowest was with Mexico, whose efficiency level decreased from 0.435 in the 1995–1999 period to 0.384 in the 2015–2019 period. Another important aspect is that the level of efficiency with the United States (Peru's second trading partner) decreased from 0.544 in the period 1995–1999 to 0.528 in the period 2015–2019, having the highest efficiency in the period 2005–2009 prior to the signing of the Trade Promotion Agreement (0.614).

Table 7. Estimated efficiency of exports from Peru to the EU, EFTA, and Asian countries (%).

	1995–1999	2000–2004	2005–2009	2010–2014	2015–2019
Belgium	0.697	0.620	0.671	0.676	0.644
Bulgaria	0.661	0.728	0.765	0.775	0.746
Finland	0.446	0.484	0.692	0.661	0.461
France	0.347	0.276	0.299	0.283	0.285
Germany	0.485	0.427	0.530	0.547	0.463
Greece	0.262	0.261	0.176	0.181	0.153
Ireland	0.319	0.117	0.105	0.127	0.146
Italy	0.595	0.458	0.559	0.551	0.465
Lithuania	0.141	0.651	0.277	0.308	0.257
The Netherlands	0.629	0.589	0.661	0.650	0.673
Poland	0.312	0.109	0.132	0.111	0.161
Portugal	0.395	0.401	0.292	0.288	0.296
United Kingdom	0.568	0.654	0.349	0.385	0.413
Slovak Republic	0.048	0.004	0.004	0.005	0.075
Denmark	0.414	0.307	0.532	0.551	0.534
Spain	0.532	0.512	0.551	0.587	0.573
Sweden	0.232	0.362	0.576	0.573	0.434
EU	**0.417**	**0.409**	**0.422**	**0.427**	**0.399**
Norway	0.567	0.538	0.437	0.399	0.385
Switzerland	0.680	0.695	0.756	0.754	0.709
EFTA	**0.624**	**0.617**	**0.597**	**0.577**	**0.547**
Singapore	0.303	0.322	0.120	0.161	0.170
Thailand	0.571	0.595	0.481	0.560	0.459
Japan	0.499	0.517	0.623	0.616	0.592
China	0.589	0.621	0.674	0.657	0.657
South Korea	0.596	0.649	0.695	0.727	0.729
BA with Asian Countries	**0.512**	**0.541**	**0.519**	**0.544**	**0.521**

BA: Bilateral agreements. BA with Asian countries (Singapore, Thailand, Japan, China, and South Korea). Note. Own elaboration.

Table 7 shows that the estimated trade efficiency of exports from Peru to the member countries of the European Union (EU) is 0.399, and that of exports to members of the European Free Trade Agreement (EFTA) is 0.547 during the period 2015–2019. The efficiencies of exports to countries with which Peru has signed bilateral agreements, in ascending order, are 0.170, 0.459, 0.592, 0.657, and 0.729 for Singapore, Thailand, Japan, China (Peru's first trading partner), and South Korea, respectively, during the period 2015–2019. The EU member countries with efficiencies of less than 30% are Slovak Republic, Ireland, Greece, Poland, Lithuania, France, and Portugal. Regarding the countries with which Peru has BA, that with a level of less than 30% is Singapore.

Table 8 shows that Peru's export efficiency ranges from 0.462 in 1995–1999 to 0.458 in 2015–2019, with a stationary trend. Therefore, the export potential between Peru and its partner countries has been increasing. Peru's export efficiency score reached its peak between 2010 and 2014 (0.487). Peru's export potential volume increased from USD 30,433.1 million in 1995–1999 to USD 220,789.1 million in 2015–2019.

Table 8. The export potential between Peru and its partner countries.

Five-Year Period	Exports (Million USD)	Export Efficiency	Potential Export (Million USD)	Export Potential (Million USD)
1995–1999	26,169.990	0.462	56,603.086	30,433.096
2000–2004	38,872.290	0.469	82,855.453	43,983.163
2005–2009	116,286.330	0.485	239,648.600	123,362.270
2010–2014	193,737.760	0.487	398,098.463	204,360.703
2015–2019	186,748.940	0.458	407,538.030	220,789.090

Note. Potential Export = exports/export efficiency; Export Potential = potential export − exports.

4.2. RQ2. Impact of Factors on Peru's Export Efficiency with Its Trading Partners

Understanding the factors that impact the country's efficiency is vital for the promotion of exports and for government decision making to intervene in the factors that negatively affect it. In this section, we try to identify the main factors that impact the level of efficiency of Peru's exports with a model using the Poisson pseudo-maximum likelihood (PPML) estimator. This estimator has been used in recent studies due to its consistent results (Abreo et al. 2021; Jagdambe and Kannan 2020; Pfaffermayr 2019). Silva and Tenreyro (2006) recommended the use of the PPML estimator in commercial gravity models instead of the ordinary least squares (OLS) method because the former includes a difference in the size of the coefficients, so they are smaller and more suitable. The PPML method corrects the problem of zero trade and heteroscedasticity in the regression model (Jagdambe and Kannan 2020; Álvarez et al. 2018). In addition, the estimator can include trade zero values in the specification, which is an advantage in the presence of a large number of zeros (Francois and Manchin 2013).

Table 9 shows the level of significance of each independent variable that affects Peruvian export efficiency in the period studied. The estimated coefficients of the regional agreements MERCOSUR (−0.611) and European Union (−0.293) are negative and statistically significant at 1%; the coefficient of the bilateral agreements with American countries is positive (0.087) and statistically significant at 1%, while that of Asian countries is negative (−0.091) and not significant for Peruvian export efficiency. The regional agreements with EFTA and CAN and the multilateral agreement with WTO are not significant for Peru's export efficiency. The institutional distance coefficient is positive and statistically significant at the 1% level. The cultural distance coefficient is negative and statistically significant at the 1% level, and the foreign direct investment coefficient is negative and not significant for Peruvian export efficiency. The coefficient of trade freedom is negative and statistically significant at the 1% level (−0.495).

Table 9. Regression of the main factors that affect the efficiency with the PPML estimator.

Variables	Coefficient	Std. Err.	Z	*p*-Value
EFTA	−0.027 ^{ns}	0.059	−0.450	0.654
CAN	0.016 ^{ns}	0.031	0.530	0.596
EU	−0.293	0.041	−7.080	0.000
MERCOSUR	−0.611	0.045	−13.520	0.000
BA American Countries	0.087	0.034	2.600	0.009
BA Asian Countries	−0.076 ^{ns}	0.071	−1.070	0.287
WTO	0.166 ^{ns}	0.145	1.150	0.252
Institutional Distance $(ID)_{ij,t}$	0.064	0.012	5.280	0.000
Cultural $Distance_{ij}$	−0.093	0.022	−4.330	0.000
$lnFDI_{jt}$	−0.005 ^{ns}	0.032	0.160	0.874
$lnTF_{it}$	−0.495	0.104	−4.740	0.000
$lnNTX_{jt}$	0.137	0.104	1.320	0.187
$lnTX_{jt}$	0.042	0.093	0.460	0.647
cons	1.878	0.577	3.260	0.001
Observations	941			
Pseudo Log-likelihood	−672.73			
R-squared	0.233			

Note: ^{ns} represents no statistical significance of the estimated coefficient.

On the other hand, the coefficient of nontraditional exports is not statistically significant. The sectors contributing to export efficiency are chemicals (0.233) and metal mechanics (0.108), while the sectors that do not contribute to efficiency are agriculture (0.018), fishing (0.010), textiles (0.055), wood and paper and their manufactures (0.070), non-metallic minerals (0.050), and iron and steel metallurgy and jewelry (0.027). The coefficient of traditional exports is negative; when analyzing the four sectors that compose it, none are statistically significant (Table 10).

Table 10. The impacts of the nontraditional and traditional export sectors on Peru's export efficiency.

The Effects of Sectors of $lnNTX_{jt}$			The Effects of Sectors of $lnTX_{jt}$		
Sectors	**Coef.**	***p*-Value**	**Sectors**	**Coef.**	***p*-Value**
Agricultural	0.018	0.704	Fishing	0.030	0.600
Fishing	0.010	0.858	Agricultural	0.069	0.166
Textiles	0.055	0.405	Miners	0.017	0.843
Wood and paper and their manufactures	0.070	0.076	Oil and natural gas	0.033	0.474
Chemicals	0.233	**0.021**			
Non-metallic minerals	0.050	0.182			
Iron and steel metallurgy and jewelry	0.027	0.699			
Metal mechanics	0.108	**0.025**			

Note: Own elaboration.

Table 11 shows the effects of the dimension of institutional distance (ID) on EF, showing that the major contributors to EF are ID voice and accountability, ID not adhering to the rule of law, and ID corruption control. In addition, all the variables of cultural distance (CD) have significant effects on EF (except power distance). CD dimensions of individualism, long-term orientation, and indulgence contribute to EF. CD dimensions, such as uncertainty avoidance and achievement culture, weaken EF.

Table 11. The impacts of institutional and cultural dimension distance on Peru's export efficiency.

The Effects of Dimensions of ID			The Effects of Dimensions of CD		
Variables	**Coef.**	***p*-Value**	**Variables**	**Coef.**	***p*-Value**
Voice and Accountability	0.250	0.000	Power Distance	−0.012	0.429
Political Stability	−0.063	0.173	Individualism	0.042	0.000
Government Effectiveness	−0.043	0.611	Achievement Culture	−0.096	0.000
Regulatory Quality	−0.021	0.773	Uncertainty Avoidance [1]	−0.077	0.000
Rule of Law [2]	−0.195	0.041	Long Term Orientation	0.079	0.000
Control of Corruption	0.801	0.000	Indulgence	0.090	0.000

[1] A negative rule of law means not being confident with the rules of society. [2] Negative uncertainty avoidance means being comfortable with uncertainty.

5. Discussion

Kumar and Prabhakar (2017) stated that the single-stage estimation procedure could accommodate exogenous variables' non-monotonic trade efficiency effects. Hence, the present study employs a single-stage panel SF model for efficiency estimation. In addition, the authors included the endogeneity test, utilizing the latest finding in 2022, the xtsfkk command. Karakaplan (2022) introduced xtsfkk as a new command for fitting panel stochastic frontier models with endogeneity. This command can control the endogenous variables in the frontier and the inefficiency term in a longitudinal setting. He demonstrated that xtsfkk performs better than standard panel frontier estimators such as xtfrontier that overlook endogeneity.

International trade and economic sustainability are inextricably connected in Peru. In the present investigation, the export efficiency scores were determined using an extended stochastic gravity model for the period 1995–2019. The results showed that Peruvian export efficiency was moderate, ranging between 0.462 and 0.458, with a stationary trend.

From 2015 to 2019, the estimated efficiency of exports from Peru and the bilateral agreements with the Americas (57.3%) helped Peru achieve significant efficiency in its exports. However, the European Union (39.9%) and MERCOSUR (34.8%) affected Peruvian exports adversely. In contrast, CAN (51.1%) and BAs with Asian countries (52.1%) had no effect.

The study showed that the market size (in terms of GDP) of Peru's trading partners has the highest significant positive impact on the total value of Peru's exports (beta = 0.576).

Peru's GDP coefficient does impact exports despite to its small market size, like the results of the study by Kaushal (2022), who indicated that India's GDP significantly impacts bilateral trade due to its economic size.

The coefficient of the distance variable was negative and statistically significant (beta = −0.113), being an important contributor in determining export efficiency according to its standardized coefficient, along the same line as Doanh et al. (2020), who stated that the ASEAN countries tend to trade less with distant countries. In contrast, Kaushal (2022) asserted that the distance is not significant for India since exports of services have increased by 50%, while exports of goods have only grown by 8% in the past decade. The coefficient of the variable border with Peru was significant and positive in the same line as Doan and Xing (2018). In recent years, exports to Chile and Colombia have shown growth of 9% and 4%, respectively.

This study evaluated the impact on the efficiency scores of four regional trade agreements (RTAs) (the Southern Common Market (MERCOSUR), European Union (EU), European Free Trade Association (EFTA), Andean Community of Nations (CAN)), twelve bilateral agreements (BAs), the World Trade Organization (WTO), institutional distance (ID), cultural distance (CD), foreign direct investment (FDI), trade freedom (TF), and traditional (TX) and nontraditional exports (NTX) by sector in the export efficiency of Peru.

The negative coefficients of MERCOSUR and EU blocs and the bilateral agreements with Asian countries obtained in the study are in line with the results obtained by Gharleghi and Shafighi (2020), who concluded that the differences in the levels of development seem to have a significant impact on trade flows. Along the same lines, Hai and Thang (2017) stated that FTAs have the disadvantage of trade diversion due to the emergence of some types of barriers that induce production and administrative costs. In contrast, CAN was found to be non-significant. The coefficient of the bilateral agreements with the countries of America is positive, in line with Kaushal (2022), who found that all agreements were statistically significant, excluding APTA, implying that regional agreements increase the technical efficiency of India's exports.

Institutional distance (ID) was positive. When ID was itemized, it showed that the rule of law dimension was negative, and the control of corruption and voice and accountability contributed positively to the ID.

These findings are in contrast to Abreo et al. (2021), who argued that most of the ID dimensions were statistically significant (except for the difference between political stability and voice and accountability) and that their effect on Colombian exports is adverse; to Doanh et al. (2020), who said that the institutional distance coefficient is negative, which implies that ASEAN export efficiency is inversely correlated with ID; and to Álvarez et al. (2018), who indicated that differences in institutions make it difficult for trade partners to understand each other's business procedures, implement contract enforcement, and guarantee security.

Cultural distance (CD) and trade freedom (TF) negatively affect export efficiency. The coefficient of cultural distance (CD) was negative. This result is supported by Doanh et al. (2020), who stated that the lack of trust, commitment, and knowledge of the international counterparty's business practices leads to high trade costs, which decreases trade efficiency, and Kristjánsdóttir et al. (2017), who found that national culture has an impact on international trade between countries, indicating that variations in national culture are likely to affect trade between countries.

The coefficient of $lnTF_{ij,t}$ was negative and significant. This finding is in contrast to Doanh et al. (2020), who affirmed that tariffs and non-tariff measures play an essential role in the growth of the trade efficiency of ASEAN countries; in the same vein, Doan and Xing (2018) indicated that tariff reductions and non-tariff measures from trading partners are among the forces driving the improvement of trade efficiency between Vietnam and partner countries.

The FDI coefficient was negative and not significant, in contrast to Doan and Xing (2018), who concluded that FDI is positive and statistically significant at 1% and therefore

contributes to boosting Vietnam's trade efficiency, while Mohanty and Sethi (2021) stated that there is a negative and significant impact of FDI on real exports in the long run, but a positive impact in the short run.

The coefficient of $lnNTX_{jt}$ was positive and statistically significant only for chemicals and metal mechanics. The sector that has contributed the most to export efficiency is the nontraditional chemical sector, which has consistently grown by 14.80% from 1995 to 2019, and the metal mechanics sector, which has grown by 13.77%. The coefficient of $lnTX_{jt}$ was positive and non-statistically significant. Specifically, none of the four traditional export sectors contributed to export efficiency. One of the reasons may be that the Peruvian export structure has changed very little. NTX reached 20.28% in 1995 and 22.49% in 2019, while the TX ranged from 79.71% in 1995 to 77.51% in 2019 (BCRP 2022a, 2022b).

6. Recommendations

The major contributors to export efficiency in Peru are the institutional distance (ID voice and accountability, corruption control, nonadherence to the rule of law), NTX (chemicals and metal mechanics), and bilateral agreements with American countries. It is advised that the government guarantee that stakeholders, both exporters and importers, trust the country's regulations, particularly the quality of contract compliance (ID's rule of law). It is not surprising that ID's control of corruption has a significant impact on trade efficiency. Countries should be confident in conducting business without dealing with internal corruption. In the same way, ID's voice and accountability—perceptions of the extent to which a country's citizens can participate in selecting their government—was shown to be a major contributor to export efficiency. Finally, bilateral agreements with American countries (Canada, USA, Mexico, Honduras, Panama, Costa Rica, and Chile) have a significant positive impact on Peruvian export efficiency. It is imperative to work on maintaining these agreements and making them sustainable (Head and Mayer 2002). In the same way, it is important to evaluate why bilateral agreements with Asian countries have no effect on Peruvian EF.

On the contrary, CD, TF, and agreements with MERCOSUR and the EU challenged the EF in Peru. Trade freedom (TF) has a negative contribution to Peruvian export efficiency. It is recommended that future agreements consider mutually reciprocal terms, focusing on products with the maximum export potential and emphasizing nontraditional products. In addition, the country needs to expand efforts to operationalize the commitments established in the declarations and international cooperation. Furthermore, it is important to develop and implement sustainable development follow-up strategies.

Peruvian export efficiency is affected by CD (indulgence, long-term orientation, individualism, uncertainty, and lack of a culture of achievement). This aligns with the findings of Doanh et al. (2020) that due to the degree to which shared norms and values differ between countries, cultural distance reduces trade efficiency because of increased trade costs.

Policy makers should direct FDI to export sectors with high added value to achieve competitiveness and diversification, and focus on rethinking the structure of the export matrix to give the necessary measures so that the export sectors with the highest added value develop and their insertion in the world value chains is achieved with a differentiated offer.

The fact that FDI inflows to the country have not been significant should encourage the government to develop policies to attract investments that participate in sectors dedicated to exports with added value, especially manufacturers, to diversify and improve the export basket.

Peru should take measures to reduce cultural distances with its trading partners and to improve commercial freedom that prevents it from negotiating more easily. In addition, the RTA of CAN should be evaluated for non-impact and MERCOSUR and the EU for having low contribution.

Nontraditional exports such as chemicals and metal mechanics contribute the most to Peruvian export efficiency. It is advised that incentive policies for nontraditional sectors

be enhanced, given that they have not improved since the 1995–2019 study period. It is important to work to promote nontraditional sectors associated with mining, such as the metal mechanical sector, which is the export sector with the greatest weight, as well as the private sector. The traditional export sectors do not contribute to export efficiency but do contribute to the public treasury, which implies much deeper measures on the part of the government.

This study did not consider foreign direct investment by export sectors, which would help clarify institutional and cultural differences by sector. In addition, data on employment generated by exports should be included in future studies to provide a review of human capital in export sectors that generate efficiency.

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