

The impact of technical barriers to trade on Vietnam's fruit and vegetable exports to key markets

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Abstract

Purpose – This paper examines Vietnam's fruit and vegetable exports to major destination markets including The United States, South Korea, China and Japan with a particular focus on the impact of technical barriers to trade (TBTs) during the period 2008–2023.

Design/methodology/approach – Using a gravity model and panel data estimation by Poisson pseudo maximum likelihood (PPML) estimator and generalized least squares (GLS) estimator, the study identifies the effects of economic fundamentals and non-tariff measures on Vietnam's fruit and vegetable exports.

Findings – The results reveal that gross domestic product (GDP) of key export markets and depreciation of the domestic currency significantly promote exports, while COVID-19 pandemic, population growth in partner countries and geographical distance exert negative impacts. Government effectiveness and deeper integration of Vietnam into global trade enhance export capacity. Among TBTs, stricter maximum residue limits (MRLs) negatively affect Vietnam's exports due to higher compliance costs and rejection risks, while the larger number of TBT measures plays the positive role in promoting export by improving product credibility and consumer trust. The interaction between MRLs and the CPTPP agreement suggests that harmonized regulatory frameworks can mitigate restrictive effects and even stimulate exports.

Research limitations/implications – A key limitation of this research is that Vietnam currently has only a limited number of CPTPP trading partners, with Japan being the main partner, which may constrain the generalizability of findings regarding CPTPP's broader effects. Due to data limitations on TBTs in Vietnam's major vegetable and fruit export markets, the model includes only a set of feasible proxy variables representing TBTs. Future research could analyze the impact of TBT on a country-by-country basis to capture potential heterogeneity across countries.

Originality/value – The findings suggest that while TBTs pose challenges, they also create opportunities for Vietnamese exporters to upgrade production standards, diversify markets and achieve sustainable growth in the global fruit and vegetable trade.

Keywords Fruit and vegetable exports, Technical barriers to trade (TBTs), Maximum residue limits (MRLs), CPTPP, Vietnam, Gravity model

Paper type Research article

1. Introduction

Fruit and vegetable exports play an increasingly important role in the global agricultural trade, contributing significantly to economic growth, rural development and food supply diversification. Over the past decades, global demand for fresh and processed horticultural products has expanded rapidly due to rising incomes; changes in consumer preferences toward healthier diets; and advances in storage, preservation and transportation technologies. Major exporters including European Union, The United States, China and several Latin American countries such as Mexico, Chile and Peru have built strong competitive advantages through large-scale production, modern agricultural techniques and well-developed supply chains. Meanwhile, emerging economies in Asia and Africa are increasingly recognized as promising

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suppliers due to favorable climatic conditions, extended harvest seasons and competitive labor costs. However, global fruit and vegetable trade faces challenges such as fluctuating prices, strict quality and safety standards and technical barriers to trade (TBTs) imposed by importing countries. These include sanitary and phytosanitary (SPS) measures, pesticide residue limits and certification requirements, which can significantly influence export competitiveness. As a result, producers and exporters must continuously adapt to meet market demands, ensure compliance with international standards and enhance value-added processing to remain competitive in an increasingly integrated and regulated global marketplace.

Vietnam possesses substantial comparative advantages in agricultural production, particularly in the fruit and vegetable sector, due to its favorable natural conditions, diverse climate zones, abundant labor supply and competitive production costs (Vu, 2020). In recent years, fruits and vegetables have become increasingly important in the national economic structure, emerging as one of Vietnam's key agricultural export commodities. This sector has recorded remarkable export growth, positioning Vietnam as one of Asia's most dynamic exporters of fruit and vegetables. The country has leveraged its diverse agro-ecological zones and expanding capacity in high-quality tropical produce such as dragon fruit, mango, lychee and passion fruit. Vietnam's export markets have also diversified, extending beyond traditional partners to high-value destinations including China, the United States, the European Union, Japan and South Korea. According to [Grand View Research \(2024\)](#), the global fresh vegetables market was valued at USD 632.54 billion in 2021 and is projected to grow at a compound annual growth rate of approximately 2.8% between 2022 and 2028. This supply shortage will create favorable conditions for Vietnam to expand its exports to international markets.

In the post-pandemic global trade context, supply chain disruptions, market volatility and rising technical protectionism through stricter sanitary, phytosanitary and technical standards pose new challenges for exporters in developing countries, including Vietnam. Vietnamese fruit and vegetable exports face increasing difficulties in meeting stringent TBTs in key markets. While these measures aim to protect importing countries, they can also serve as sophisticated forms of trade protectionism, creating obstacles for exporters. In big markets such as the EU, the United States, Japan, South Korea and China, requirements for quality, food safety, traceability and environmental protection are becoming more rigorous, demanding full compliance to access these markets. Meanwhile, the rapid expansion of next-generation free trade agreements (FTAs), such as the CPTPP and EVFTA, offers both opportunities and pressures regarding compliance, regulatory reform and integration into global value chains. Vietnam's fruit and vegetable sector has yet to fully capitalize on these FTA opportunities. Understanding how technical barriers affect Vietnam's key export destinations is therefore crucial for developing strategies to enhance competitiveness, ensure market compliance and sustain export growth. This highlights the urgent need to examine how TBTs and trade agreements shape agricultural export performance and strengthen Vietnam's export competitiveness.

For these reasons, this paper examines the impact of TBTs on Vietnam's fruit and vegetable exports to key markets including China, The United States, Japan and South Korea during the period 2008–2023. These are major and demanding markets with increasingly stringent requirements for quality standards, food safety, traceability and environmental protection. Therefore, exported products, including fruits and vegetables, must fully comply with these criteria to access these markets. This study aims to analyze the current situation of fruit and vegetable exports in Vietnam and clearly identify the technical barriers that Vietnamese fruits and vegetables are facing in major markets, while also examining the specific impacts of TBT measures on export activities. The research contributes to building a sustainable development strategy for the fruit and vegetable sector, while promoting export growth, particularly in the context of Vietnam's increasing participation in FTAs, which opens up opportunities for deeper integration into the global market. This paper focuses on two questions:

- (1) What is the current status of Vietnam's fruit and vegetable exports?

(2) How do TBTs affect Vietnam's fruit and vegetable exports to key markets?

The paper is organized into five sections. The next section presents a literature review. [Section 3](#) provides methodology and research model. The results of estimation are mentioned in [Section 4](#). The final section gives discussion and conclusions.

2. Literature review and theoretical framework

2.1 Literature review

TBTs have been widely studied in the international trade literature, with scholars debating their dual role as both protective measures and potential obstacles to market access. Early empirical studies emphasize their trade-restrictive effects, particularly for developing economies. [Wilson and Otsuki \(2004\)](#) showed that stricter maximum residue limits (MRLs) substantially reduced African exports of cereals, dried fruits and nuts to European Union. They argued that compliance with such measures imposed significant costs on exporters, particularly those in low-income countries with limited access to advanced testing and monitoring technologies. Similarly, [Disdier et al. \(2008\)](#) conducted a meta-analysis of the effects of SPS measures and technical regulations on agricultural trade. The research compared how SPS and TBT measures imposed by importing countries (mainly OECD members such as the EU, Japan and the United States) affect agricultural exports from developing countries worldwide. Their results confirmed that, on average, such regulations tend to have trade-restrictive effects, particularly on exports from developing countries that often lack the technological and financial capacity to comply with strict requirements. The study also emphasized that the negative effect is more pronounced in perishable goods, such as fruits and vegetables, where compliance with standards related to pesticide residues, traceability and food safety is especially demanding. These results highlighted the negative impacts of TBTs imposed by developed OECD countries such as the EU, Japan and the United States, including higher compliance costs, stricter technological requirements and reduced export volumes from developing countries. SPS and TBT measures can act as non-tariff barriers, particularly affecting exporters with limited capacity to comply with international standards. A paper uses cross-country data covering both developed and developing nations, emphasizing that exporters in developing countries face more difficulties meeting stringent standards set by developed-country markets such as the EU, the United States, Japan ([Beghin et al., 2015](#)). Stricter food safety regulations imposed by high-income OECD countries may reduce trade volumes of exporters in sensitive sectors. Exporters from less-developed and least-developed countries (LDCs) are more constrained by these regulations compared to exporters from developed countries ([Xiong and Beghin, 2014](#)). From a value chain perspective, compliance with SPS and TBT standards can reshape global agri-food supply chains, often excluding small-scale producers who lack the resources to meet certification requirements ([Henson and Humphrey, 2010](#)). [Siyakiya \(2017\)](#) investigated the impact of TBTs on trade using a gravity model. The study employed export data from South Africa covering all products and product groups exported to 57 selected countries, including both developing and developed economies for the period 1995–2015. The finding showed that TBTs exert a stronger negative impact on mechanical and electrical products compared to other product categories. Overall, the study revealed that an increase in the number of TBTs reduces average exports by 4.88%. The level of TBTs affect Pakistan's imports from its trading partners by employing the Poisson pseudo-maximum likelihood (PPML) estimation method ([Mustafa et al., 2020](#)). Their findings reveal that, in addition to the TBT measures imposed by the importer, factors such as Pakistan's GDP and that of its partners, exchange rates, tariffs, geographical distance and contiguity significantly influence partner countries' exports. The study concludes that TBTs were also utilized as an instrument to manage Pakistan's growing trade deficit. TBTs caused significant capital losses for exports from Jiangsu, China. These measures have resulted in partial market loss, reduced export competitiveness and a sharp decline in both export volume and export

growth rate. The negative impacts are also largely attributed to delays in customs clearance and inspection procedures (Xiong *et al.*, 2023)

However, more recent studies highlight that TBTs can also generate positive long-term effects by encouraging exporters to improve production processes, adopt international standards and enhance product quality. While compliance with food safety and quality standards is costly, it can act as a catalyst for modernization in agricultural sectors, leading to better competitiveness in global markets (Jaffee and Henson, 2005). In the case of fresh produce exports from Africa, meeting international standards facilitated access to high-value markets such as the EU, leading to higher export revenues and improved farm incomes. Thus, while TBTs initially present barriers, they can also function as “catalysts for upgrading”, enabling firms to build stronger reputations and integrate more deeply into global value chains (Maertens and Swinnen, 2009). While TBT and SPS measures may reduce trade flows in the short term, they can also encourage quality upgrading and long-term competitiveness (Shepherd and Wilson, 2013).

Maertens and Swinnen (2009) found that high food safety standards in export markets have mixed effects. While they create barriers for some producers, they also provide opportunities for others to integrate into global value chains through contract farming and certification schemes. SPS measures, particularly in food safety and quality, act as both trade barriers and catalysts for improving product quality, depending on the capacity of exporting firms and countries to adapt (Anders and Caswell, 2009). The impact of TBTs on the exports of Egyptian firms during the period 2005–2011 is employed by gravity model with multidimensional fixed effects. By examining both the intensive and extensive margins of firms’ exports as well as estimating the probabilities of entry and exit, the result reveals that the impact of TBTs on firms’ product diversification is positive for agricultural sectors and mixed for non-agricultural sectors. Moreover, firms tend to increase their market diversification in response to TBTs, particularly larger firms targeting destinations in Africa and Asia. By contrast, there is less evidence of diversification toward destinations in Europe (Kamal and Zaki, 2018). Ferro *et al.* (2015) constructed a standards restrictiveness index and analyzed its impact on agricultural exports. They found that stricter standards reduce the likelihood of trade, but for firms that comply with the standards, the impact on trade volume is neutral. Therefore, SPS and TBT measures have dual effects. In one hand, they restrict trade in the short run, especially for small- and medium-sized exporters in developing countries. In other hand, they may also yield long-term benefits by promoting compliance with international norms, improving product quality and fostering sustainable competitiveness.

Existing studies in Vietnam highlighted that non-tariff measures (NTMs) including TBTs and SPS standards are playing an increasingly important role in shaping the country’s agricultural exports, affecting market access, competitiveness and compliance costs for exporters. Nguyen *et al.* (2022) focused on Vietnam’s agricultural products exports to the EU using panel data from 2001 to 2020, analyzing the impacts of SPS measures and TBTs. Using a gravity model, their study finds that SPS and TBTs imposed by the EU have a positive and statistically significant effect on Vietnam’s export of agricultural products. In the long term, non-tariff measures do not affect Vietnam’s agricultural exports. However, non-tariff measures are also found to have a negative impact on Vietnam’s agricultural exports to ASEAN+6 countries (ASEAN and China, Japan, South Korea, India, Australia and New Zealand) during 2015–2019 (Huynh and Bui, 2022). Nguyen *et al.* (2023) employed a gravity model to analyze rice and coffee exports to CPTPP markets, showing that NTMs significantly affect market access and the impact of NTMs on exports is mixed. Vietnam’s accession to the CPTPP brings many integration opportunities, although the process is slow. The impacts of technical non-tariff measures on Vietnam agricultural imports from least developed countries (LDCs) and non-LDCs are heterogeneous in terms of the measures’ sophistication level. Non-tariff measures namely labelling, marking, and packaging requirements increase agricultural imports from LDCs, while there is no significant impact on those from non-LDCs (Nguyen *et al.*, 2024).

Existing studies in Vietnam have mainly examined the effects of non-tariff barriers on agricultural exports as a whole. In contrast, this study specifically investigates how TBTs affect Vietnam's fruit and vegetable exports to major markets. By narrowing the focus to this subsector, the findings provide more targeted and policy-relevant insights. Furthermore, this research integrates TBTs and Free Trade Agreements (FTAs) to explore their interaction effects – specifically, whether agreements such as the CPTPP can mitigate the adverse impacts of TBTs on fruit and vegetable exports. The analysis also incorporates the effects of the COVID-19 pandemic and government effectiveness on export performance, thereby contributing updated empirical evidence to the literature.

2.2 Theoretical framework

TBTs are regulations, standards, testing and certification procedures allowing countries to implement legitimate policy objectives such as consumer protection, human health, environmental protection and national security do not create unnecessary obstacles to trade (Maskus *et al.*, 2005). Due to their diverse and flexible forms, technical barriers have a wide scope of influence. In practice, technical barriers have affected both exporting and importing countries in both positive and negative ways.

For exporting countries, technical barriers imposed by importing countries require continuous improvement in product quality, enhancement of production capacity, investment in technological innovation, managerial upgrading and greater competitiveness of their goods. This situation calls for governments in exporting countries to accompany enterprises, provide support and actively seek appropriate policy solutions to help firms overcome such technical barriers. These efforts not only contribute to strengthening the competitiveness of the economy, enterprises and export goods but also expand market access, increase export turnover, improve income and generate additional employment for the economy. Compliance with the stringent environmental standards of importing markets serves as a driving force for sustainable development, particularly in the field of environmental protection. Strict technical requirements such as limits on greenhouse gas emissions, the use of recycled materials or ensuring environmentally friendly production processes have generated significant positive changes for the environment in exporting countries (World Bank, 2008). However, to comply with the technical barriers imposed by importing countries, exporting firms often face increasing production costs. These costs include improving production conditions, modifying production processes, upgrading raw materials and packaging to meet stringent requirements. To overcome such technical barriers, enterprises need to make substantial investments in modern machinery, advanced technology and quality management systems. Technical barriers also cause direct losses to producers if export products fail to meet the prescribed standards. In cases where an export shipment is found to contain even a minor defect that does not comply with one of the mandatory technical standards, the shipment may be denied entry, returned or even destroyed (Wilson and Otsuki, 2004).

For importing countries, technical barriers play an important role in protecting consumer rights. By requiring imported products to fully comply with established standards, technical barriers contribute to improving the overall quality of goods in the market. The application of technical barriers also serves as an instrument for environmental protection in importing countries. By imposing strict technical standards, governments restrict the entry of environmentally harmful products and permit only those goods that comply with environmental protection requirements to access the domestic market. Such regulatory measures not only reduce the risk of environmental pollution but also play a vital role in preserving natural resources and sustaining ecological balance, thereby aligning trade policy with broader sustainable development objectives. However, technical barriers also function as a protectionist instrument, limiting the massive influx of foreign goods into the domestic market and thereby safeguarding domestic production. Technical barriers may also reduce the incentive for domestic industries to develop. When governments employ technical barriers as

a protectionist measure for domestic production, local firms face less competitive pressure from international producers. Consequently, they may have weaker incentives to innovate technologically, improve production processes and enhance product quality. The excessive application of technical barriers by importing countries may provoke negative reactions from their trading partners. Exporting nations may resort to retaliatory measures or impose higher technical barriers on products from the importing country, potentially leading to trade conflicts and reducing the efficiency of bilateral exchange activities.

Developed countries are increasingly enforcing more stringent technical barriers, posing greater challenges for LDC in accessing international markets. Vietnam's participation in new-generation trade agreements such as the CPTPP in 2019 not only expands its export markets but also serves as an important institutional impetus for domestic regulatory reform. Implementing CPTPP commitments requires Vietnam to adjust and enhance its legal framework, policies and administrative procedures to meet high standards in policy transparency, fair competition, intellectual property protection, labor and environmental regulations. The agreement contributes to the harmonization of domestic regulations with international best practices, thereby improving the investment climate and enhancing national competitiveness. Although the CPTPP primarily governs trade among its members, its effects can extend beyond the bloc through institutional spillover mechanisms. The implementation of CPTPP commitments requires Vietnam to reform its domestic legal and regulatory frameworks to meet high standards of transparency, competition, intellectual property protection, labor and environmental management. These institutional improvements enhance overall governance quality and reduce transaction costs for all trading partners, including non-member countries such as the United States, South Korea and China. Therefore, the CPTPP reflects not only direct trade liberalization effects but also reflects broader institutional and competitiveness gains that indirectly strengthen Vietnam's agricultural export performance to both member and non-member markets.

3. Methodology

3.1 Data

This study employs a quantitative analysis method using annual secondary data for the period 2008–2023. The fruit and vegetable data were collected from the Vietnam Statistical Yearbook, National Statistics Office of Vietnam and Vietnam Customs. The study also uses data from World Bank indicators, World Trade Organization (WTO), the UNCTAD Trade Analysis Information System (TRAINS), the Ministry of Food and Drug Safety (MFDS) of Korea (formerly the Korea Food and Drug Administration, KFDA), the Japan Food Chemical Research Foundation, The United States Department of Agriculture (USDA), for the regression analysis.

3.2 Methodology

The gravity model of trade has become one of the most widely used empirical frameworks in international economics (Tinbergen, 1962). The model has been extensively applied to examine the effects of various determinants on trade flows between countries. Its robustness in estimating bilateral trade flows has established it as one of the most stable and consistent empirical relationships in the field of economics (Leamer and Levinsohn, 1995). Subsequent studies have further developed the model by incorporating multilateral resistance terms (Anderson and van Wincoop, 2003), institutional and policy factors such as free trade agreements and TBTs (Baier and Bergstrand, 2007; Shepherd, 2013). These extensions have enhanced their explanatory power and relevance in contemporary trade analysis.

With the objective of evaluating the impact of TBTs on Vietnam's fruit and vegetable exports to key destination markets, this study employs PPML estimator within the framework of the gravity model, drawing on both its theoretical foundation and prior

empirical studies. The PPML approach is adopted to address heteroscedasticity, following the insights of Santos-Silva and Tenreyro (2006), who argue that standard empirical methods are not well suited for estimating gravity equations. Furthermore, Santos-Silva and Tenreyro (2006) demonstrate that OLS estimation tends to exaggerate the importance of geographical proximity and linkages, with heteroscedasticity being the main source of bias. To overcome these limitations, the study relies on the PPML method as a robust and consistent alternative. In addition, the study also applies generalized least squares (GLS) estimation for panel data as a complementary robustness check. This method is typically employed when the assumptions of the ordinary least squares (OLS) model are violated, particularly in the presence of heteroskedasticity and autocorrelation. In the model, variables are transformed using the logarithm to improve model fit and mitigate heteroskedasticity. The Breusch–Pagan/Cook–Weisberg test is used for the presence of heteroskedasticity in the model. The Wooldridge test is used for autocorrelation in panel data. Due to data limitations on TBTs in Vietnam’s major vegetable and fruit export markets, the model includes only a set of feasible proxy variables representing TBTs.

The proposed model is specified as follows.

$$\begin{aligned} \ln EX_{hft} = & \beta_0 + \beta_1 \ln POP_{ft} + \beta_2 \ln POP_{ht} + \beta_3 \ln GDP_{ft} + \beta_4 \ln GDP_{ht} + \beta_5 TO_{ft} + \beta_6 TO_{ht} \\ & + \beta_7 EX_{hft} + \beta_8 \ln DIS_{hft} + \beta_9 X_{1t} + \beta_{10} X_{2t} + \beta_{11} X_{3t} + \beta_{12} X_{4t} + \beta_{13} BOR \\ & + \beta_{14} CPTPP_{ft} + \beta_{15} I_t + \beta_{16t} COVID_t + \beta_{17} GE_{ft} + \beta_{18} GE_{ht} + \varepsilon_{hft} \end{aligned}$$

where:

\ln denotes the natural logarithm; f denotes destination country; h denotes Vietnam; t denotes months from 2008 to 2023.

$\ln EX_{hft}$: natural logarithm of Vietnam’s fruit and vegetable exports to export country f by month t .

$\ln POP_{ft}$: natural logarithm of population of partner country f by month t .

$\ln POP_{ht}$: natural logarithm of population of f by month t .

$\ln GDP_{ft}$: natural logarithm of gross domestic product (GDP) of partner country f in f by month t .

$\ln GDP_{ht}$: natural logarithm of gross domestic product (GDP) of Vietnam in f by month t .

TO_{ft} : trade openness of partner country f by month t .

TO_{ht} : trade openness of Vietnam f by month t .

EX_{hft} : The exchange rate between Vietnam Dong and the US dollar by month t .

$\ln DIS_{hft}$: natural logarithm of geographical distance between capital of Vietnam and capital partner country

X_{1t} : dummy = 1 if country f has origin requirements for imports from Vietnam at time t ; = 0 otherwise.

X_{2t} : dummy = 1 if country f has packaging regulations for imports from Vietnam at time t ; = 0 otherwise.

X_{3t} : maximum residue limits (MRLs) of the partner country for fruits and vegetables imported from Vietnam f by month t (Vietnam Customs, 2025)

X_{4t} : number of TBT measures applied by country f to Vietnamese agricultural products f by month t (The UNCTAD Trade Analysis Information System, 2025)

BOR: dummy variable takes value = 1 if the partner country shares a land border with Vietnam; = 0 otherwise

$CPTPP_{ft}$: dummy variable takes value = 1 if country *f* is a CPTPP member at time *t*; = 0 otherwise. CPTPP variable is included mainly as a control for international economic integration.

I_t : the interaction term between X_{3t} and $CPTPP_{ft}$. It is a test of the effect between trade agreements and TBTs.

$Covid_t$: dummy variable takes a value of 1 for the years 2020–2022 to capture the period when the COVID-19 pandemic exerted the strongest impact on global trade and supply chains, and 0 otherwise.

GE_{ft} : government effectiveness of partner countries according to [World Bank indicators \(2025\)](#) measuring administrative efficiency and public service quality

GE_{ht} : government effectiveness of Vietnam according to [World Bank indicators \(2025\)](#) measuring administrative efficiency and public service quality

ε_{hft} : error term.

4. Results and discussion

4.1 Descriptive statistics

[Table 1](#) reports summary statistics for the variables used in the research.

In [Table 1](#), the average export value of Vietnamese fruits and vegetables to key markets (EX) is approximately 34.205 million USD, with a wide variation from 0.241 million USD to over 1,083 million USD. Regarding market size, the average population of importing countries (POPf) is approximately 470 million people, with a wide dispersion between small economies such as Korea (about 50 million people) and large ones such as China (about 1.4 billion people). By contrast, Vietnam's domestic population (POPh) remains relatively stable at around 92 million people, with only minor variation during the study period. In terms of economic conditions, the GDP per capita of partner countries (GDPCf) averages 34,221 USD, but the range is large, highlighting the income disparity between developed markets (The United States, Japan, Korea) and emerging market (China, especially in the earlier years). Meanwhile, Vietnam's GDP per capita (GDPCh) is much lower, averaging 2,730 USD, though it shows steady growth from 1,164 USD in 2008 to 4,282 USD in 2023. Trade openness (TOf) in partner countries averages 47.5% of GDP, ranging from 20.5% to more than 100%, reflecting heterogeneous levels of integration into global trade. Vietnam's trade openness (TOh), however, is much higher at an average of 150.6%, underscoring the high degree of dependence on international trade relative to its GDP.

Exchange rate (EX) refers to the bilateral exchange rate between USD and Vietnam Dong (VND). It indicates how many units of VND are required to obtain one unit of USD. In this dataset, ER has an average value of about 21,537, but with large variation (from 15873.02 to 25,000). A higher EX implies that the VND is weaker relative to USD, which tends to make Vietnamese exports more price-competitive abroad. Conversely, a lower EX indicates a stronger VND, potentially reducing the competitiveness of Vietnam's exports. Geographical distance (DIS) averages 5,321 km, with the shortest being China (about 1,916 km) and the farthest being The United States (13,814 km). The variable captures transportation costs and logistical challenges in trade.

The dummy variables (X1 for origin requirements and X2 for packaging regulations) have mean values close to one, implying that in most partner countries and periods, Vietnam exports were subject to these conditions under existing trade agreements. TBTs are reflected in X3

Table 1. Descriptive statistics of variables in the model

Variables	Obs	Mean	Std.Dev	Min	Max
EX (thousand USD)	768	34204.88	77861.57	240.94	1,083,403
POP _f (million)	768	470.0551	535.5311	49.05	1412.6
POP _h (million)	768	92.4875	4.170636	85.59	98.86
GDP _f (USD)	768	34221.17	19688.3	3468.33	82769.41
GDP _h (USD)	768	2730.237	923.701	1163.8	4282.1
TO _f	768	47.470	24.429	20.5	105.5
TO _h	768	150.631	21.679	113.9	186.7
EX	768	21537.02	2064.665	15873.02	25,000
DIS (km)	768	5321.403	4924.503	1915.61	13,814
X1	768	0.988	0.108	0	1
X2	768	0.983	0.129	0	1
X3	768	273.746	142.978	0	550
X4	768	347.776	299.819	0	800
BOR	768	0.25	0.433	0	1
CPTPP	768	0.079	0.271	0	1
I	768	20.0625	69.105	0	276
COVID	768	0.25	0.433	0	1
GE _f	768	1.131	0.503	-0.005	1.805
GE _h	768	-0.041	0.167	-0.248	0.243

Source(s): Author's calculation

(maximum residue limits, MRLs) and X4 (number of TBT measures). On average, partner markets apply between 274 and 348 measures, but the large variation (ranging from 0 to 800) shows that some markets impose very stringent regulatory requirements, while others are relatively less restrictive.

The border-sharing dummy (BOR) takes the value of one for 25% of observations, corresponding to China as the only partner with a land border. Finally, the mean of CPTPP dummy is 0.08, meaning that only about 8% of Vietnam's fruit and vegetable export observations in the sample are directed to CPTPP member countries. This low share highlights that exports are concentrated in non-CPTPP markets such as China, The United States and South Korea, while among the four key markets under study, only Japan is a CPTPP member. The mean of interaction variable (I) is 69.105. The external shock representing by COVID variable has an average value of 0.25. The average values of Government Effectiveness (GE) of partner countries and Vietnam are 1.131 and -0.041, respectively. This indicates that Vietnam's institutional quality, in terms of governance and public service efficiency, remains lower than that of its major trading partners. This institutional gap may affect Vietnam's ability to comply with and adapt to complex TBTs in high-standard export markets.

4.2 Findings

Vietnam's key fruit and vegetable export markets include China, The United States, Japan and South Korea. These are large markets that account for the majority share of Vietnam's fruit and vegetable export value. The following table presents Vietnam's fruit and vegetable export value in general, as well as in key markets, during the period 2008–2023.

In [Table 2](#), Vietnam's fruit and vegetable exports showed a clear upward trend during 2008–2023. The period 2008–2011 marked the initial stage, with exports mainly destined for China through informal trade, characterized by large volumes but low value added. From 2012, exports grew rapidly, rising from USD 827 million to USD 3,507 million in 2017, driven by market diversification and greater access to demanding destinations such as The United States,

Table 2. The export value of key markets and whole market during the period 2008–2023

Year	Vietnam's fruit and vegetable export value of key markets (million USD)	Vietnam's fruit and vegetable export value (million USD)	Proportion (%)
2008	120	406	29.62
2009	117	438	26.79
2010	148	460	32.17
2011	241	630	38.20
2012	335	827	40.52
2013	443	1,073	41.29
2014	616	1,489	41.34
2015	2,079	2,839	73.21
2016	1,981	2,460	80.53
2017	2,966	3,507	84.56
2018	3,143	3,814	82.40
2019	2,950	3,704	79.63
2020	2,279	3,271	69.68
2021	2,441	3,545	68.85
2022	2,121	3,316	63.95
2023	4,291	5,601	76.61

Source(s): Author's calculation

the EU, Japan and South Korea, supported by free trade agreements. Between 2018 and 2022, growth slowed due to US–China trade tensions, the COVID-19 pandemic, rising logistics costs and stronger competition from regional and global exporters. Nevertheless, in 2023, exports reached a record high of USD 5,601 million, signaling a strong recovery and more sustainable development of the industry. Similarly, Vietnam's fruit and vegetable exports to its four key markets also followed an upward trend, rising from USD 120 million in 2008 to USD 4,291 million in 2023. The share of these markets in Vietnam's total fruit and vegetable exports increased from nearly 30% in 2008 to a peak of around 85% in 2017, before declining to 77% in 2023.

In [Table 3](#), export share of Vietnam's fruit and vegetable products in key markets has undergone a significant transformation between 2008 and 2023. In 2008, China overwhelmingly dominated Vietnam's export market, accounting for 84.8% of total exports. However, by 2023, this share had declined sharply to 40.7%. In contrast, exports to more demanding markets such as Japan, South Korea and The United States recorded substantial growth. Japan's share increased from 3.9% in 2008 to 25.6% in 2023, highlighting Vietnam's ability to meet stringent SPS measures as well as traceability requirements. South Korea also emerged as a key destination, with its share rising from 5.3% to 16.2%, partly

Table 3. Export share of Vietnam's fruit and vegetable products in key markets in 2008 and 2023

Countries	Export share in 2008	Export share in 2023
China	84.80	40.69
Japan	3.85	25.60
South Korea	5.25	16.17
USA	6.10	17.54
Total	100	100

Source(s): Author's calculation

facilitated by the Vietnam–Korea Free Trade Agreement (VKFTA), which provided tariff reductions and greater market access. Similarly, the United States expanded its share from 6.1% to 17.5%, reflecting Vietnam’s success in upgrading its export structure by supplying not only fresh but also processed products that comply with USDA and FDA standards. Therefore, Vietnam’s export markets is shifting away from overdependence on China toward developed economies with stricter requirements. While China remains the single largest importer, the growing shares of Japan, South Korea and The United States demonstrate Vietnam’s improved competitiveness, integration into high-standard markets and the positive impact of free trade agreements such as the CPTPP and VKFTA. This structural shift suggests that Vietnam’s fruit and vegetable industry is moving toward greater sustainability and resilience in the global market.

The Breusch–Pagan/Cook–Weisberg test for heteroskedasticity yields a *P*-value of $0.000 < 0.05$, indicating the presence of heteroskedasticity in the model. The PPML estimator is robust to certain forms of model misspecification, particularly those caused by heteroskedastic errors, and is therefore employed as the primary estimation technique. In addition, the Wooldridge test for autocorrelation in panel data produces a *p*-value of $0.011 < 0.05$, suggesting the existence of serial correlation. To account for this issue, the study also applies GLS estimation for panel data as a complementary robustness check. By In this way, PPML serves as the main approach to ensure consistency in the presence of heteroskedasticity, while GLS provides an additional verification of robustness against serial correlation.

In Table 4, by PPML method, *R*-squared in the model is 0.914, indicating that the model explains more than 91% of the variation in exports. For gravity-type data estimated using PPML, this level of explanatory power is considered good, suggesting that the model is appropriate. GLS model appears statistically valid and consistent with economic theory,

Table 4. The estimated results about the effect of technical barriers to trade on Vietnam’s fruit and vegetable exports

Variables	Pseudo Poisson maximum likelihood (PPML)	Generalized least squares (GLS)
lnPOP _f	−0.114*** (0.011)	−2.231*** (0.201)
lnPOP _h	0.225 (0.281)	6.222 (5.176)
GDP _f	0.071*** (0.009)	1.428*** (0.161)
GDP _h	−0.002 (0.027)	−0.348 (0.504)
TO _f	−0.0004 (0.000)	−0.005 (0.005)
TO _h	0.0005*** (0.000)	0.008** (0.003)
EX	0.0001*** (2.53e−06)	0.0002*** (0.000)
lnDIS	−0.041*** (0.011)	−0.636*** (0.200)
X1	−0.008 (0.010)	−0.114 (0.163)
X2	−0.001 (0.008)	−0.056 (0.159)
X3	−0.004* (0.002)	−0.079*** (0.027)
X4	0.0001*** (0.000)	0.002*** (0.000)
BOR	0.317** (0.030)	6.127*** (0.540)
CPTPP	−0.199** (0.081)	−3.518*** (1.410)
I	0.001** (0.003)	0.013** (0.005)
COVID	−0.007*** (0.003)	−0.126** (0.052)
GE _f	0.003 (0.006)	0.0869 (0.293)
GE _h	0.0132* (0.019)	0.264** (0.125)
<i>R</i> -squared	0.914	
Prob > χ^2		0.000

Note(s): Standard errors are robust in the parentheses

***, ** and * are statistically significant at 1%, 5% and 10% levels, respectively

Source(s): Author’s calculation

complementing the PPML results. The result of the GLS model in Table 4 indicates findings consistent with those obtained using the PPML method.

For the partner countries' population variable ($\ln POP_f$), the coefficient is negative and statistically significant at the 1% level, indicating that an increase in the population of partner countries is associated with a decline in Vietnam's fruit and vegetable export values to these four major markets. This finding suggests that Vietnam's export performance in this sector is not directly linked to population growth in the importing countries but rather depends on consumer demand and consumption habits. Partner countries such as The United States, Japan, China and South Korea possess well-developed agricultural sectors but face shortages of tropical fruits and vegetables. Consequently, Vietnam still enjoys considerable advantages in exporting these products to such markets. For the partner countries' per capita income variable ($\ln GDP_{Cf}$), the coefficient is positive and statistically significant at the 1% level, indicating a positive relationship with Vietnam's fruit and vegetable exports to major destination markets. This result implies that rising per capita income in importing countries stimulates consumer demand for a greater variety of fruits and vegetables, as these products are perceived to be beneficial for health. Consequently, higher income levels in developed and highly demanding markets such as The United States, Japan, and South Korea create favorable opportunities for Vietnam's fruit and vegetable exports. Domestic trade openness (TO_h) is positive and significant at the level 1%, suggesting that greater integration of Vietnam into global trade enhances export capacity, including fruit and vegetable products. The exchange rate (EX) variable is positive and significant at the 1% level, indicating that currency depreciation makes Vietnamese fruits and vegetables relatively cheaper, thereby enhancing their competitiveness and boosting exports to partner countries. The coefficient of (DIS) is negative and significant at the 1% level, which indicates that greater distance from Vietnam to partner country reduces Vietnam's fruit and vegetable exports. This result is consistent with the gravity model of trade, which suggests that transportation costs, information frictions and logistical barriers increase with distance, thereby discouraging trade flows.

Among technical barriers factors, technical barriers show positive and negative, highlighting the differentiated influence of trade policy measures on export flows. For Vietnam's fruit and vegetable sector, this dual perspective suggests that overcoming technical barriers is not only a challenge but also an opportunity to strengthen its global position. The coefficient of the maximum residue limits (X_3) of the partner country for fruits and vegetables imported from Vietnam is negative and significant, which implies that stricter food safety regulations reduce Vietnam's export performance. This result indicates that MRLs act as a technical barrier to trade: the more stringent the requirements, the more difficult it becomes for Vietnamese producers to access foreign markets. Although meeting such standards may enhance product reputation in the long run, the short-term effect is a contraction in export value due to the challenges and costs associated with compliance. For the variable representing the number of TBT measures imposed by partner countries on Vietnamese agricultural products (X_4), the coefficient is positive and statistically significant at the 1% level. This result suggests that TBTs, when properly addressed, may have a trade-promoting effect. Compliance with stricter technical standards may enhance export performance by improving product quality, transparency, and consumer trust in importing markets. Stricter requirements on quality, safety, and labeling can enhance the credibility and perceived value of Vietnamese agricultural exports, thereby improving access to high-standard markets such as the United States, Japan or South Korea. Compliance with these measures enables Vietnamese exporters to signal product reliability and meet consumer expectations, which in turn contributes to higher export values. Thus, while TBTs are often regarded as trade-restrictive, in this context they appear to stimulate improvements in production standards and competitiveness, ultimately facilitating export growth.

The negative and statistically significant coefficient of the CPTPP dummy indicates that Vietnam's fruit and vegetable exports to CPTPP member countries are generally lower than those to non-member markets, largely because among the four key markets, only Japan is a

CPTPP member, while China accounting for the largest share of Vietnam's fruit and vegetable exports is not a CPTPP member. However, the interaction variable between CPTPP and MRL (I) is positive and statistically significant at the level 1%. This indicates that within the CPTPP framework, stricter MRL requirements are less restrictive and may even exert a trade-promoting effect. A possible explanation is that CPTPP provides a more transparent and harmonized regulatory environment, which reduces uncertainty and facilitates compliance for Vietnamese exporters. Moreover, the agreement encourages firms to upgrade production technology, enhance quality control and adopt international best practices. As a result, MRL standards within CPTPP markets, rather than acting purely as barriers, can create opportunities for Vietnamese exporters to improve competitiveness and strengthen their market presence.

The negative coefficient of the COVID variable indicates that an external shock such as COVID-19 pandemic had an adverse impact on Vietnam's fruit and vegetable exports to partner countries, likely due to supply chain disruptions, logistics constraints and reduced global demand. The positive coefficient of Vietnam's government effectiveness indicates that improvements in domestic institutional quality – such as better governance, regulatory efficiency and policy implementation – enhance Vietnam's fruit and vegetable exports. This suggests that effective government performance supports exporters by reducing administrative barriers, improving export facilitation and strengthening compliance with international standards.

5. Conclusion

The empirical results reveal that Vietnam's fruit and vegetable exports to major markets are shaped by both economic fundamentals and non-tariff measures. The estimation results indicate that the variables such as GDP of key export markets, government effectiveness and trade openness of Vietnam, depreciation of the domestic currency, number of TBT measures applied by key export markets, geographical proximity and the interaction variable between CPTPP and maximum residue limits of partner countries exert positive effects, whereas the variables such as Covid-19 pandemic, population growth in partner countries, geographical distance, maximum residue limits of partner countries and partner country is a CPTPP member have negative effects on Vietnam's fruit and vegetable exports to major destination markets. The results clarifies the dual role of TBTs under CPTPP commitments and trade agreements can mitigate the restrictive effects of TBTs.

Rising incomes in importing countries are a key driver of export growth, while exchange rate depreciation further enhances competitiveness. The significant influence of per capita income of key export markets and exchange rates highlights the need for flexible trade promotion strategies that target high-income markets and exploit currency advantages to expand export opportunities. In contrast, population growth in partner countries and greater geographical distance exert negative effects, reflecting the importance of demand structure and trade costs. The results also highlight the nuanced role of trade openness. Although reduced openness in partner markets does not significantly hinder exports of essential commodities such as fruits and vegetables, Vietnam's deeper global integration strengthens export capacity. Given the crucial role of geographical proximity, Vietnam should continue to modernize cross-border trade infrastructure with China and other neighboring markets to reduce transaction costs for perishable goods. The positive effect of government effectiveness on Vietnam's fruit and vegetable exports suggests that improvements in institutional quality and administrative efficiency can significantly enhance export performance. The negative effect of COVID-19 pandemic on Vietnam's fruit and vegetable exports highlights the vulnerability of agricultural trade to global disruptions. Strengthening supply chain resilience – through diversification of export markets, investment in logistics infrastructure and digitalization of customs and trade procedures – is essential to mitigate similar shocks in the future.

TBTs show mixed impacts. Since stricter MRLs in partner countries reduce fruit and vegetable exports, Vietnam should strengthen monitoring systems, upgrade testing facilities and provide technical assistance to exporters in fruit and vegetable sector to ensure compliance. The positive role of TBT measures suggests that policymakers should encourage firms to improve production technology, adopt international certifications and invest in quality assurance systems, thereby transforming technical barriers into drivers of competitiveness. As the CPTPP framework mitigates the negative impact of stricter MRLs, Vietnam should leverage this agreement by promoting deeper regulatory alignment and supporting exporters in meeting harmonized standards.

Based on the research findings, several policy implications can be drawn. First, the government should strengthen quality and food safety control by upgrading testing systems for chemical residues and supporting enterprises in adopting advanced technologies and international standards to comply with MRL regulations in importing markets. Strengthening governance through transparent regulatory frameworks, efficient public service delivery and reduced bureaucratic barriers can improve firms' ability to comply with international standards, reduce transaction costs and foster a more predictable business environment. This, in turn, facilitates exporters' market access and competitiveness, particularly in high-standard markets. Second, technical barriers should be transformed into drivers of competitiveness by encouraging enterprises to obtain international certifications, improve production processes, packaging and traceability systems, thereby enhancing the credibility and competitiveness of Vietnamese agricultural products. Third, cross-border trade infrastructure, including logistics systems, cold storage facilities and customs procedures at border areas, particularly with China, should be further developed to reduce costs and risks for perishable goods such as fruits and vegetables. Fourth, opportunities from the CPTPP should be leveraged by providing enterprises with better access to information about harmonized standards, enabling them to meet international requirements and benefit from preferential market access. Finally, Vietnam should diversify both export markets and its product portfolio by expanding to high-income countries while simultaneously exploring other potential destinations to reduce over-dependence on a few large markets. These policy directions, if effectively implemented, will not only help Vietnamese enterprises overcome technical barriers but also promote sustainable growth and enhance the international competitiveness of Vietnam's fruit and vegetable exports.

A key limitation of this research is that Vietnam currently has only a limited number of CPTPP trading partners, with Japan being the main partner, which may constrain the generalizability of findings regarding CPTPP's broader effects. Due to data limitations on TBTs (TBTs) in Vietnam's major vegetable and fruit export markets, the model includes only a set of feasible proxy variables representing TBTs. Future research could analyze the impact of TBT on a country-by-country basis to capture potential heterogeneity across countries.

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Further reading

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