JOURNAL OF EASTERN EUROPEAN AND CENTRAL ASIAN RESEARCH
Vol.11 No.1 (2024)

HOW TECHNOLOGICAL READINESS, AMONG OTHER FACTORS, INFLUENCES AGRICULTURAL EXPORTS FROM VIETNAM TO THE EUROPEAN UNION

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ABSTRACT

The agricultural sector is vital to Vietnam's economy, contributing significantly to food security, employment, and export revenues. As the European Union (EU) emerges as a promising market for Vietnam's agricultural exports, Vietnam must adapt and embrace technological advancements in the agricultural sector to penetrate and excel in the highly competitive and regulated EU market. Technological readiness refers to Vietnam's preparedness to leverage modern advancements in agriculture. This study examines how technological readiness, among other factors such as GDP, population, distance, agricultural land, institutions, and the technological gap, influences the trajectory of Vietnam's agricultural exports to its principal trading partners in the EU. Preliminary findings indicate a positive correlation between technological readiness and increased agricultural exports, drawing significant policy implications. These insights underscore the potential of technology integration in enhancing Vietnam's position in the EU market and the global agricultural export landscape.

Keywords: technology readiness; technology gap; Vietnam; EU; agriculture; gravity model

DOI: https://doi.org/10.15549/jeecar.v11i1.1440

INTRODUCTION

Vietnam's agriculture sector has been a cornerstone of its economic progress, with the nation now standing as the 2nd largest agricultural exporter in Southeast Asia and 15th worldwide (Dat, 2023). The export value of its agricultural products surged from $4.2 billion in 2004 to $41.3 billion in 2019, constituting 15.68% of the nation's total exports (GSO, 2022). Leading this export charge are staples such as rice, coffee, pepper, tea, cashews, cassava, alongside significant contributions from sectors like rubber and seafood. Vietnam has also developed a robust manufacturing sector, with furniture being one of its key export products (Darr & Pretzsch, 2021). Primary markets for these products include China, Europe, the US, ASEAN countries, Japan, and South Korea.

Trade agreements have played a critical role in facilitating Vietnam's agricultural exports to the EU. The EU-Vietnam Free Trade Agreement (EVFTA), which came into force in August 2020, has been mainly instrumental in reducing tariffs and non-tariff barriers, enabling greater market access for Vietnamese agricultural products (Dragusha et al., 2023; Grumiller et al., 2018;

Thanh, 2015). According to data from Vietnam's Ministry of Industry and Trade and the General Department of Customs, trade between Vietnam and the EU's 27 member states has experienced consistent growth from August 2020 until July 2022 (VCCI, 2022). Specifically, exports in 2021 and the first seven months of 2022 witnessed substantial year-over-year increases, reaching $40.12 billion (14.1% growth) and $27.69 billion (21.39% growth), respectively. This cumulative export value of $83.4 billion over two years since the EVFTA's implementation averages at $41.7 billion annually. The significant trade growth attained under the EVFTA deserves recognition, considering the formidable backdrop of the COVID-19 pandemic. Although the pandemic upended global trade dynamics through disrupted supply chains and logistical crises, the EVFTA showcased its resilience by generating favorable trade outcomes within a remarkably brief timeframe.

Despite the achievements of Vietnam's agricultural industry, the country faces challenges in maximizing its export potential. Issues such as suboptimal information and distribution channels, insufficient investment policies for agricultural development, and inadequate linkages in the agricultural value chain all contribute to the low-added value of exported products. Additionally, importing agricultural products into the EU market requires adherence to strict regulations and requirements. Identifying and analyzing the determinants of Vietnam's exports to the EU market is thus of paramount importance in overcoming these obstacles.

Technological readiness refers to the state of preparedness and adaptability of a country, industry, or organization to adopt and exploit new technological innovations (Parasuraman, 2000). In agriculture, technological readiness encompasses various aspects, such as mechanization, digitalization, biotechnology, and sustainable farming practices (Hall, 2003). Studies suggest that higher technological readiness levels can enhance agricultural products' quality, safety, and sustainability, making them more competitive in international markets (Trienekens, 2011). Access to international markets, such as the EU, offers significant opportunities for developing countries like Vietnam to enhance agricultural exports, generate income, and foster economic growth (K. Anderson & Martin, 2005). However, entering the EU market requires compliance with stringent standards, regulations, and certifications related to quality, safety, and sustainability (Disdier et al., 2008). Adopting advanced technologies can facilitate compliance with these requirements, ultimately contributing to increased market access and competitiveness (Giovannucci & Ponte, 2005; Hoa & Tuyen, 2021).

Notwithstanding the extensive literature detailing the role of technological advancement in economic growth and export competitiveness, a conspicuous gap persists when exploring Vietnam's entire agricultural export landscape to the EU. The Technological Readiness Index (TRI), a renowned metric for assessing individual proclivity towards tech-centric experiences provided by the World Economic Forum (WEF), has not been applied in the context of agricultural exports, despite being employed at the macro scale to determine a nation's technological readiness (Schwab, 2018). This study utilizes an extended gravity model to show how technological readiness can impact economic ties between Vietnam and the European Union, specifically focusing on the agricultural sector. The model incorporates various national factors explored in prior research, such as GDP, population, distance, agricultural land, institutional factors, and the technological gap. Additionally, this study introduces the variable of technological readiness measured by the TRI, providing a nuanced perspective to analyze the complexities of agricultural exports.

LITERATURE REVIEW

The Endogenous Growth Theory, based on (Romer, 1993), emphasizes the significance of technological advancement as an endogenous factor that drives sustained economic growth. Unlike the traditional neoclassical models, where technology is seen as an exogenous factor, Romer (1990) treated technological change as resulting from intentional investment decisions made by profit-seeking entities. (Grossman & Helpman, 1993) expanded on this by illustrating that technological innovation boosts a country's ability to produce novel, high-quality goods. Consequently, such nations experience

augmented competitiveness in the international arena, leading to heightened exports (Hallward-Driemeier et al., 2002). The underlying idea is that as countries invest in technological advancements, they can produce more sophisticated goods or offer services at competitive prices, making them more attractive in the international marketplace. Porter (2011) underscored the significance of advanced factors, including technology infrastructure, in conferring a competitive advantage to nations. Several cross-country studies, such as Amiti & Freund (2010), found a positive correlation between technological readiness and export diversification and growth. Specifically, nations with a higher technological readiness index tend to diversify their export basket and tap into more sophisticated export markets. Baldwin & Lopez-Gonzalez (2015) observed that countries with high technological readiness are more likely to participate in global value chains, further enhancing their export potential.

A comprehensive examination of the existing literature uncovers numerous studies that have utilized gravity models to analyze the various factors that influence Vietnam's agricultural exports to the EU market. Do (2006) focused on the trade between Vietnam and 23 OECD EU countries and revealed that GDP and population had a notable impact on export turnover. Further, Vũ (2017) predicted that removing tariffs between Vietnam and the EU, particularly in the agricultural sector, would significantly boost trade. Mỹ & Linh (2017) studied the correlation between Vietnam's agricultural exports and agricultural land area from 1997 to 2014, revealing a negative impact on export turnover. Hoang et al. (2019) highlighted positive factors like financial market development, trade freedom, technological readiness, and labor freedom that favorably impact Vietnam's potential agricultural exports to the EU. Nha et al. (2020) identified technology, infrastructure, and government policies as significant factors affecting the export of Vietnam's coffee to the EU market.

DATA AND METHODOLOGY

The gravity model has emerged as a ubiquitous tool for quantifying the impact of various factors on the scope of international trade. Pöyhönen (1964) and Tinbergen (1962) first employed this model in their analyses, and since the latter half of the 1970s, extensive research has been devoted to affording the model with a solid theoretical and experimental foundation. Despite its youth, the gravity model has proven to be a potent analytical instrument, aiding researchers in better understanding the intricate forces governing international trade. According to this law, the force of gravity is directly proportional to the magnitude of the economies and inversely proportional to the square of the distance between them. This implies that an increase in the magnitude of an entity results in a commensurate rise in the force of gravity while widening the distance between them leads to a decrease in the gravitational force between them. The general gravity model applied to exports has the following form:

$$EXPijt = A(\frac{GDPit * GDPjt}{DISij})^{\beta} \quad (1)$$

Where EXPij is the volume of export trade between countries i and j; GDPit and GDPjt are the GDPs of country i and j; DISij reflects the distance between country i and j (measured in kilometers or miles); A is a constant.

This research explores how technological readiness impacts Vietnam's agricultural exports to the EU. To systematically approach this, the study is guided by the core research question: "How does technological readiness, among other factors, influence the agricultural export from Vietnam to the European Union?" To cater to the specifics of this research, the gravity model was extended, thereby incorporating variables pertinent to the research objective. The adapted model is represented as

$$LnEXP_{ij} = \beta_0 + \beta_1 Ln(PGDP_{it} * PGDP_{jt}) + \beta_2 Ln(POP_{it} * POP_{jt}) + \beta_3 Ln(DIS_{jt}) + \beta_4 Ln(AGREARE_{it} * AGRIAREA_{jt}) + \beta_5 Ln(INST_{it} * INST_{jt}) + \beta_6 Ln(TECHNESS_{it} * TECHNESS_{jt}) + \beta_7 Ln(TECHGAP_{ijt}) + \varepsilon_{ijt} \quad (2)$$

The dataset consists of trade data for agricultural products between Vietnam and eight major EU trading partners. Specifically, these partners include the United Kingdom (during its tenure as an EU member until 2019), Spain, Poland, Netherlands, Italy, Germany, France, and Belgium. These countries were selected based on their pronounced import volumes from Vietnam, underscoring the salience of these trading relationships in the realm of Vietnam's

agricultural exports to the EU market. The dataset covers 11 years, from 2009 to 2019, providing a comprehensive view of the trends and patterns in agricultural trade between Vietnam and the selected EU countries. Besides the data capture, various aspects of the trading relationships, such as technological readiness ($TECHNESS_{it}$*$TECHNESS_{jt}$), technological gap ($TECHGAP_{ijt}$), GDP ($PGDP_{it}$*$PGDP_{jt}$), the distance between trading partners (DIS_{jt}), and other relevant factors such as population (POP_{it}*POP_{jt}), the proportion of agricultural land area ($AGREAREA_{it}$*$AGRIAREA_{jt}$), institutional quality ($INST_{it}$*$INST_{jt}$), allow for an in-depth analysis of the role of technological readiness in promoting Vietnam's agricultural exports to the EU. The model incorporates variables related to panel data analysis conducted to estimate the effects of these variables on agricultural exports over time while controlling for unobservable country-specific and time-specific factors. The acronyms of the variables are explained in Table 1.

Table 1: Variable description and data sources

Variable	Definition	Expected sign	Data sources	References
EXi_{jt}	Export value of agricultural products from country i to country j in year t; thousand USD		UN Comtrade	Pöyhönen (1964); Tinbergen (1962)
$PGDP_{it}$* $PGDP_{jt}$	Gross domestic product of country i and country j at time t; USD/person	+	WB	Pöyhönen (1964); Tinbergen (1962)
POP_{it}*POP_{jt}	Population of country i and j at time t; thousand people	+	WB	Nha et al. (2020); Do (2006)
$DIST_{ijt}$	Distance between country i and country j; kilometer	+	WB	Pöyhönen (1964); Tinbergen (1962)
$AGREAREA_{it}$* $AGRIAREA_{jt}$	The ratio between the area of agricultural land and the surface area of a country; %	+	WEF	Nha et al. (2020)
$TECHNESS_{it}$* $TECHNESS_{jt}$	Technology readiness index of country i and j at time t; take values from 1 to 7, where 7 is the best	+	WEF	Proposed by author
$TECHGAP_{ijt}$	Technological gap between country i and j at time t	+	WEF	Nha et al. (2020)
$INST_{it}$*$INST_{jt}$	Institutional quality of country i and j at time t; take values from 1 to 7, where 7 is the best	+	WEF	Nha et al. (2020)

Comprehensive datasets were sourced from the UN Comtrade, the World Bank (WB), and the World Economic Forum, ensuring data reliability and credibility. The data underwent rigorous validation processes, with inconsistencies and outliers addressed systematically. Panel data analysis was adopted, considering the dataset's cross-sectional (countries) and time-series (years) dimensions. This allows for capturing variations across countries over time and offers controls for unobservable country-specific and time-specific factors. Stata 17 software was utilized, as well as the panel data estimation model, which encompasses various estimation models: pooled (OLS), fixed (FEM), and random (REM) effect models. Initially, the Breusch-Pagan

Lagrange (LM) test is employed to determine the most suitable OLS or panel effect model. Subsequently, the Hausman test was conducted to ascertain the most appropriate model—FEM or REM.

Table 2 displays the results of the extended gravity model that captures the relationship between variables in equation (2) and provides estimations from different models, including pooled (OLS), fixed (FEM), and random (REM) effect models.

RESULTS AND DISCUSSIONS

Table 2: Summary results of extended Gravity Model

Variables	Pooled	FEM	REM
$Ln(AGRIAREA_{it}*AGRIAREA_{jt})$	-0.0631	0.587***	-0.0153
	-0.0676	-0.0808	-0.234
$LnDIST_{ijt}$	3.703	-6.816***	0.207
	-2.618	-0.809	-2.688
$Ln(INST_{it}*INST_{jt})$	-0.532	-1.715***	-0.75
	-1.624	-0.382	-0.707
$Ln(PGDP_{it}*PGDP_{jt})$	0.136	-0.0926***	-0.0795***
	-0.137	-0.0117	-0.0104
$Ln(POP_{it}*POP_{jt})$	-0.000661	9.424***	2.127
	-0.207	-0.758	-2.643
$TECHGAP_{ijt}$	0.334	0.172***	0.101
	-0.366	-0.0205	-0.222
$TECHNESS_{ijt}$	-0.189***	0.0265**	-0.0218
	-0.0404	-0.0113	-0.0347
Wald test	-	60.26***	-
Hausman test	-	430.35***	-

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

The Hausman and Wald test results with p-value = 0.000 < 0.05 indicate that the FEM is the best model for this research. Specific results have the following highlights:

Ln(AGRIAREAit*AGRIAREAjt) represents the interaction of the logarithm of agricultural areas of Vietnam and its EU trading partners. The positive and statistically significant coefficient of 0.587 in the FEM suggests that a 1% increase in the combined agricultural area of Vietnam and its trading partners is associated with a 0.587% increase in Vietnam's agricultural exports to the EU. This implies the crucial role of land size in influencing agricultural trading dynamics. Specifically, the proportion of the agricultural land area of Vietnam and its trading partners in the EU positively impacts Vietnam's agricultural exports to the EU. First, a larger agricultural land area indicates a higher potential for agricultural production, which can lead to increased exports. The availability of arable land and the proportion of land dedicated to agricultural activities can affect the potential for agricultural output and trade between countries. Second, considering its EU trading partners' vast agricultural land areas, the competitive landscape becomes more intricate. A broader agricultural terrain in the EU suggests that these countries have significant agricultural capacities of their own, potentially intensifying competition for Vietnam. This necessitates Vietnam to leverage its cost advantages, quality, and unique product offerings. Indeed, economies of scale come into play; larger agricultural expanses can dilute

production costs over more substantial output levels, fostering lower average costs and bolstering international market competitiveness. Thus, even if the EU has substantial agricultural lands, Vietnam's cost-efficient production can render its agricultural products more palatable in the EU market. Third, larger agricultural land areas can increase agricultural productivity by adopting advanced technologies and farming practices (Fuglie & Rada, 2013). With more extensive land resources, there is a greater incentive for adopting new technologies and innovations to enhance productivity and competitiveness. As a result, the proportion of agricultural land area in Vietnam and its EU trading partners can positively impact Vietnam's agricultural exports to the EU by driving technological readiness and improved farming practices.

The negative coefficient of -6.816 for Ln(DISTijt) in the FEM, which is statistically significant, shows that as the logarithm of distance between Vietnam and its trading partners increases by 1%, Vietnam's agricultural exports to the EU decrease by roughly 6.816%. This result is in line with the gravity model of trade and highlights the negative impact of transportation costs and other distance-related trade barriers. Specifically, the geographical distance between Vietnam and its trading partners has a negative impact on Vietnam's agricultural exports to the EU. The explanation can be justified through various factors well-established in international trade literature. One key factor is transportation costs. As the geographical distance between trading partners increases, the transportation costs associated with shipping goods also rise (Samuelson, 1952). Higher transportation costs can make products more expensive, reducing their competitiveness in the destination market. In the case of Vietnam's agricultural exports to the EU, the longer distance can lead to increased costs of shipping perishable agricultural products, which may negatively impact export volumes. Another reason is the impact of distance on information flows and cultural differences. Greater distance between trading partners can lead to increased communication barriers and reduced understanding of each other's markets, which can hinder trade. For Vietnam's agricultural exports to the EU, the increased distance may make it more challenging to access market information, navigate regulatory requirements, and understand consumer preferences, negatively impacting exports. Moreover, time-sensitive products may be adversely affected by longer shipping times. Many agricultural products, especially perishable ones, have a limited shelf life and require timely delivery to maintain their quality (Hillberry & Hummels, 2008). As the distance between Vietnam and its EU trading partners increases, so does the shipping time, which can lead to product degradation and a reduction in the desirability of these products in the EU market.

The institutional quality interaction term Ln(INSTit*INSTjt) yields a coefficient of -1.715 in the FEM. This negative, statistically significant coefficient indicates that the aggregate institutional quality of Vietnam and its trading partners negatively impacts Vietnam's agricultural exports to the EU market. It is generally accepted that institutional quality improvements can positively impact international trade (Anderson & Marcouiller, 2002; Nunn & Trefler, 2014). However, the results of this study indicate that an increase in aggregate institutional quality between Vietnam and its trading partners could have a negative impact on Vietnam's agricultural exports to the EU. One possible explanation for this negative impact is the regulatory divergence between Vietnam and the EU. Higher institutional quality often implies stronger regulations and standards, such as sanitary and phytosanitary (SPS) measures, which aim to protect human, animal, and plant health. If the SPS measures in the EU are more stringent than those in Vietnam, it could increase the compliance costs for Vietnamese exporters, making their products less competitive in the EU market. This could lead to reduced agricultural exports from Vietnam to the EU. Another reason for the negative impact of aggregate institutional quality on Vietnam's agricultural exports to the EU is the potential for increased competition (Helpman et al., 2008). Higher institutional quality often leads to a more efficient allocation of resources and increased productivity. As the institutional quality of Vietnam and its trading partners improves, the agricultural sector's competitiveness in both regions may increase, leading to greater competition in the EU market. This could result in a lower market share and reduced agricultural exports from Vietnam to the EU.

Furthermore, the relationship between aggregate institutional quality and trade may be non-linear (Rodrik et al., 2004). Institutional quality improvements may positively impact trade by reducing transaction costs and promoting investment. Beyond a certain threshold, however, further improvements in institutional quality could have diminishing returns or even adverse effects on trade if they lead to increased bureaucracy, regulatory burden, and complexity.

The negative coefficient of -0.0926 in the FEM for the interaction of the logarithm of GDPs signals that as the combined GDPs of Vietnam and its trading partners grow, Vietnam's agricultural exports to the EU might face downward pressure. While the aggregate GDP of Vietnam and its trading partners is generally expected to impact Vietnam's agricultural exports to the EU positively, there are instances where it could negatively impact trade. First, one reason for the negative impact is the income elasticity of demand for agricultural products (Matsuyama, 2000). As the aggregate GDP of Vietnam and its trading partners increases, indicating a rise in income levels, the demand for agricultural products may not increase proportionally. Consumers in higher-income countries often diversify their consumption patterns, shifting their demand from basic agricultural products to more sophisticated and processed goods.

Consequently, Vietnam's agricultural exports may face reduced demand in the EU market as income levels rise, negatively impacting trade. Second, another possible explanation is the economy's structural transformation (Kongsamut et al., 2001). As the aggregate GDPs of Vietnam and its trading partners grow, their economies will likely shift from agriculture-based to more industrial and service-oriented sectors. This structural transformation can decrease agricultural production and export capacity in Vietnam and its trading partners. Moreover, the EU may increasingly focus on importing high-value, processed goods rather than raw agrarian products, negatively impacting Vietnam's agricultural exports. Third, the negative impact of aggregate GDP on Vietnam's agricultural exports to the EU could be related to the environmental and sustainability concerns associated with agricultural production (Grossman & Krueger, 1995). As the aggregate GDPs of Vietnam and its trading partners increase, there may be growing awareness and emphasis on environmental conservation and sustainable development. This heightened focus on sustainability could lead to the implementation of stricter environmental regulations and standards, which may raise the cost of agricultural production and hinder Vietnam's agricultural exports to the EU.

Ln(POPit*POPjt) has a positive coefficient of 9.424 for the FEM, indicating that a rise in the aggregate population of Vietnam and its trading partners can significantly enhance Vietnam's agricultural exports to the EU. The explanation can be justified through various factors well-established in international trade literature. One key factor is the market size effect (Krugman, 1991). A larger aggregate population in Vietnam and its trading partners implies a bigger market for agricultural products. As the population grows, the demand for food and agricultural products increases, providing Vietnamese exporters with a larger customer base and driving growth in agricultural exports to the EU. Another reason for the positive impact of the aggregate population on Vietnam's agricultural exports to the EU is the diversification of demand (Imbs & Wacziarg, 2003). A larger population often entails more diverse consumer preferences, tastes, and needs. This can increase the demand for a wider range of agricultural products, including those exported by Vietnam, such as tropical fruits, spices, and coffee. The diversification of demand can lead to greater opportunities for Vietnam's agricultural exports in the EU market.

Additionally, the demographic structure of the population can contribute to the positive impact of the aggregate population on Vietnam's agricultural exports to the EU (Bloom et al., 2003). A growing and aging population may change consumption patterns, with an increased preference for healthier and more diverse food options, including fruits, vegetables, and other agricultural products. This shift in consumption patterns can create new opportunities for Vietnam's agricultural exports to the EU.

The aggregate technology readiness (TECHNESSijt) of Vietnam and its trading partners positively impact Vietnam's agricultural exports to the EU market with a positive and significant coefficient (0.0265) in the FEM. This relationship can be attributed to several factors

explored in the literature on international trade, technological advancements, and agriculture. First, technology readiness can boost agricultural productivity in Vietnam (Fuglie & Rada, 2013). As technology readiness increases, farmers can access and adopt more efficient farming techniques, such as precision agriculture, genetically modified crops, and advanced irrigation systems. This can result in higher yields and better-quality products, making Vietnam's agricultural exports more competitive in the EU market. Second, improved technology readiness can enhance supply chain efficiency and logistics (Christopher, 2016). Better transportation, warehousing, and distribution technology can reduce transportation costs, minimize spoilage and waste, and ensure that perishable agricultural products reach the EU market faster and in better condition. This can improve the competitiveness of Vietnam's agricultural exports, leading to increased trade. Third, technology readiness can facilitate compliance with the EU's stringent food safety and quality standards (Jaffee & Henson, 2005). Advanced technologies, such as traceability systems and rapid contaminant detection methods, can help Vietnamese producers meet the EU's requirements for imported agricultural products. This can increase the likelihood of Vietnam's agricultural exports gaining access to the EU market. Fourth, technology readiness can foster better market information and communication (Aker & Mbiti, 2010). Enhanced information technology can enable Vietnamese producers and exporters to access timely and accurate information about the EU market, including consumer preferences, price trends, and regulatory changes. This can help them adapt their production and marketing strategies, ultimately boosting agricultural exports to the EU.

TECHGAPijt has a coefficient of 0.172 in the FEM model, which is positive and significant, infers that a technological disparity between Vietnam and its trading partners can be advantageous for Vietnam as it positively impacts Vietnam's agricultural exports to the EU. This relationship can be attributed to several factors in the literature on international trade, comparative advantage, and technology transfer. First, the technology gap can give Vietnam a comparative advantage in labor-intensive agricultural production (Grossman & Helpman, 1993). As Vietnam's trading partners possess more advanced technologies and focus on capital-intensive production, Vietnam can take advantage of its relatively lower labor costs to specialize in labor-intensive agricultural products. This comparative advantage can make Vietnam's agricultural exports more competitive in the EU market. Second, the technology gap can promote technology transfer and spillovers from the EU to Vietnam (Coe & Helpman, 1995). The EU's advanced agricultural technologies and practices can be transferred to Vietnam through foreign direct investment, technical assistance, and trade in intermediate goods. This technology transfer can help improve Vietnam's agricultural productivity, product quality, and compliance with EU standards, increasing agricultural exports to the EU. Third, the technology gap can stimulate innovation and adaptation of technologies in Vietnam (Acemoglu et al., 2006). The need to catch up with more technologically advanced trading partners can encourage Vietnam to invest in research and development, adopt new technologies, and adapt them to local conditions. This process of innovation and adaptation can enhance the competitiveness of Vietnam's agricultural sector and boost exports to the EU. Fourth, the technology gap can create opportunities for niche market specialization. As Vietnam's trading partners focus on advanced, high-value agricultural products, Vietnam can exploit niche markets by producing and exporting traditional or specialty agricultural products, such as tropical fruits, organic produce, or traditional rice varieties, which may be in demand in the EU market.

CONCLUSION AND RECOMMENDATION

This study has explored the role of technological readiness in promoting Vietnam's agricultural exports to the European Union market. The findings have yielded significant insights indicating that higher technology readiness levels in Vietnam's agricultural sector can positively impact agricultural exports to the EU. Factors contributing to this positive relationship include comparative advantage, technology transfer, innovation, niche market specialization, increased agricultural productivity, enhanced supply chain efficiency, and improved compliance with food safety and quality standards.

Based on the findings of this study, the following recommendations are proposed to

enhance Vietnam's agricultural exports to the EU market. First, the Vietnamese government and the private sector should invest in research and development to improve agricultural productivity, product quality, and compliance with EU standards. This can include adopting precision agriculture, genetically modified crops, and advanced irrigation systems. Second, Vietnam should actively seek opportunities for technology transfer from the EU and other advanced countries through foreign direct investment, technical assistance, and trade in intermediate goods. This can help improve the country's agricultural productivity and competitiveness in the EU market. Third, Vietnam should identify and exploit niche markets in the EU by producing and exporting traditional or specialty agricultural products, such as tropical fruits, organic produce, or traditional rice varieties. This can help differentiate Vietnamese agricultural products from its competitors and cater to the diverse preferences of EU consumers. Fourth, the Vietnamese government and private sector should invest in advanced transportation, warehousing, and distribution technologies to reduce transportation costs, minimize spoilage and waste, and ensure that perishable agricultural products reach the EU market faster and in better condition. Fifth, Vietnam should leverage information technology to provide timely and accurate information about the EU market, including consumer preferences, price trends, and regulatory changes, to help producers and exporters adapt their production and marketing strategies accordingly. Sixth, The Vietnamese government should work closely with the private sector, including farmers, agricultural cooperatives, and exporters, to develop and implement strategies for improving technological readiness and competitiveness in the agricultural sector. Lastly, Vietnam should collaborate with the EU and other trading partners on capacity-building initiatives, knowledge exchange, and technology transfer to promote sustainable and inclusive growth in the agricultural sector. By implementing these recommendations, Vietnam can further leverage the positive impact of technological readiness on its agricultural exports to the EU market, ultimately contributing to the country's economic growth and development.

The present study has some limitations that can draw some suggestions for future research. First, regarding the dataset's scope, the temporal span from 2009 to 2019 potentially neglects recent technological shifts or advancements post-2019 in the agricultural sector. Geographically, the study's lens on major EU trading partners could inadvertently omit insights from other EU nations that might have evolving trade interactions with Vietnam. Second, from a methodological standpoint, while the gravity model offers a robust framework, its static nature might not fully capture dynamic interactions or feedback mechanisms intrinsic to international trade. The potential for omitted variable bias looms, suggesting that other significant factors could influence Vietnam's agricultural exports to the EU, which remain unaccounted for in the current model.

Moreover, given the interplay of multiple variables in the panel data analysis, econometric challenges such as endogeneity or multicollinearity might arise. Third, the analysis has focused on the aggregate technology readiness level in Vietnam's agricultural sector without delving into the specific dimensions of technological readiness. This limits the understanding of the distinct impacts of each dimension on export performance. Last, the study has not examined the barriers to technology adoption in Vietnam's agriculture sector nor explored potential strategies to overcome these challenges. This limits the applicability of the findings in informing effective policy interventions.

Based on the current study's limitations, future research could focus on the following areas. First, extending the dataset to integrate post-2019 data and insights from a broader spectrum of EU countries can offer a more comprehensive view. Second, embracing dynamic modeling approaches that account for intricate interactions and feedback loops could provide a more holistic understanding of the Vietnam-EU agricultural trade dynamics. Third, future studies should examine the various dimensions of technological readiness, such as mechanization, digitalization, biotechnology, and sustainable farming practices, to understand their respective impacts on Vietnam's agricultural exports to the EU. This would provide a more nuanced understanding of the role of technological readiness in promoting export performance. Last, other control variables could be added to the research model to draw more implications,

such as barriers to technology adoption and policy incentives in promoting technology adoption.

While the influence of technological readiness on Vietnam's agricultural exports has been recognized, there is a gap in the literature regarding the quantification of this impact, specifically in relation to the EU market. Many existing studies have approached the topic broadly, covering a range of factors without diving deep into the role of technology and its readiness. The current study fills this research gap by focusing specifically on technological readiness and its influence on Vietnam's agricultural exports to the EU. By employing an extended gravity model on trade data for agricultural products between Vietnam and eight major EU trading partners, this study offers a detailed, quantitative exploration of how technological readiness can enhance agricultural export competitiveness. The findings are intended to be instrumental for policymakers looking to promote technological interventions in the agricultural sector.

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ACKNOWLEDGEMENT

The author gratefully acknowledges the financial support from the Banking Academy of Vietnam

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