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Heterogeneity effect of technical measures: Evidence from the Vietnam seafood trade

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Abstract

The free trade movement sweeping across the globe has destabilized the role of tariffs and emphasized the importance of technical measures as the main tool for regulating trade. The effect of technical measures on trade flow is both controversial and ambiguous despite their undeniable popularity in both theoretical and empirical literature. Empirical evidence shows both a positive and negative relationship between technical measures and trade volume which raises the question of "what determinants create and dictate the heterogeneity associating with the effect of technical measures on trade". This paper aims at constructing a theoretical foundation that explains the mechanics by which technical measures affect trade flow and identifies the existence of the heterogeneity effect of SPS and TBT measures on Vietnam's seafood exports by using a gravity model with a combination of PPML and moderator estimation. Accordingly, an additional SPS measure boosts the export of Vietnam's seafood by 0.3% but an additional TBT measure decreases Vietnam's seafood export by 1.9% on average. Furthermore, the results of this study also confirm the moderating role of firms' efficiency and consumers' preferences in determining the impact of technical barriers on trade. This paper also recommends some solutions for the Vietnamese government and enterprises to enhance their ability to comply with TBT and SPS measures to promote seafood export.

Keywords: Gravity model, Heterogeneity, Moderator variables, Sanitary phytosanitary, Technical barriers, Vietnam's seafood.

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1. Introduction

The literature surrounding trade has put immense emphasis on the role of technical measures which according to UNCTAD categorization include sanitary and phytosanitary measures (SPS) and technical barriers to trade (TBT). The evolution of free trade supported by the increasing popularity of regional agreements and recessive tariff rates has incentivized countries to implement non-tariff measures especially technical barriers and sanitary phytosanitary measures to regulate trade [1]. The COVID-19 pandemic also changed the public perception of health and food safety which boosted demand for stricter quality and sanitary requirements for exported products [2]. SPS and TBT measures have grown exponentially in pure number as well as product coverage [3, 4]. The progressive importance of technical measures (TBT, SPS) sparked interest among both researchers and policy makers regarding the effect of these regulations on trade [5-7]. Theoretically, there is a wide spread consensus among researchers that technical measures create excessive compliance costs and therefore negatively affect trade. However, the literature has failed to prove this empirically which show a mixed effect of technical measures on trade. Technical regulations can significantly facilitate or hinder trade [8] based on the specific products or markets that enter the data. Some studies suggest a negative effect of technical measures on trade even though the intensity of such effect varies across products [9-13] while others found both positive and negative effects on trade [4, 8, 14, 15]. This heterogeneity leads to a new field of research that aims at laying a theoretical foundation explaining the mechanics of technical measures' effect on trade. Marette and Beghin [16] explained the mechanics on the supply side by applying the linear production function and market equilibrium while [17] derived their framework from the demand size. Both show that factors on the supply and demand sides translate into the heterogeneity of technical measures' impact. However, there are issues that remain undiscussed: Can the heterogeneity in technical measures' effect on trade be explained from both the supply and demand sides in a single framework? And can such a framework be proven using empirical evidence?

This study is based on the work of Marette and Beghin [16] and Beghin, et al. [17] to establish a general theory that accounts for the role of both supply and demand factors in moderating the effect of technical measures on trade. Then, we try to model such factors and estimate them using Vietnam seafood export data to prove the robustness of the theory. The reasons for choosing this particular industry in Vietnam to enter the estimation data are three folds. Firstly, Vietnam is a country with many advantages in exporting seafood products including wild caught seafood and farm raised seafood. In recent years, data collected from UN-COMTRADE shows that seafood is one of the 10 commodity groups with the largest export turnover in the country. Vietnam's seafood exports in 2020 and 2021 are 8.41 billion USD (ranked 8th) and 8.89 billion USD (ranked 9th) respectively. In 2022, Vietnam's seafood export turnover continued to rank 8th with value of about 10.92 billion USD, an increase of more than 7 billion USD compared to 2007 - the first year of Vietnam as a member of the WTO. However, such a volume of trade is not evenly distributed among the industry and only concentrates on a particular group of seafood products. Such characteristics allow for the analysis of technical measures' effects between closely related product groups which show the impact of supply side factors. Secondly, Vietnam seafood exports are heavily regulated with both TBT and SPS measures which allow us to compare the effects of both TBT and SPS on trade flow being categorized as food products. According to UNCTAD, there are about 1,250 TBT and SPS measures used for fishery products in countries around the world, accounting for about 80% of non-tariff measures related to fishery products of which technical standards, regulation of ecolabels and traceability for wild-caught and farm-raised fish are increasingly important factors for ensuring market access, ensuring a sustainable, safe and sustainable harvest and consumer protection [18]. Lastly, the data related to Vietnamese seafood exports is readily accessible and can be reliably collected by the research team which allows for more accurate estimation results.

In the next section, the paper presents the constructed theory to explain the effect of technical measures on trade. After that, the paper introduces the methodology and data collection process. Then, the paper shows the estimation results and discussion followed by a conclusion and some recommendations. The paper ends by stating limitations and directions for future research.

2. Literature Review

Heterogeneity associated with the impact of technical measures has been widely proven in empirical literature. Schlueter, et al. [8] argued that sanitary regulations are distinctive in types and requirements which leads to differences in effect on trade. SPS measures relating to pest control, microbiological and residual restrictions act as trade catalysts while processing, treatment and distribution regulations have contrasting effects. Schlueter, et al. [8] suggested that the effect of technical measures in trade is theoretically ambiguous and can only be effectively proven by using disaggregated data and adequate estimation strategies. Shepotylo [15] used a disaggregated data set of seafood trade at the HS 4-digits level to reach similar conclusions based on such an idea. The results show that SPS measures expand seafood exports at extensive margins but impede the growth of intensive margins. In contrast, TBT measures negatively influence trade extensive margin and positively influence trade intensive margins. These results reveal that technical measures also impact different dimensions of trade which can only be scouted for using product specific data. The question remains: do industry intrinsic characteristics alter the impact of technical measures? Fernandes, et al. [14] tackle this issue with a firm-product data set. The paper suggests that while sanitary, phytosanitary and technical barriers measures are beneficial for trade, their effect is much more pronounced in smaller firms. According to Fernandes, et al. [14], this phenomenon is the result of entering new product markets and enhancing export quality. Santeramo and Lamonaca [4] have proven that SPS measures is not universal across countries but alters according to development level. The author concluded that SPS measures positively affect developing importers but do not show a significant relationship with trade with developed importers. Moreover, an enhancing trade effect is found when trades have different economic development levels. Overall, the literature has solidified the existence of heterogeneity in the impact of technical measures on trade across different dimensions. This realization has invoked the demand for theoretical research to explain this heterogeneity.

Marette and Beghin [16] using a production function have developed a mathematical theory to explain the channel through which technical measures affect trade. The authors concluded that production efficiency plays an important part in moderating the effect of technical measures. The trade of businesses from developing countries can be negatively affected due to a lack of efficiency in the production process. This effect is much more prominent when the technical measures applied are not in compliance with international standards. Beghin, et al. [17] contribute to the theoretical literature by developing a model explaining the impact of technical measures on trade using the utility function regarding the demand side. The model emphasizes the role of information asymmetry as technical measures are believed to be beneficial for trade when consumers have access to accurate and sufficient information.

The above discussed literature review reveals a gap for theoretical research dedicated to explaining the impact of technical measures on trade holistically in a model with factors covering both the supply and demand sides. This paper addresses the research gap by constructing a theory that takes into account both the demand and supply factors in a single model and then establishes an empirical strategy to test the model's predictability.

3. Heterogeneity in the Impact of Technical Measures: The Baseline Theory

The diverse impact of non-tariff measures can be intuitively derived from differences in exporters' efficiency and consumers' perceptions. Businesses face different magnitudes of costs adapting to standards and regulations which businesses with existing high-quality products witness negligible to no alternation in cost. Regarding demand, information asymmetry is a source of distortion; rigorous consumers are more perceptive of both positive and negative changes in product quality. The mixture of these elements creates a spectrum of effects that standards can impose on trade. Theoretically, this idea can be formalized with a model similar to Marette and Beghin [16]; Beghin, et al. [17] and Bratt [19] which introduce a framework to analyze the effect of standards on demand, domestic and foreign supply functions. Marette and Beghin [16] proposed a supply function that includes parameters λ and γ representing suppliers' minimum effort and endowment advantages respectively. λ captures the producer's effort and also the probability of a safe product ranging between $0 \leq \lambda \leq 1$. Intuitively, producers supply unsafe products with the probability (1- λ). γ is a proxy for production advantages that are assumed to favor foreign producers with $\gamma < 1$. The following profit functions for domestic and foreign producers can be derived: Equation 1 shows the profit function of domestic producers while Equation 2 shows the profit function of foreign producers.

$$\pi_d = px_d - C\lambda^2 x_d - \frac{x_d^2}{2} \quad (1)$$

$$\pi_f = px_f = \gamma C\lambda^2 x_f + \frac{x_f^2}{2} \quad (2)$$

The quantities needed to maximize producers' profit are $x_d = p - C\lambda^2$ and $x_f = p - \gamma C\lambda^2$. The total supply curve is $x = x_d + x_\gamma = 2p - C\lambda^2 - \gamma C\lambda^2$.

The theoretical framework of Marette and Beghin [16] was expanded to internalize damages caused by unsafe products. However, it is arguable that consumers not only experience damages from unsafe products but at the same time gain benefits from products whose quality follows the imposed standard. Hence, Equation 3 shows an expanded version of Marette and Beghin's [16] demand curve as follows:

$$Q = a - p - I(1-\lambda)r\left(\frac{x_F}{x}\right) + I\lambda t\left(\frac{x_F}{x}\right) \quad (3)$$

A binary variable I denotes the perception of consumers towards product quality which takes the value of 1 if consumers have perfect information regarding the standard and 0 otherwise. r and t are proxy for per unit damage and benefit of using an unsafe and safe product respectively which makes the term $-I(1-\lambda)r\left(\frac{x_F}{x}\right)$ represent the potential damage of unsafe products and $I\lambda t\left(\frac{x_F}{x}\right)$ the potential benefits of safe products.

Equation 4 shows the equilibrium price derived from the abovementioned supply and demand function.

$$p = \frac{a - I(1-\lambda)r\left(\frac{x_F}{x}\right) + I\lambda t\left(\frac{x_F}{x}\right) + c\lambda^2 + \gamma c\lambda^2}{3} \quad (4)$$

The equilibrium price alters as standards are imposed on foreign producers. Equation 5 shows the equilibrium price and foreign supply demand curve in the market where no standards are imposed ($\lambda = 0$).

$$p = x_F = \frac{a + Ir\left(\frac{x_F}{x}\right)}{3} \quad (5)$$

Equation 6 shows the equilibrium price in a market where standards are imposed ($\lambda = 1$).

$$p = \frac{a + It\left(\frac{x_F}{x}\right) + c + c\gamma}{3} \quad (6)$$

Equation 7 shows the foreign supply curve affected by standards.

$$x_F = \frac{a + It\left(\frac{x_F}{x}\right) + c + c\gamma}{3} - \gamma C \quad (7)$$

Equations 8 and 9 show the differences in quantity supplied between a standards and no standards regime.

$$\Delta x_F = \frac{It\left(\frac{x_F}{x}\right) + C + \gamma C}{3} - \gamma C + \frac{I\left(\frac{x_F}{x}\right)r}{3} \quad (8)$$

$$\Delta x_F = \frac{I\left(\frac{x_F}{x}\right)(t+r)}{3} + C\left(\frac{1}{3} - \frac{2}{3}\gamma\right) \quad (9)$$

The quantity of supply for foreign producers also depends on consumers' perceptions of safety. Two separate scenarios are analyzed.

Scenario 1: The market suffers from information asymmetry (I = 0). Equation 10 shows the difference in quantity supplied before and after standards are applied in a market that suffers from information asymmetry.

$$\Delta x_F = C\left(\frac{1}{3}-\frac{2}{3}\gamma\right) \quad (10)$$

When consumers are indifferent regarding product safety, foreign producers' quantity of supply will depend on relative advantages (γ) in production compared to domestic producers. More efficient foreign producers (γ approaches 0) will witness less cost and even a surplus in quantity supply ($\Delta x_F > 0$). Less efficient foreign producers (γ approaches 1) will suffer from decreasing trade volume ($\Delta x_F < 0$). Hence, producers' efficiency in adapting to changes in standards and regulations dictates the fluctuation in trade volume in the market plagued by market asymmetry.

Scenario 2: The market has information symmetry (I = 1). Equation 11 shows the differences in quantity supplied before and after standards are applied in a market with information symmetry.

$$\Delta x_F = \frac{\left(\frac{x_F}{x}\right)(t+r)}{3} + C\left(\frac{1}{3}-\frac{2}{3}\gamma\right) \quad (11)$$

In this case, Δx_F not only depends on the efficiency parameter γ but also on the benefit and damage parameters *t* and *r*. Even in the case, the term $C\left(\frac{1}{3}-\frac{2}{3}\gamma\right) < 0$ which translates to inefficient foreign producers, a sufficient magnitude of the t parameters can curve the negative effect and result in a heightened trade volume. The contrast is also true as the overwhelming negative effect of inefficiency can dwarf the positive effect of consumers' benefits, thus decreasing the overall quantity of supply from foreign producers. Hence, the mixture of effects from consumers' perceptions and producers' efficiency dictates the volume of supply for foreign producers.

According to the above framework which is based on the work of Marette and Beghin [16] and Beghin, et al. [17], new standards affect trade volume through two main channels. First, standards create an efficiency barrier which encourages foreign producers to possess more efficient production processes and price out less-efficient producers. Second, standards influence consumers' demand through the attractiveness of enhanced product quality. However, the contrary holds true as low-quality products also deter consumption. The mixture of these forces creates a spectrum of effects that standards have on trade volume. The two abovementioned channels often alternate between different product groups as knowledge spill-over tends to equalize production efficiency within certain industries and intrinsic characteristics of products influence consumers perceptions. Hence, theoretically, the heterogeneity effect of standards exists between product groups.

4. Methodology

4.1. Estimated Model: Structural Gravity Model

This paper applies the structural gravity framework made common by Anderson and Van Wincoop [20] which is widely applied and supported in empirical research in the field of international economics. The structural gravity model is well- established theoretically and can derive from both the demand and supply sides. A common practice is to derive the structural gravity model from the Armington constant elasticity of substitution utility function (CES) by maximizing utility conditioning under budget constraints. Equation 12 shows the derived model explaining sectoral bilateral trade ($X_{ijk,t}$).

$$Xijk,t = \frac{Y_i E_j}{\pi_{ik,t}} \frac{t_{ijk,t}}{P_{jk,t}} \Theta_{ijk,t} \quad (12)$$

Y_i and E_j are size terms accounting for the relative demand and supply of the importer and exporter. Theoretically, size variables are positively correlated with trade which indicates that large economies import more from all sources and also export more to all destinations. The trade cost term $\frac{t_{ijk,t}}{\pi_{ik,t}P_{jk,t}}$ includes multilateral resistance terms $\pi_{ik,t}$ and P_{jk,t_j} which proxy for the relative competitiveness of country *i* and *j*. $\Theta_{ijk,t}$ accounts for time varying and time-invariant factors of transaction costs.

Equation 13 shows the exponential form of the abovementioned structural.

$$Xijk,t = exp[\alpha_{ik,t} + \alpha_{jk,t} + \alpha_{ijk} + t_{ijk,t}]\ x\ \varepsilon_{ijk,t} \quad (13)$$

Consistently with the CES derived structural gravity model, $X_{ijk,t}$ denotes the sectoral, time-specific bilateral trade between country *i* and *j*. $\alpha_{ik,t}$ and $\alpha_{jk,t}$ denote country-sector-time specific fixed effects which is a common practice to control for exporter and importer multilateral resistance terms respectively. These terms capture any sector specific characteristics that change over time for the importer and exporter. α_{ijk} accounts for the country-pair-sector fixed effect which proxies for time-invariant characteristics between trade partners including distance, colony ties, landlocked or language similarity. The inclusion of country-pair-sector fixed effect is argued to be vital to solve the problem of endogenous trade policies. Equation 14 shows the functional of the time-varying trade cost vector $t_{ijk,t}$ which represents the time-varying trade cost.

$$t_{ijk,t} = \beta_1 RTA_{ij,t} + \beta_2 \tilde{t}_{ijk,t} + \beta_3 SPS_{ijk,t} + \beta_4 TBT_{ijk,t} \quad (14)$$

$RTA_{ij,t}$ is a dummy variable signaling the existence of a free trade agreement between trading partners at time t. The term $\tilde{t}_{ijk,t}$ represents the bilateral tariff between i and j and is defined as $\tilde{t}_{ijk,} = ln(1+tariff)$, *tariff* is the ad-valorem tariff level that importer *j* imposes on exporter *i* at time *t*. $SPS_{ijk,t}$, $TBT_{ijk,t}$ are a set of vectors representing product specific technical measures imposed by *j* on *i* at time *t*. $SPS_{ijk,t}$ and $TBT_{ijk,t}$ entering the model are calculated as the accumulated technical measures that were imposed on product *k* by importer *j* . The count variable of stock technical measures allows for the phase-in effect of technical measures in which products require a certain period to comply with new regulations. $SPS_{ijk,t}$ and $TBT_{ijk,t}$ are more likely to show a positive correlation with trade by accounting for the improvement of products.

4.2. Estimation Strategy

This paper uses a combination of a moderator variable estimator and a Poisson Pseudo Maximum Likelihood estimator (PPML). The moderator estimator provides information on the moderating effect of supply and demand factors in the model while the PPML estimator is used to address the problematic characteristics of trade data [21]. The following section discusses in detail the purposes of each estimator:

4.2.1. Moderating Estimator: Modeling Heterogeneities in Technical Measures Effect

The baseline theory shows that the technical measures affect trade by creating an efficiency barrier as well as influencing consumers' demand. Therefore, modeling such channels into the model is essential for examining the existence of heterogeneities as well as confirming the accuracy of the baseline theory in explaining international trade under the influence of technical measures.

Theoretically, higher awareness regarding health and overall-wellbeing corresponds with a higher level of responsiveness towards both negative and positive changes in product quality. However, this effect can only manifest under the condition of relatively symmetric information either through the availability of marketing infrastructure or the sufficient effort of consumers to scout for details. Such characteristics thrive in developed countries where high levels of income encourage further demand for strict product standards and better organization of food risk media [4]. We investigate this hypothesis by incorporating a set of dummy variables $d_{j,t}$ (=1 if j is classified as a developed country at time t, = 0 otherwise) representing the development level of the importers to act as a moderator variable for the technical measures effect. The development level variable is expected to boost positive effects and dampen the negative effects of technical measures.

A common empirical strategy among gravity practitioners is to use finer disaggregated data due to the fact that technical measures are imposed differently for each tariff-line which creates sectoral disparity in the effect of these regulations on trade. Data on HS4 digits is collected and fitted into the model to account for such heterogeneities across sectors. Sectoral level data also allows the model to control firms' efficiency. Sectors with a larger overall trade volume are more efficient and have better adaptability to technical regulations due to economies of scale and knowledge spill over among firms. Therefore, the efficiency barrier enters the model as a moderator for the SPS and TBT effect through a set of dummy variables controlling for sector size $d_{k,t}$ (=1 if sector k has an average trade volume that surpasses the overall average trade, = 0 otherwise).

The estimation process is outlined as follows:

First, the dummy variables $d_{j,t}$, $d_{k,t}$ are first entered into the model to scout for the existence of direct effect between development, efficiency and trade. Equation 15 shows the estimated gravity function with the inclusion of efficiency and development level dummies.

$$X_{ik,t} = \mu + \alpha_{ik,t} + \alpha_{jk,t} + \alpha_{ijk} + \beta_1 RTA_{ij,t} + \beta_2 \tilde{t}_{ijk,t} + \beta_3 SPS_{ijk,t} + \beta_4 TBT_{ijk,t} + \beta_5 d_{j,t} + \beta_6 d_{k,t} \quad (15)$$

Second, if a significant effect between the independent variables $SPS_{ijk,t}$, $TBT_{ijk,t}$ and trade is detected, the 2 model containing 4 sets of interaction terms between $d_{j,t}$, $d_{k,t}$ *and* $SPS_{ijk,t}$, $TBT_{ijk,t}$ are constructed to account for moderator effect. Equations 16 and 17 show the estimated function to scout for moderation effect.

$$X_{ijk,t} = \mu + \alpha_{ik,t} + \alpha_{jk,t} + \alpha_{ijk} + \beta_1 RTA_{ij,t} + \beta_2 \tilde{t}_{ijk,t} + \beta_3 SPS_{ijk,t} + \beta_4 TBT_{ijk,t} + \beta_5 d_{j,t} + \beta_6 d_{k,t} + d_{k,t} * SPS_{ijk,t} + d_{k,t} * TBT_{ijk,t} + \varepsilon_{ijk,t} \quad (16)$$

$$X_{ijk,t} = \mu + \alpha_{ik,t} + \alpha_{jk,t} + \alpha_{ijk} + \beta_1 RTA_{ij,t} + \beta_2 \tilde{t}_{ijk,t} + \beta_3 SPS_{ijk,t} + \beta_4 TBT_{ijk,t} + \beta_5 d_{j,t} + \beta_6 d_{k,t} + d_{j,t} * SPS_{ijk,t} + d_{j,t} * TBT_{ijk,t} + \varepsilon_{ijk,t} \quad (17)$$

Due to the collinearity problem, the 2 sets of interactions related to countries development level and firm efficiency need to be estimated separately. Models 3 and 4 capture the moderating effect of $d_{j,t}$, $d_{k,t}$ through a set of interaction terms whose significant coefficients indicate the existence of the moderating effect. The directions of the moderating effects are described through a plot graph.

4.2.2. Poisson Pseudo Maximum Likelihood Estimator: Controlling for Heteroskedasticity and Zero Trade Flow

Heteroskedasticity is an intrinsic characteristic of trade data that potentially creates biased and inconsistent results if the gravity model is estimated in log linear form due to Jensen' inequality. Silva and Tenreyro [21] suggest using a Poisson Pseudo Maximum Likelihood (PPML) estimator to tackle this problem as the PPML estimator is robust with heteroskedasticity. PPML allows model 1 to be estimated under the assumption of proportionality between conditional means and variance.

Trade data is also plagued with zero values which are categorized as structural and statistical [4]. Structural zeros relate to no or negligible trade activity between partners and statistical zeros are the results of rounding or measurement errors. PPML allows model 1 to be estimated in multiplicative form which bypasses the problem and allows information regarding zero trade value to enter the model.

5. Data

The estimated data covers a time period between 2007 and 2021. The data consists of seafood export volume from Vietnam to 29 trading partners at the HS-4 digits level which contains all seafood products categorized as HS0301 to

HS0308 and canned sea food categorized as HS1604 and HS1605 in the harmonized system. The countries selected 95% of the overall Vietnamese seafood trade over the period. Importers are categorized by development level according to the UN classification which is used to construct the development dummy variable ($d_{j,t}$). Transitional economies such as Ukraine and Russia are classified as developing countries for the sake of argument. Members of the European Union enter the model separately because some countries like the Netherlands impose their own technical measures in addition to the Union's unified policies.

Table 1 shows the description of estimated data categorized according to countries development levels. The data description shows a disparity in trade policies between countries with different levels of development. Developed countries have heavier regulations overall but especially focus on SPS measures with a mean of 5.802. Developing countries have a lower overall number of regulations and SPS in particular but they have a higher rate of applied TBT measures compared to developed countries with a mean of 0.525 measures.

Table 1.
Data description of technical measures distribution based on countries development level.

Development level	Number of countries	Mean $SPS_{ijk,t}$	Mean $TBT_{ijk,t}$
Developed	13	5.802	0.163
Developing	16	2.625	0.525

Table 2 shows the description of estimated data categorized according to products. The products in the data set also show an apparent uneven distribution in Vietnamese seafood export volume (see Table 2). Certain product lines have exceptional export value such as 0304 (fish fillets and other fish meat), 0306 (crustaceans, live, fresh, chilled frozen), 0307 (molluscs, live, fresh, chilled, frozen), 1604 (prepared or preserved fish), 1605 (Crustaceans, molluscs and other aquatic invertebrates prepared or preserved). These are counted as main export products and denoted as 1 in the dummy variable $d_{k,t}$ to account for firms' efficiency. These products are also more heavily protected by SPS regulations with an average of 4.06 SPS measures. Manufactured products such as 1604 and 1605 are regulated by more TBT measures on average.

Table 2.
Data description of technical measures distribution based on products.

Product code	Average trade	Mean $SPS_{ijk,t}$	Mean $TBT_{ijk,t}$
0301	324256.4	4.35	0.27
0302	842638	6.06	0.305
0303	9221004	5.31	0.319
0304	6.11e+07	4.802	0.36
0305	3401302	2.809	0.301
0306	6.19e+0.7	5.1	0.378
0307	1.56e+07	5.28	0.31
0308	54995.76	1.61	0.22
1604	1.29e+07	2.62	0.62
1605	3.86e+07	2.52	0.52

Seafood export volume from Vietnam to destinations categorized at the 4 digits level of the harmonized system classification is collected from the UN-COMTRADE database. Information regarding tariff is extracted from the WTO Tariff download facility for the period of research. The trade relationship between Vietnam and importers is also controlled by an $RTA_{ij,t}$ dummy variable that is collected from the WTO data base. Data relating to TBT and SPS measures is collected from the WTO, SPS and TBT platform - ePing which provide comprehensive information regarding the measure such as content, date of notification and date of withdrawal.

6. Results

The Poisson Pseudo Maximum Likelihood (PPML) estimation's results are reported in Table 3. Column 1 records the results of the baseline model 1 while column 2 records the expanded model which accounts for development and efficiency dummy variables. The results of models 3 and 4 are reported in columns 3 and 4 which include the moderator terms of development and efficiency variables respectively. Coefficients in models 1 and 2 show the direct effect of the controlled variables on trade while coefficients in models 3 and 4 show the moderating effect of the included interaction variables.

According to the base line (1) and expanded model 2, the direct effects of the dependent variables strictly comply with gravity theory. Tariff has a statistically significant and negative effect on Vietnamese seafood exports. On average, a percent increase in tariff hinders trade by 0.29 percent. Vietnam also exports significantly more seafood to trading partners with trade agreements. The coefficients of SPS and TBT variables also show a significant effect on trade despite disparity in directions. On average, an addition of SPS measures boosts trade by 0.3% ($(e^{0.003} - 1) * 100$). On the contrary, TBT impedes trade and in addition TBT measures decrease Vietnam seafood trade by 1.9% ($(e^{-0.0201} - 1) * 100$). Efficiency

$(d_{k,t})$ has a significant effect on the seafood trade. However, there is no relationship between importer development status and Vietnamese seafood exports.

Model 3 shows statistically significant coefficients relating to interaction terms between development level and technical measures which indicates the existence of a moderating effect of $d_{j,t}$ on SPS and TBT. Model 4 also shows a significant moderating effect of firm efficiency level. However, the interpretation of the moderating effects requires plotting diagrams.

Table 3.
Estimation results.

Variables	Model 1	Model 2	Model 3	Model 4
Tariff $(\tilde{t}_{ijk,t})$	-0.29 (0.004)	-0.29 (0.004)	-0.27 (0.010)	-0.307 (0.002)
RTA $(RTA_{ij,t})$	2.738 (0.000)	1.19 (0.000)	1.83 (0.000)	1.04 (0.000)
SPS $(SPS_{ijk,t})$	0.003 (0.039)	0.003 (0.039)	0.054 (0.000)	0.007 (0.000)
TBT $(TBT_{ijk,t})$	-0.0201 (0.030)	-0.0201 (0.030)	0.585 (0.000)	-0.091 (0.377)
Developed $(d_{j,t})$		0.33 (0.461)	4.89 (0.000)	4.205 (0.000)
Efficiency $(d_{k,t})$		6.05 (0.000)	-4.09 (0.001)	9.58 (0.000)
$d_{j,t}$* $SPS_{ijk,t}$			-0.05 (0.001)	
$d_{j,t}$*$TBT_{ijk,t}$			-0.89 (0.000)	
$d_{k,t}$ *$SPS_{ijk,t}$				-0.006 (0.000)
$d_{k,t}$ *$TBT_{ijk,t}$				-0.129 (0.011)

Note: The table shows the results of 4 different models. Model 1 is the baseline gravity model. Model 2 expands on the baseline model to include development and efficiency dummies. Model 3 includes development-TBT, development-SPS interaction terms. Model 4 includes efficiency-TBT and efficiency-SPS interaction terms. All models include a set of importer-sector-time; exporter-sector-time; importer-exporter-product fixed effects. P-values are recorded in parentheses. "*" indicates multiplicative functions.

7. Discussion

The coefficient still shows an overwhelming negative effect of tariff on trade regarding the controlled variables. Even though are losing their place as the prime method for trade protection due to the increasing popularity of trade agreements, they still establish a tremendous barrier to trade whenever they exist. This is exceptionally prominent in the food trade as countries are reluctant to compromise on tariff reductions in these industries due to the risk of food security. Evidently, tariff rates in agriculture and commodities (especially meat product) in general and seafood specifically are substantially higher than others [22, 23]. This again emphasizes the importance of countries commitments to abolish tariff barriers through the use of free trade agreements which also show a significant role in promoting trade in the model.

Overall, technical measures show a clear disparity in effect. Our results of the heterogeneity effect of TBT and SPS are common features of agricultural trade research such as Sandaruwan, et al. [24] and Shepotylo [15]. Specifically, the result show that SPS measures act as catalysts promoting Vietnam' seafood trade volume. Schlueter, et al. [8], Santeramo and Lamonaca [4] argued against the use of aggregated data to examine the effect of SPSs because regulations might be both trade impeding and trade promoting which will cancel each other out resulting in ambiguous results. However, our paper successfully shows a significant relationship between SPS and trade by using a sectoral specific data set. Furthermore, we actually allow for the adjustment of firms to comply with regulations which suggest that SPS measures actually set a higher standard for Vietnamese businesses, making Vietnam's seafood more competitive globally and more likely to be accepted by consumers by using a count variable for the stock SPS measure. This "standard as catalyst" effect can also be found in research by Santeramo and Lamonaca [4], Disdier, et al. [25], Wood, et al. [26] and Fernandes, et al. [14]. In contrast, TBT measures are shown in the results to restrict Vietnam's seafood exports. The descriptive data analysis shows that Vietnam's seafood export flow is more likely to face TBT measures entering developing countries. Hence, Vietnamese seafood export is hindered by TBT measures as developing countries have the tendency to exploit technical measures as a protectionist tool. The evidence for this claim is the number of specific trade concerns (STCs) raised against TBT measures for seafood which is often used to query for more transparency or protest unreasonable measures. According to the WTO, SPS and TBT platforms from 2007-2021, there are 35 STCs raised by WTO members for TBT regulations and only 16 STCs for SPS even though the number of SPS measures was almost 6 times higher than TBT for seafood products.

Figures 1 and 2 show the moderator effect between countries development levels and technical measures. Overall, the moderating effect between development levels and TBTs, SPSs on trade confirms the suggested baseline theory. SPS and TBT measures imposed by developed countries tend to encourage higher trade volume than measures imposed by developing countries. This effect is especially prominent when the number of measures is large. According to the baseline theory, this moderating effect is the result of increasing consumers' demand for regulated imported products and higher information transparency which are prominent traits of countries with higher development levels. More pronounce trade enhancing moderating effects at a larger number of TBT and SPS measures again proves the importance of allowing the data to take into account the improvement of products to comply with new regulations by applying count stock variables of TBTs and SPSs. This supports the argument of Santeramo and Lamonaca [4] for the importance of disentangling the effect of TBT and SPS according to country-pair development level.

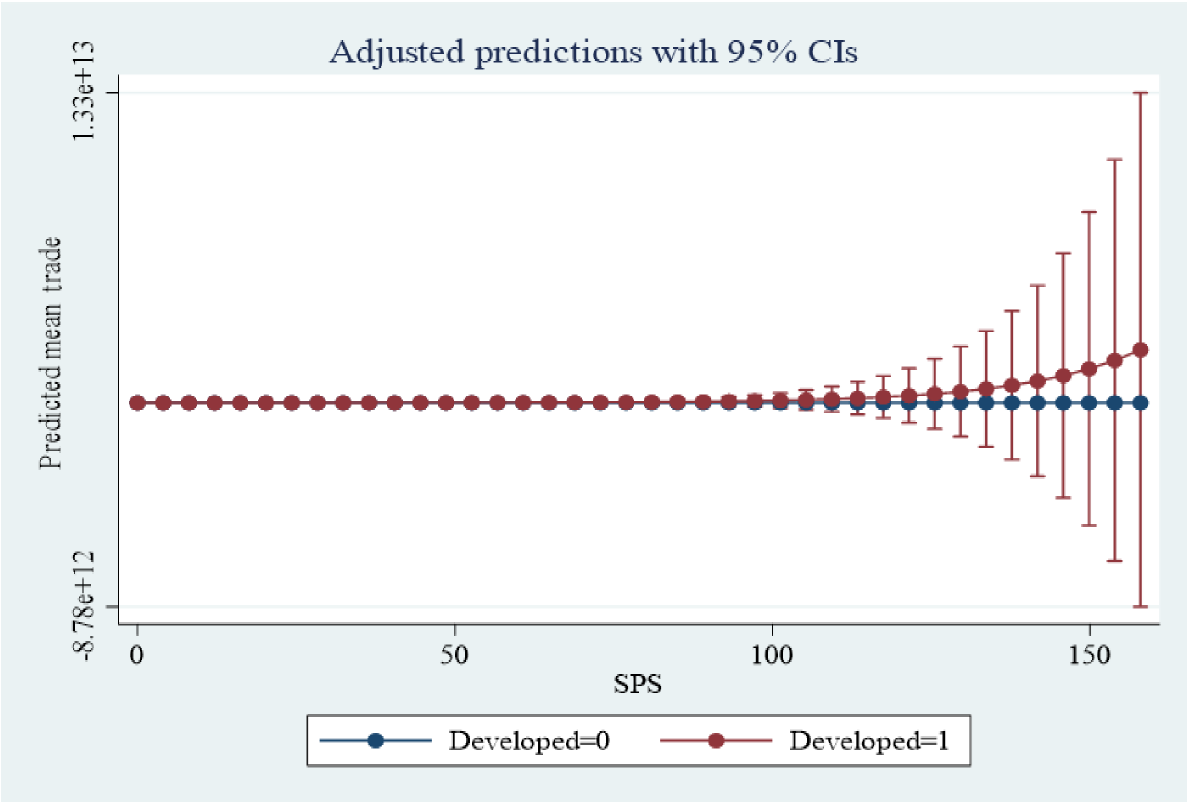

Figure 1
Moderating effect between development level and SPSs.

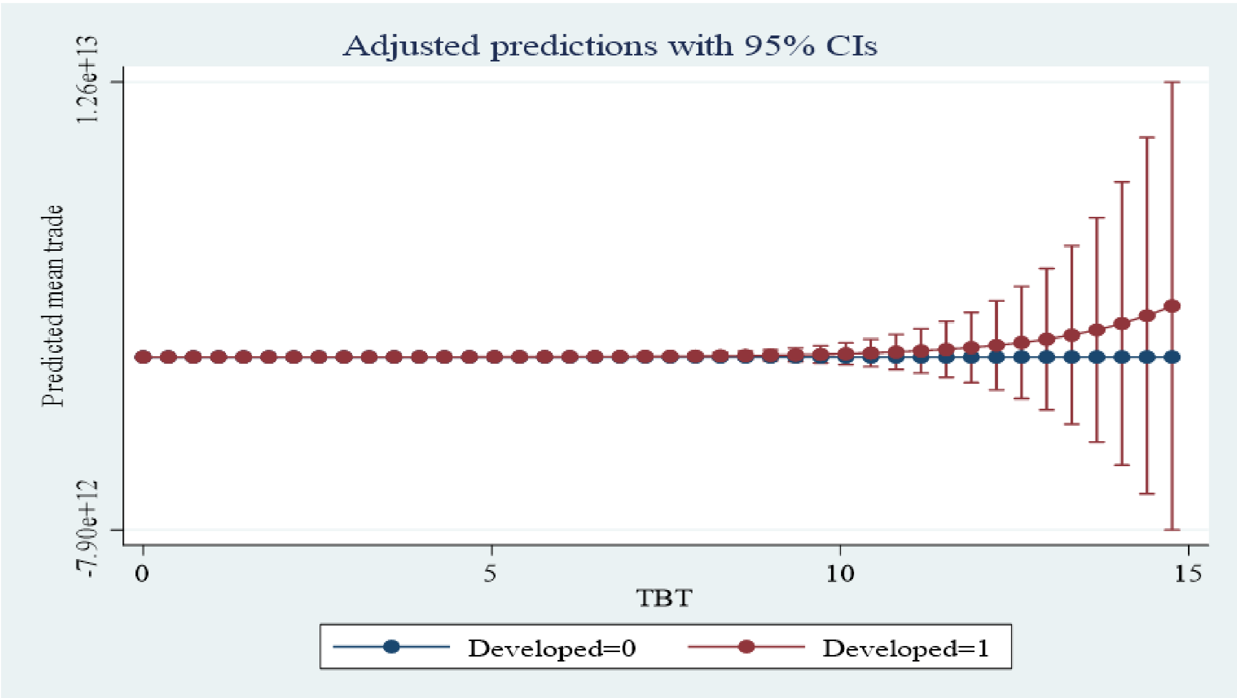

Figure 2.
Moderating effect between development level and TBTs.

Figures 3 and 4 show the moderating effect of firms' efficiency. Again, the results confirm the baseline theory constructed above. Technical regulations create barriers that favor businesses with more efficient production and a higher rate of innovation which aid the process of alteration to meet the technical requirements. Such businesses congregate in industries or sectors with a larger volume of trade (whether efficient firms create larger industries or larger industries attract more efficient firms is up to discussion) and create both external and internal economic scale effect. Diagram 3 shows that larger sectors of seafood export are much more versatile and even have higher trade flow when facing SPS measures. However, it is noticeable that in diagram 4, the moderating effect actually converges at a higher number of TBT which shows the restrictiveness of TBT measures as even efficient firms struggle to comply with the increasing number of TBTs.

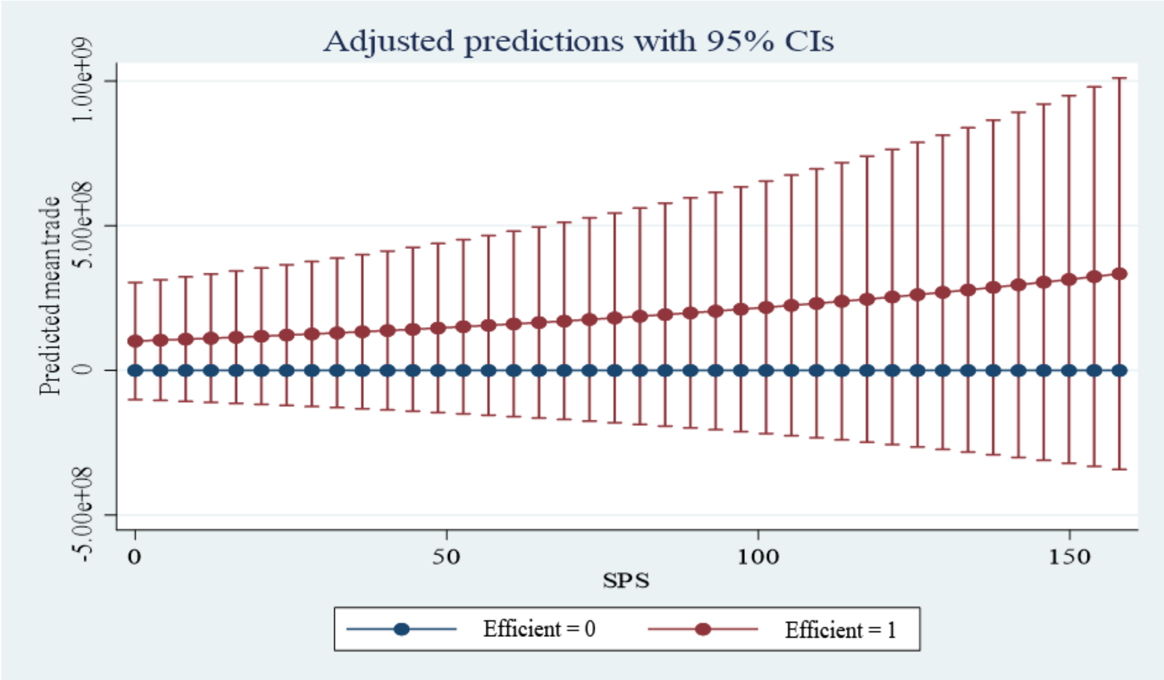

Figure 3.
Moderating effect between efficiency and SPSs on trade.

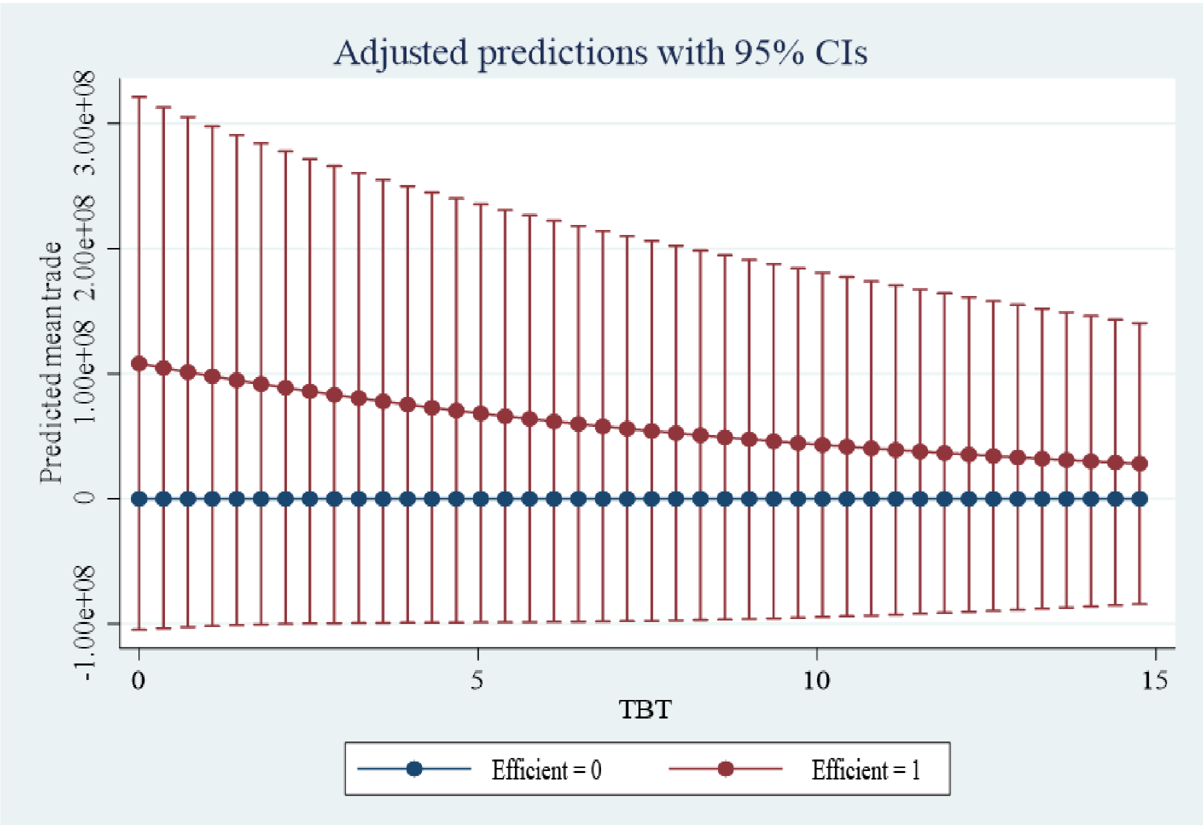

Figure 4.
Moderating effect between efficiency and TBTs on trade.

8. Conclusion and Recommendations

Seafood is a product group that has played an important role in contributing to Vietnam's total export turnover in recent years. Vietnam has many opportunities to export seafood products to the international market in the situation that Vietnam enjoys preferential tariffs from signed free trade agreements. The USA, EU, Japan, China and Korea are the leading markets in which Vietnam's seafood export turnover gets the most. However, these are also markets with many strict TBT and SPS measures that impact Vietnam's seafood exports. This study offers a theoretical model of the heterogeneous impact of standards across product groups and evaluates the impact of TBT and SPS measures on Vietnam's seafood exports by using the gravity model and PPML estimation method. Accordingly, the results show that on average, an addition to SPS measures boosts trade by 0.3%. On the contrary, TBT impedes trade and in addition, TBT measures decrease Vietnamese seafood trade by 1.9%.

The Vietnamese government as well as seafood processing and exporting businesses need to focus on the following fundamental solutions in order to benefit from free trade agreements going forward and adjust to the TBT and SPS requirements of the import markets:

- The Vietnamese government, functional ministries and agencies continue to strengthen the management of seafood production and processing activities to meet standards and regulations on quality, food safety and hygiene, and environmental protection in import markets.
- The Vietnamese government should promote research and application of scientific and technological achievements and invest in aquaculture infrastructure as well as infrastructure supporting the preservation, transportation and processing of seafood products.
- Vietnamese seafood processing and exporting enterprises need to proactively and actively approach and contact domestic agencies to get the best support on market information and maintain close relationships with overseas trading partners as well as legal consulting companies to update the regulations of TBT and SPS in foreign markets and to proactively meet such regulations.
- Vietnam's seafood processing and exporting enterprises need to continue to develop close associations with partners such as suppliers, farming households, cooperatives and purchasing businesses, processing businesses, transportation corporations , distribution businesses, customers, state agencies, etc. to create a sustainable supply chain and be able to provide a stable source of goods in both quantity and quality that is capable of meeting technical and sanitary regulations.

9. Limitations and Future Research

This paper still has deficiencies even despite the authors' best efforts. . In terms of methodology, businesses' production efficiency and consumer preferences have been generalized into a set of dummy variables. Even though, theoretically, the set of dummy variables can act as a proxy for the factors of concern, empirically, they performed well in the model and showed meaningful results that supported and adhered to the baseline theory. However, the generalization of production efficiency and consumer preferences neglects the complexity of these factors which may offer further insight into the issue. Due to funding constraints, the recommendations introduced are based on the collected estimation results and the authors' subjective understandings of Vietnam's seafood export activities. Therefore, the suggested set of policies has not taken into account the reality of Vietnam's seafood businesses adaptation strategies to comply with technical measures which reduces the applicability of our recommendations.

These limitations pave the way for the following directions for future research:

Firstly, even though it can be used adequately to test for the predictability of the baseline theory, the use of Vietnam seafood data hasn't allowed for the dynamic of technical measures between countries and industries. So, there should be research dedicated to further confirmation of the constructed theory using a set of global data that contains information regarding multiple countries.

Secondly, further endeavors to expand the literature on quantifying and modeling internal economics of scale and consumers' perceptions of product quality and hygiene are essential to introduce the complexity of these factors into the model.

Thirdly, survey-based research should be conducted to scout for the reality of Vietnam' seafood businesses adaptation strategies which will navigate research attempts to recommend policies to enhance Vietnam's business capability to comply with technical measures.

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