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Article

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The effect of Sanitary and Phytosanitary measures on Vietnam's rice exports

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Abstract

We have witnessed increasing concerns about the impacts of food safety standards on agricultural trade. This paper explores how Sanitary and Phytosanitary (SPS) measures affect Vietnam's rice exports. Using different estimation methods to handle overdispersion and zero trade flows for data of Vietnam's rice exports to 20 major importing countries over the period 2000–2015 based on gravity model, the results show that, although GDP, population, distance and production are still vital factors, the SPS measures imposed by importing countries have significant impacts on Vietnam's rice export. The findings suggest that importers implementing SPS measures have experienced considerably lower trade with Vietnam compared to importers that do not use a phytosanitary treatment. However, this effect decreases when income of importers increases.

JEL classification: F13; Q17; Q18; C33

Keywords: Rice; Export; Sanitary and Phytosanitary measures; Gravity model

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1. Introduction

Rice production has long played a vital role in national food security and political stability of Vietnam. Rice has also a noticeable effect on social security as it is absolutely indispensable to the daily life of the 91 million Vietnamese and an essential source of income for more than 60 million people living in agricultural and rural areas. Besides, rice is considered as one of the main crop in Vietnam, making up more than 90% of total cereal production (Bettman et al., 2014). Rice production in 2015 accounted for 45.22 million tons, which increased by 30%, compared with the figure for 2000.¹ The continuous increase in the rice production over the past two decades has helped Vietnam not only ensure food security in the country but also become one of the largest rice exporters in the world. However, rice export market share of Vietnam in recent years has experienced a decrease, as Vietnam's rice exports have faced severe competition from Thailand, India and other emerging markets such as Cambodia, decreasing market share of rice Vietnam's export in the key markets (as shown in Fig. 1). A reduction in rice export may have significant effect Vietnam's economy,

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¹ See General Statistics Office of Vietnam. <https://www.gso.gov.vn/> (Accessed 14.01.17).

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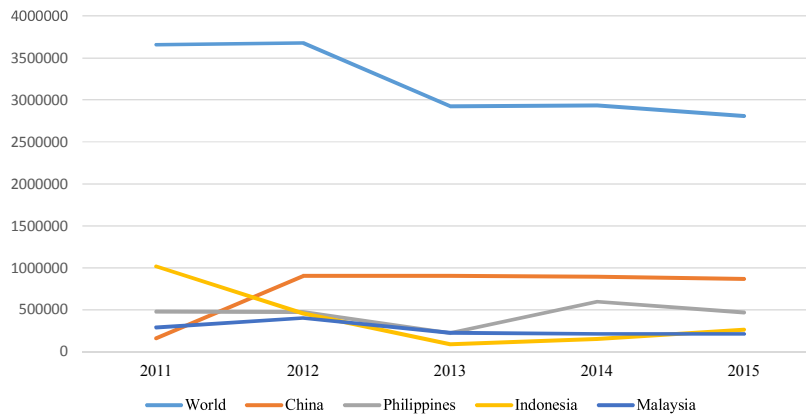


Fig. 1. List of key importing markets for rice exported by Vietnam, 2011–2015, USD Thousand.

Source: www.trademap.org. ITC calculations based on UN COMTRADE and ITC statistics.

as rice is one of the main export products of Vietnam, accounting for 1.74% of Vietnam's export value in 2015² and contributing a significant part to the national income.

In addition, the downward trend of global market in demand for rice is likely to cause growing uncertainty about Vietnam rice export. Timmer et al. (2010) predicted that the global rice consumption will witness a modest decline in the next decade. There are a number of reasons for that. Firstly, the population growth rate in Asian countries has decreased. Secondly, there has been a rise of per capita income in a variety of rice importers in Asia. In addition, the amount of rice per capita consumed has been reduced as people tend to substitute rice with other products containing more protein and vitamins such as processed preparations of rice, vegetables, bread, fish and meat. Furthermore, major importing countries start to increase their rice acreage and number of rice crops for domestic demand. As a result, the forecast is that there will be reduction in the rice price in global market by the next 10–20 years (Timmer et al., 2010). These external economic conditions may affect Vietnam's rice export.

Compared to the strong competitors, the quantity of rice export in Vietnam is higher, but the amount of turnover is lower. In 2015, the quantity of rice exports of Vietnam was 6603 thousand tons, holding the third position in the world, following by Thailand and India, but Vietnam's share in value in world's export was only 12.4%, compared to the figure of 28.1% of India.³ Although rice export prices in Vietnam are significantly lower than those in other countries in the world, the gap between the rice export prices of Vietnam and the world has been narrowed due to an increase in the quality of rice.

Government policies have greatly affected international trade, especially trade in agricultural products. Particularly, the developed countries have implemented SPS measures to limit agricultural imports from less developed countries where technical standards and food safety are often low. In the situation of Vietnam, there are some cases of export rejection in recent years, when agricultural products such as fish and aquatic products, animal product and vegetables have been violated SPS standards. Ministry of Agriculture and Rural Development estimated that about 10,000 tons of rice of 16 Vietnamese enterprises has been returned from the US in the past 4 years. The reason is that there were residues of Acetamiprid, Chlopyripos, Hexaconazoe contained in plant protection drugs which help treat some diseases such as rice blast, borers, pests.⁴ Meanwhile, according to the Vietnam Food Association (VFA) in the first 6 months of 2016, more than 500 containers of fragrant rice of Vietnam were returned due to substandard goods. VFA also said that in the past few years, especially in 2016, a lot of fragrant rice export orders of the famous Vietnamese rice exporters have been returned because of the residue of plant protection products.

² This figure is calculated by author based on data from www.trademap.org.

³ See Trade statistics for international business development. http://www.trademap.org/Country_SelProduct_TS.aspx?nvpm=11111100611411111211121111 (Accessed 12.06.17).

⁴ See VietNamNet News. <http://vietnamnet.vn/vn/kinh-doanh/thi-truong/gao-viet-dinh-doc-bi-tra-ve-xu-nguoi-che-thi-xu-ta-xai-338862.html>. (Accessed 12.01.17).

Consumers now tend to demand higher quality of rice and they only accept rice which is likely to meet some specific quality. The unfavorable changes in the quality standards can arise from specific regulation of some particular importers. The changes in the standard of quality is increasingly common and more stringent. Consequently, any change in the quality standards of certain importer or country specific regulations will have considerable impacts on Vietnam's rice exports.

Technical measures such as SPS regulations become essential to a number of agricultural products, including rice as the problems such as food safety and the protection of plant and animal health become increasingly sensitive (Peterson et al., 2013). A set of regulations based on a risk assessment, not discriminatory between nations with homogeneous conditions are allowed by the World Trade Organization (WTO) Agreement on the SPS measures.

There is growing public concerns about health and safety issues which encourage the governments to improve quality and safety of agricultural products by non-tariff measures such as SPS measures and technical barriers to trade (TBT) (Peterson et al., 2013). According to World Trade Report, the numbers of SPS and TBT notifications have experienced significant increases with the highest figure being seen in 2014.⁵

The effect of SPS and other technical regulations on international trade patterns is vital and its importance has been emphasized and investigated by many studies such as Henson and Loader (2001), Otsuki et al. (2001), Jaffee and Henson (2004), Okello and Roy (2007), Minten et al. (2009), Anders and Caswell (2009), Disdier and Tongeren (2010), Maertens and Swinnen (2009). However, there is a shortage of empirical studies of impact of SPS on agricultural trade in Vietnam.

Do implementations or changes in the regulations on food safety affect Vietnam's export of rice? In order to handle the question and to obtain the objective, this study aimed to examine the relationship between the overall export quantity of Vietnam's rice and food safety regulation. The paper is structured as follows: Section 2 gives overall information about rice production and export of Vietnam in recent years. Section 3 discusses the empirical model based on gravity model which was used to assess the effect of SPS measures on rice export in Vietnam. The data sources used in the empirical estimate were presented in Section 4. Section 5 will discuss analysis and findings based on the estimated results. The final section of the study concludes and discusses some policy implications.

2. Vietnam's rice production and export

According to USDA, Vietnam was ranked third in the list of world's largest rice exporters in 2015. In 2010, the country was the leading rice producer and exporter in the world (Hanh and Chen, 2015). The production of rice rose gradually from 31,020.00 thousand tons in 2000–44134.00 in 2015 (Table 1), because there is an improvement in productivity of rice production. However, according to the Resolution of Vietnam's Congress from 2010 to 2020, the reduction of paddy land will have been 307.75 thousand hectares due to urbanization, construction and factory infrastructure, and plant replacement. The rate of share world production slightly fluctuated around 5–6% during the research period. Table 1, however demonstrates that although there was a steady growth in rice production in Vietnam, the share world export by volume has been experiencing a remarkable decrease since the year 2009.

The reduction in growth rate of rice exports has caused many concerns in Vietnam. Some believe that the declining share of rice exports of Vietnam in the world market is due to the rise of rice production, based on the relative comparative advantage in other rice exporting countries such as Cambodia, others believe that the demand on higher quality of rice of some importers has caused to decline in growth in Vietnam's rice export.

Although Vietnam has exported its rice to many countries in the world, its partners are quite concentrated (as shown in Fig. 2.) China, The Philippines, Indonesia, Malaysia, Singapore and Hong Kong were the top six importers, accounting for nearly 80% of Vietnam's rice export values from 2011 to 2015 (Table 2) China was the largest importer of Vietnam's rice. The average annual rice imports from Vietnam made up about 28.2% of Vietnam's total rice exports between 2011 and 2015. The Philippines was the second export destination country which was responsible for nearly US\$ 449 million of export each year. Côte d'Ivoire was a leading importer of Vietnam' rice in Africa constituting approximately US\$ 158.2 million yearly export and equal to 5.99% of total rice export from Vietnam. The United States was the main buyer of Vietnam' rice in North America with the average value of export being at about US\$ 26.8 million on a yearly basis. Belgium, Netherlands, France and Poland were 4 major destinations of Vietnam's rice

⁵ See World Trade Organization. <http://i-tip.wto.org/goods/Forms/GraphView.aspx?period=y&scale=lg> (Accessed 12.01.17).

Table 1
Rice production and export profiles in Vietnam, 2000–2015.

Year	Production (000 tons)	Shared world production (%)	Export quantity (000 tons)	Share world export volume (%)
2000	31020	5.43	3528	14.53
2001	31873	5.36	3245	11.63
2002	32617	6.03	3795	13.77
2003	33458	5.89	4295	15.72
2004	34418	5.95	5174	17.91
2005	34503	5.65	4705	16.21
2006	34730	5.59	4522	14.22
2007	36932	5.47	4649	15.74
2008	38904	5.63	5950	20.24
2009	39989	5.68	6734	21.19
2010	42194	5.71	7000	19.19
2011	43443	5.88	7717	19.31
2012	44059	5.97	6700	16.97
2013	45058	5.96	6325	14.34
2014	45066	6.07	6606	14.16
2015	44134	6.44	5088	13.06

Source: Data on production are collected from USDA (www.usda.gov), data on export are calculated by author based on data from USDA (www.usda.gov).

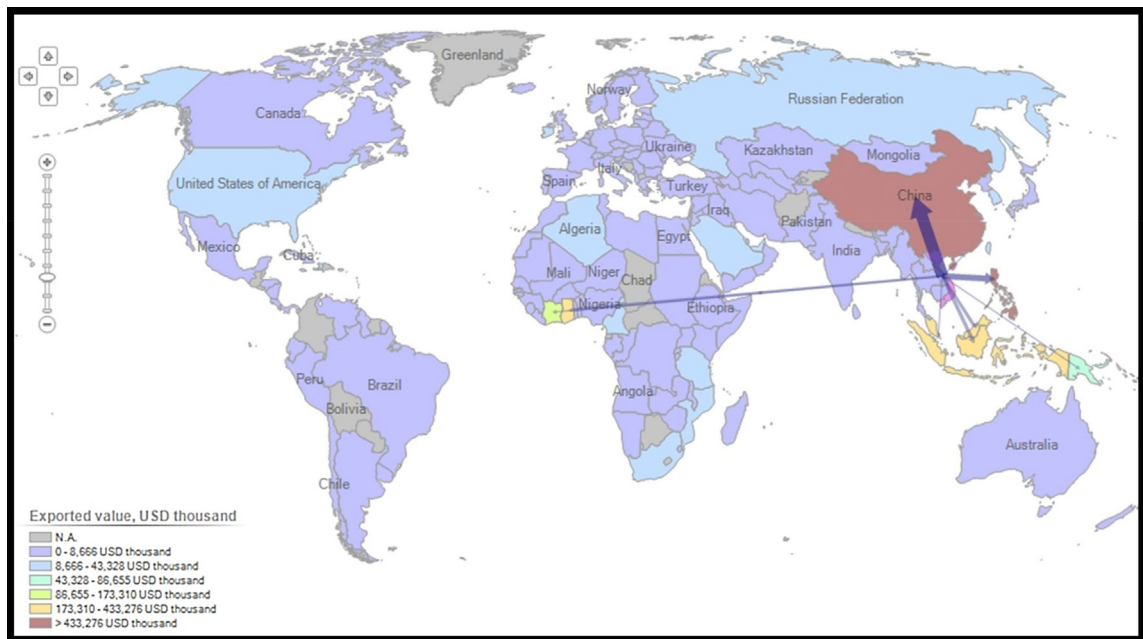


Fig. 2. List of importing markets for rice exported by Vietnam in 2015, thousands of USD.

Source: www.trademap.org. ITC calculations based on UN COMTRADE and ITC statistics.

export in EU. Import by Russian Federation was around US\$ 20.1 accounting for just only 0.76% of rice exports in Vietnam. Export value of rice to Australia was approximately US\$ 5.051. Based on the regional distribution the top 20 importers of Vietnam's rice made up more than 90% of total rice export from Vietnam in the period from 2011 to 2015.

The striking feature is that Vietnam's rice exports to these countries have witnessed diversified trend in the period of 5 years. As can be seen from the Table 2 that the higher growth rates of rice imports from Vietnam are especially concentrated on those countries which used to import relatively small quantity of Vietnam's rice. By contrast, there

Table 2
Annual average exports of rice from Vietnam to major importers based on regional distribution and average annual growth rate in 2011–2015.

Importers	Average annual export value (000 USD)	Share in Vietnam's export value (%)	Cumulative percentage of export value (%)	Average annual growth rate in exported value (%)
Asia				
China	745168.65	28.23	28.23	40
The Philippines	448973.67	17.01	45.23	2
Indonesia	397271.48	15.05	60.28	–32
Malaysia	271550.62	10.29	70.57	–12
Singapore	129010.08	4.89	75.45	–23
Hong Kong, China	94736.15	3.59	79.04	–9
Korea	13029.66	0.49	79.53	17
Japan	4348.99	0.16	79.70	
Africa				
Côte d'Ivoire	158191.67	5.99	85.69	–10
Angola	28687.05	1.09	86.78	–39
Algeria	25181.90	0.95	87.73	–13
South Africa	14042.64	0.53	88.26	32
North America				
The United States of America	26804.15	1.02	89.28	21
Europe				
Russian Federation	20080.92	0.76	90.04	1
Belgium	8290.01	0.31	90.35	–25
Netherlands	4227.49	0.16	90.20	9
France	1890.01	0.07	90.27	41
Poland	1271.58	0.05	90.25	16
Spain	1060.93	0.04	90.29	–8
Australia	5051.28	0.19	90.48	0

Source: Author's calculation, selected data from Trade Map (www.trademap.org).

were significant decreases in the import value of rice of many previously primary buyers. For instance, countries such as France, South Africa, The United States, Korea and Poland have dramatically increased their rice imports from Vietnam with the average annual growth rates being more than 16% between 2011 and 2015 (Table 2). Other countries, such as Angola, Indonesia, Singapore, Belgium and Malaysia have experienced sharply decreases of more than 12% in the average annual growth rate during the same period.

As shown in Fig. 3 some countries like that Brazil, Mongolia, Cambodia, Libya and Cameroon have experienced a dramatic increase of more than 100% in the growth rate of export value in 2015.

3. Methodology and empirical model

The technical standards reflected by SPS measures may be the major obstacles to rice export of Vietnam. The study is intended to measure the influence of SPS measures on Vietnam's rice exports. Rice was chosen because not only is rice particularly vital to Vietnam's agricultural exports, but it is also the targets of SPS regulations. Increasing and frequency of changes in food safety regulations may impose higher risks and additional costs to rice exported from Vietnam. The main question is to what extent the changes in food safety regulations have affected Vietnam's rice export. This section is aimed to quantitatively analyze the effects of standards.

In the empirical econometric analysis, we analyze 20 countries, of which 6 are in Asia, 4 are in Africa, 8 are in Europe and 1 in Oceania and 1 in North America. These countries made up above 90% of Vietnam's rice exports in the period from 2011 to 2015 and can considerably affect rice exports in Vietnam. Other nations accounted for a small number of Vietnam's rice exports or have not recently imported rice from Vietnam, and therefore, they have limited influence on Vietnam's rice export. Consequently, these countries are not considered in the empirical model.

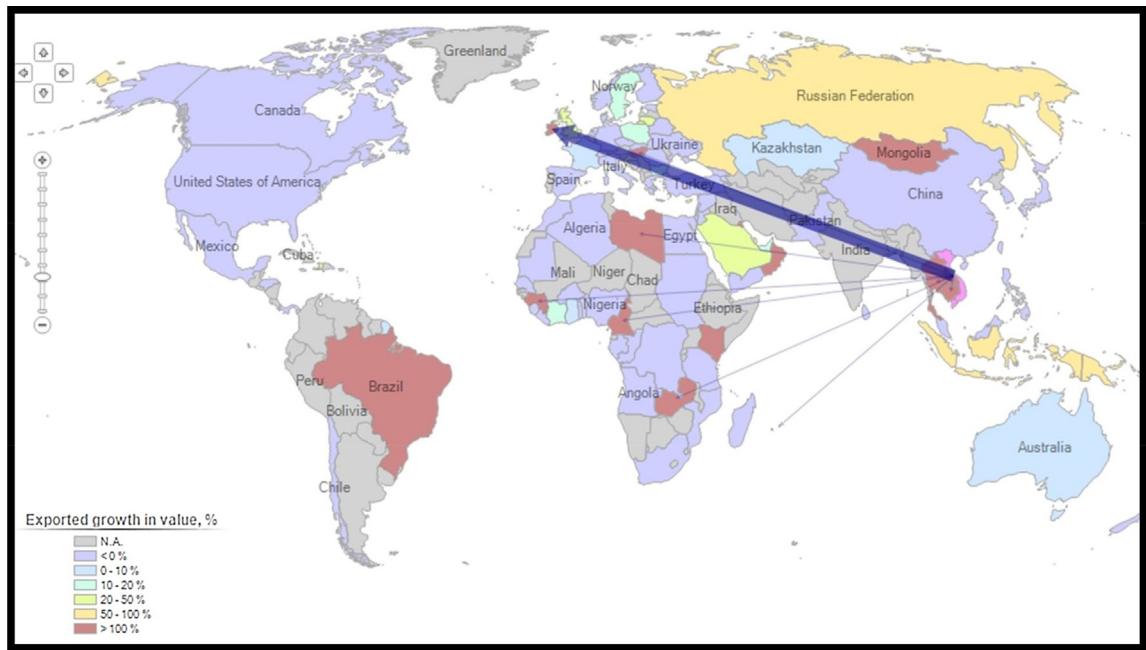


Fig. 3. Annual growth rate (%) of rice imported from Vietnam by geographical location between 2014–2015.

Source: www.trademap.org. ITC calculations based on UN COMTRADE and ITC statistics.

Gravity model are widely applied to study agricultural trade and measure the impact of food safety regulations and standards on trade. Traditional gravity model was first introduced by Tinbergen (1962) to determine the levels of bilateral trade flows with the absence of discriminating trade impediments. Based on Newton's gravity law, there were three main explanatory variables in the model of Tinbergen including GNP exporting country, GNP importing country and transportation cost (distance).

Wei et al. (2012) estimated the effects of food safety standards on China's tea exports using a gravity model. They showed that the maximum residue level (MRL) of pesticides such as endosulfan, fenvalerate and flucythrinate established by importing countries have considerably influenced China's tea exports. They found out that, after controlling for real gross domestic product GDP in China and importing countries, production, distance and tariff, a 1% decrease in the MRL on endosulfan can reduce China's tea export by 0.06%, and the effect of the MRL of fenvalerate is larger (0.16%). Dou et al. (2015) also used a gravity model to test the relationship between Chinese vegetable exports and MRLs regulation imposed by the importing countries. The results estimated that the number of regulated pesticides increased by 1% leads to a decrease the export value by 0.31%. Chen et al. (2008) used a gravity model of agricultural product to analyze the effect of food safety standards on China's export of vegetables and aquatic products. They showed that a 1% decrease in the value of Chlorpyrifos MRL results in a reduction of China's vegetable exports by 0.28%. By using gravity model, Shepotylo (2016) studied the effect of SPS measure on extensive margins and intensive margins of exports in seafood trade. The results suggest that SPS measures increase extensive margins and decrease intensive margins. Similar methods have been used to analyze the effects of non-tariff measures by Wilson et al. (2003), Wilson and Otsuki (2004), Ferro et al. (2015), Kareem (2016).

A gravity model has also been used in this study to analyze the impacts of food safety regulations on Vietnam's rice exports. The natural logarithmic form of gravity trade model related study on the effect of food safety regulations on rice exports is as follows:

$$\begin{aligned} \ln(X_{ijt}) = & \beta_0 + \beta_1 \ln(GDP_{j,t-1}) + \beta_2 \ln(POP_{jt}) + \beta_3 \ln(DIST_{ij}) + \beta_4 \ln(Land_{jt}) + \beta_5 \ln(POP_{it}) \\ & + \beta_6 \ln(PROD_{i,t-1}) + \beta_7 \ln(Priceratio_t) + \beta_8 \ln(TARIFF_{jt} + 1) + \beta_9 SPS_{jt} + \beta_{10} SPS_{jt} \\ & * \ln(GDP_{j,t-1}) + \varepsilon_{ijt} \end{aligned} \quad (1)$$

where i, j, t stand for exporting country (Vietnam), importing countries and trade year respectively. The parameters β are coefficients to be estimated and ε_{ijt} is the error term which is assumed to be normally distributed with mean zero. The time period covered in this study is from 2000 to 2015.

In model (1), X_{ijt} stands for the real export value of rice from Vietnam to country j in year t . Real exports are derived from dividing the export value of rice by rice export price index, which is provided by General Statistics Office of Vietnam.⁶ $GDP_{j,t-1}$ is the real gross domestic products (GDP) of the importing country j in year $t-1$, which is measured in billions of U.S. dollars. The GDP is deflated by using the GDP deflator, and it captures the purchasing power, the size of the economies and the demand side effect of the rice. POP_{jt} is the population of importing country j in year t , determining the market size of importers. Bilateral distance between the capital cities of Vietnam and importers, denoted as $DIST_{ij}$, is used as a resistance factor in the model. $Land_{jt}$ represents the total arable land of importing countries j in year t . When importer countries have more arable land, they could produce more agricultural products, which may lead to decrease in rice export of Vietnam. This variable also denotes the size of the economies. POP_{it} is the population of exporting country i in year t and determines domestic consumption. $PROD_{i,t-1}$ denotes Vietnam's total rice production lagged by one year. It captures the supply side effect on the export of rice. The rice production reflects the potential capacity for rice exports in Vietnam. The production and GDP of importers in current year may be endogenous because it could be influenced by the ongoing export opportunities. Therefore, the variables of $GDP_{j,t-1}$ and $PROD_{i,t-1}$ are lagged by one year to avoid the potential endogeneity (Chen et al., 2008; Wei et al., 2012; Dou et al., 2015). $Priceratio_t$ is a relative price ratio in year t . It equals the rice price, at which country j imports from Vietnam divided by the average import rice price in the world. A possible explanation for a decrease in rice export of Vietnam might be the change in its quality. However, the study of quality is limited by the difficulty to measure, as quality is not directly observable. Using time-varying country-specific fixed effects as a consistent alternative to control a country's resistance to trade with partners in the rest of the world can cause omitted variable bias. To overcome this limitation, the relative price ratio is constructed in the model as a proxy for the quality of rice (Baldwin and Harrigan, 2011; Baldwin and Tadashi, 2008; Crozet et al., 2011). The simple average import tariff rates imposed by importing countries on rice exports from Vietnam, denoted as $TARIFF_{jt}$, is used as another resistance factor in the model. As there are zero tariff in a variety of nations, we add 1 to the original tariff value (Peterson et al., 2013; Ferro et al., 2015; Wilson and Otsuki, 2004). Based on the information about the initiating and affected countries, SPS variable is set (Henson and Loader, 2001). SPS_{jt} is a binary variable equal to one if importer j imposes SPS measures on rice imported from Vietnam, and zero otherwise. Interaction of the binary SPS variable and importers' GDP is introduced, which allows us to measure the simultaneous effect of SPS measures and GDP of importing countries on rice export of Vietnam.

Using log-normal methods to estimate gravity model has been considered as popular approaches to study international bilateral trade flows. The problem stems from that the traditional way of estimating a gravity model, which takes logarithms and estimates its log-linear version, cannot deal with zero trade values, hiding a considerable amount of information explaining why some countries trade very little. As a result, zero trade value will become missing data points. Therefore, there are some alternative approaches that can be used to handle zero trade. One frequently applied and very convenient method is to just add a very small value to replace the zero trade flow before taking logarithms (Yotov et al., 2016). Pseudo Poisson maximum likelihood (PPML) estimator, advocated by Santos-Silva and Tenreyro (2006), can be served as another alternative method. This approach can be used to the levels of trade, therefore the non-linear form of the gravity model will be estimated and problem of zero-trade values will be avoided. The Poisson model has originally been applied for count data, however, this model can also be developed to non-negative continuous variables (Woolridge, 2002). However, important assumption of PPML's estimator is equidispersion, which means the conditional variance of dependent variable and its conditional mean are equal. Burger et al. (2009) have given attention to the possible use of modified Poisson models — negative binomial pseudo maximum likelihood model (NBPML), zero-inflated Poisson pseudo maximum likelihood model (ZIPPML) and zero-inflated negative binomial pseudo maximum likelihood model (ZINBPML) in gravity trade model when the conditional variance is higher than the conditional mean due to overdispersion or/and excess zero trade values. From the major advantages of these methods, in this study PPML, NBPML, ZIPPML and ZINBPML estimators have also been used. With this in mind, the Poisson estimation

⁶ http://www.gso.gov.vn/default_en.aspx?tabid=780.

framework for gravity trade model yields:

$$\begin{aligned}
 X_{ijt} = \exp & \left[\alpha_j + \alpha_t + \beta_1 \ln(GDP_{j,t-1}) + \beta_2 \ln(POP_{jt}) + \beta_3 \ln(DIST_{ij}) + \beta_4 \ln(Land_{jt}) \right. \\
 & + \beta_5 \ln(POP_{it}) + \beta_6 \ln(PROD_{i,t-1}) + \beta_7 \ln(Priceratio_t) + \beta_8 \ln(TARIFF_{jt} + 1) \\
 & \left. + \beta_9 SPS_{jt} + \beta_{10} SPS_{jt} * \ln(GDP_{j,t-1}) \right] \varepsilon_{ijt}
 \end{aligned} \tag{2}$$

where α_j and α_t are importers and year fixed effects.

In the context of rice export, there are some reasons why zero trade values may results. First, a bilateral distance may limit rice trade between countries in particular years. Second, rice production or harvest deficit can take place due to weather and disease, which may result in reduction in ability to export of Vietnam. In addition, tariff and cumulative SPS measures are likely to inflate the zero trade flows (Peterson et al., 2013).

A SPS measure of a country comes into force in a certain year when it is released in that year or prior to the year considered, but still valid or has not been withdrawn. The dataset includes SPS measures initiated and measures entered into force, while excludes withdrawn measures. Cumulative SPS measures data were applied with the deduction of any withdrawal and addition of new measures.⁷ The cumulative standards can be measured by following simple formulate (Kareem, 2016):

$$Z_t = Z_{t-1} + \rho_t - \omega_t \tag{3}$$

where Z_t and Z_{t-1} denote the current and previous cumulative number of SPS measures, ρ_t is the number of addition SPS measures in year t and ω_t stands for the number of SPS measures, withdrawn in year t .

4. Data

Rice exports data are collected from the United Nations Commodity Trade Statistics Database (COMTRADE) of the United Nations Conference on Trade and Development (UNCTAD). HS 1006 is the main commodity for the study. GDP data are from the World Development Indicators (WDI) database of the World Bank. Population data come from WDI database of the World Bank. The bilateral distance between the capital cities of Vietnam and importers are taken from the Institute for Research on the International Economy (CEPII). Arable land data are from Food and Agriculture Organization (FAO). Vietnamese rice production statistics are from the United States Department of Agriculture (USDA) statistical database. Price data come from COMTRADE and UNCTAD. Import tariff rates set by importing countries are from World Trade Organization (WTO) and Trade Analysis Information System (TRAINS) of the UNCTAD. SPS data for this analysis are taken from the WTO Integrated Trade Intelligence Portal (I-TIP). Table 3 summarizes basic statistics of all the variables considered in the estimated models.

As can be seen from the Fig. 4, the frequency of distribution of the rice export value strongly deviates from normal distribution (kurtosis = 19.35, skewness = 3.93).

5. Econometric results and discussion

In this section, using the various estimation methods considered above, zero trade flow in the gravity equation has been included. Firstly, the results of the log-normal model, estimated by ordinary least square (pooled OLS), fixed-effect (FE) and random effect (RE) methods have been reported, in which the Breusch–Pagan Lagrangian multiplier test (LM) and Hausman test have been adopted to choose a preferred estimator. Then, the results for PPML estimator and modified Poisson models that can correct for overdispersion and excess zeros have been presented, in which likelihood ratio test of overdispersion (α), the Vuong test (Vuong, 1989), Akaike Information Criterion (AIC) and Bayesian information Criterion (BIC) have been used to compare different estimators. Finally, the RE estimator using

⁷ That is, there are two SPS measure that importing country j imposes or initiates during the period of time from 01/01/2000 to 31/12/2000 for HS code 1006 and in the following period from 01/01/2001 to 31/12/2001, another one is added, then I added them together to give total SPS measures for this product as 3. If in the next year 2002 there is no measure added but a measure withdrawn in existence, then the total SPS measure for this commodity is 2 and so on.

Table 3
Basic statistics of main variables use in the estimated model.

Variable	Obs	Mean	Std. Dev.	Min	Max
Vietnam's rice export value (U.S. \$)	320	7.15e+07	1.72e+08	0	1.03e+09
Importer's GDP (Million U.S. \$)	320	1686733	3306833	8936.063	1.80e+07
Importer's population (Million people)	320	131.1312	283.8171	4.027887	1371.22
Bilateral distance (Kilometer)	320	7192.096	3679.139	868.03	13362.15
Importer's arable land (000 ha)	320	27710.89	46095.55	0.56	175400
Exporter's population (Million people)	320	84.65954	4.296211	77.6309	91.7038
Exporter' production (000 tones)	320	38274.88	4992.921	31020	45066
Relative price ratio	320	0.8509027	0.3585921	0.298791	2.76259
Bilateral tariff (Percent)	320	21.41903	31.30657	0	100
SPS dummy	320	0.121875	0.3276537	0	1
Cumulative SPS measures	320	2.1125	8.773348	0	84

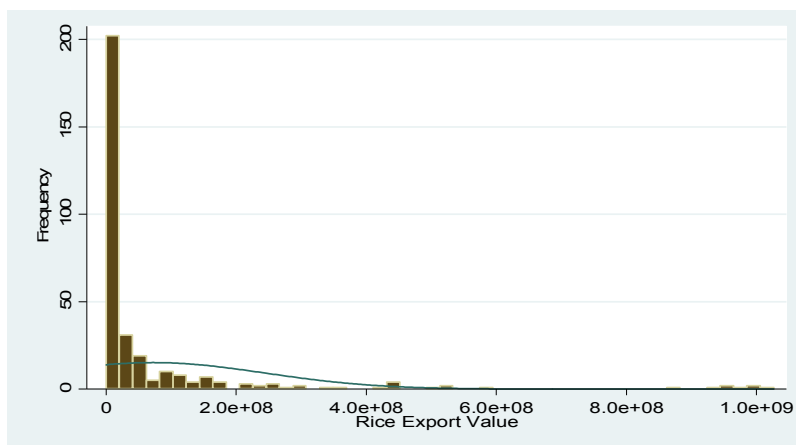


Fig. 4. Distribution of trade value, U.S. \$.

log-normal model without zero flow trade, an extension model of the log-normal RE, including zero flow, and the preferred estimator of modified Poisson models have been chosen to analyze the results.

The results of the log-normal model, where the zero trade values have been omitted from the sample, are provided in [Table A1](#) in Appendix A. Overall, SPS measures have negatively affected rice's export of Vietnam. Furthermore the statistically significant variables have the same signs and its scale of influence is not very different. The table also presents the results of LM and Hausman test. The LM test helps decide between a RE regression and a simple OLS regression. The null hypothesis in the LM test is that variances across entities is zero. The result of LM implies that we can reject the null and conclude that the RE model is appropriate. Furthermore, to decide between FE or RE models we can run the Hausman test where the null hypothesis is that RE is the preferred model compared to the alternative FE model ([Greene, 2008](#)). The result of Hausman test indicates that RE model is preferred.

[Table A2](#) in the Appendix A reports the PPML, NBPML, ZIPPML and ZINBPML estimators. The negative effects of SPS measures on Vietnam's rice export have also been showed in the table. It can be inferred that, most variables are highly statistically significant and its estimated coefficients tend to be lower than those of OLS, FE and RE estimates. The likelihood ratio test of overdispersion (α) and Vuong test are employed to affirm if the PPML is more appropriate model compare with the ZINBPML. This is provided in the last row of [Table A2](#) in the Appendix A. Here, alpha is statistically significantly different from zero, therefore, NBPML and ZINBPML are favored over PPML. Using the AIC and BIC, the performance of NBPML, ZIPPML and ZINBPML are also tested. However, the ZINBPML estimator shows the lowest AIC and BIC results, which means that the ZINBPML should be preferred over the NBPML and ZIPPML.

The estimation results of different techniques compared above for gravity trade model, along with robust standard errors, are presented in [Table 4](#). The RE estimator which applies the logarithm of export values as the dependent

Table 4
 Estimation results of SPS measures imposed by importing countries, 2000–2015.

	RE (without zeros) $\ln(X_{ijt})$	RE (with zeros) $\ln(X_{ijt}+1)$	ZINBPML (with zeros) (X_{ijt})
Log (importer's GDP)	−0.962*** (0.250)	−1.385*** (0.312)	−0.876*** (0.0564)
Log (importer's population)	1.060** (0.512)	1.373** (0.571)	1.435*** (0.116)
Log (distance)	−0.945 (0.580)	−1.486** (0.658)	−0.698*** (0.128)
Log (importer's arable land)	−0.120 (0.187)	−0.0381 (0.270)	−0.280*** (0.0388)
Log (exporter's population)	3.538 (6.144)	11.23 (11.35)	−6.401 (4.711)
Log (exporter' production)	9.005*** (3.486)	10.83* (5.849)	9.432*** (2.035)
Log (relative price ratio)	0.829** (0.408)	0.305 (0.666)	0.577** (0.229)
Log (bilateral tariff + 1)	−0.112 (0.156)	−0.195 (0.243)	−0.0373 (0.0432)
SPS dummy	−4.986** (2.459)	−5.945* (3.586)	−2.749* (1.647)
SPS* Log (importer's GDP)	0.391** (0.177)	0.433* (0.254)	0.257** (0.120)
Inflate equation results			
Log (distance)			1.724*** (0.289)
Log (bilateral tariff + 1)			0.209 (0.138)
Log (exporter' production)			−10.49*** (3.203)
Cumulative SPS measures			0.0421** (0.0213)
Observation	287	300	300
Overdispersion (α)			0.366***
RESET test p -values	0.2765	0.7950	0.9318

Robust standard errors are in parentheses. One, two, three asterisks denote significance at 10%, 5% and 1% levels, respectively.

variable is reported in the first column. The second column shows the results of estimation of RE, in which the zero trade values have been added by a small constant (export value plus 1) in order to avoid sample selection bias. Finally, the third column presents the results of the ZINBPML estimator.

The first point to notice is that the effects of the independent variables on export value of bilateral trade are of the same sign using various estimators. However, most coefficients differ substantially between the model without zeros and those with zeros. From the Table 4, it can be inferred that most of parameter estimates of the transformed model with zeros by adding a very small number tend to be higher compared to the model without zeros and transformed model ZINBPML, except for the effect size of importers' population.

With respect to the ZINBPML and RE without zeros models, the coefficients on importer's GDPs (with one year time lag) are not, as generally believed, positive. This result is somewhat counterintuitive: the elasticities of estimated GDP are statistically significant and equal to just around — 0.9. This rather contradictory result may be due to the fact that Vietnam's rice is an inferior good. The result, as shown in column 3 Table 4, indicates that an increase of 1% in income of importing countries which do not apply SPS measures to this commodity leads to a decrease in trade by approximately 0.88% holding other variables constant. This result further support the idea of Timmer et al. (2010).

The coefficient of importers' population capturing the demand side effect on the Vietnam's rice export is considerably larger under ZINBPML estimator than others: the elasticity is 1.453. This is, an additional percentage increase in population of importers will increase the demand for Vietnam's rice by 1.453%.

Not surprisingly, importers facing a remoteness of bilateral distance have lower trade with Vietnam than the others with the estimated elasticities being just about -1.32 for RE estimator with zero trade and -0.7 for ZINBPML estimator.

The ZINBPML estimate reveals that the agricultural land variable is negative and statistically significant with the estimated elasticity being -0.28 , whereas other estimates show that increasing agricultural land of importing countries does not influence trade flows. It predicts that Vietnam's rice export will decrease by 0.28% when the trading partners have expanded their agricultural land by 1% .

Vietnam's rice production (with one year time lag) is statistically and positively significant across all specifications. The estimated results indicate that an increase of 1% in production will substantially enhance Vietnam's rice exports by about 9% . This emphasizes the role of domestic production capacity which can stimulate growth of Vietnam's rice export.

The current study found that the estimated coefficients for the relative price ratio have positive sign and are statistically significant under RE without zeros and ZINBPML estimators. If the price ratio increases by 1% the rice export value will experience a growth of 0.58% following ZINBPML estimator (column 3, Table 4). It could be argued that the positive results may be due to quality competitiveness of Vietnam's rice.

When it comes to a discussion of the effects of the effect of SPS measures on Vietnam's rice export, it is obviously that at the same level of income importers applying SPS measures have experienced remarkably lower trade with Vietnam compared to importers that do not use a phytosanitary treatment, across all estimates. One interesting finding is that the coefficient for the SPS-GDP with one year time lag interaction is positive and statistically significant under all estimation methods. When GDPs of importers using SPS measures increase by 1% , their spending on Vietnam's rice import will decline only by 0.62% ($-0.876\% + 0.257\%$) (column 3, Table 4), which means they have expended more than countries that do not apply SPS measures by 0.257% (Fig. A1a in Appendix A). This also reflects that average marginal effect of SPS measures decreases when importer's GDPs increase (Fig. A1b in Appendix A). A possible explanation for this is that Vietnam might accumulate experience and beforehand considers the SPS requirements for market access and might ensure sufficient compliance prior entering the market. This result is in line with Kareem (2016), Schlueter et al. (2009) and Peterson et al. (2013).

On the question of tariff effect, this study found that the coefficients on the bilateral tariff for almost estimation methods have the expected negative sign, whereas these estimates provide no significant evidence of this variable. This result is likely to be related to the low and remaining low tariff rates throughout the sample period. Similarly, this study did not detect any evidence for the influence of Vietnam's population on rice export. This result may be explained by the fact that on the supply side there is surplus in the home market, which means that Vietnam could totally ensure domestic rice consumption.

In the third column of Table 4, ZINBPML estimator is used, introducing a logistic inflation equation. This allows to separate Vietnam's rice export in relation to the probability of an observation belonging to "certain zero" group from those observations which are at risk of having a zero flow. ZINBPML estimate reveals that bilateral distance, production and cumulative number of SPS measures affect the probability of Vietnam's rice trade, which could be derived from the logistic-based zero inflation equation. It is interesting to note that bilateral distance and cumulative number of SPS measures increase the likelihood of "certain zeros", while production reduces this likelihood. If the bilateral distance between Vietnam and trading partner increased by 1% , the odds that country pairs being in the never-trading group would increase by 1.724% . In the same way, if the cumulative number of SPS measures required by importers increased by 1% , the odds that the importer would be in the "certain zero" group would increase by 44.66% .⁸ By contrast, increasing rice production of Vietnam by 1% reduces the odds of never trading by 10.49% .

A heteroscedasticity-robust reset test (Ramsey, 1969) was used to check the adequacy of all the estimated models. It checks the correct specification of the conditional expectation. The null hypothesis is that the additionally constructed regressor is insignificant. The p -values are presented at the bottom of the Table 4. All estimators pass the reset test, that is, the models are correctly specified.

⁸ Cumulative SPS measures enter the link function of the Poisson linearly, not log-linearly. An average effect of varying cumulative SPS measures is computed from its mean by using the sample standard deviation given. The effect on the probability of zero trade becomes: $(e^{0.421 \times 8.77} - 1) \times 100\%$ (Burger et al., 2009).

6. Conclusion

As one of the world's largest rice producer and exporter, Vietnam has witnessed a decreasing trend in rice export growth rate in recent years. The objective of the study is to assess the effect of non-tariff measures including SPS measures on rice exports of Vietnam. To measure the effect, a series of empirical analyses applying the gravity model are conducted. In these analyses the impact of SPS measures on Vietnam's rice export is tested. The empirical regression results indicated that countries imposing the SPS measures on Vietnam's rice export have much lower trade compared with importers that do not require phytosanitary treatment holding the same level of income. Using the SPS-GDP as variable interaction, this study demonstrates a remarkable result: the negative effect of SPS measures on trade diminishes as income of importers increases. Thus, there is a room for promoting rice export of Vietnam when meeting non-tariff phytosanitary measures. The research has also shown that increasing rice production can boost export of this commodity of Vietnam significantly.

There are some applications in these findings. Firstly, variations in conditions of rice production and the characteristics of consuming population, as well as different non-tariff regulations at a national level suggest that developing country exporters will have met challenges when export their agricultural products. This also implies that these countries will have to comply with standards set by other countries, especially by developed nations. Furthermore, the stricter SPS measures imposed by some countries to control the import and protect domestic consumers reflect the importer's concerns on domestic production. Therefore, the conventional rice production technologies of Vietnam should be taken into account. Vietnam and other developing countries can obtain valuable lessons to improve food safety by introducing measures and investing in food production, as well as processing before exporting their products to demanding markets.

Appendix A.

Table A1
Impact of SPS measures using OLS, FE and RE estimates.

	OLS ln(X_{ijt})	FE ln(X_{ijt})	RE ln(X_{ijt})
Log (importer's GDP)	-1.059*** (0.0849)	-0.371 (1.040)	-0.962*** (0.250)
Log (importer's population)	1.028*** (0.176)	1.961 (5.143)	1.060** (0.512)
Log (distance)	-0.907*** (0.228)	0 (.)	-0.945 (0.580)
Log (importer's arable land)	-0.104 (0.0735)	-1.473 (2.264)	-0.120 (0.187)
Log (exporter's population)	-0.0246 (8.207)	0.785 (5.942)	3.538 (6.144)
Log (exporter' production)	10.42*** (3.436)	7.511 (4.500)	9.005*** (3.486)
Log (relative price ratio)	1.096*** (0.370)	0.788* (0.417)	0.829** (0.408)
Log (bilateral tariff +1)	-0.104* (0.0612)	-0.0902 (0.194)	-0.112 (0.156)
SPS dummy	-5.297** (2.657)	-5.312** (2.140)	-4.986** (2.459)
SPS* Log (importer's GDP)	0.455** (0.195)	0.404** (0.155)	0.391** (0.177)
Observation	287	287	287
Breusch-Pagan LM			61.08
Prob.			0.0000
Hausman			3.85
Prob.			0.9209

Robust standard errors are in parentheses. One, two, three asterisks denote significance at 10%, 5% and 1% levels, respectively.

Table A2
Impact of SPS measures using PPML and modified Poisson estimates.

	PPML (X_{ijt})	NBPML (X_{ijt})	ZIPPML (X_{ijt})	ZINBPML (X_{ijt})
Log (importer's GDP)	−0.843*** (0.135)	−0.913*** (0.0584)	−0.834*** (0.0985)	−0.876*** (0.0564)
Log (importer's population)	1.055*** (0.306)	1.490*** (0.118)	1.044*** (0.164)	1.435*** (0.116)
Log (distance)	−0.913*** (0.264)	−0.741*** (0.130)	−0.907*** (0.180)	−0.698*** (0.128)
Log (importer's arable land)	−0.170 (0.141)	−0.281*** (0.0394)	−0.168* (0.0893)	−0.280*** (0.0388)
Log (exporter's population)	2.744 (8.245)	−6.207 (4.830)	2.579 (5.881)	−6.401 (4.711)
Log (exporter' production)	8.469*** (2.289)	9.668*** (2.088)	8.467*** (2.346)	9.432*** (2.035)
Log (relative price ratio)	0.536 (0.559)	0.532** (0.230)	0.538* (0.326)	0.577** (0.229)
Log (bilateral tariff +1)	0.0902 (0.0565)	−0.0595 (0.0443)	0.0905 (0.0745)	−0.0373 (0.0432)
SPS dummy	−3.826*** (0.887)	−2.947* (1.720)	−3.801* (2.224)	−2.749* (1.647)
SPS* Log (importer's GDP)	0.284*** (0.0631)	0.273** (0.125)	0.282* (0.167)	0.257** (0.120)
Inflate equation results				
Log (distance)			1.725*** (0.288)	1.724*** (0.289)
Log (bilateral tariff +1)			0.208 (0.137)	0.209 (0.138)
Log (exporter' production)			−10.39*** (3.165)	−10.49*** (3.203)
Cumulative SPS			0.0416* (0.0214)	0.0421** (0.0213)
Observation	300	300	300	300
Overdispersion (α)		0.728***		0.369***
AIC	152,784,669.5	7789.4	151,751,991.1	7724.5
BIC	152,784,710.3	7833.9	151,752,050.3	7787.5
Vuong				15.77***

Robust standard errors are in parentheses. One, two, three asterisks denote significance at 10%, 5% and 1% levels, respectively

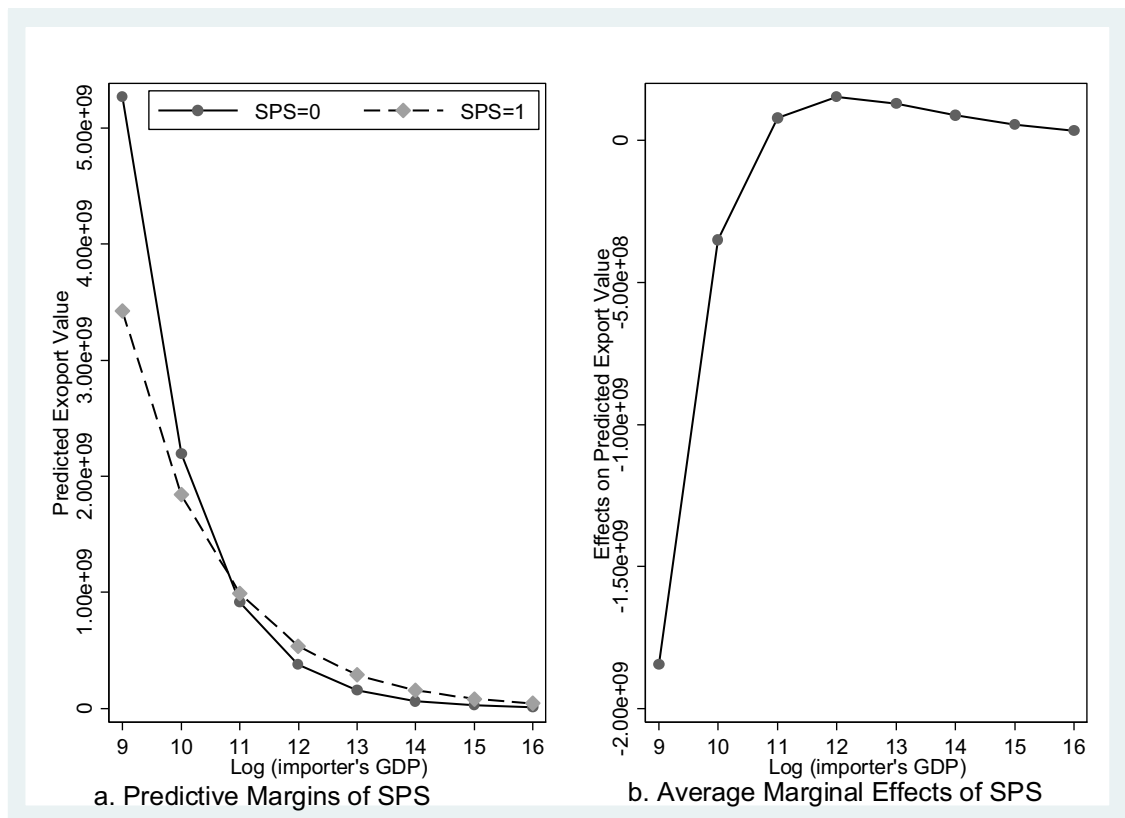


Fig. A1. The Effect of SPS measures on rice export value.

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