A Stochastic Analysis of Vietnam Bilateral Trade Efficiency

Ho Dinh Bao
National Economics University, Vietnam
Email: hodinhbao@yahoo.com

Pham Van Minh
National Economics University, Vietnam
Email: minhpv@neu.edu.vn

Pham Vinh Thai
National Economics University, Vietnam
Email: thai71qn@gmail.com

Truong Nhu Hieu
National Economics University, Vietnam
Email: truongnhuhieu89@gmail.com

Received: 30 January 2018 | Revised: 26 June 2018 | Accepted: 02 July 2018

Abstract

This paper used a stochastic frontier gravity model to evaluate the bilateral trade efficiency of Vietnam using the bilateral trade data of Vietnam's main trade counterparts in the period 2000-2015. Trade efficiency means the actual trade in comparison with the trade potential. Empirical results show that Vietnam's trade performance was significantly lower than the potential level. Joining the WTO did not improve trade efficiency. The impact of FTAs on exploiting bilateral trade potential is heterogeneous across counterparts.

Keywords: Stochastic frontier gravity model; trade potential; free trade agreement.

JEL code: F13, F14 , F53, F60.

1. Introduction

From the initial ideas of Tinbergen (1962), the gravity model was widely used in studies of international economics. It was built on the idea of Newton's Law of Universal Gravitation, which implied that business between two countries was under the effect of the scale and gap between them. It was a function of the properties of the exporting country, the importing country and the obstacles between these two countries. This model in international trade has proven surprisingly stable over time and across different samples of countries and methodologies (Chaney, 2011).

In the conventional gravity equation, the distance between two countries has a negative effect on trade, and the size of the two economies, which is often determined by GDP, has a positive effect on trade volume. Existing international trade theories could explain the impact of economic size on trade, but none explains the role of distance (Chaney, 2011). Recently, gravity models have been developed based on a strong theoretical basis. Anderson (1979) was the first to develop the economic theoretical basis for gravitation equations under assumptions about product differentiation by source and constant elasticity of substitution on expenditure. The most influential theoretical contribution to the gravity model was probably that of Eaton and Kortum (2002) with a theoretical gravity model which was constructed from the supply side based on the Ricardian model of intermediate input trade, and Anderson and Wincoop (2003) through the popularization of the Armington assumption emphasized the importance of the impact of trade costs on overall equilibrium.

There are several studies using the gravity model to evaluate the efficiency of Vietnam's bilateral trade with its partner countries, such as studies that have been conducted by Do (2006), Tu and Dao (2008), Tran Pham (2010), Phan (2011), Nguyen et al. (2011), Vu and Mai (2012), Nguyen (2012), To (2012), Hoang et al. (2013), Hoang and Bui (2013), Nguyen and Tran (2014), and Tran and Tran (2016). Most of these studies applied a conventional gravity equation to estimate the impact of determinants on the actual volume of bilateral trade flows between Vietnam and its counterparts. The determinants considered were the GDP of Vietnam, the GDP of the countries importing goods from Vietnam, the FDI of other countries in Vietnam, the exchange rate, geographical distance, and population.

However, the improvement of the actual level of bilateral trade flows does not mean an improvement in trade efficiency. Bilateral trade efficiency means that the actual volume of trade flow between two countries achieves its maximum trade capacity. In fact, the trade volume of Vietnam with the other countries is always below the potential level. This implies that the estimates given by those studies by using a conventional gravity model on Vietnam's trade data set to examine trade efficiency were probably biased, and policy implications from these studies have been limited.

The gravity model in the framework of stochastic frontier analysis has emerged as a widely effective method to estimate the gap between actual trade volume and the maximum trade capacity. This paper used this methodology to evaluate the bilateral trade efficiency of Vietnam with its trade partners. The study used

bilateral data constructed in the period 2000-2015. By using stochastic frontier analysis inefficient components of bilateral trade transactions between Vietnam and its counterparts are measured. The bilateral trade inefficiency is determined by the difference between the actual trade value and the potential level that Vietnam may achieve.

2. Methodology

2.1. Stochastic frontier gravity model

The international trade efficiency of a country might be estimated by using the gravity model in the framework of stochastic frontier analysis. An advantage of stochastic frontier gravity model (SFGM) is that it solves the problem of imprecise specification and biased estimation of the conventional gravity model. In SFGM, trade performance between two countries is not only affected by their geographical distance, it is also affected by policies, institutions and regulations that facilitate or inhibit trade and investment and promote openness right across the economy (Armstrong et al., 2008).

Trade performance is measured by the actual level of trade. Trade potential is determined as the maximum level of trade that can be achieved on the frontier that can be estimated with the assumption of free trade. It means there is no barrier between countries regarding to institutions, regulation, transport etc. (Drysdale et al., 2000; Kalirajan, 1999; Armstrong et al., 2008). SFGM, on the basic of stochastic frontier production function developed by Aigner et al. (1977), Meeusen and Van den Broeck (1977), argued that the actual level of trade between economies hardly achieves (or even cannot achieve) the potential level. It means that the trade performance is always below the trade potential between economies (Kalirajan, 2008). In other words, there always exists an inefficiency in trade activities between a country and its counterparts. The key idea of this model is that it includes two error terms, one to account for trade efficiency and the other refers to stochastic error or measurement error (Drysdale et al., 2000)

The frontier gravity model can be expressed as: $nX_{ij} = lnf(Z_i;\beta)exp(v_i - u_i)$

Where the term X_{ij} represents the actual export from a country to country *j*. $f(Z_i;\beta)$ is a function of the determinants of potential bilateral trade (Zi) and a vector of unknown parameters β. v_i is a stochastic error term which is assumed to follow normal distribution $N(0, \sigma^2_v)$. u_i is a single-side error term (non-negative), which is referred to by Anderson (1979), representing the combined effects of inherent economic distance bias in terms of institutional, political and social distance. This bias creates the difference between actual and potential trade between two countries. u_i is assumed to have a half-normal distribution with mean μ and variance σ^2_u or exponential distribution (Drysdale 2000, 262). This model is estimated by MLE to tackle the issues of heteroskedasticity and non-normality.

2.2. Estimated model

We argue that the actual level of trade is below trade potential. In other words, there always exists an inefficiency in trade activities. Therefore, $u_{ij,t}$ is non-negative.

The export model used in this study is:

$$ln\_BilExport_{ij,t} = \alpha_0 + \alpha_1 lnY_{i,t} + \alpha_2 lnE_{j,t} + (1-\sigma)ln\tau_{ij,t} + v_{ij.t} - u_{ij,t}$$

The import model used in this study is:

$$ln\_BilImport_{ij,t} = \alpha_0 + \alpha_1 lnY_{j,t} + \alpha_2 lnE_{i,t} +$$

$(1-\sigma)ln\tau_{ij,t} + v_{ij.t} - u_{ij,t}$

$$(1-\sigma)\ln\tau_{ij,t} = \beta_1 \ln DIS_{ij} + \beta_2 CNTG_{ij} + \beta_3 CLNY_{ij} + \beta_4 LLOCK_j + \sum_k \kappa_k RTA_{ij,t} + \beta_6 BTA_{ij,t} + \tilde{\tau}_{ij,t}$$

$BilExport_{ij,t}$ is export from country *i* to country *j* at time *t*. $BilImport_{ij,t}$ *is* import of country *i* from country *j* at time *t*; $Y_{i,t}$ and $Y_{j,t}$ are gross domestic product of country *i* and *j* respectively at time *t;* $E_{i,t}$ and $E_{j,t}$ are expenditure of country *i* and *j* respectively at time *t*; $DIS_{i,j}$ is the distance between the capital city of country *i* to a capital city of country *j*. $CNTG_{ij}$ is a dummy variable equal to 1 if *i* and *j* share a common border; $CLNY_{ij}$ is a dummy equal to 1 if *i* and *j* was in the common colonial system. LLOCK*j* is a dummy equal to 1 if country *j* has no coast. $RTA_{ij,t}$ and $BTA_{ij,t}$ are dummy variables which respectively represent regional and bilateral trade agreements which are effective at time *t*. $\tau_{ij,t}$ is trade costs between *i* and *j* at time *t*. $\tilde{\tau}_{ij,t}$ represents unobserved factors which affect $\tau_{ij,t}$. $v_{ij,t}$ is a normally distributed statistical error term. $u_{ij,t}$ refers to the difference between the actual and potential of trade between I and j at time t and is non-negative. Parameters K_k and β_6 measure impacts of trade agreements to import/ export flow of country *i* with country *j*. The estimated coefficients denote elasticity of imports or exports volume in a change of corresponding explanatory variables. The definition and measurement of variables is presented in detail in Appendix 1.

We argue that the actual level of trade is below trade potential. In other words, there always exists an inefficiency in trade activities. Therefore, $u_{ij,t}$ is non-negative and its variance is assumed to consists of two components represented as below:

$$\sigma^2_{u_{ij,t}} = \exp(\gamma_0 + \omega_{ij,t}) \quad \text{or} \quad \ln\sigma^2_{u_{ij,t}} = \gamma_0 + \omega_{ij,t}$$

Where γ_0 is an average variance of error term referring to trade inefficiency, $\omega_{ij,t}$ is a random component of trade efficiency's variance.

Our study used data from a variety of sources. Import and export data of Vietnam and all its trading partners were taken from the International Monetary Fund's Direction of Trade Statistics. Data on nominal GDP and final consumption expenditures were taken from the World Bank database. Distance between capital cities was taken from CEPII (Centre d'Etudes Prospectives et d'Informations Internationales). Data of free trade agreements were referenced by the Design of Trade Agreements (DESTA) database and Regional Trade Agreements Information System (RTA- IS).

3. Empirical results

3.1. Impact of economic integration on bilateral trade of Vietnam

The appropriateness of the methodology for the data is firstly tested. The null hypothesis is that the mean of inefficient component (μ) equals to 0 (alternative is $\mu \neq 0$). As the null hypothesis is supported it indicates that the half- normal or exponential distributions fit the dataset. The likelihood ratio test statistics are given by:

$\lambda = -2[L(H_0) - L(H_1)]$

$L(H_0)$ is the log-likelihood of the model with restricted normal distribution; L(H1) is the log-likelihood of the model with unrestricted distribution. The ratio λ follows *mixed* χ^2 distribution with *j* degree of freedom. *j* is computed as the difference between the number of parameters of restricted and unrestricted models. As

H_0 is a model with half- normal distribution, the Chi-square statistic is 3.84 with a statistical significance level of 5%. As H_0 is a model with exponential distribution, the Chi-square statistic is 2.71 with a level of significance at 10%. These results indicate that there is no statistical evidence to reject the null hypothesis. Therefore, the assumption that the inefficiency component is half-normal or exponentially distributed is appropriate with the dataset.

The results of estimating models of bilateral export and import volume of Vietnam and its counterparts with an assumption of half-normal distribution or exponential distribution $u_{ij,t}$ are respectively shown in Figures 1 and 2. Column (1) and (3) show results of estimation with a stable and consistent pattern of variance over time (year fixed effect), whereas columns (2) and (4) are estimated results with a pattern of variance that changes over time. In general, the results of models with controlled and with uncontrolled year fixed effect are not significantly different.

The likelihood ratio test reveals that trade inefficiency exists at a conventional level of statistical significance. The null hypothesis (H_0: $\sigma_u = 0$) is rejected at a significance level of 0.01. Estimated parameters of γ_0 are statistically significant in models with half-normal distribution as well as exponential distribution. In addition, time dummy variables explain the variation in the variance of systematic noise, which is reported in the model $ln\sigma_v^2$.

Results in estimated models with half-normal and exponential distribution are quite similar. In general, estimated coefficients of Vietnam economy size, expenditure of counterparts, and variables referring to geographic characteristics are statistically significant at the conventional levels and the signs are what they would be expected to be. (Figure 1 and 2). The size of Vietnam's economy and last consumption expenditures have a positive effect on trade performance. Counterparts' expenditure elasticity of Vietnamese export is nearly 1. Domestic expenditure elasticity of Vietnamese import is approximately 1.5 and 1.7 in the model without and with year fixed effect respectively. This implies the Vietnamese preference to import goods.

Geographic distance is a significant obstacle to bilateral trade. The coefficients of this variable for Vietnam's exports and imports are estimated to be negative and statistically significant at a level of 1%. Values of Vietnam's exports and imports with non-contiguous countries are lower than with contiguous countries, whereas the sharing of a border boosts cross border trade between the two countries. Export value increases about three times and imports increase about 1.5 times if partner countries share borders with Vietnam. There is no statistical evidence of significant impact of colonial relations on bilateral trade.

Dummy variables are added in the model to measure the impact of regional economics' integration and the joining of free trade agreements on the export and import of Vietnam. Estimated coefficients of the WTO in all models have positive signs and are statistically significant at the conventional levels. They indicate that joining the WTO has boosted the real value of Vietnam's exports and imports. Furthermore, the magnitude of coefficients reveals that the impact on export is much stronger than on import. With u_i following half-normal distribu-

Table 1: Estimated result of models with u_i follows half-normal distribution

VARIABLES	(1) ln_BilExports	(42) ln_BilExports	(3) ln_BilImports	(4) ln_BilImports
ln*Y_vie*	1.459***	1.427***		
	(0.106)	(0.103)		
ln*Y_partner*			0.808***	0.783***
			(0.018)	(0.018)
ln*E_vie*			1.557***	1.749***
			(0.269)	(0.273)
ln*E_partner*	0.929***	0.926***		
	(0.015)	(0.015)		
ln*DIS*	-0.312***	-0.313***	-0.576***	-0.469***
	(0.054)	(0.053)	(0.073)	(0.071)
CNTG	2.034***	2.131***	1.236***	1.437***
	(0.254)	(0.255)	(0.298)	(0.312)
LLOCK	-0.909***	-0.908***	-0.585***	-0.614***
	(0.081)	(0.081)	(0.099)	(0.096)
CLNY	0.108	0.104	0.390	0.437
	(0.318)	(0.315)	(0.434)	(0.451)
WTO	0.258**	0.345***	0.722***	0.945***
	(0.126)	(0.124)	(0.160)	(0.162)
GSTP	-0.101	-0.054	-0.536***	-0.437***
	(0.074)	(0.073)	(0.155)	(0.147)
AFTA	2.546***	2.572***	2.111***	2.181***
	(0.216)	(0.226)	(0.254)	(0.297)
AIFTA	-0.899**	-0.849**	-0.924**	-0.827**
	(0.367)	(0.340)	(0.434)	(0.334)
ACFTA	-0.746***	-0.867***	-0.052	-0.038
	(0.260)	(0.266)	(0.311)	(0.335)
AKFTA	0.493	0.470	0.781*	0.945***
	(0.366)	(0.341)	(0.424)	(0.332)
AJFTA	-0.011	0.012	-0.538	-0.650*
	(0.325)	(0.296)	(0.415)	(0.372)
AANFTA	0.231	0.267	0.277	0.241
	(0.315)	(0.293)	(0.372)	(0.289)
BFTAs	0.636	0.686*	1.503**	1.684***
	(0.457)	(0.407)	(0.627)	(0.539)
Constant	-38.837***	-38.268***	-35.533***	-41.169***
	(2.685)	(2.590)	(6.653)	(6.720)
$ln\sigma_v^2$	0.043	0.473***	0.075	1.278***
	(0.079)	(0.167)	(0.101)	(0.204)
$ln\sigma_u^2$	0.467***	-0.148	1.959***	1.569***
	(0.148)	(0.341)	(0.065)	(0.096)
Log likelihood	-3205.188	-3183.848	-4456.930	-4402.269
Prob >= chibar2 (LR test of σ_u=0)	0.000		0.000	
Observations	1,935	1,935	2,190	2,190
Control for Year FE in variance equation ($ln\sigma_v^2$)	NO	YES	NO	YES

Notes:
*Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1*
In export models: GSPT consists of 49 countries
In import models: GSPT consists of 7countries

Source: Authors' calculation

Table 2: Estimated result of models with u_i follows exponential distribution

Variables	(1)	(4)	(7)	(10)
	ln_BilExports	ln_BilExports	ln_BilImports	ln_BilImports
lnY_vie	1.499***	1.485***		
	(0.104)	(0.100)		
lnY_partner			0.818***	0.791***
			(0.018)	(0.017)
l*nE_vie*			1.551***	1.775***
			(0.262)	(0.266)
l*nE_partner*	0.925***	0.916***		
	(0.015)	(0.015)		
lnDIS	-0.337***	-0.353***	-0.548***	-0.459***
	(0.053)	(0.052)	(0.074)	(0.071)
CNTG	2.017***	2.065***	1.323***	1.442***
	(0.243)	(0.243)	(0.277)	(0.289)
LLOCK	-0.866***	-0.850***	-0.550***	-0.576***
	(0.080)	(0.079)	(0.098)	(0.095)
CLNY	0.126	0.082	0.443	0.427
	(0.303)	(0.298)	(0.393)	(0.391)
WTO	0.208*	0.272**	0.690***	0.909***
	(0.123)	(0.123)	(0.157)	(0.159)
GSTP	-0.084	-0.044	-0.491***	-0.392***
	(0.072)	(0.071)	(0.154)	(0.150)
AFTA	2.523***	2.530***	2.199***	2.188***
	(0.210)	(0.222)	(0.253)	(0.292)
AIFTA	-0.899**	-0.876***	-0.890**	-0.811**
	(0.353)	(0.312)	(0.438)	(0.357)
ACFTA	-0.759***	-0.894***	-0.087	-0.046
	(0.252)	(0.259)	(0.298)	(0.323)
AKFTA	0.462	0.474	0.666	0.764**
	(0.354)	(0.314)	(0.430)	(0.353)
AJFTA	-0.008	0.015	-0.564	-0.606*
	(0.312)	(0.284)	(0.391)	(0.355)
AANFTA	0.241	0.248	0.374	0.359
	(0.302)	(0.267)	(0.363)	(0.294)
BFTAs	0.634	0.618*	1.643***	1.753***
	(0.436)	(0.373)	(0.572)	(0.495)
Constant	-39.801***	-39.155***	-36.464***	-42.589***
	(2.610)	(2.509)	(6.482)	(6.566)
$ln\sigma_v^2$	0.098*	0.420**	0.389***	1.353***
	(0.054)	(0.164)	(0.079)	(0.190)
$ln\sigma_u^2$	-0.711***	-0.840***	0.831***	0.443***
	(0.138)	(0.147)	(0.094)	(0.120)
Log likelihood	-3183.3185	-3162.0683	-4437.776	-4383.91
Prob >= chibar2 (LR test of σ_u=0)	0.000		0.000	
Observations	1,935	1,935	2,190	2,190
Control for Year FE in variance equation ($ln\sigma_v^2$)	NO	YES	NO	YES

Notes:
*Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1*
In export models: GSPT consists of 49 countries.
In import models: GSPT consists of 7countries.
Source: Author's calculation

tion, joining the WTO has led to an increase of nearly 26% (in the model without year fixed effect) and nearly 34% (in the model with year fixed effect) in Vietnam's export volume, whereas it has led the Vietnamese export volume to increase by 72% (in the model without year fixed effect) and approximately 95% (in the model with year fixed effect). These figures are slightly smaller with an assumption of exponential distribution but keep in the same order of magnitude. In contrast, despite receiving preferential treatment in bilateral trade transactions, the scale of Vietnam's goods exporting to countries in the Global System of Trade Preferences (GSTP) and Vietnam's imports from the GSTP countries was much lower than that of the others. This result was because most countries in GSTP were developing countries and the value of international trade transaction was low.

It is emphasized that AFTA had a strong positive effect on the scale of trade. Vietnamese export to AFTA countries was 5 times larger than to others, while the import volume to AFTA countries was 3.2 times the import volume from other countries. To detach the marginal impact of each Free Trade Agreement with the counterparts (ASEAN + 6) on the size of Vietnam's bilateral trade, we added corresponding dummy variables to the estimation model: AIFTA (ASEAN - India), ACFTA (ASEAN – China), AKFTA (ASEAN-Korea), AJFTA (ASEAN-Japan), AANFTA (ASEAN-Australia-New Zealand). The stochastic gravity model estimation recorded negative effects of AIFTA on both imports and exports. ACFTA also had negative impact on Vietnam's exports but this agreement did not have significant effect on Vietnamese imports. The estimated results did not find a statistically significant impact of the other agreements.

3.2. Exploiting the trade potential from the integration of Vietnam

Estimated results shows that WTO enrollment does not improve the trade efficiency of Vietnam. Exploitation of the trade potential in Vietnam is still relatively low. Before joining the WTO, Vietnam's actual bilateral export value is only 60.8% of the potential level in the model with exponentially distributed u_i and even just 54.5% of the potential level in the case of half-normal distributed u_i. These numbers changed slightly to 60.3% and 54.4% respectively after Vietnam joined the WTO. Meanwhile, trade benefits from regional economic integration, to some extent, still stands at a low level. The estimated results of the model with exponentially distributed u_i show that on average Vietnam has only benefited from about 63% of the export potential before signing free trade agreements among ASEAN and six important trading counterparts (ASEAN + 6). This figure had even reduced to 60.5% after the agreement officially came into force. The number is even lower (54.4%) as u_i is assumed to follow half-normal distribution (see Table 3).

Among the signatories to the ASEAN + 6, the export potential of Vietnam to Australia, South Korea, and Japan is better exploited than to New Zealand and China and India. In the period before the agreements entered into force and in the model with half-normal distributed u_i, the actual export value of Vietnam was made up with 71% of its export potential to Australia, 65.2% to South Korea and 64.8% to Japan; while the figure to New Zealand, Chi-

Table 3: Exploitation of trade potential under the agreements and regions in the export model

	u follows half-normal distribution				*u* follows exponential distribution			
	PERIOD		PERIOD		PERIOD		PERIOD	
REGIONAL	Before the validity	After the validity	Before the WTO	After the WTO	Before the validity	After the validity	Before the WTO	After the WTO
WTO	-	-	54.5	54.4	-	-	60.8	60.3
GSTP	-	-	55.5	54.6	-	-	62.4	60.4
AFTA	-	-	54.9	54.3	-	-	62.0	60.2
EVFTA	-	-	55.2	53.8	-	-	62.3	59.5
EAEU	-	-	-	54.4	-	-	-	60.3
TPP	-	-	56.6	54.1	-	-	64.2	59.9
RCEP	-	-	56.5	54.0	-	-	64.0	59.8
AGREEMENTS								
AIFTA	55.3	54.4	-	-	62.8	60.5	-	-
ACFTA	55.0	54.4	-	-	62.2	60.5	-	-
AKFTA	55.3	54.4	-	-	62.7	60.5	-	-
AJFTA	55.3	54.4	-	-	62.7	60.5	-	-
AANFTA	55.4	54.4	-	-	62.9	60.5	-	-
BFTAs	56.2	54.4	-	-	64.8	60.5	-	-

Source: The author's calculations from the bilateral trade data in the period 2000-2015.

na and India are 58.7 %, 54.8% and 48.4% respectively. After the free trade agreements with these countries took effect, trade performance decreased in most of the countries except for India. The bilateral trade efficiency of Vietnam accounted for 61.4% (to South Korea), 62.6% (to Australia) and 62,4% (to India). The figures for Chile, Japan, New Zealand, Japan and China are 57.4 %, 56.3%, 55.5% and 51.7% respectively.

Estimated export efficiency is higher in the model with exponential distribution in comparison with the results of the former model, especially the export performance of Vietnam to Australia, South Korea and Japan reached more than 72% of potential levels. In addition, the studies measured the trade efficiency of Vietnam with Chile. Similar to the case of India, the validity of the BFTA of Vietnam and Chile had led to a reduction in exploiting the export potential of Vietnam to this country (see Table 4).

Estimated results in Tables 4 and 5 are in line

Table 4: Exploitation of national trade potential in the export model

Countries	*u* follows half-normal distribution				*u* follows exponential distribution			
	ASEAN+6		BFTAs		ASEAN+6		BFTAs	
	Before the validity	After the validity	Before the validity	After the validity	Before the validity	After the validity	Before the validity	After the validity
India	48.4	62.4	-	-	54.7	70.7	-	-
China	54.8	51.7	-	-	62.4	59.5	-	-
South Korea	65.2	64.1	-	-	72.1	72.1	-	-
Japan	64.8	56.3	64.8	55.1	72.1	64.6	72.0	63.6
Australia	71.0	62.6	-	-	77.2	71.1	-	-
New Zealand	58.7	55.5	-	-	66.4	63.9	-	-
Chile	-	-	56.2	57.4	-	-	64.1	66.6

Source: The authors' calculation

Table 5: Exploitation of trade potential under the agreements and regions in the import model

REGION	u follows half normal distribution				u follows exponential distribution			
	PERIOD		PERIOD		PERIOD		PERIOD	
	Before the validity	After the validity	Before WTO	After WTO	Before the validity	After the validity	Before WTO	After WTO
WTO	-	-	31.6	31.6	-	-	44.9	44.2
GSTP	-	-	33.4	31.6	-	-	44.4	44.2
AFTA	-	-	29.3	31.3	-	-	43.6	43.9
EVFTA	-	-	25.6	31.1	-	-	41.1	43.5
EAEU	-	-	-	31.6	-	-	-	44.2
TPP	-	-	40.2	31.0	-	-	53.2	43.7
RCEP	-	-	38.8	30.5	-	-	51.4	43.2
AGREEMENT								
AIFTA	32.2	31.6	-	-	46.0	44.5	-	-
ACFTA	32.5	31.5	-	-	46.4	44.5	-	-
AKFTA	31.3	31.6	-	-	45.2	44.5	-	-
AJFTA	32.9	31.6	-	-	46.6	44.5	-	-
AANFTA	33.3	31.5	-	-	46.7	44.5	-	-
BFTAs	37.0	31.6	-	-	51.4	44.5	-	-

Source: The author's calculations from the bilateral trade data in the period 2000-2015.

with the fact that the trade policies of Vietnam aim to stimulate exports and minimize imports, especially imports of final consumer goods from other countries. Additionally, it can be seen that ASEAN + 6 countries have well benefited from the trade agreements with Vietnam. Table 6 shows that South Korea, China, India and New Zealand have increased their capacity to exploit the trade potential with Vietnam after the agreements between these countries and

Table 6: Exploitation of national trade potential in the import model

Countries	u follows half-normal distribution				u follows exponential distribution			
	ASEAN+6		BFTAs		ASEAN+6		BFTAs	
	Before the validity	After the validity	Before the validity	After the validity	Before the validity	After the validity	Before the validity	After the validity
India	47.4	60.4	-	-	59.2	67.7	-	-
China	42.8	44.9	-	-	55.6	58.3	-	-
South Korea	59.8	62.2	-	-	67.4	70.0	-	-
Japan	50.9	43.6	51.7	41.6	61.3	56.4	61.8	55.0
Australia	51.4	48.9	-	-	61.8	59.6	-	-
New Zealand	52.6	53.4	-	-	62.7	62.6	-	-
Chile	-	-	47.2	19.8	-	-	58.7	36.4

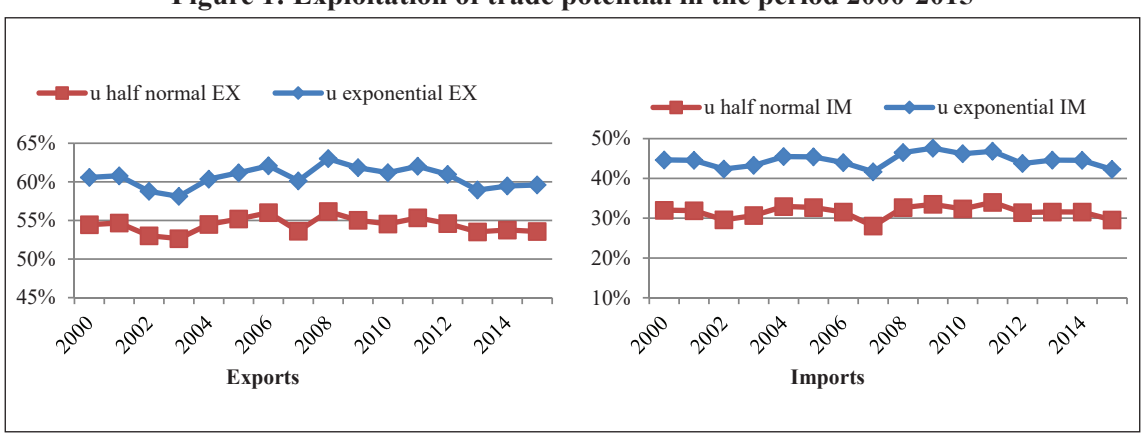
Source: The author's calculations from the bilateral trade data in the period 2000-2015.

Vietnam came into force (ASEAN Free Trade Agreement). Whereas the capacity to exploit the trade potential of Australia, Japan and Chili had declined after FTAs came in force.

The model u_i exponentially distributed shows the better results of exploiting the trade potential of other countries with Vietnam. When u follows exponential distribution rather than half-normal distribution, the estimated trade efficiency after FTAs of all Vietnam's observed counterparts increased. The largest improvement can be seen in the case of Chile (from 19.8% to 36.4%), China (from 44.9% to 58.3%) and Japan (from 43.6 to 56.4%).

On average, Vietnam exploits about 54% of its trade potential level (when u_i is half-normal-

Figure 1: Exploitation of trade potential in the period 2000-2015



Source: The authors' calculation

ly distributed) or about 61% (when u_i is exponentially distributed). However, the capacity to exploit the trade potential of Vietnam has fallen below these average levels since 2013. In contrast, Vietnam accounts for about 32% and 45% of the import-export potential level in the case of u_i being half-normal and exponentially distributed respectively (see Figure 1).

4. Conclusion

In this paper, the stochastic frontier gravity model was introduced for analyzing the efficiency or the exploitation of Vietnam's bilateral trade potential with its main counterparts. This model was used for bilateral trade data developed in the period 2000-2015. Estimated results show that there was trade inefficiency at conventional statistical significance levels. Vietnam has a much lower import potential than export potential. This reflects the fact that recent trade policies of Vietnam are aiming to promote exports and limit imports, especially imports of final consumer goods. On average, Vietnam accounts for 54% - 61% of the potential export value and that corresponds to assumptions that the inefficient component has a half-normal distribution or exponential distribution. However, the capacity to exploit the trade potential of Vietnam has fallen below these levels since 2013. The trade partner countries had exploited about 32% - 45% of the import potential of Vietnam in the study period from 2000 to 2015.

On the one hand, the capacity to exploit the trade potential of Vietnam is still standing at a low level and it has not even been improved since Vietnam's joining of the WTO. Before joining the WTO, the actual bilateral export value of Vietnam was only 54.5% - 60.8% of its potential and it stood at 54.4% - 60.3% after Vietnam joined the WTO. In addition, Vietnam does not seem to receive much trade benefits from the signing of free trade agreements. Calculations with an assumption of exponential distribution have proved that, on average, Vietnam had made up only about 63% of its potential export value before the signing of the FTAs between ASEAN and six main trading counterparts (ASEAN+6). After the agreements were signed and entered into force, the trade efficiency slightly reduced to about 60.5%. The figures corresponding to the half-standard assumption of trade inefficiencies are 55.4% and 54.4% respectively.

Among the signatories to ASEAN (ASEAN + 6), Vietnam took advantage more of the better export potential to Korea, Australia, and India than to Japan, New Zealand and China. The actual bilateral export value of Vietnam accounts for 65.2% - 72.1% of the export potential to South Korea, 64.8% - 72.1% to Japan, 48.4% - 54.7% to India, 54.8% - 62.4% to China, and over 71% to Australia and 58.7% - 66.4% to New Zealand in the period before the agreements entered into force. After the free trade agreements with these countries took effect, export efficiency declined in most of the countries except for India and Chile. Specifically, Vietnam's exports to India reached 62.4% - 70.7% of the potential level. The corresponding figures for China are 51.7% - 59.5%, 64.1% - 72.1% (South Korea), 56.3% - 64.6% (Japan), 62.6% - 71.1% (Australia) and 55.5% - 63.9% (New Zealand) Meanwhile, the ASEAN + 6 countries have well exploited their trade benefits from the signing of trade agreements with Vietnam. For instance, Korea, China and India have increased their capacity to exploit the trade potential with Vietnam after the agreements between Vietnam and these countries successfully came into force.

Appendix 1: Definition, measurement of variables

Code	Variable	Definition and measurement	Source	Expected sign
BILATERAL TRADE (X)				
BilExports	Bilateral exports	Total export turnover of Vietnam	UN Com Trade	
BilImports	Bilateral imports	Total import turnover of Vietnam		
CHARATERISTICS OF COUNTRIES				
Y_vie	Vietnam's nominal GDP	Vietnam's nominal GDP in 2010 (in USD). Used in Export model	WB	+
Y_partner	Nominal GDP of Vietnam's trade partners	Nominal GDP in 2010 (USD) of Vietnam's trade partner. Used in Import model		
E_vie	Vietnam's final consumption expenditure	Vietnam's finale consumption expenditure in 2010(USD). Used in import model	WB	+
E_partner	Final consumption expenditure of Vietnam's trade partners	A Counterpart's final consumption expenditure in 2010 (in USD). Used in export model.	WB	+
DIS	Distance from Capital	Simple distance between capitals (capitals, km)	CEPII	+
CNTG	Contiguous	A dummy (= 1 if Vietnam and its counterparts have cross-border trade)		-
LLOCK	Landlocked	A dummy (= 1 if a counterpart has no coast)		+
CLNY	Colony	A dummy (= 1 if Vietnam and its counterpart were in same colonial system)		
DUMMY FOR TRADE AGREEMENTS (RTA & BTA)				
WTO	World Trade Organization	= 1 after Vietnam officially jointed to WTO in year of 2007		+
GSTP	Global System of Trade Preferences among Developing Countries	= 1 if a counterpart applies Global System of Trade Preferences with good originated from Vietnam	DESTA	-
				-
AFTA	ASEAN Free Trade Agreement	= 1 if a counterpart is member of AFTA, since it is valid to the counterpart.	RTA-IS	+
AIFTA	ASEAN-India Free Trade Agreement	= 1 if a counterpart joined in AIFTA, since it is valid to the counterpart.		+
ACFTA	ASEAN-China Free Trade Agreement	= 1 if a counterpart joined in ACFTA, since it is valid to the counterpart.		+
AKFTA	ASEAN-Korea Free Trade Agreement	= 1 if a counterpart joined in AKFTA, since it is valid to the counterpart.		+
AJFTA	ASEAN-Japan Free Trade Agreement	= 1 if a counterpart joined in AJFTA, since it is valid to the counterpart.		+
AANFTA	ASEAN-Australia-New Zealand Free Trade Agreement	= 1 if a counterpart joined in AANFTA, since it is valid to the counterpart.		+
BFTAs	Bilateral Free Trade Agreements	= 1 if a counterpart and Vietnam singed a Free Trade Agreement, since it is valid to the counterpart.		+
EVFTA	EU- Vietnam Free Trade Agreement	= 1 if the EU counterpart and Vietnam singed a Free Trade Agreement, since it is valid to the counterpart.		+
EAEU	Eurasian Economic Union	= 1 if a counterpart joined in EAEU, since it is valid to the counterpart.		+
RCEP	Regional Comprehensive Economic Partnership	= 1 if a counterpart joined in EAEU, since it is valid to the counterpart.		+
TPP	Trans-Pacific Partnership	= 1 if a counterpart joined EAEU, since it is valid to the counterpart.		+

Appendix 2: Exploiting trade potential of Vietnam in period of 2000-2015

Year	*u* follows half-normal distribution		*u* follows exponential distribution	
	Exports	Imports	Exports	Imports
2000	54%	32%	61%	45%
2001	55%	32%	61%	45%
2002	53%	30%	59%	42%
2003	53%	31%	58%	43%
2004	54%	33%	60%	45%
2005	55%	33%	61%	45%
2006	56%	32%	62%	44%
2007	54%	28%	60%	42%
2008	56%	33%	63%	46%
2009	55%	33%	62%	48%
2010	55%	32%	61%	46%
2011	55%	34%	62%	47%
2012	55%	31%	61%	44%
2013	54%	32%	59%	45%
2014	54%	32%	59%	45%
2015	54%	30%	60%	42%
Mean	54%	32%	61%	45%

Source: The Authors' calcualtion

Acknowledgement:

This artice is conducted within the research project "The Impact of Free Trade Agreements on Efficiency in Exploiting Potential of Exports and Imports of Vietnam' funded by National Economics University. Project code: KTQD/E2018/14.

References

Aigner, D., Knox Lovell, C.A. and Schmidt, P. (1977), 'Formulation and estimation of stochastic frontier production function models', *Journal of Econometrics*, 6(1), 21-37.

Anderson J. E. and Wincoop E. (2003), 'Gravity with Gravitas: a solution to the border puzzle', *American Economic Review*, 93 (1), 170-192.

Anderson, J.E. (1979), 'A theoretical foundation for the gravity equation', *American Economic Review*, 69(1), 106-116.

Armstrong, S., Drysdale, P. and Kalirajan, K. (2008), 'Asian trade structures and trade potential: an initial analysis of South and East Asian trade', *Working paper No.32*, EABER, Canberra.

Chaney, T. (2018), 'The gravity equation in international trade: An explanation', *Journal of Political Economy*, 126(1), 150-177.

Do, Tri Thai (2006), 'A gravity model for trade between Vietnam and twenty-three European countries', Master thesis, Department of Economics and Society, Dalarna University, Sweden.

Drysdale, P.D., Huang, Y. and Kalirajan, K. (2000), 'China's trade efficiency: Measurement and determinants', in *APEC and Liberalisation of the Chinese economy*, Drysdale P, Zhang Y, Song L (Eds.), Asia Pacific Press, Canberra.

Eaton, J. and Kortum, S. (2002), 'Technology, geography, and trade', *Econometrica*, 70(5), 1741-1779.

Hoang, Chi Cuong and Bui, Thi Thanh Nhan (2013), 'The impact of the global financial crisis 2008 on foreign trade in Vietnam', *Journal of Science and Development*, 11(5), 751-766.

Hoang, Chi Cuong, Do, Thi Bich Ngoc, Bui, Thi Phuong Mai and Dang, Huyen Linh (2013), 'Trade liberalization and foreign direct investment in Vietnam: An approach through Hausman-Taylor gravitation model and estimation', *Journal of Science and Development*, 11(1), 85-96.

Kalirajan, K. (1999), 'Stochastic varying coefficients gravity model: an application in trade analysis', *Journal of Applied Statistics*, 26(2), 185-193.

Kalirajan, K. (2008), 'Gravity model specification and estimation: Revisited', *Applied Economic Letter*, 15, 1037-1039.

Meeusen, W. and van den Broeck, J. (1977), 'Efficiency estimation from Cobb-Douglas production functions with composed error', *International Economic Review*, 18(2), 435-444.

Nguyen, Anh Thu (2012), 'Assessing the impact of Vietnam's integration under AFTA and VJEPA on Vietnam's trade flows, gravity model approach', *Yokohama Journal of Social sciences*, 17(2), 137-148.

Nguyen, Anh Thu and Tran, Trung Duc (2014), 'Analyzing the impacts of ASEAN trade liberalization on Vietnam's trading of electronics products', Paper under project QGTĐ 13.22, Vietnam National University.

Nguyen, Thi Ha Trang, Nguyen, Thi Thanh Tam and Vu, Hoang Nam (2011), 'An inquiry into the determinants of the Vietnamese product export', *Working paper* No. 8, DEPOCEN.

Phan, Van Tam (2011), 'Direct investment from Japan into Vietnam', doctoral dissertation, Graduate Academy of Social Sciences.

Tinbergen, J. (1962), *Shaping the World Economy: Suggestions for an International Economic Policy*, New York: The Twentith Century Fund.

To, Trung Thanh (2012), 'Challenging trade deficit', in *Annual Economic Report 2012 of the Economic Committee: From macroeconomic instability to restructuring*, To Trung Thanh and Nguyen Tri Dung (Eds.), Tri Thuc publisher.

Tran, Trung Hieu and Pham, Thi Thanh Thuy (2010), 'Application of gravity models in international trade: Factors influencing the export of Vietnam', *Journal of Economic Management*, 31, 12-25.

Tran. Nhuan Kien., and Tran, T. P.Thao (2016). Determinants of intra-industry trade for Vietnam's manufacturing industry. *Journal of Economics and Development*, *18*(1), 5-18.

Tu, Thuy Anh and Dao, Nguyen Thang (2008), 'Factors affecting the concentration of Vietnam's trade with the ASEAN+ 3', *Project NC-05/*2008, CEPR, VNU University of Economics and Business.

Vu, Kim Dung and Mai, Thi Lan Huong (2012), 'Vietnam trade relations and 19 key partners - Analyzing factors influencing and policy recommendations', *Journal of Economics and Development*, Special Volume. 88-92.