Gravity Analysis of Environmental Goods Focusing on Bilateral Tariff Rates*

Atsuko Matsumura
Department of Economics, Tokyo International University

1. Introduction

This paper investigates the determinants of bilateral trade of environmental goods (EGs) with a focus on bilateral tariff rates. Bilateral tariff rates are a main part of trade relationships developed through regional trade agreements (RTAs), and thus it is important when conducting this study to examine the effect of RTAs along with the effect of bilateral tariff rates such as most-favored nation (MFN) tariffs and tariffs of generalized system of preferences (GSP) under World Trade Organization (WTO).

EGs are useful for protecting the environment, and the importance of trade liberalization of the EGs has been widely recognized since the 2001 Doha Ministerial Declaration of WTO. This declaration initiated the reduction or elimination of tariff and non-tariff barriers to trade in environmental goods and services (EGSs). In 2011, the WTO report TN/TE/20 was released with the Annex II.A, which contains a list of the EGs based on HS (Harmonized System) classification six-digit level. In 2012, the Asia-Pacific Economic Cooperation (APEC) put together a list of 54 environmental goods and affirmed their commitment to reduce applied tariff rates to five percent or less by the end of 2015. This is specified in Annex C of the 2012 Vladivostok Declaration. Then on July 8, 2014 at the WTO, 14 members, including China, the European Union (EU) and the United States, launched plurilateral negotiations on trade liberalization for EGs. Presently there are 46 countries engaged in the negotiations.[1]

The potential impact of trade liberalization and trade increase of EGs is easily illustrated. This leads to import demand expansion through import price decrease resulting from tariff reduction, especially in fast-growing developing economies with comparatively high tariff rates on these goods. Importing EGs at a lower price makes it possible to access climate-friendly goods with clean energy technologies, which could have substantial effect for climate change mitigation. Especially for the renewable energy sector, cost has been the principal obstacle to the deployment of renewable energy-based electricity generation in developing countries; the reduction or removal of these tariffs contributes significantly to improving access to these goods. Access to more energy-efficient technologies at a lower cost may be particularly important for

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[1] See Matsumura (2016a), (2016b), (2019) for details about the trade liberalization of environmental goods.

industries that must comply with environmental policies, which place the burden of emission reductions on the emitters.[2]

Effects of trade liberalization on climate change mitigation can be seen not only on the demand side of the importing countries, but also on the production side of those goods in the importing countries. Increased imports give producers in the importing countries the opportunity to learn and benefit from technological advances, and allow larger markets for environmental goods leading to profits from economies of scale by production increase. There are examples that indicate that trade liberalization of environmental goods increases local capabilities for innovation and adaptation of domestic technology rather than simply fostering dependence on the transfer of foreign technology. [3]

Trade increase in EGs affects producers in the exporting countries as well. The production of EGs has the following characteristics. Firstly, at the initial stage of production, sunk costs for research and development are enormous, and secondly, the degree of product differentiation can be large depending on the producers. Consequently, many EGs are produced in monopolistic competitive industries having monopolistic power such that each variety is produced with scale economies. Production increase realized by trade liberalization in the exporting countries having comparative advantage leads to average cost decrease and profit increase based on economies of scale, which induces the entry of new firms with new varieties.

The trade benefit for users on the demand side realized by trade liberalization is the expansion of choices among the varieties with lower prices as a result of increased competition among producers of both exporting and importing countries. Accordingly, these effects on the monopolistic competitive environmental industries will lead to an increase in the world deployment of EGs, which will possibly induce successful environmental protection.

The present analysis investigating trade determinants is conducted for ten disaggregated EGs. Seven goods are especially useful for renewable energy production. However, the photovoltaic cells sector is not included as the effect of bilateral tariff rates for this sector was previously examined in Matsumura (2016b) and Matsumura (2019). Also three sectors are instruments for monitoring environmental conditions. These ten goods are taken from APEC list of environmental goods, shown in Table 1 under HS 2012 classification at the six-digit level.

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[2] See WTO (2009), UNEP (2012) and UNEP (2014) for details.

[3] WTO (2009) shows the example of Ghana where the reduction of certain import tariffs has encouraged the adoption of energy-efficient lighting.

The estimation model is based on the fixed effect approach of the gravity model with importer and exporter dummy variables. This model is useful for examining the effect of bilateral tariff rates and other proxies of trade costs, such as distance and dummy variable of common language and that for each region. As bilateral tariff rates are reduced through preferential treatment in RTAs, the effects are examined together by including the detailed bilateral tariff rates in each RTA. Following Hayakawa (2013), exporters are assumed to use the lowest tariff rates in this paper although multiple tariff schemes are available in most country pairs.

The estimation results are carefully investigated to show cases in which the coefficients of bilateral tariff rates are robustly significant for the ten environmental goods examined in this study. In addition to the tariff rates, other important determinants of trade of each EG are derived by examining the details of estimation results.

The paper is structured as follows. In the next section, the literature on the effects of tariffs and determinants of trade in EGs are briefly reviewed. Section 3 describes theoretical foundation of the gravity model for the disaggregated goods, specification of the estimating model and data. Section 4 presents the estimation results for the determinants of trade in each EG and the comparison among the results of ten goods. Section 5 concludes.

2. Related Literature for Trade in Environmental Goods

While the present study examines the determinants of bilateral trade in disaggregated EGs, Disdier et al. (2009) examines the determinants of bilateral trade in each items included in cultural goods. In Disdier et al. (2009), the effect of common language, colonial links, proximity of cultural tastes on bilateral trade in cultural goods are examined carefully based on the gravity equation with importer and exporter fixed effects interacting with year dummies. Although they emphasize the importance of the liberalization of trade of cultural goods in future multilateral trade negotiations, they do not introduce bilateral tariffs in the estimation.

Other papers reviewed here introduce bilateral tariff rates implicitly in the gravity model. Hayakawa (2013) examines the seriousness of omitting bilateral tariff rates from gravity equations for aggregated manufacturing goods. He concludes that omitting bilateral tariff rates presents no serious issue related to the omitted variable bias, and he also clarified that the dummy variable for RTAs and importer and exporter fixed effects are not a statistical substitute for tariff rates.

Disdier et al. (2015) investigates impacts of tariff cuts on three components of the three types of trade margins for the exports from 18 emerging countries to 25 main importing countries. Based on the model with the first-differences trade data between 1996 and 2006 with country-pair fixed effects to control for the potential endogeneity of tariffs and long-run bilateral trade growth shocks, Disdier et al. (2015) clarifies a positive effect of tariff cuts at both the extensive and intensive trade margins, though the effects are relatively modest. Also, based on the basic gravity model, the coefficients of tariff rates are negative and significant in all cases estimated for extensive margin and intensive margin, although the results are confined to a case for a part of world bilateral trade confined for exports from emerging countries.

In papers which examine the determinants of the trade of environmental goods, the following papers show the estimation results according to their specific purposes. Jomit (2014) examines the aggregated environmental goods using the gravity model estimated by OLS. For exports of EGs from India to 58 countries for the period between 1991 and 2011, the coefficient of GDP of the importing countries, the common colonizer, and membership in bilateral trade agreements are positively significant. Cantore et al. (2018) shows that the trade of EGs based on OECD classification depends on GDP, transaction costs and uncertainty using trade data from 1999 to 2014 across 71 countries. In an analysis focusing on the renewable energy industries including solar photovoltaic cells and wind power, Kuik et al. (2018) shows the effectiveness of demand-pull policies on trade increase.

Related to research on environmental protection by change in trade, Zhais and Martinez-Zarzoso (2018) estimates the effects of two international agreements (Rotterdam Convention and the Stockholm Convention) on environmental protection which reduce trade in hazardous chemicals or persistent organic pollutants. The results from the gravity model show that when the exporters ratify the Rotterdam Convention we observe a significant reduction of imports of non-OECD countries from OECD countries in hazardous chemicals. In the case of the Stockholm Convention, a reduction in persistent organic pollutants is observed.

Matsumura (2016a) examines the determinants affecting trade structure in EGs, by investigating the trade of environmental goods in the APEC list for each group of HS84, HS85, and HS90, from 2009 to 2012.[4] Based on the gravity model, the trade share of parts and components is the driving force of trade increase in EGs in the APEC region for the HS84 and HS90 groups, and in Japan-ASEAN FTA for the HS85 group, because

[4] This analysis includes 43 countries with 17 countries in APEC, 21 countries in EU, and 5 countries such as Brazil, India, South Africa, Switzerland, and Turkey.

of the proliferation of complex supply chain networks in EGs. On the other hand, for EU countries, trade is higher for the two countries with higher ratio of final goods than the two countries with higher ratio of parts and components. This suggests that international production fragmentation is not found to be the major determinant of trade of EGs in the EU region.

The analyses from these five papers for the determinants of the trade of EGs are based on the traditional gravity model by including some explanatory variables according to the objectives of each study, and they do not include importer and exporter fixed effects.

Matsumura (2016b) investigates the effect of bilateral tariff rates for specific renewable energy related products, taking example of photovoltaic cells sector, which is classified in HS nine-digit level under the heading of HS854140. This analysis focuses on the period 2000-2004, a period with tariff reduction and trade increase for the photovoltaic cells sector, and clarifies the significant effect of bilateral tariff rates on the trade by the fixed effect approach of the gravity model in addition to the traditional model.

However, later Matsumura (2019) shows that the effect of tariffs on trade depends on the goods being traded. It was found that there was a clear effect of tariffs on the trade of photovoltaic cells but not on the trade of wind-powered electric generating sets and equipment, during the period of trade liberalization of each good being investigated. With regards to the regional effects, this paper shows that the trade of wind-powered electric generating sets and equipment is active among EU countries and the trade of photovoltaic cells is active among APEC countries. This type of estimation includes bilateral tariff rates influenced by all the existing trade integration agreements, so that both the effects of trade integration agreements and the effect of bilateral tariff rates are taken into consideration. The present study examining the trade determinants of ten EGs is the extension of Matsumura (2019).

3. Estimating Model and Data

3-1 Theoretical Foundation of Gravity Model for Disaggregated EGs

The theoretical foundation of the gravity model is based on the trade theory of monopolistic competition with CES type expenditure function and iceberg trade costs.[5]

[5] A detailed theoretical explanation is given in Anderson and van Wincoop (2003), Anderson (2010), De Benedictis and Taglioni (2011), and Feenstra (2016), and the way how to derive the estimation equation from the theory is given by Disdier et al. (2009), Hayakawa (2013), Head and Mayer (2014), and Tanaka (2015).

Increasing returns to scale is assumed in producing differentiated varieties of the good in each country and they ship those to all countries with an iceberg trade cost in which the trade costs are proportional to the volume shipped.

According to Anderson (2010), the frictionless and homogeneous world implies that the proportion of spending by destination country *j* on goods from country *i* in the sum of purchases from all origins is equal to the global proportion of spending on goods from country i

$$X_{ij}/E_j = Y_i/Y \qquad (1)$$

where X_{ij} is the import value of country *j* from country *i*, E_j is the sum of purchases in country *j* from all origin countries, Y_i is the total sales by origin country i, and Y is world spending. On the other hand, as the observed trade value X_{ij} is affected by frictions in the real world along with random influences, the ratio of observed trade value X_{ij} to predicted frictionless trade, Y_iE_j/Y can be explained by various proxies for trade costs for frictions by the empirical gravity models

For the analysis of gravity model for each disaggregated EGs, this relationship can be applied to disaggregated goods, indexed by *k*.

$$X_{ij}^k = Y_i^k E_j^k / Y^k = s_i^k b_j^k Y^k \qquad (2)$$

where $s_i^k = Y_i^K/Y^K$ is country *i*' s share of the world's sales of goods *k* and $b_i^k = Y_I^K/Y^K$ is country j's share of the world spending on good *k*, and Y^k is world sales of good *k*.

According to Anderson and van Wincoop (2003), the theory based gravity model can be derived in the following way. By specifying the demand structure as Constant Elasticity of Substitution (CES) exports from country *i* to country *j* in product *k*, X_{ij}^k expenditure is given by

$$X_{ij}^k = \left(\frac{p_{ij}^k}{P_j^k}\right)^{1-\sigma^k} E_j^k \qquad (3)$$

where σ_k is the elasticity of substitution among differentiated varieties of the goods, p_{ij}^k is the price charged by country *i* for exports to country *j*, and P_j^k is the CES price index, E_j^k is expenditure in country *i* for good *k*. The CES price index is given by

$$P_j^k = \left[\sum_i (p_{ij}^k)^{1-\sigma^k}\right]^{1/(1-\sigma^k)} \qquad (4)$$

As iceberg trade costs are assumed, p_{ij}^k can be written as $p_i^k t_{ij}^k$, using supply price received by producers in country i , p_i^k and trade costs, t_{ij}^k , where $t_{ij}^k - 1$ is ad-valorem tax equivalent of trade costs.

Together with the market-clearing conditions, the gravity equation system for good *k* can be shown as

$$X_{ij}^k = \frac{E_j^k Y_i^k}{Y^k}\left[\frac{t_{ij}^k}{P_j^k \Pi_i^k}\right]^{1-\sigma^k} \tag{5}$$

$$(\Pi_i^k)^{1-\sigma^k} = \sum_j \left[\frac{t_{ij}^k}{P_j^k}\right]^{1-\sigma^k} \frac{E_j^k}{Y^k} \tag{6}$$

$$(P_j^k)^{1-\sigma^k} = \sum_i \left[\frac{t_{ij}^k}{\Pi_i^k}\right]^{1-\sigma^k} \frac{Y_i^k}{Y^k} \tag{7}$$

where Π_i^k and P_j^k are outward and inward multilateral resistance, respectively, and this system shows that the bilateral trade depends on relative trade barriers, with those key variables. It suggests that the trade flow of good k from country i to country j is increased by high trade costs from other suppliers to j as captured by inward multilateral resistance, and high resistance to shipments from country i to its other markets than country j, captured in outward multilateral resistance, increases trade from country i to country j.

3-2 Econometric Specification and Data

Based on the theoretical foundation in the previous section, the determinants of the trade of each of the ten disaggregated EGs are examined by fixed effect approach of the gravity model, using importer and exporter dummy variables.

The specification of the fixed effect approach of the gravity model in this study can be shown as follows:

$$\ln X_{ij} = \theta + \mu_i fe_i + \lambda_j fe_j + \delta_1 lnDIST_{ij} + \beta_1 \ln(1 + TAR_{ij}) + \beta_2 CL_{ij} + \beta_3 AP_{ij} + \beta_6 EU_{ij} + u_{ij} \quad \cdots \tag{8}$$

where X_{ij} denotes the value of exports from country i to partner j, fe_i is country dummy variable, fe_j is partner country dummy variable and u_{ij} is a stochastic error. $DIST_{ij}$ is the distance between capitals of the pair countries, TAR_{ij} is bilateral tariff rates of the country j from country i. CL_{ij} is the dummy variable for common language, AP_{ij} is the dummy variable for the membership of APEC, and EU_{ij} is the dummy variable for the membership of EU.

The bilateral tariff rates reflected by RTAs are introduced in the estimating equation to take into account the trade cost from the point of view of trade policy. For the proxies to examine the effects of other trade costs, some dummy variables are introduced in the estimating equation. The dummy variable for common language takes one for two countries with common official language and zero in other cases, regional dummy variable of APEC takes one for two countries belonging to APEC and zero otherwise, and the regional dummy variable of EU takes one for two countries belonging to EU and zero otherwise.

According to Redding and Venables (2004), one is added to all trade flows before taking logarithms, as zeros are genuine zeros rather than missing values based on the accuracy of the bilateral trade flows data. Importer and exporter fixed effects are included in all the regressions in the form of country dummies, based on the pioneering work of Redding and Venables (2004). As Disdier et al. (2009) clarifies, those fixed effects incorporate the size effects, but also the price and number of varieties in the exporting country and the size of demand and the price index of the importing country.

In order to examine the trade network in South-East and East Asia instead of APEC, the dummy variable of the 15 countries and regions including so-called ASEAN plus 3 countries (Japan, Korea, and China), and the regions of Hong Kong and Taiwan is introduced. This dummy variable *AS3* takes 1 for two countries among those 15 countries and regions, and 0 otherwise. The gravity equation is altered as shown by equation (9).

$$\ln X_{ij} = \theta + \mu_i fe_i + \lambda_j fe_j + \delta_1 lnDIST_{ij} + \beta_1 \ln\left(1 + TAR_{ij}\right) + \beta_2 CL_{ij} + \beta_3 AS3_{ij} + \beta_6 EU_{ij} + u_{ij} \quad \cdot\cdot\cdot \quad (9)$$

The recent four years 2013-2016 are selected for the estimation period based on the panel data. In addition to Pooling Ordinary least squared method (OLS) and Random effect model, Poisson pseudo-maximum-likelihood methods (PPML) proposed by Silva and Tenreyro (2006) is also applied in the analysis, to avoid the inconsistency occurring when the gravity equation is estimated using a log-log functional form, in the presence of heteroscedasticity and zero trade flows, for a robustness check. In this case, the left hand side term is taken in levels. Random effect model is selected because the time invariant distance variable is included in the estimation model.

The ten EGs selected from APEC list of EGs are based on six-digit level of harmonized system HS2012 for estimation as shown in Table 1. The environmental benefits for these ten goods are also indicated in this table. The first seven items in the Table are environmental goods used for renewable energy production. Specifically, HS841290 is the item which includes the wind turbines and hubs, HS850231 includes wind-powered electric generating sets and equipment, HS850239 includes electric generating sets and rotary converter for production of renewable energy, and HS850300 includes the parts and components for those goods. Also, HS850490 includes important parts and components for electrical transformers, static converters and inductors.

HS901380 includes heliostats orient mirror in concentrated solar power systems, and HS901390 includes parts of HS901380. The last three items belonging to the precision machinery, HS90, are the principal instruments for measuring or checking the environmental conditions, such as the flow, level, pressure or other variables of liquids or gases, and their parts and components.

Table 1. List of Environmental Goods Included in this Study

HS2012 number	HS Code Description	Environmental Benefit
841290	Engine and motor parts	Integral components to wind turbines (wind turbines and hubs)
850231	Wind-powered electric generating sets and equipments	Electricity generation from renewable resources
850239	Electric generating sets and rotary convertors Biogas generating sets; Gas generator	Electricity generation from renewable resources
850300	Parts suitable for use with the machines of heading 8502.	Parts for electricity generation from renewable resource
850490	Parts for electrical transformers, static converters and inductors	Used to convert DC from renewable energy generating sets into conventional AC electricity
901380	Optical devices, appliances and instruments	Heliostats orient mirrors in concentrated solar power systems to reflect sunlight on to a ESP receiver
901390	Parts of optical devices, appliances and instruments	Heliostats orient mirrors in concentrated solar power systems to reflect sunlight on to a ESP receiver
902610	Instruments for measuring or checking the flow, level, pressure or other variables of liquids or gases.	Used to measure, record, analyse and assess environmental samples or environmental influences, such as . air quality monitors and dust emissions monitors
902620	Instruments for measuring or checking the flow, level, pressure or other variables of liquids or gases.	Manometers used in power plants, water delivery systems, and other applicatiosn such as monitoring indoor air, which have important environmental applications.
902690	Parts for articles of subheading 9026.	Used to measure, record, analyse and assess environmental samples or environmental influences.

Source: APEC (2012)

The data used for the estimation are described briefly as follows. The bilateral trade values of each of the ten sectors (in US dollars) for 70 trading countries are taken from the Global Trade Atlas online data, providing customs trade data reported by the government of each country and region. The data of bilateral distance between capitals of the pair countries and the data for common language are from the CEPII (Centre d'Etude Prospectives d'Informations Internationales) database.

The data sources of bilateral tariffs reflected by trade integration agreements are the WTO Tariff Download Facility and FedEx Trade Network, World Tariff Account Information. Together with the information from the WTO website for "Regional Trade Agreements Database" for each country, the analysis uses the preferential tariff rate of each trade integration agreement for each country, based on the assumption that exporters are assumed to use the lowest tariff rates in this paper although multiple tariff schemes are available in most country pairs.

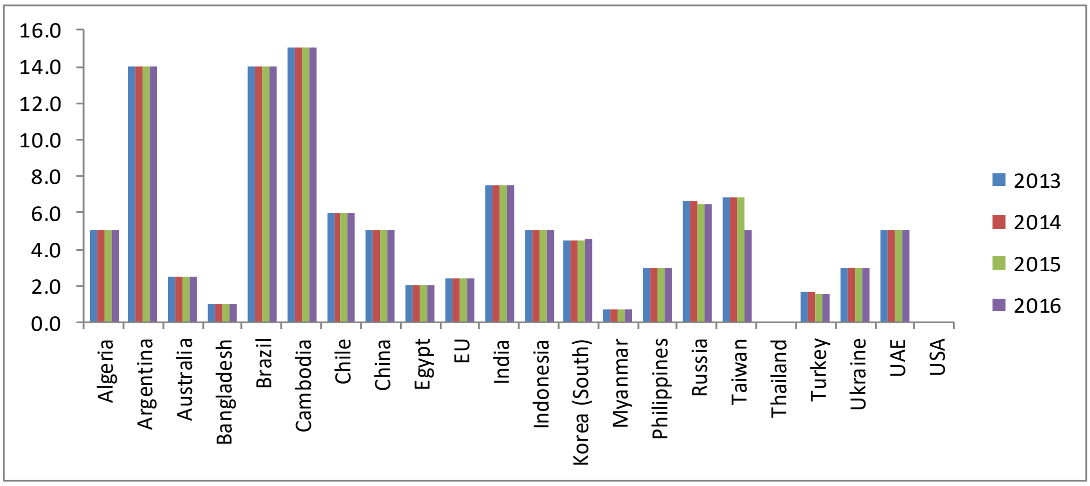
70 countries are included in the analysis as shown in the appendix as Table A.1. Developed and newly industrialized countries belonging to APEC and EU, and another seven countries are introduced in the estimation as exporting and importing countries. 18 developing countries are included only as the importing countries, as those countries have no significant exports.

The descriptive statistics of each variable by good are shown from Table A2 to Table A11 in the appendix.

Ten figures, from Figure 1 to Figure 10, present applied MFN tariff rates of the twenty-two selected countries, for each HS six-digit number respectively. These tariff rates are taken from the database for bilateral tariff rates constructed for the present study, in order to show a trend of tariff rates levied by the representative countries. Together with the information with respect to bilateral tariff rates in the descriptive statistics, in Table A2 to Table A11, it is shown that sectors of HS902610, HS902620, and HS 902690 have relatively low bilateral tariff rates, because of tariff elimination of many main countries. On the contrary, the sectors of HS850300, HS850490, and HS901390 have high tariffs because of the relatively high tariffs in the main countries including the USA and the EU. Japan is not included in those figures as its applied MFN tariff rates are zero for those EGs.

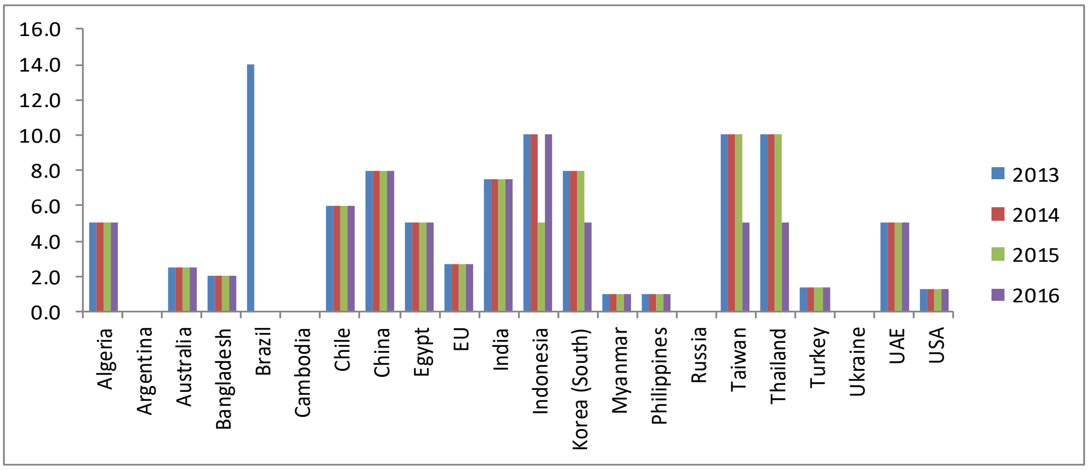
In some APEC member countries and regions, applied MFN tariff rates were reduced to less than 5% in 2015 or 2016 following the commitment of APEC. For example, Thailand and Taiwan reduced those of HS841290, HS850231, HS850239, and HS901380 in 2015 or 2016.

Figure 1. Applied MFN Tariff Rates for Selected Countries, HS841290 (%)



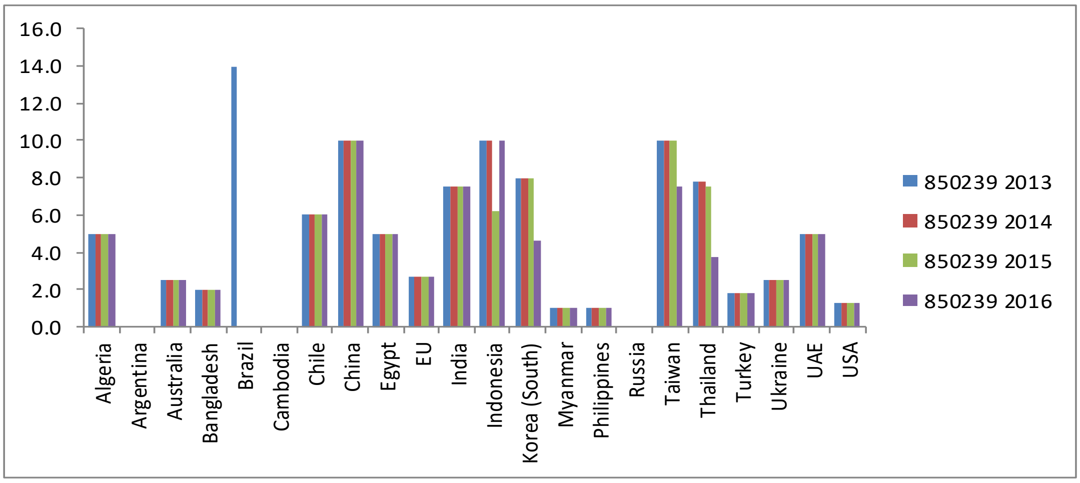
Source: Tariff Download Facility, WTO.

Figure 2. Applied MFN Tariff Rates for Selected Countries, HS850231 (%)



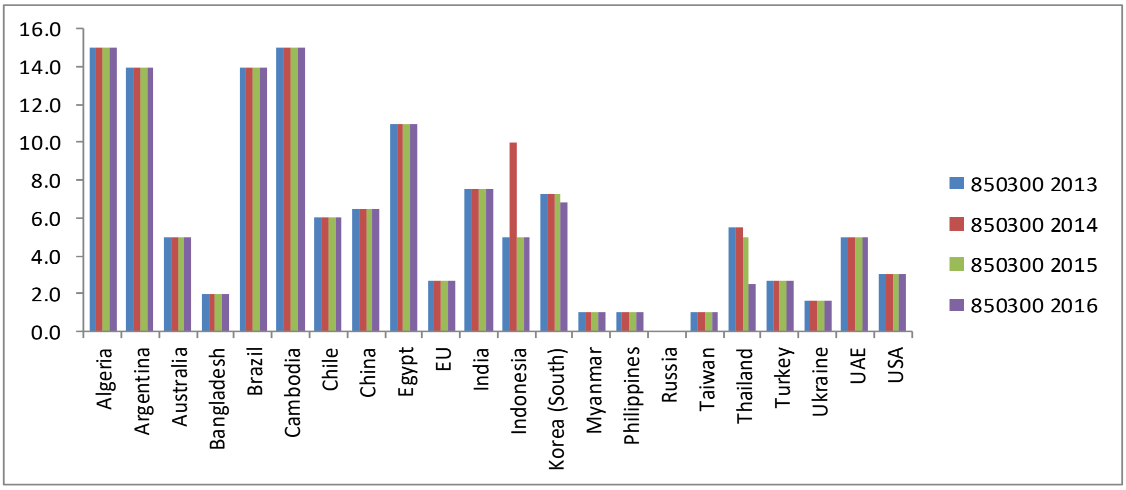
Source: Tariff Download Facility, WTO.

Figure 3. Applied MFN tariff rates for selected countries, HS850239 (%)



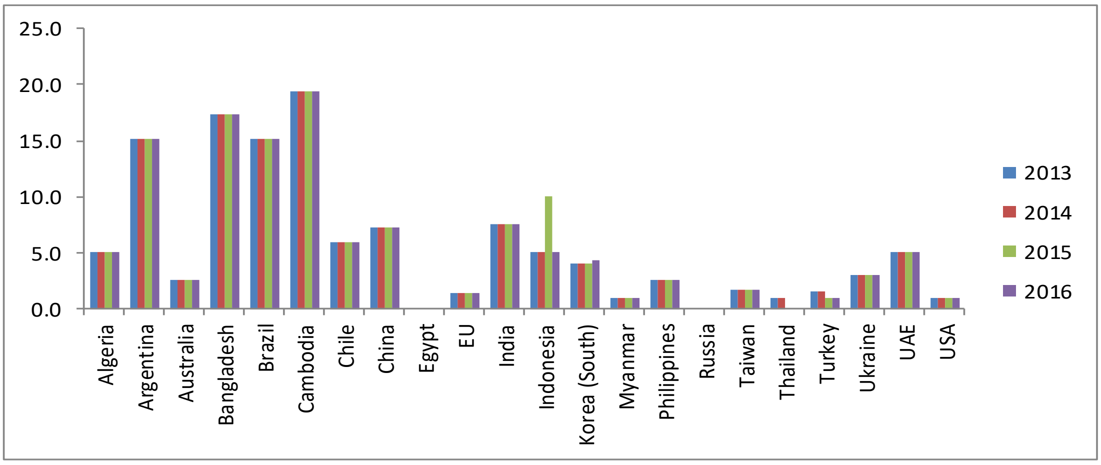
Source: Tariff Download Facility, WTO.

Figure 4. Applied MFN tariff rates for selected countries, HS850300 (%)



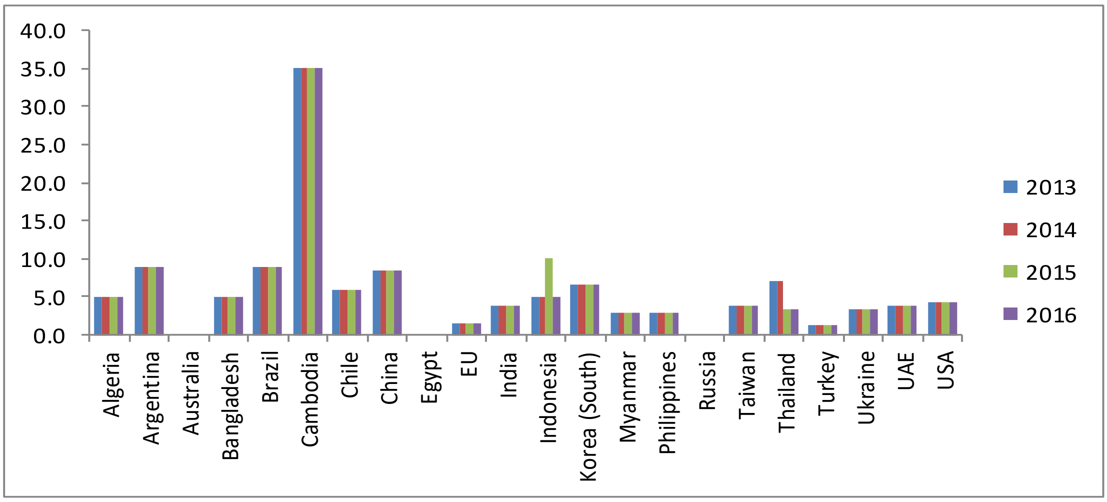
Source: Tariff Download Facility, WTO.

Figure 5. Applied MFN Tariff Rates for Selected Countries, HS850490 (%)



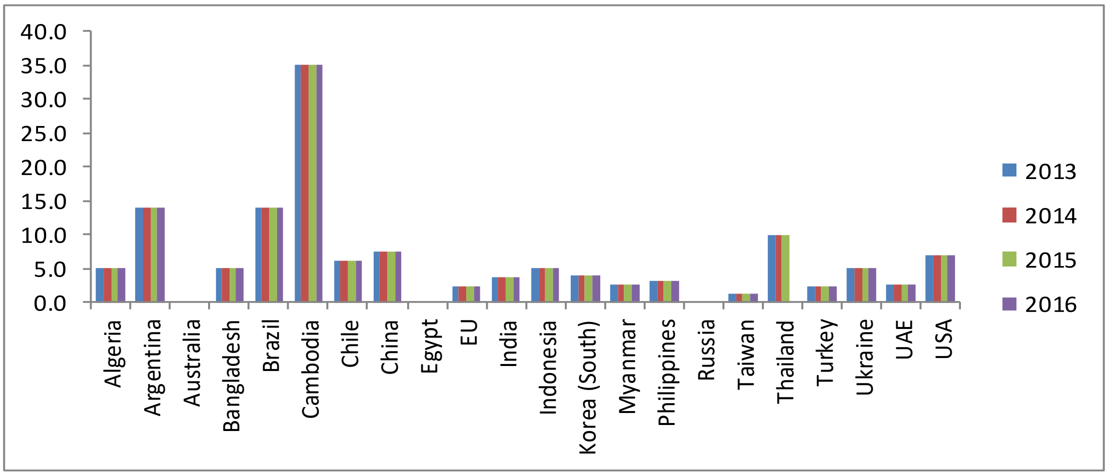
Source: Tariff Download Facility, WTO.

Figure 6. Applied MFN Tariff Rates for Selected Countries, HS901380 (%)



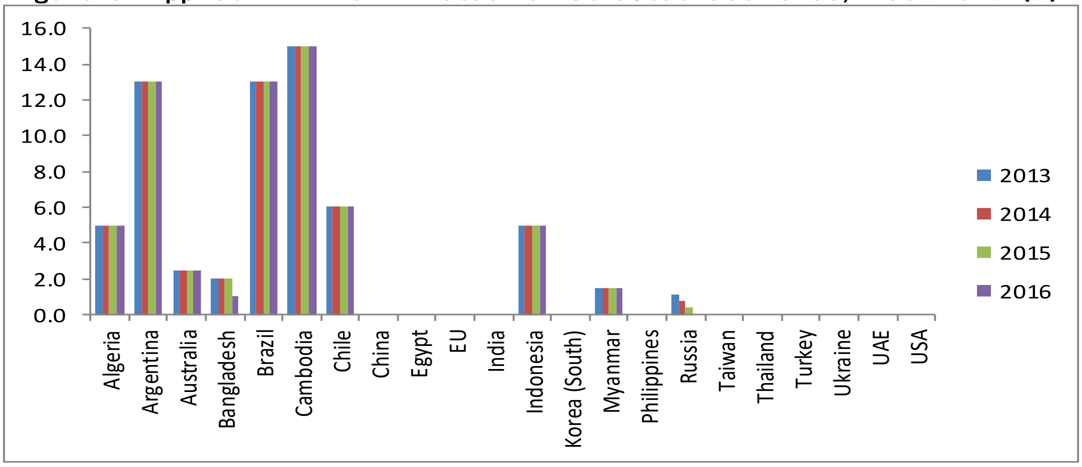
Source: Tariff Download Facility, WTO.

Figure 7. Applied MFN Tariff Rates for Selected Countries, HS901390 (%)



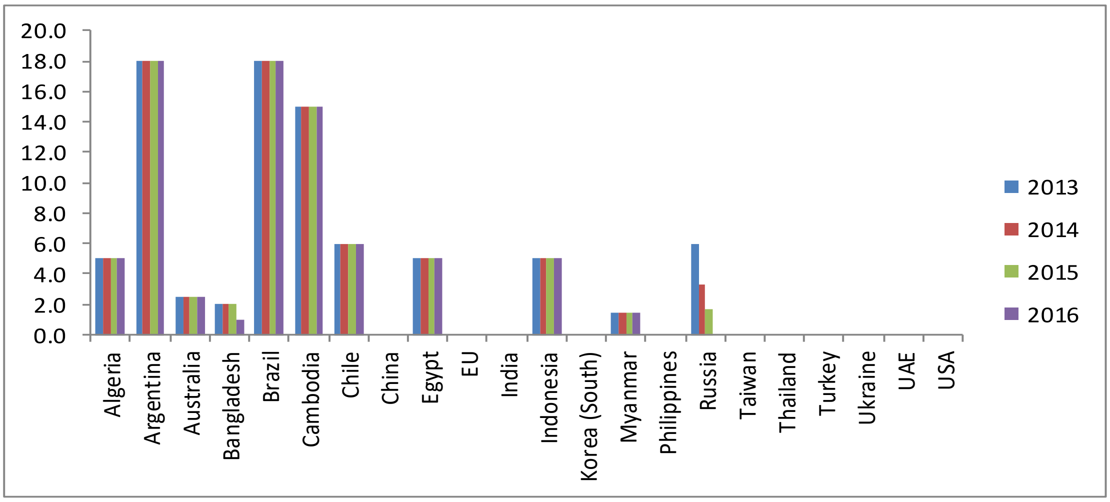
Source: Tariff Download Facility, WTO.

Figure 8. Applied MFN Tariff Rates for Selected Countries, HS902610 (%)



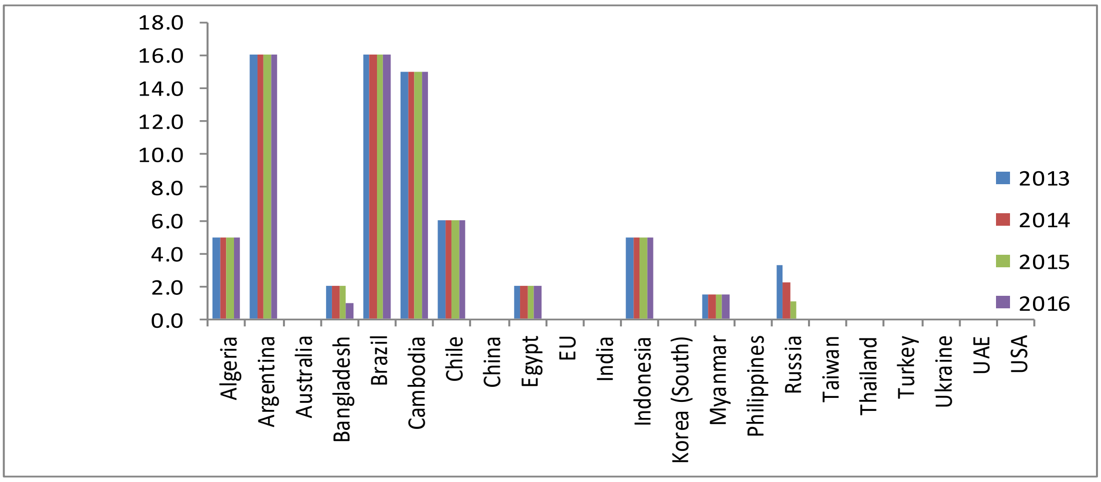
Source: Tariff Download Facility, WTO.

Figure 9. Applied MFN Tariff Rates for Selected Countries, HS902620 (%)



Source: Tariff Download Facility, WTO.

Figure 10. Applied MFN Tariff Rates for Selected Countries, HS902690(%)



Source: Tariff Download Facility, WTO.

4. Estimation Results

This section presents the results of the estimation of gravity equation (8). Importer and exporter fixed effects are included in all the regressions for the three estimation methods, Pooling OLS, Random effect model, and PPML.

4-1 Effects of Bilateral Tariff Rates and Trade Integration Agreements

Table 2 shows the estimation results of Pooling OLS, Random effect model, and PPML, for each of the environmental goods belonging to HS84 and HS85, and Table 3 shows those for each of the environmental goods belonging to HS90.

Focusing on the effects of the bilateral tariff rates with the effects of RTAs, the results for each environmental good show differences, which suggest the existence of good-specific characteristics. For HS850300 (parts and components for electricity generation from renewable sources), the coefficients of bilateral tariff rates are significant at the 1% level in all the three estimation methods ranging between -0.308 and -0.413. For the good HS902620 (manometers for monitoring environmental conditions), the coefficients are significant at the 1 % level in Pooling OLS and PPML and significant at the 5% level in Random effect model ranging between -0.175 and -0.242. For the good HS902610 (instruments for monitoring the air quality and other environmental conditions), those coefficients are significant at the 1% level in Pooling OLS and Random Effect Model and significant at the 10% level in PPML ranging between -0.117 and -0.434.

For HS850490 (parts for electrical transformers, static converters and inductors for renewable energy production), those coefficients are significant at 1% level in Pooling OLS at -0.308 and PPML at -0.254, and for HS902690 (parts and components for monitoring environmental conditions) the coefficients are significant at the 1% level in Pooling OLS at -0.283 and significant at the 5% level in Random effect model at -0.259. For HS841290 (wind turbines and hubs), the coefficients of bilateral tariff rates are significant at the 1% level in PPML at -0.378.

For three goods with significant coefficients in all the three estimation models, the elasticity of bilateral tariff rate for imports ranges between 0.117 and 0.434 which is on a similar scale as the results in Disdier et al.(2015) for the exports of emerging countries. Furthermore, even for the six goods shown above, the elasticities are stable between 0.117 and 0.434. The effects of bilateral tariff rates together with the tariff liberalization by RTAs are shown to be robustly important in such an item as HS850300 which includes many kinds of parts and components of the machines used for renewable energy production. This is also true for such items as HS902620 and HS902610 which include instruments for monitoring air quality or pressure for environment protection purposes.

Table 2. Estimation Results for the EGs of HS84 and HS85

	ln(*Xij*)		*Xij*	ln(*Xij*)		*Xij*	ln(*Xij*)		*Xij*
	Pooling OLS	RE model	PPML	Pooling OLS	RE model	PPML	Pooling OLS	RE model	PPML
	HS841290 Integral components to wind turbines			HS850231 Wind-powered electric generating sets			HS850239 Electric generating sets, rotary convertors		
Constant	30.135 ***	30.131 ***	20.505 ***	8.809 ***	8.821 ***	23.126 ***	20.465 ***	20.319 ***	19.608 ***
	(0.665)	(1.132)	(0.588)	(0.649)	(0.991)	(2.166)	(0.781)	(1.210)	(1.167)
ln(*Tariffij* + 1)	−0.006	0.038	−0.177 **	−0.039	−0.093	0.149	−0.386 ***	−0.148	0.035
	(0.064)	(0.098)	(0.075)	(0.068)	(0.090)	(0.260)	(0.081)	(0.112)	(0.115)
ln(*DISTij*)	−1.975 ***	−1.981 ***	−0.663 ***	−0.644 ***	−0.639 ***	−1.092 ***	−1.541 ***	−1.561 ***	−0.936 ***
	(0.053)	(0.093)	(0.045)	(0.053)	(0.082)	(0.192)	(0.063)	(0.100)	(0.089)
DCLij	1.033 ***	1.035 ***	0.062	0.498 ***	0.499 ***	0.405	0.900 ***	0.914 ***	−0.478 **
	(0.121)	(0.206)	(0.091)	(0.122)	(0.184)	(0.304)	(0.156)	(0.242)	(0.233)
DAPECij	0.490 ***	0.493 **	0.677 ***	−0.020	−0.029	−0.771	0.512 ***	0.583 **	0.047
	(0.151)	(0.250)	(0.139)	(0.126)	(0.185)	(0.603)	(0.179)	(0.274)	(0.355)
DEUij	0.671 ***	0.684 ***	0.617 ***	0.219 *	0.181	1.340 *	−0.746 ***	−0.649 ***	−0.807 **
	(0.133)	(0.220)	(0.156)	(0.126)	(0.192)	(0.752)	(0.148)	(0.222)	(0.393)
Adjusted R^2	0.683	0.683		0.387	0.387		0.397	0.396	
Observations	15,552	15,552	15,552	15,552	15,552	15,552	15,552	15,552	15,552
Exporter Fixed Effects	yes	yes	yes	yes	yes	yes	yes	yes	yes
Importer Fixed Effects	yes	yes	yes	yes	yes	yes	yes	yes	yes

	ln(*Xij*)		*Xij*	ln(*Xij*)		*Xij*
	Pooling OLS	RE model	PPML	Pooling OLS	RE model	PPML
	HS850300 Parts of machines under heading 8502			HS850490 Parts for transformers, converters and inductors		
Constant	33.141 ***	33.106 ***	19.713 ***	28.931 ***	28.813 ***	18.990 ***
	(0.718)	(1.216)	(0.547)	(0.686)	(1.197)	(0.540)
ln(*Tariffij* + 1)	−0.400 ***	−0.308 ***	−0.413 ***	−0.308 ***	−0.050	−0.254 ***
	(0.068)	(0.102)	(0.053)	(0.080)	(0.111)	(0.069)
ln(*DISTij*)	−2.380 ***	−2.394 ***	−0.793 ***	−2.007 ***	−2.030 ***	−0.848 ***
	(0.059)	(0.101)	(0.040)	(0.056)	(0.100)	(0.038)
DCLij	1.102 ***	1.100 ***	0.392 ***	0.709 ***	0.723 ***	0.494 ***
	(0.137)	(0.228)	(0.086)	(0.128)	(0.218)	(0.107)
DAPECij	0.250	0.308	0.546 ***	1.261 ***	1.330 ***	0.967 ***
	(0.171)	(0.276)	(0.127)	(0.152)	(0.255)	(0.120)
DEUij	−0.184	−0.159	−0.167	−0.439 ***	−0.375 *	−0.750 ***
	(0.147)	(0.242)	(0.133)	(0.136)	(0.225)	(0.117)
Adjusted R^2	0.665	0.665		0.681	0.681	
Observations	15,552	15,552	15,552	15,552	15,552	15,552
Exporter Fixed Effects	yes	yes	yes	yes	yes	yes
Importer Fixed Effects	yes	yes	yes	yes	yes	yes

Note: *Xij* is bilateral exports from country I to partner j plus1.

Standard errors are shown in parentheses.

*** shows significant at 1% level, ** at 5% level, and * at 10% level.

Table 3. Estimation Results for the EGs of HS90

	ln(*Xij*)		*Xij*	ln(*Xij*)		*Xij*	ln(*Xij*)		*Xij*
	Pooling OLS	RE model	PPML	Pooling OLS	RE model	PPML	Pooling OLS	RE model	PPML
	HS901380 Heliostats orient mirrors in concentrated solar power			HS901390 Parts of HS901380			HS902610 Instruments for measuring or checking the flow, level, pressure or other variables of liquids or gases.		
Constant	19.511 ***	19.564 ***	18.456 ***	17.977 ***	18.091 ***	15.439 ***	30.335 ***	30.306 ***	17.690 ***
	(0.695)	(1.168)	(1.037)	(0.670)	(1.109)	(1.280)	(0.662)	(1.122)	(0.644)
ln(*Tariffij* + 1)	-0.011	0.025	0.261 ***	-0.287 ***	-0.196 **	-0.233	-0.434 ***	-0.312 ***	-0.117 *
	(0.073)	(0.102)	(0.090)	(0.079)	(0.083)	(0.160)	(0.090)	(0.120)	(0.066)
ln(*DISTij*)	-1.467 ***	-1.473 ***	-0.967 ***	-1.183 ***	-1.196 ***	-0.699 ***	-1.923 ***	-1.933 ***	-0.554 ***
	(0.055)	(0.094)	(0.076)	(0.053)	(0.089)	(0.095)	(0.053)	(0.092)	(0.050)
DCLij	1.240 ***	1.240 ***	1.255 ***	1.031 ***	1.028 ***	1.274 ***	1.353 ***	1.353 ***	0.510 ***
	(0.124)	(0.203)	(0.170)	(0.121)	(0.202)	(0.246)	(0.125)	(0.210)	(0.067)
DAPECij	1.108 ***	1.115 ***	-0.399	1.649 ***	1.663 ***	0.352	0.056	0.056	0.535 ***
	(0.159)	(0.255)	(0.275)	(0.159)	(0.266)	(0.305)	(0.146)	(0.235)	(0.128)
DEUij	0.390 ***	0.397 *	-0.417	-0.387 ***	-0.359 *	-0.832 ***	0.430 ***	0.416 *	0.291 **
	(0.136)	(0.220)	(0.274)	(0.132)	(0.214)	(0.282)	(0.131)	(0.212)	(0.113)
Adjusted R^2	0.657	0.657	0.965	0.629	0.629		0.679	0.679	
Observations	15,552	15,552	15,552	15,552	15,552	15,552	15,552	15,552	15,552
Exporter Fixed Effects	yes	yes	yes	yes	yes	yes	yes	yes	yes
Importer Fixed Effects	yes	yes	yes	yes	yes	yes	yes	yes	yes

	ln(*Xij*)		*Xij*	ln(*Xij*)		*Xij*
	Pooling OLS	RE model	PPML	Pooling OLS	RE model	PPML
	HS902620 Manometers for monitoring indoor air etc. with many environmental applications			HS902690 Parts for articles of subheading 9026.		
Constant	26.153 ***	26.137 ***	15.171 ***	25.919 ***	25.937 ***	17.633 ***
	(0.612)	(1.025)	(0.450)	(0.631)	(1.036)	(0.397)
ln(*Tariffij* + 1)	-0.242 ***	-0.175 **	-0.193 ***	-0.283 ***	-0.259 **	-0.020
	(0.075)	(0.082)	(0.059)	(0.085)	(0.109)	(0.077)
ln(*DISTij*)	-1.739 ***	-1.744 ***	-0.477 ***	-1.719 ***	-1.721 ***	-0.664 ***
	(0.048)	(0.083)	(0.038)	(0.050)	(0.085)	(0.031)
DCLij	1.363 ***	1.364 ***	0.491 ***	1.209 ***	1.209 ***	0.192 ***
	(0.112)	(0.189)	(0.072)	(0.117)	(0.192)	(0.066)
DAPECij	0.452 ***	0.451 **	0.607 ***	0.554 ***	0.553 **	0.530 ***
	(0.138)	(0.225)	(0.099)	(0.142)	(0.225)	(0.097)
DEUij	0.708 ***	0.700 ***	0.390 ***	0.107	0.104	0.147
	(0.120)	(0.197)	(0.092)	(0.123)	(0.196)	(0.099)
Adjusted R^2	0.719	0.719	0.879	0.702	0.702	
Observations	15,552	15,552	15,552	15,552	15,552	15,552
Exporter Fixed Effects	yes	yes	yes	yes	yes	yes
Importer Fixed Effects	yes	yes	yes	yes	yes	yes

Note: *Xij* is bilateral exports from country I to partner j plus1.
Standard errors are shown in parentheses.
*** shows significant at 1% level, ** at 5% level, and * at 10% level.

4-2 Effects of distance and common language

The effects of other proxies for trade costs, such as distance and dummy variable for common language are examined. As shown in Table 2 and Table 3, distance has a negative and significant effect on trade flows of all the ten goods in all the three estimation methods. The coefficients are significant at the 1% level, ranging between -0.644 for HS850231 (wind-powered electric generating sets and equipment) and -2.380

for HS850300 (parts for electricity generation from renewable resources) in the Pooling OLS, between -0.639 for HS850231 and -2.394 for HS850300 in Random effect model, and between -0.477 for HS902620 (Manometers for monitoring environmental conditions) and -1.092 for HS850231 in PPML. Despite the coefficients varying among the goods and estimation methods, the clear impact of distance between two countries is robustly clarified by these results.

The effects of a common official language between two countries on trade flows are examined by the dummy variable, shown as DCL in Table 2 and Table 3. The coefficients of DCL are positive and significant at the 1% level, for seven goods out of ten, HS850300 (parts and components for electricity generation from renewable sources), HS850490 (parts for electrical transformers, static converters and inductors for renewable energy production), HS901380 (heliostats orient mirrors), HS901390 Parts and components of heliostats orient mirrors), HS902610 (instruments for monitoring environmental conditions), HS902620 (manometers for monitoring environmental conditions), HS902690 (parts and components for monitoring environmental conditions). The coefficients range between 0.709 for HS850490 and 1.363 for HS902620 in the Pooling OLS, between 0.723 for HS850490 and 1.364 for HS902620 for Random effect model, and 0.192 for HS902690 and 0.494 for HS850490 in PPML. For HS841290 (wind turbines and hubs) and HS850231 (wind-powered electric generating sets and equipment)), the coefficients in the Pooling OLS and Random effect model are positive and significant at the 1% level, but this effect is not significant in the PPML method. As the largest effect, common official language makes countries' bilateral trade in HS902620 exp(1.364)-1=291% larger in Random effect model, and as the smallest effect, common official language makes countries' bilateral trade 21% larger for HS902690 in PPML, everything else being equal.

If those effects in PPML for distance and common language for EGs are compared with those in Disdier et al. (2009) for cultural goods, the effects of distance between -0.23 and -1.04 for cultural goods are slightly smaller than the case of EGs, and the effects of common language between 0.65 and 1.68 for cultural goods are much larger than the case of EGs between 0.19 and 0.51. Accordingly, the common language has larger impact on the trade in the cultural goods in which language is influential and proximity has larger impact on the trade in the EGs in which proximity is influential with smaller transport cost.

4-3 Regional Effects

As for the EU dummy variable, the coefficients for only two goods, HS841290 (wind turbines and hubs) and HS902620 (manometer for monitoring the environmental conditions) are positive and significant at the 1% level in all the three estimation methods. In the case of HS841290 the coefficients are stable among the estimation methods, ranging between 0.617 and 0.684, which signifies that EU membership makes countries' bilateral trade 85.3% ~ 98.2 % larger. Those coefficients vary between 0.390 and 0.708 for HS902620, which signifies that EU membership makes countries' bilateral trade 47.7% ~103.0% larger. For the other 8 goods, the EU dummy coefficients are not significant.

On the other hand, the dummy variable for APEC is positive and significant (always significant at the 1% level, except for HS902690 in Random effect model: significant at the 5% level) in all the three methods for four goods out of ten, HS841290 (wind turbines and hubs), HS850490 (Parts for electrical transformers, static converters and inductors for renewable energy production), HS902620 (manometers for monitoring environmental conditions), and HS902690 (parts and components for monitoring environmental conditions). The coefficients vary between 0.490 for HS841290 and 1.330 for HS850490, which signifies that APEC membership makes countries' bilateral trade 63.2% ~ 278.1% larger.

For HS850239 (electric generating sets and rotary converters for renewable energy production), HS901380 (heliostats orient mirrors), and HS901390 (parts and components for heliostats orient mirrors), the coefficients of APEC dummy are positive and significant in the Pooling OLS and Random effect model, but the effect is denied in PPML, while for the case of HS850300 (parts for electricity generation from renewable resources), the APEC dummy is positive and significant only in PPML.

For the case of HS902620, the coefficients of both bilateral tariff rates and regional dummies of APEC and EU are significant with right sign at the 1% or 5% level, so that as in Hayakawa (2013), it is clarified that dummy variable of RTA is not a statistical substitute for tariff rates. This suggests that the membership in EU and APEC foster trade flows not only through the tariff reduction but also through regional elements.

For examining the effect of trade networks among the countries of South-East and East Asia, equation (9) is estimated in the same methods as equation (8). The results are shown in Table 4 for the goods belonging to HS84 and HS85 and in Table 5 for the goods belonging to HS90. In all the regressions, as the coefficients of EU dummy are not stable, it is not included, and the analysis focuses on the effect of the trade network only in South-East and East Asia.

The estimated coefficients of dummy variable of South-East and East Asia are positive and significant at the 1% level in all the three estimation methods for three goods, HS850490 (parts for electrical transformers, static converters and inductors for renewable energy production), HS901380 (heliostats orient mirrors), HS901390 (parts and components for heliostats orient mirrors), except the coefficient in PPML of HS901390 which is significant at the 5% level. The magnitude of the coefficients in Pooling OLS, Random effect model and PPML are 2.158, 2.182, and 0.517 respectively for HS850490, 1.822, 1.837, and 1.568 respectively for HS901380, and 3.519, 3.531, and 1.066 respectively for HS901390. Accordingly, considerably large effects are clarified for the trade network among countries in South-East Asia and East Asia in these goods. For example, this kind of trade network raises bilateral trade by a factor of exp(1.066)=2.9 to exp(3.531)=34.2 for HS901390, exp(1.568)=4.8 to exp(1.837)=6.3 for HS901380, and exp(0.517)=1.7 to exp(2.182)=8.9, everything else being equal.

For HS841290 (wind turbines and hubs), HS850239 (electric generating sets and rotary convertors for renewable energy production), HS850300 (parts for electricity generation from renewable resources), HS902610 (instruments for monitoring air quality etc.), HS902620 (manometers for monitoring environmental conditions), and HS902690 (parts and components for monitoring environmental conditions), these coefficients are positive and significant at the 1% level in both Pooling OLS and Random effect model, but it is not positive and significant in PPML.

Table 4. Estimation Results including DAS3, for the Environemental Goods of HS84 and HS85

	ln(*Xij*)		*Xij*	ln(*Xij*)		*Xij*			
	Pooling OLS	RE model	PPML	Pooling OLS	RE model	PPML			
	HS841290			HS850231			HS850239		
	Integral components to wind turbines			Wind-powered electric generating sets			Electric generating sets, rotary convertors		
Constant	30.702 ***	30.728 ***	23.071 ***	9.121 ***	9.085 ***	24.186 ***	17.172 ***	17.268 ***	18.768 ***
	(0.595)	(1.021)	(0.501)	(0.617)	(0.940)	(1.677)	(0.729)	(1.133)	(1.124)
ln(Tariff + 1)	-0.061	-0.008	-0.378 ***	-0.084	-0.114	-0.063	-0.303 ***	-0.103	0.075
	(0.064)	(0.096)	(0.082)	(0.065)	(0.086)	(0.244)	(0.078)	(0.108)	(0.112)
ln(DIST)	-2.006 ***	-2.016 ***	-0.851 ***	-0.673 ***	-0.666 ***	-1.238 ***	-1.190 ***	-1.226 ***	-0.844 ***
	(0.050)	(0.087)	(0.040)	(0.053)	(0.081)	(0.168)	(0.060)	(0.093)	(0.104)
DCL	1.013 ***	1.015 ***	0.061	0.491 ***	0.492 ***	0.291	0.960 ***	0.968 ***	-0.509 **
	(0.121)	(0.206)	(0.092)	(0.122)	(0.184)	(0.324)	(0.155)	(0.241)	(0.231)
DAS3	1.344 ***	1.346 ***	-0.250	-0.046	-0.048	-1.706 **	2.853 ***	2.885 ***	0.355
	(0.205)	(0.339)	(0.155)	(0.202)	(0.300)	(0.711)	(0.288)	(0.454)	(0.437)
Adjusted R^2	0.683	0.683	0.833	0.387	0.387	0.851	0.401	0.401	0.646
Observations	15,552	15,552	15,552	15,552	15,552	15,552	15,552	15,552	15,552
Exporter Fixed Effects	yes	yes	yes	yes	yes	yes	yes	yes	yes
Importer Fixed Effects	yes	yes	yes	yes	yes	yes	yes	yes	yes

	ln(*Xij*)		*Xij*	ln(*Xij*)		*Xij*
	Pooling OLS	RE model	PPML	Pooling OLS	RE model	PPML
	HS850300			HS850490		
	Parts of machines under heading 8502			Parts for transformers, converters and inductors		
	Pooling OLS	RE model	PPML	Pooling OLS	RE model	PPML
Constant	31.197 ***	31.277 ***	20.694 ***	28.328 ***	28.435 ***	19.615 ***
	(0.650)	(1.097)	(0.513)	(0.614)	(1.069)	(0.511)
ln(Tariff + 1)	-0.371 ***	-0.292 ***	-0.460 ***	-0.351 ***	-0.080	-0.228 ***
	(0.065)	(0.097)	(0.047)	(0.078)	(0.109)	(0.067)
ln(DIST)	-2.177 ***	-2.198 ***	-0.835 ***	-1.867 ***	-1.910 ***	-0.800 ***
	(0.056)	(0.096)	(0.042)	(0.052)	(0.091)	(0.043)
DCL	1.129 ***	1.125 ***	0.393 ***	0.730 ***	0.741 ***	0.514 ***
	(0.137)	(0.228)	(0.082)	(0.127)	(0.217)	(0.103)
DAS3	1.977 ***	1.999 ***	0.011	2.158 ***	2.182 ***	0.517 ***
	(0.220)	(0.373)	(0.131)	(0.201)	(0.358)	(0.181)
Adjusted R^2	0.667	0.667	0.831	0.682	0.681	0.884
Observations	15,552	15,552	15,552	15,552	15,552	15,552
Exporter Fixed Effects	yes	yes	yes	yes	yes	yes
Importer Fixed Effects	yes	yes	yes	yes	yes	yes

Note: *Xij* is log bilateral exports from country I to partner j plus1.

Standard errors are shown in parentheses.

*** shows significant at 1% level, ** at 5% level, and * at 10% level.

Table 5. Estimation Results including DAS3, for the Environemental Goods of HS90

	ln(*Xij*)		*Xij*	ln(*Xij*)		*Xij*	ln(*Xij*)		*Xij*
	Pooling OLS	RE model	PPML	Pooling OLS	RE model	PPML	Pooling OLS	RE model	PPML
	HS901380			HS901390			HS902610		
	Heliostats orient mirrors in concentrated solar power			Parts of HS901380			Instruments for measuring or checking the flow, level, pressure or other variables of liquids or gases.		
Constant	20.380 ***	20.434 ***	15.830 ***	17.028 ***	17.068 ***	13.657 ***	29.586 ***	29.526 ***	19.727 ***
	(0.645)	(1.089)	(0.891)	(0.616)	(1.019)	(0.997)	(0.580)	(0.971)	(0.384)
ln(Tariff + 1)	0.002	0.034	0.275 ***	−0.156 **	−0.130	−0.194	−0.359 ***	−0.267 **	−0.121 *
	(0.074)	(0.104)	(0.082)	(0.077)	(0.082)	(0.153)	(0.090)	(0.118)	(0.064)
ln(DIST)	−1.496 ***	−1.502 ***	−0.685 ***	−0.996 ***	−1.001 ***	−0.440 ***	−1.860 ***	−1.863 ***	−0.708 ***
	(0.051)	(0.087)	(0.084)	(0.048)	(0.081)	(0.093)	(0.047)	(0.081)	(0.033)
DCL	1.228 ***	1.228 ***	1.182 ***	1.056 ***	1.055 ***	1.135 ***	1.353 ***	1.354 ***	0.481 ***
	(0.124)	(0.202)	(0.162)	(0.119)	(0.198)	(0.260)	(0.124)	(0.210)	(0.062)
DAS3	1.822 ***	1.837 ***	1.568 ***	3.519 ***	3.531 ***	1.066 **	1.390 ***	1.409 ***	−0.236 *
	(0.241)	(0.396)	(0.337)	(0.248)	(0.431)	(0.427)	(0.203)	(0.339)	(0.133)
Adjusted R^2	0.657	0.657	0.965	0.633	0.633	0.906	0.679	0.679	0.849
Observations	15,552	15,552	15,552	15,552	15,552	15,552	15,552	15,552	15,552
Exporter Fixed Effects	yes	yes	yes	yes	yes	yes	yes	yes	yes
Importer Fixed Effects	yes	yes	yes	yes	yes	yes	yes	yes	yes

	ln(*Xij*)		*Xij*	ln(*Xij*)		*Xij*
	Pooling OLS	RE model	PPML	Pooling OLS	RE model	PPML
	HS902620			HS902690		
	Manometers for monitoring indoor air etc. with many environmental applications			Parts for articles of subheading 9026.		
Constant	27.321 ***	27.297 ***	17.830 ***	25.935 ***	25.935 ***	19.577 ***
	(0.550)	(0.924)	(0.478)	(0.561)	(0.932)	(0.374)
ln(Tariff + 1)	−0.177 **	−0.143 *	−0.166 ***	−0.214 **	−0.215 **	0.009
	(0.075)	(0.082)	(0.056)	(0.084)	(0.109)	(0.075)
ln(DIST)	−1.844 ***	−1.845 ***	−0.685 ***	−1.692 ***	−1.692 ***	−0.814 ***
	(0.044)	(0.076)	(0.045)	(0.045)	(0.077)	(0.033)
DCL	1.338 ***	1.339 ***	0.455 ***	1.210 ***	1.210 ***	0.198 ***
	(0.112)	(0.191)	(0.064)	(0.117)	(0.192)	(0.065)
DAS3	0.783 ***	0.790 **	−0.356 **	1.179 ***	1.179 ***	−0.326 ***
	(0.201)	(0.341)	(0.169)	(0.204)	(0.335)	(0.107)
Adjusted R^2	0.718	0.718	0.874	0.703	0.703	0.868
Observations	15,552	15,552	15,552	15,552	15,552	15,552
Exporter Fixed Effects	yes	yes	yes	yes	yes	yes
Importer Fixed Effects	yes	yes	yes	yes	yes	yes

Note: *Xij* is log bilateral exports from country I to partner j plus1.
Standard errors are shown in parentheses.
*** shows significant at 1% level, ** at 5% level, and * at 10% level.

5. Conclusion

This paper investigates the major determinants of trade of ten disaggregated EGs selected from the APEC list with each purpose for environmental protection. The analysis is based on the fixed effect approach of gravity model including importer and exporter dummy variables and the effects of bilateral tariff rates are focused together with the effects of RTAs. The trade data cover a wide range of exporting and importing countries, and the estimations are conducted according to the three estimation methods: Pooing OLS, Random effect model and PPML.

Firstly, through examination of the estimation results for the effects of bilateral tariff rates, the good-specific characteristics are clarified. For three out of ten EGs, the coefficients are negative and significant in all three methods, with the relatively modest elasticities of tariff rates ranging between 0.117 and 0.434. Secondly, while all of ten EGs examined in this study are impacted by distance with relatively large effect, seven goods out of ten are impacted by common language with smaller coefficients. Despite the coefficients varying among the goods and estimation methods, the clear impact of distance between two countries is clarified by these results. This shows that trade of all the EGs examined in this paper is quite active among the countries closer to each other with cheaper transport costs. Thirdly, although the effect of joining in the trade network of South-East and East Asia is clarified only for three goods, the coefficients of these three EGs are much larger than the cases of EU and APEC. Accordingly, a concrete trade network must be constructed in some of the EGs among the South-East and East Asian countries.

The characteristics of determinants of each EG are clarified by this analysis. For the case of HS902620, manometer for monitoring environmental conditions, as the coefficients of both bilateral tariff rates and regional dummies of APEC and EU are significant with right sign at the 1% or 5% level, it is clarified that dummy variable of RTA is not a statistical substitute for tariff rates. For HS850300,the important parts and components for the necessary machines for electric generation from renewable resources, while the coefficients of tariff rates are significant at the 1% level and stable among the three estimation methods ranging between -0.308 and -0.413, the regional effects cannot be seen. For HS850490 which includes the important parts and components of electrical transformers, converters and inductors, while the effect of APEC membership is very large and stable among the three estimation methods, the effect of tariff rate is not clarified in Random effect model.

According to the detailed investigation for the effects of each EG, trade expansion through tariff reduction together with the regional effects are clarified for some of the EGs examined in this study. For this reason it is worth the effort to continue reducing tariff rates on more EGs among APEC and WTO members joined in the plurilateral trade negotiations to expand trade in EGs for beneficial effects of environmental protection.

Table A1. Countries Included in this Study

Exporting and Importing Countries			Importing Countries
APEC	EU	Others	
Australia	Austria	Brazil	Algeria
Canada	Belgium	India	Argentina
Chile	Bulgaria	Israel	Bangladesh
China	Croatia	Norway	Belarus
Hong Kong	Cypress	South Africa	Cambodia
Indonesia	Czech Republic	Switzerland	Colombia
Japan	Denmark	Turkey	Costa Rica
Korea	Estonia		Egypt
Malaysia	Finland		Ghana
Mexico	France		Kazakhstan
New Zealand	Germany		Kenia
Papua New Guinea *	Greece		Myanmar
Peru	Hungary		Nigeria
Philippines	Ireland		Paraguay
Russia	Italy		Saudi Arabia
Singapore	Latvia		Ukraine
Taiwan	Lithuania		United Arab Emirates
Thailand	Luxembourg		Uruguay
United States	Malta		
Vetnam	Netherland		
	Slovakia		
	Slovenia		
	Spain		
	Sweden		
	United Kingdom		

*Papua New Guinea is inculded in the study only as importing country,
though it is listed in the group of APEC not in the group of importing countries.

TableA2. Descriptive Statistics for HS841290

	EX	TAR	DIS	ln EX	ln TAR	ln DIS	DCL	DAPEC	DEU	DAS3
Obs.	15,552	15,552	15,552	15,552	15,552	15,552	15,552	15,552	15,552	15,552
Mean	1,561,627	1.979	6,987	6.692	0.678	8.471	0	0	0	0
Std. Dev.	12,400,000	3.221	5,201	5.983	0.850	1.013	0	0	0	0
Min	0	0	60	0	0	4	0	0	0	0
Max	780,000,000	15.000	120,560	20.474	2.773	11.700	1	1	1	1

Table A3. Descripstatistics for HS850231

	EX	TAR	DIS	ln EX	ln TAR	ln DIS	DCL	DAPEC	DEU	DAS3
Obs.	15,552	15,552	15,552	15,552	15,552	15,552	15,552	15,552	15,552	15,552
Mean	1,807,471	1.625	6,987	1.389	0.582	8.471	0	0	0	0
Std. Dev.	30,200,000	2.695	5,201	3.976	0.810	1.013	0	0	0	0
Min	0	0	59.617	0	0	4.088	0	0	0	0
Max	2,210,000,000	14.000	120,560	21.516	2.708	11.700	1	1	1	1

TableA4. Descriptive Statistics for HS850239

	EX	TAR	DIS	ln EX	ln TAR	ln DIS	DCL	DAPEC	DEU	DAS3
Obs.	15,552	15,552	15,552	15,552	15,552	15,552	15,552	15,552	15,552	15,552
Mean	743,543	1.293	6,987	2.657	0.473	8.471	0	0	0	0
Std. Dev.	8,278,161	2.431	5,201	4.968	0.755	1.013	0	0	0	0
Min	0	0	59.617	0	0	4.088	0	0	0	0
Max	432,000,000	14.000	120,560	19.884	2.708	11.700	1	1	1	1

Table A5. Descriptive Statistics for HS850300

	EX	TAR	DIS	ln EX	ln TAR	ln DIS	DCL	DAPEC	DEU	DAS3
Obs.	15,552	15,552	15,552	15,552	15,552	15,552	15,552	15,552	15,552	15,552
Mean	4,069,086	2.171	6,987	7.673	0.692	8.471	0	0	0	0
	24,500,000	3.574	5,201	6.410	0.897	1.013	0	0	0	0
Min	0	0	59.617	0	0	4.088	0	0	0	0
Max	834,000,000	15.000	120,560	20.542	2.773	11.700	1	1	1	1

Table A6. Descriptive Statistics for HS850490

	EX	TAR	DIS	ln EX	ln TAR	ln DIS	DCL	DAPEC	DEU	DAS3
Obs.	15,552	15,552	15,552	15,552	15,552	15,552	15,552	15,552	15,552	15,552
Mean	2,737,374	2.064	6,987	7.899	0.594	8.471	0	0	0	0
Std. Dev.	31,900,000	4.231	5,201	6.044	0.889	1.013	0	0	0	0
Min	0	0	59.617	0	0	4.088	0	0	0	0
Max	1,860,000,000	20.714	120,560	21.346	3.078	11.700	1	1	1	1

Table A7. Descriptive Statistics for HS901380

	EX	TAR	DIS	ln EX	ln TAR	ln DIS	DCL	DAPEC	DEU	DAS3
Obs.	15,552	15,552	15,552	15,552	15,552	15,552	15,552	15,552	15,552	15,552
Mean	16,200,000	2.007	6,987	5.330	0.596	8.471	0	0	0	0
Std. Dev.	298,000,000	4.512	5,201	5.968	0.874	1.013	0	0	0	0
Min	0	0	59.617	0	0	4.088	0	0	0	0
Max	16,000,000,000	35.000	120,560	23.494	3.584	11.700	1	1	1	1

Table A8. Desctiptive Statistics for HS901390

	EX	TAR	DIS	ln EX	ln TAR	ln DIS	DCL	DAPEC	DEU	DAS3
Obs.	15,552	15,552	15,552	15,552	15,552	15,552	15,552	15,552	15,552	15,552
Mean	2,793,435	1.829	6,987	4.228	0.532	8.471	0	0	0	0
Std. Dev.	63,400,000	4.606	5,201	5.592	0.843	1.013	0	0	0	0
Min	0	0	59.617	0	0	4.088	0	0	0	0
Max	5,690,000,000	35.000	120,560	22.461	3.584	11.700	1	1	1	1

Table A9. Descriptive Statistics for HS902610

	EX	TAR	DIS	ln EX	ln TAR	ln DIS	DCL	DAPEC	DEU	DAS3
Obs.	15,552	15,552	15,552	15,552	15,552	15,552	15,552	15,552	15,552	15,552
Mean	1,224,328	1.251	6,987	7.536	0.343	8.471	0	0	0	0
Std. Dev.	6,486,765	3.286	5,201	5.855	0.770	1.013	0	0	0	0
Min	0	0	59.617	0	0	4.088	0	0	0	0
Max	216,000,000	15.000	120,560	19.193	2.773	11.700	1	1	1	1

Table A10. Descriptive Statistics for HS902620

	EX	TAR	DIS	ln EX	ln TAR	ln DIS	DCL	DAPEC	DEU	DAS3
Obs.	15,552	15,552	15,552	15,552	15,552	15,552	15,552	15,552	15,552	15,552
Mean	2,075,104	1.481	6,987	7.661	0.372	8.471	0	0	0	0
Std. Dev.	13,600,000	4.064	5,201	5.789	0.813	1.013	0	0	0	0
Min	0	0	59.617	0	0	4.088	0	0	0	0
Max	489,000,000	18.000	120,560	20.009	2.944	11.700	1	1	1	1

Table A11. Descriptive Statistics for HS902690

	EX	TAR	DIS	ln EX	ln TAR	ln DIS	DCL	DAPEC	DEU	DAS3
Obs.	15,552	15,552	15,552	15,552	15,552	15,552	15,552	15,552	15,552	15,552
Mean	1,014,818	1.393	6,987	6.902	0.316	8.471	0	0	0	0
Std. Dev.	6,323,640	4.063	5,201	5.781	0.800	1.013	0	0	0	0
Min	0	0	59.617	0	0	4.088	0	0	0	0
Max	192,000,000	16.000	120,560	19.075	2.833	11.700	1	1	1	1

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