Export of Environmental Goods: India's Potential and Constraints*

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Abstract

The increasing awareness of climate change and its impact on overall economic growth has encouraged many countries to pursue environmental friendly production and consumption of goods and services. Based on their comparative advantages, developing countries too are emerging as exporters of environmental goods and services (EGS) along with developed countries. An important question in this context is whether these emerging EGS exporting developing economies are able to realize their export potential fully. Using data between 1996 and 2010, this paper identifies the constraints that make India, which is one of the emerging EGS exporters, not able to realize its export potential of environmental goods (EG). The empirical results show that the growth of India's exports of EG was negatively affected by its 'behind the border' constraints, such as weak infrastructure and institutions, while the effect of 'explicit beyond the border' constraints, such as partner-countries' tariff and exchange rate on the exports of EG was relatively small. The reduction of India's trading partners' 'implicit beyond the border' constraints, such as weak infrastructure and institutions has made significant contribution to India's exports of EG, especially during the period 2005 – 2010.

Keywords: Environmental goods and services, stochastic frontier gravity model, 'behind the border' constraints, 'explicit beyond the border constraints', 'implicit beyond the border' constraints, Asia-Pacific countries.
JEL Classifications: Q56 and Q58.

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1. Introduction

The East Asian experience confirms that one of the important sources of economic growth is export promotion. While export promotion of goods, particularly manufacturing goods would contribute to economic growth positively, they do generally contribute negatively in terms of environmental degradation. Thus, there is a great concern expressed in the literature about striking a balance between exports and environment, which is more important for developing countries, though it is important for developed countries too (Garnaut, 2011). India, which is one of the fast growing emerging economies, has increased the levels of living of its people in terms of increasing the per capita GDP since its 1991 economic reform. Based on the World Bank (WB) data, although India's economic growth was 1 percent in 1991, it has increased gradually and reached a peak at 9.8 percent in 2007. Therefore, per capita gross domestic product (GDP) rose from USD 308 to approximately USD 1500 between 1991 and 2011. It also has attracted the attention of the world that India's growth trajectory would lead to various negative impacts on the environment. For example, India's remarkable economic growth has put pressure on energy demand and caused environmental problems such as air pollution, water pollution, garbage pollution and land quality degradation (Agarwal 2011). India's cumulative energy related CO2 emission is expected to reach 80 billion tons in 2030 (IEA, 2009). As a consequence, The Indian government has issued policy statements on forestry, abatement of pollution, national conservation strategy and environment and development to deal with those problems.

There have been many initiatives to solve energy security and to address carbon emissions. India's first National Action Plan on climate change was released in 2008 with the objective of reducing 5 percent of energy consumption by 2015 in comparison with a 'business as usual' (BAU) scenario. In addition, a target of installing 20 GW of solar power in 2020 has been set for the National Solar Mission. Indian government also committed to cut its carbon intensity up to 25 percent in the period from 2005 to 2020 (Gaba et al., 2011).

The increasing awareness of climate change not only in India but also in the world leads to the requirements of environmental protection which results in high demand for environmental goods

and services (EGS)[1]. During 2007 – 2008, the global market value of low carbon and EGS was £3,046 billion, in which Asia accounted for 38 per cent and India 6.3 per cent (BERR 2009). Also, the high demand for services concerning the equipment for filtration and purification of water and solid waste handling and disposal in Thailand, Malaysia, Philippines and Indonesia will provide great opportunities for countries like India to export EGS, because the environmental goods and services production has emerged as a distinct industry in India recently. For example, the share of EGS in total exports rose from 1.4 percent in 1996 to reach a peak of 2.28 percent in 2009 (Figure 1). However, despite the low effective tariffs on EGS, the "behind the border" constraints, such as weak infrastructure, institutions and non-tariffs barriers in many EGS exporting countries including India are very high. Consequently, trade and investment in EGS are low in comparison with those in pollution intensive products. It is in this context, the important questions are: Whether India has achieved fully its export potentials of environmental goods (EG)? If not, how can India improve its export potentials of EG? Given the importance of the Asia-Pacific countries for India's EG exports, the top 10 Asia-Pacific markets are considered for empirical analysis in this study. These countries include: Australia, Canada, China, Indonesia, Japan, Malaysia, Republic of Korea, Singapore, Thailand, Vietnam, and the United States.

The paper is structured as follows. The next section provides the concepts of EGS and overview of India's exports of EG. Section 3 describes the theoretical and empirical models, and data. Section 4 describes the empirical model and discusses the results of estimation along with the results of the decomposition of the changes in EG exports between 1996 and 2000 and between 2005 and 2010. The conclusions and policy implications are drawn in section 5.

2. Overview of EG and Indian Exports of EG

2.1. Issues with the Definition

The definition of EGS has been a contentious issue in the WTO negotiations. Why it is so? There are several issues emanating from different perceptions concerning which good can be called as environmental good and which service is called environmental service due to the following reasons: multiple-end use; relativism, attribute disclosure; and 'like' products at the WTO

[1] The link between trade in environmental goods (EG) and environmental services (ES) has been widely acclaimed (Jha, 2008). For example, technology, designing and engineering of waste treatment system fall under environmental services, but the provision of these environmental services is often integrated with the provision of the associated equipments.

(Balineau and de Melo, 2011). Nevertheless, some workable definitions of EG are followed in empirical analysis. For example, Hamwey (2003) describes that an environmental good is considered any equipment, material or technology used to address a particular environmental problem (Goods for Environmental Management-GEM) or as a product that is itself "environmentally preferable" (Environmentally Preferable Product – EPP) to other similar products because of its relatively benign impact on the environment. Another description of EGS is "goods and services which measure, prevent, limit, minimize or correct environmental damage" (OECD/EUROSTAT, 1999, p.9).

There are also narrow and broader definitions of EG. Environmental goods can be narrowed down to goods whose use results in a beneficial environmental impact, such as catalytic converters for automobile exhausts. In this definition, environmental goods are actually the capital goods or technologies which are required for 'end-of-the pipe' pollution abatement. The broader definition, on the other hand, takes into account the environmental characteristics of the goods themselves and/or their production processes. This includes the industrial goods used to provide environmental services to address pollution and waste affecting water, soil and air. These goods generally have multiple end-uses and they have relatively less negative impacts on the environment at the production, consumption or disposal stage, or even in terms of being produced in an environmentally benign manner or with 'clean technology'. Examples of these types of goods include: pumps, valves, compressors, tanks and containers, chemicals used in water purification, air/water filters, trash compactors, brooms, plastic lining material for landfill sites, ceramic wares and furnaces used in incineration, sorting equipment for recycling, measuring equipment to monitor the environment, noise reducing mufflers, etc (Katti 2005).

The issue of classification of EG is important because it will set clear parameter on the types of goods that are actually liberalized. There are different approaches towards identification of goods that WTO members have proposed over the past few years for multilateral liberalization of trade in EG. The first suggestion is a list of environment-friendly products which is proposed by the "Friend of Environmental Goods" group including Canada, EU, Japan, Republic of Korea, New Zealand, Norway, Switzerland, Taiwan and the US. The list has a wide-ranging coverage containing 153 goods with the aim of securing a zero tariff for these products by 2013. In addition, India has advocated the "Environmental project approach", whereby each WTO member would designate a national authority to select environmental project based upon criteria

developed by the Special Session of the Committee on Trade and Environment. Following the framework of WTO, EG can be classified by 12 groups namely, air pollution control, management of solid and hazardous waste and recycling systems, Clean up or remediation of soil and water, renewable energy plant, heat and energy management, waste water management and potable water treatment, environmentally preferable products, based on end use or disposal characteristics, cleaner or more resource efficient technologies and products, natural risk management, natural resources protection, noise and vibration abatement, and environmental monitoring, analysis and assessment equipment (Monkelbann 2011).

2.2. India's exports of EGS

Although the sector which produces EGS was virtually non-existent in India two decade ago, India has been turning into a major exporter as well as a promising market for EGS. The domestic environmental industry is still highly disorganized and is dominated by the small scale units. The environmental business is shared by a number of entities including equipment suppliers, system suppliers, engineering procurement and construction contractors, consultants and service providers (Katti 2005).

The contribution of EG exports has been increasingly important for India. Table 1 shows the export values of EG by groups over time. Before 2006, the group of waste water management and portable water treatment brought the highest value in terms of EG exports. However, the export of renewable energy plant has played the most important role in the contribution (more than USD 2 trillion in 2010) of EG exports. The export of air pollution control also brings high income for India, for example it accounted for more than USD 1 trillion in 2010.

According to the recent data of India's exports of EG, the Asia-Pacific countries are the important markets for EG from India and the value of India's EG exports to these markets is increasing overtime. The US is a major importing partner, which imports most of India's EG; for example, about 20 per cent of the EG consisting of renewable energy plant group was exported to the US market by India in 2010. The values of India's goods in the groups of waste water management and potable water treatment and noise and vibration abatement sold in the US were around USD 300 million and USD 180 million respectively. In addition, China, Thailand, Malaysia and Australia are also dominant importers of India's EG in the groups of clean up or remediation of soil and water (China – USD 10 million, Malaysia – USD 8 million), management

of solid and hazardous waste and recycling systems (Thailand – USD 34 million) and heat and energy management (Australia – USD 35 million).

3. Theoretical and Empirical Models, and Data

3.1. Theoretical Model

Gravity model which is based on Newton's law in physics is the most successful approach to empirically examine the factors affecting trade between countries. The model was first applied by Tinbergen (1962), in which, the export between two countries has a positive relation with GDP but negative relationship with the geographic distance between countries. Although the gravity model is criticized for its lack of theoretical underpinnings, many researchers including Anderson (1979), Bergstrand (1989) and Deardorff (1995) have provided theoretical underpinning for the gravity model. The basic gravity model can be written as:

$$\text{Ln } E_{ij} = \alpha + \beta_1 \text{ Ln } GDP_i + \beta_2 \text{ Ln } GDP_j + \beta_3 \text{ Ln } POP_i + \beta_4 \text{ Ln } POP_j + \beta_5 \text{ Ln } DIS_{ij} + v_{ij} \qquad (1)$$

Where 'Ln' refers to natural logarithm; E_{ij} refers to exports between country i and country j; GDP_i is the gross domestic product of country i that may be interpreted as the ith country's productive capacity (supply side), while GDP_j refers to that of the jth country; POP_i denotes the size of the population of the ith country that may be interpreted as the consumption capacity (demand side), while POP_j is that of the jth country; and DIS_{ij} refers to the geographical distance between two major ports of country i and j. The statistical error term 'v_{ij}' is the overall catch term for rest of the factors that influence trade between countries i and j. This error term is erroneously assumed to be distributed randomly without any important influence on trade between countries, which is restrictive, as country-specific constraints such as infrastructural and institutional frameworks play crucial role in determining trade relations between countries. These country-specific constraints are named in the literature as 'behind the border' constraints that exist in the exporting country and 'beyond the border' constraints that exist in the importing country.

There are many studies that tried to improve the basic gravity model. For example, Harris and Mátyás (1998) showed that there are some omitted variables in the basic model such as exchange rates and foreign currency reserves. They also proved that current exports and those of the previous year were highly related. Also, Anderson and van Wincoop (2003) argued that the conventional ordinary least squares estimation may suffer from omitted variables bias and the comparative statics analysis would be unfounded. Another problem of the gravity model with respect to the omitted variables concerns the exclusion of 'trade resistances', such as non-tariff

barriers from the gravity equation. To deal with these problems, researchers have suggested different methods of modelling and estimation of the gravity equation. For example, some suggested fixed effects models (e.g. Bayoumi and Eichegreen 1997), while Egger and Pfaffermayr (2003) suggested the use of panel data models which are non-linear in trade costs, and Feenstra (2002) used price differences between trading partners in his specification of the gravity model. Since McCallum (1995), many empirical papers have used 'remoteness' variables, generally defined by $\sum_{m \neq j} \frac{d_{im}}{y_m}$, where *d* is distance and *y* is GDP and the whole term represents the weighted average distance of country *i* from all its trading partners, except the particular partner j. Anderson and van Wincoop (2003) criticized these remoteness variables and suggested another multilateral resistance term. The multilateral resistance term implies that when we observe no movement in the trade determinants between country i and country j but a change in country k's trade with country i , then this will affect trade between countries i and j. However, Anderson and van Wincoop assumed symmetric trade costs to solve their model, which is an unrealistic assumption. Thus, these above solutions are either not based on any theoretical arguments or cannot fully capture the inherent bias in the empirical estimation. These also give biased results for not taking care of heteroskedasticity and non-normality of the error term of the gravity equation, which emanate from the omitted variables bias.

Kalirajan (2008) suggested an alternative methodology to model and estimate the gravity model taking into account of country-specific constraints related to trade, which have bearings on heteroskedasticity and non-normality of the error term, drawing on the modelling and estimation procedures used in the stochastic frontier production function literature. The advantage of using the stochastic frontier gravity model is that it is possible to incorporate and measure the effects of country-specific 'behind the border' and 'beyond the border' constraints on exports, when the researcher does not have full information about these constraints. The stochastic frontier gravity model that incorporates the overall impact of 'behind the border' and 'beyond the border' constraints along with the conventional determinants of exports can now be written as follows:

$$\text{Ln } E_{ij} = \alpha + \beta_1 \text{ Ln } GDP_i + \beta_2 \text{ Ln } GDP_j + \beta_3 \text{ Ln } POP_i + \beta_4 \text{ Ln } POP_j + \beta_5 \text{ Ln } DIS_{ij} - u_{ij} + v_{ij}$$

It is assumed that u_{ij} is zero if the influence of overall "behind the border constraints" is not significant and otherwise, it takes a positive value. u_{ij} is assumed to follow a truncated normal distribution, truncated at zero and v_{ij} is assumed to represent the 'beyond the border' constraints

and other left-out variables including statistical errors. It is assumed to follow a full normal distribution with mean zero and a constant variance.

Now, export potential is defined as the maximum possible exports that can be achieved in contrast to the average exports often estimated using the conventional gravity model analysis. Export potential can be used as an estimate of what exports would be in the hypothetical case of most frictionless and free trade possible under present circumstances observed throughout the world. Export performance, therefore, is a measure consisting of the ratio of actually realized level of exports to potential exports and the latter can be estimated by using the stochastic frontier gravity model for export flows. This measure is relevant in the present context of examining the impact on the export performance of the exporting country not only of its trade policy reforms, but also of the importing countries. Also, export performance is not only affected by policies that promote or limit exchange of goods and services, but is also affected by infrastructure and institutions that facilitate or inhibit trade and investment between countries. Hence, it is useful from the policy perspective to identify the factors that contribute to a country's export performance, which is attempted in the following paragraphs.

Drawing on Kalirajan (2008), Figure 2 shows that the export growth can be decomposed in terms of different components of the determinants of export growth, such as 'natural' determinants, 'behind the border' determinants, and 'beyond the border' determinants, where the latter can further be divided into 'explicit beyond the border' determinants, and 'implicit beyond the border' determinants. Thus, the export of EG depends on many factors. First, it depends on the GDP and population of importing countries. The assumption is that higher GDP and population in the foreign countries would generally lead to increase in demand for EG from India. However, the relationship between distance and EG exports is negative due to the higher cost of transportation. These factors can be named as 'natural determinants' of export flows between countries.

Next, 'explicit beyond the border' determinants such as the relative price of the imported goods and services that are mainly influenced by importing countries' tariff and exchange rate are another factors affecting export performance. This factor is expected to have negative correlation with EG exports because increasing tariffs and the devaluation of the domestic currencies lead to higher imported prices in domestic market. Therefore, the demand for imports is reduced.

Different kinds of institutional and infrastructural rigidities that exist in the exporting countries, such as poor port facilities may influence exports negatively and these factors may be referred to as 'behind the border' determinants in the home country, which are under the control of the exporting countries. The 'behind the border' determinants in the case of EG exports mostly include licence and market access restrictions, restrictions on foreign equity and joint venture partners, a legal system with limited effectiveness in terms of enforcement, and limited protection of intellectual property rights. For example, one of the major 'behind the border' constraints in the case of wind turbine exports is lack of international standards for certification and approval because differing standards has effectively become a major trade barrier (Alavi, 2007). Thus, lack of knowledge about the different types of such non-tariff barriers that exist in partner countries is an important 'behind the border' constraints in exporting countries.

Unfortunately, it is difficult for the researchers to quantify all the 'behind the border determinants' individually. Nevertheless, the combined effects of all these determinants can be modelled as a random variable with a truncated normal distribution.

Also, different kinds of institutional and infrastructural rigidities that exist in the importing countries also would influence export flows negatively, and these factors may be called as 'implicit beyond the border' determinants, which are beyond the control of the exporting countries. It is modelled as a random variable with a full normal distribution.

Free trade agreements (FTA) that are in the forms of improvement in trade promotion and facilitation policies of both India and its trading partners are expected to positively influence EG exports of India. A dummy variable (TA) can be used to represent whether there are such trade agreements and the influence of these factors on exports may be named as 'mutually induced determinants'.

India's export potential of EG with respect to its individual trading partners in a particular time period can be calculated by multiplying the estimated coefficients of the model (2) with the actual values of the determinants of exports used in the model (2) with the assumption that u_{it} is zero indicating that there are no 'behind the border' constraints in India. The difference between such potential exports between two time periods denote the change in India's potential exports with respect to the concerned trading partner. The methodology for decomposing the changes in exports between two time periods is explained in Figure 2. F_1 is the potential export frontier of home country in period 1 and in the absence of any 'behind the border constraints', Y_1^* in period

1 is called potential exports for the given export determinants, say, X_1. The actual export is Y_1, that is less than Y_1^* due to the existence of 'behind the border constraints' emanating from infrastructure constraints, institutional rigidities and other similar weakness in home country. EI_1 is the export inefficiency resulting from 'behind the border constraints', which prevent the export in period 1 from reaching its potential. EI_1 is measured as the vertical distance between actual exports and potential exports for the given export determinants X_1. However, 'implicit beyond the border constraints' tend to change due to multilateral or bilateral negotiations or trade facilitation steps taken by the partner countries. These would generally shift the potential export frontier from F_1 to F_2 in period 2. Nevertheless, while Y_2^* represents the potential exports without any 'behind the border constraints' in home country, Y_2 is the actual exports, which is less than Y_2^* due to the existing 'behind the border constraints' in home country in period 2. Potential exports growth due to reduction in 'implicit beyond the border constraints' can be measured as the vertical distance between the frontier in period 1 (Y_1^*) and the frontier in period 2 (Y_1^{**}) evaluated for the same levels of determinants of exports, X_1 in period 1. This is calculated first by multiplying the actual levels of determinants of exports in period 1 with their relevant estimated frontier coefficients of period 2 and secondly taking the difference between this calculated export level and the potential export of period 1.

The change in realized exports can be decomposed as follows (Khan and Kalirajan 2011):

$$D = Y_2 - Y_1 = A + B + C \quad (3)$$

$$= [Y_1^* - Y_1] + [Y_1^{**} - Y_1^*] + [Y_2 - Y_1^{**}]$$

$$= [Y_1^* - Y_1] + [Y_1^{**} - Y_1^*] + [Y_2^* - Y_1^{**}] - [Y_2^* - Y_2]$$

$$= \{[Y_1^* - Y_1] - [Y_2^* - Y_2]\} + [Y_1^{**} - Y_1^*] + [Y_2^* - Y_1^{**}]$$

$$= \{EI_1 - EI_2\} + CIBBC + GCD$$

Where,

$EI_1 - EI_2$ = difference between export inefficiency in period 1 and period 2 resulting from changes in 'behind the border' constraints in home country.

CIBBC = change in export due to the trade facilitation steps taken by the partner countries, leading to changes in 'implicit beyond the border' constraints.

GCD = change in exports due to the sum of changes in the core natural determinants of trade like GDP and population; changes in 'mutually induced determinants, such as trade agreements; and changes in 'explicit beyond the border' constraints, which include tariffs and exchange rates.

Thus, the changes in exports between two periods may result from the reduction in 'behind the border' constraints over time through home country' domestic reforms; reduction in both 'explicit and implicit beyond the border' constraints in partner countries due to partner countries' reforms and mutual discussions; increase in export demand in partner countries due to increase in partner countries' GDP levels and population; and implementation of trade agreements between home and partner countries.

3.2. Empirical Model

The empirical stochastic frontier gravity model, which is used in this study, is:

$$Ln(X_{ij}) = \alpha_1 + \alpha_2 ln(GDP_{ij}) + \alpha_3 ln(POP_{ij}) + \alpha_4 ln(DIST_{ij}) + \alpha_5 Ln(EXR_{ij}) + \alpha_6 Ln(T_{ij}) + \alpha_7 Ln(TA_{ij}) - u_{ij} + v_{ij} \quad (2)$$

In which, X_{ij} describes India's exports of the j^{th} group of EGS to country i; GDP_i and POP_i measures the gross domestic product (GDP) and population of country i; $DIST_i$ indicates the distance from New Delhi to the capital city of the India's partner country i; EXR_{ij} is the nominal exchange rate of local currency of India's trading partners and is in US dollar; T_{ij} is the average tariff for the j^{th} group of EGS of importing country i ; TA_{ij} is a dummy variable, which is equal to 1 if the country i have a trade agreement with India, otherwise 0; u_{it} refers to the combined effect of "behind the border constraints" in India; and v_{ij} is "normal" statistical error term and implicit "beyond the border" constraints. It is assumed that u_{ij} is zero if the influence of "behind the border constraints" is not significant and otherwise, it takes a positive value. u_{ij} is assumed to follow a truncated normal distribution, truncated at zero and v_{ij} is assumed to follow a full normal distribution with mean zero and a constant variance. Using the joint density functions of u_{ij} and v_{ij}, the maximum likelihood estimation can be used to estimate the production coefficients, $\alpha_1 \ldots \alpha_7$ along with the total variance and the parameter γ, which is the ratio of the variance due to the combined effect of 'behind the border constraints' to total variance of exports. Thus, γ indicates whether 'behind the border constraints' are one of the determinants of total exports of EG and it serves as a robustness test for the gravity model given in equation (2). When γ is significant, it means that 'behind the border constraints' are important determinants of EG exports. The

software FRONTIER 4.1 (Coelli 1996) is used to estimate the above model (1) for 4 different years, 1996, 2000, 2005 and 2010[2].

3.3. Data

EG used in this study are the WTO 153 list, which are divided into 12 groups. The data of exports of EG from India is collected from the official website of World Integrated Trade Solution (WITS) in the period between 1996 and 2010, while GDP, population, exchange rate and are derived from the official website of World Bank (WB) and the data of distance is calculated between capital cities between India and its partner countries through website of Distance Calculator. Tariff data is extracted from WITS by HS 6-digits and then tariff is calculated by average tariff for 12 groups of EGS. Trade agreements are collected from the website of the Ministry of Commerce and Industry of India. The data consist of cross-country balanced data for 4 years, which means that four year samples used for the estimations are identical in terms of India's trade partners for each of EG category. Sample size by EG export categories is given in Table 2, which shows that there are 289 observations in 1996, 2000, 2005, and 2010.

4. Results of Estimation and Decomposition of Changes in India's Exports of EG

4.1. Results of Estimation

The estimated results of the determinants of India's total exports of EG are shown in Table 3. The high value of γ, which varies from 0.90 to 0.95 at the 1 percent level of significance, confirms that the selected stochastic frontier gravity model framework (Equation 1) for the present study is statistically valid for the present data set. It also shows that the variation of India's exports of EG mostly comes from the inefficiency emanating from 'behind the border' constraints. This implies that India has to eliminate its 'behind the border' constraints by improving its infrastructure and institutions to increase its EG exports.

All the coefficients vary over time from 1996 to 2010, which indicates that the influence of different types of determinants of EG exports has been changing over time. As a kind of sensitivity analysis to prove the robustness of the estimated results, the stochastic frontier gravity

[2] Foreign direct investment (FDI) variable is not included in the model because there is no uniform data available on FDI for EG classified by the WTO 153 list.

model was estimated in the panel data framework using the FRONTIER 4.1 software and the results are given in the Appendix Table[3]. The interesting result of the panel data estimation is that the coefficient of the time trend is significant at the 5% level, which confirms the individual year estimation results of variation of coefficients given in Table 3.

The results in Table 3 show that the coefficients of GDP are positive at the 1 percent significant level. The coefficients first increased from 0.1718 in 1996 to 0.2203 in 2000 and then declined to 0.1762 in 2010, which shows that during the period between 1996 and 2000 the GDP of partner countries had an increasingly positive effect on India's EG exports, while in later periods the impact was smaller. There may be many reasons for that. For example, as India's trading partners' GDP increases, they may produce import-substituting EG, which then would reduce the imports from India.

The coefficients of exchange rate have negative signs as expected with the significance at least of 10 percent in 2010. This means that when India's partner countries depreciate their currencies, the prices of EG imported from India are relatively more expensive. Consequently, the demand of India's EG is reduced. This factor is not under the control of India and belongs to the 'explicit beyond the border' constraints.

Tariff is another crucial factor in determining India's exports of EG. In 1996, tariff does not have any effect on EG exports from India. However, it has significantly and negatively influenced the exports in 2000. Since then the coefficient of tariff became insignificant and has been on a declining trend from 2000 until recently. This indicates the effectiveness of reducing the 'explicit beyond the border' constraints by India's trading partners through implementing their trade policy reforms to reduce trade costs to benefit their importers. Such policy measures also benefit EG exporting countries including India.

The coefficient of trade agreement is not significant during the sample periods. Thus, trade agreements, which are mostly in the form of either reduced or zero tariffs, do not appear to be effective in promoting India's EG exports. This may be explained by observing the actual export activities of India. For example, there is not any trade agreement between India and the US but the value of India's export of EG to the US accounted for 20 percent of total EG exports in 2010. Also, as discussed above that the reduction in the 'explicit beyond the border' constraints by

[3] We thank the referee of this Journal for suggesting this approach of testing.

India's trading partners has the potential to make tariff less important to India's EG export growth.

4.2. Results of Decomposition of Changes in India's Exports of EG

Changes in India's EG exports is decomposed for the selected 10 Asia-Pacific economies, which are the major trading partners of India for EG, for 2 periods 1996 – 2000 and 2005 – 2010.

The decomposition of the output growth of EG for each trading partner of India is done by working through the following steps: (i) the actual export growth between 2000 and 1996 is calculated as $(Y_2 - Y_1)$ given in equation (3); (ii) the difference between the estimated frontier exports (Y_1*) and the actually realized output (Y_1) in year 1996 is calculated, which is named as EI_1 given in equation (3); (iv) the difference between the estimated frontier exports and the actually realized output in year 2000 is calculated, which is named as EI_2 given in equation (3); (v) frontier export, Y_1** given in equation (3) is obtained by multiplying the actual levels of the determinants of exports of 1996 by the 2000 estimates of the frontier coefficients; (vi) the difference between Y_1** and Y_1* is calculated, which is named as the change in export growth due to the changes in "implicit beyond the border" constraints in the partner countries; (vii) the difference between EI_1 and EI_2 is calculated, which is named as the change in export growth due to the changes in "behind the border" constraints in India; and (viii) the differences calculated in step (vi) and in step (vii) are added together and this amount is then subtracted from $(Y_2 - Y_1)$ to get $(Y^*_2 - Y^{**}_1)$ given in equation (3), which is named as the change in exports due to the sum of changes in "explicit beyond the border" constraints and in the core natural determinants of exports, such as GDP and population. The results thus obtained in the above steps of (vi), (vii), and (viii) are presented as percentages of output growth in Table 4. Similar calculations were done for the output growth between 2005 and 2010 and the results are presented in Table 4.

Table 4 shows that in most cases, the 'behind the border' constraints, which are under the control of India, have negative effects on India's EG exports growth, while the reduction of the 'implicit beyond the border' constraints, which are under the control of India's trading partners, have contributed strongly positively to the EG exports growth. For example, the 'behind the border' constraints in India has contributed to the decline of EG export growth during 1996-2000 and 2005-2010 to Australia by 24% and 22% respectively. However, India's EG exports growth to Australia was influenced more by the reduction in the 'implicit beyond the border' constraints implemented by Australia rather than its increased demand arising from increased GDP and

population. Similar is the case with all other countries shown in Table 4. These results thus indicate that India should take serious reform measures to eliminate its 'behind the border' constraints.

As the above analysis concerns the decomposition of exports growth of total EG, it may be interesting to see the decomposition of exports growth of individual categories of EG to understand whether the determinants and decomposition of exports growth of individual categories differed across categories. Two major product groups - Environmentally preferable products (EPP), based on end use or disposal characteristics and Environmental monitoring, analysis and assessment equipment, which represents the GEM category, - are taken for further analysis in this paper[4]. The results of estimation of the determinants of EPP are given in Table 5. Both the size and significance of the γ coefficient imply that the estimated stochastic frontier gravity model is appropriate to gauge the determinants of exports growth of EPP. It is worth noting that there is not much difference between the determinants of EPP exports and total EG exports during the periods of analysis. Table 6 shows the results of estimation of determinants of the GEM category - Environmental monitoring, analysis and assessment equipment. The significance of the γ coefficient indicates that the selected model is appropriate to explain the influence of the selected determinants on exports. The determinants of this GEM category appear not to be differing sufficiently from the determinants of EPP and the total EG exports. Now, the decomposition of EPP exports growth and GEM category exports growth are done following the methods described above and the results are given in Tables 7 and 8 respectively. The results can be summarized as follows:

Environmentally preferable products (EPP), based on end use or disposal characteristics (Table 7)

India's exports of the EPP were substantially negatively influenced by the export inefficiency arising from the 'behind the border' constraints in both periods. On the other hand, the large reductions in the 'implicit beyond the border' constraints in India's partner countries arising from either bilateral/multilateral negotiations or trade facilitation measures taken by them in both periods. In contrast, the contribution of the reduction in 'explicit beyond the border' constraints to India's export growth of this EG group was relatively small during 2005 – 2010.

[4] We thank the referee of this Journal for this suggestion.

Environmental monitoring, analysis and assessment equipment (Table 8)

As observed with respect to the EPP exports growth, the effect of the 'behind the border' constraints was significant for India's export growth of this GEM group of Environmental monitoring, analysis and assessment equipment during the period 1996 – 2000. However, the reductions in the 'implicit beyond the border' constraints dominated and positively contributed to India's export growth of this GEM group of EG in the next period. Nevertheless, for example, though the reduction in Malaysia's 'implicit and explicit beyond the border' constraints caused 14 percentage points increase in India's exports of EG of the GEM group to Malaysia from the first period (1996-2000) to the second period (2005-2010), India's institutional and infrastructure rigidities reduced Malaysia's imports by 8 percentage points during the same periods. Consequently, India's exports of EG of Environmental monitoring, analysis and assessment equipment group to Malaysia declined significantly during the period 2005 – 2010 from its potential level.

Thus, the above analyses indicate that the sources of EG exports growth both at the aggregate level and the individual product group level appear to be similar.

5. Conclusions

EG can bring more benefit to the Indian economy in terms of not only increasing its national income through exports, but also of improving its environmental conditions at the national level. A stochastic frontier gravity model is used to examine whether India has achieved its EG export potential with its top ten export markets of the Asia-Pacific economies, using the WTO 153 list classified into 12 groups. The advantage of using the stochastic frontier gravity model is that it is possible to incorporate country-specific 'behind the border' and 'beyond the border' constraints into the conventional gravity model to estimate their impacts on India's exports of EG. In this context, the researcher need not have the detailed information on the 'behind the border' and 'beyond the border' constraints, but these constraints are represented as independently distributed random variables with different distributional functions. The analysis was done for 4 years 1996, 2000, 2005 and 2010. The results show that the contributions of GDP of partner countries have positive effect, while the distance between India and its trading partners, exchange rate, and tariffs have negative effects on the exports of India's EG. Next, the changes in India's exports of EG were decomposed into different components, such as growth due to reductions in the 'behind

the border', 'implicit beyond the border' and' explicit beyond the border' constraints along with 'natural determinants' and 'mutually induced policy determinants'. The results show that the institutional and infrastructure rigidities of India, which are the main causes for the emergence of the 'behind the border' constraints, exert dominant negative effects on its exports of EG to India's trading partners in the Asia Pacific. On the other hand, the reduction in India's trading partners' 'implicit beyond the border' constraints has made significant contribution to India's exports of EG between 1996 and 2010. The export growth changes due to 'explicit beyond the border' constraints are relatively small. Thus, these results, which hold good whether the analysis is done at the aggregate total EG exports level or individual EG categories level, indicate to India that it should eliminate its 'behind the border' constraints.

Therefore, in terms of policy suggestion to promote exports of EG, India needs to strengthen its policies to remove the 'behind the border' constraints to improve its infrastructure and institutional framework, which are central to India's exports. Though due to lack of uniform data, we could not identify what are the 'behind the border' constraints, some evidence-based conjectures can be made. For example, India can improve the performances of its exporting firms by disseminating knowledge and laws related to EG of the importing countries. Also, port facilities can be improved for efficient functioning and bureaucratic delays in dispatching EG can be avoided. With respect to the advanced technology involved in the production of EG, Lema and Lema (2012) have argued that the conventional technology transfer mechanisms such as FDI, patent licensing and imports are crucial. In this context, it is well known that India's FDI policy has been very restrictive until recently (Sahoo et al., 2014), which has been an institutional rigidity influencing EG export growth negatively.

A limitation of this study concerns the following. The impact of the changes in the 'implicit beyond the border' constraints to India's exports of EG is measured by the vertical distance between the frontier in period 1 and the frontier in the period 2, evaluated for the same level of determinants of exports for period 1. This impact may also include the changes in the price of EG which lead to changes in the value of Y_1^{**}. Due to lack of the proper data availability, this study does not separate the effects of the changes in prices from the impact of the 'implicit beyond the border' constraints.

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Figure 1. Contribution of EGS in total exports of India (%)

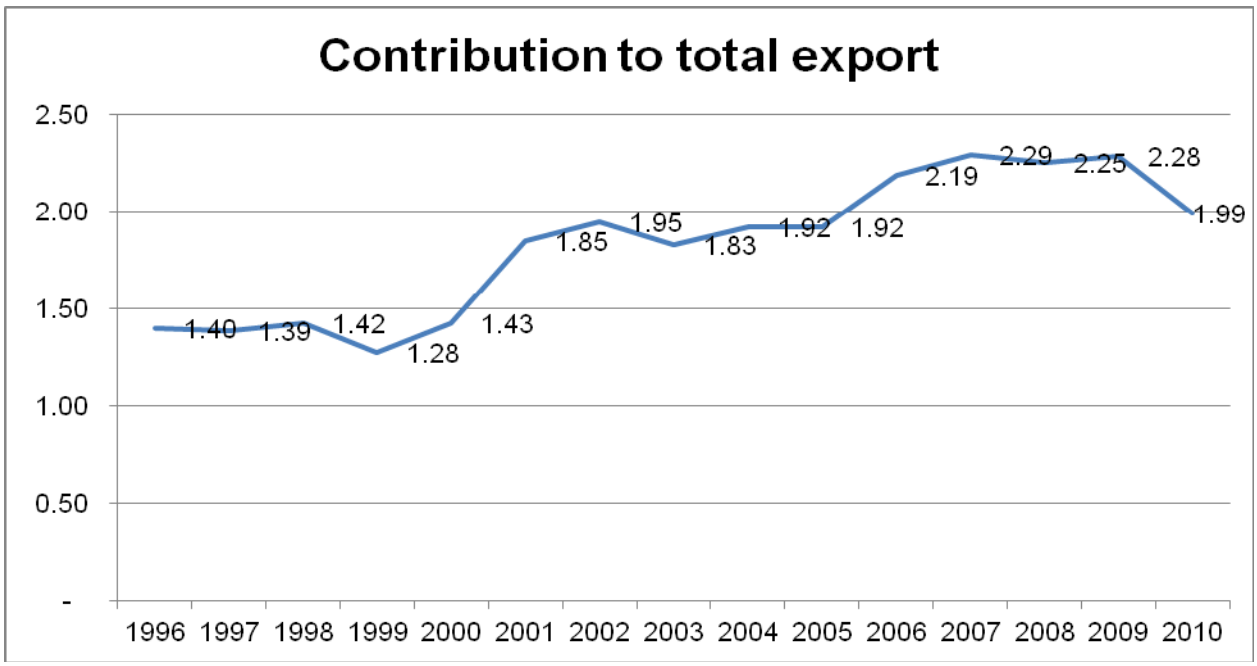
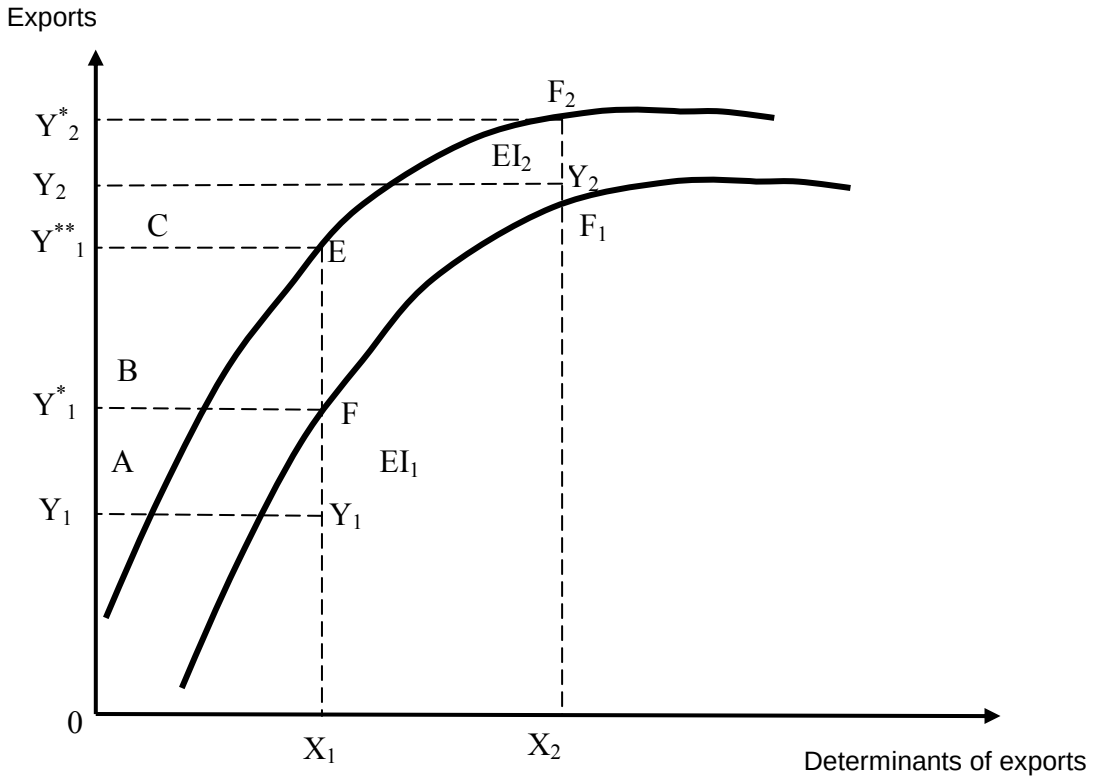


Figure 2: Export growth decomposition



Source: Khan and Kalirajan (2011).

Table 1: India's exports of different categories of EG to the world ('000 USD)

Product description	2005	2006	2007	2008	2009	2010
Air pollution control	214,623	437,949	540,241	724,312	626,656	1,033,679
Management of solid and hazardous waste and recycling systems	423,145	466,624	604,740	681,157	587,238	546,804
Clean up or remediation of soil and water	17,514	25,529	64,292	64,099	90,333	69,379
Renewable energy plant	608,770	1,172,015	1,551,932	2,627,162	2,071,148	2,210,387
Heat and energy management	37,862	41,158	72,490	101,267	207,895	195,493
Waste water management and potable water treatment	810,145	1,045,467	1,333,873	1,855,767	1,542,465	1,746,190
Environmentally preferable products, based on end use or disposal characteristics	73,641	75,547	71,444	93,548	63,886	116,729
Cleaner or more resource efficient technologies and products	13,520	9,075	7,826	13,001	18,564	36,918
Natural risk management	17,508	31,711	34,224	41,729	82,670	30,817
Natural resources protection	18,403	20,553	10,424	14,378	21,906	29,685
Noise and vibration abatement	368,355	472,822	562,707	658,961	469,918	624,469
Environmental monitoring, analysis and assessment equipment	99,006	102,801	156,070	233,237	295,494	330,205

Table 2: Sample Size: India's Exports by EG Categories to its Partner Countries

Group Number	Group name	No observations
1	Air pollution control	32
2	Management of solid and hazardous waste and recycling systems	31
3	Clean up or remediation of soil and water	16
4	Renewable energy plant	32
5	Heat and energy management	16
6	Waste water management and potable water treatment	32
7	Environmentally preferable products, based on end use or disposal characteristics	27
8	Cleaner or more resource efficient technologies and products	18
9	Natural risk management	9
10	Natural resources protection	13
11	Noise and vibration abatement	32
12	Environmental monitoring, analysis and assessment equipment	31
	Total	289

Table 3: Maximum Likelihood Estimates of the Stochastic Frontier Gravity model
(Dependent variable: India's total exports of EG in logarithm)

Category	1996	2000	2005	2010
Constant	4.2863***	2.7020***	3.2250***	3.4197***
	(1.2665)	(0.8762)	(1.0232)	(1.1412)
Ln GDP	0.1718**	0.2203***	0.1860**	0.1762**
	(0.0852)	(0.0706)	(0.0828)	(0.0853)
Ln Population	0.1840*	0.2881***	0.4380***	0.2399*
	(0.0978)	(0.1123)	(0.2067)	(0.1315)
Ln Distance	-0.7985***	-0.5621***	-0.4339*	-0.3875*
	(0.2230)	(0.1398)	(0.2332)	(0.2029)
Ln Exchange rate	-0.0986***	-0.0929**	-0.1262***	-0.0853*
	(0.0245)	(0.0426)	(0.0336)	(0.0449)
Tariff	-0.0115	-0.0200**	-0.0625***	-0.0423*
	(0.0156)	(0.0094)	(0.0162)	(0.0225)
Trade agreement dummy	0.2611	0.1252	0.1186	0.0614
	(0.2187)	(0.1320)	(0.1289)	(0.0583)
Gamma	0.9511***	0.9465***	0.8999***	0.9347***
	(0.1961)	(0.1813)	(0.1829)	(0.1862)
Log likelihood	-234.56	-264.32	-258.56	-264.72
Number of observations	289	289	289	289

Note:
Figures in parentheses are standard errors of estimates.
***, **, * show the significant level at 1%, 5%, and 10% levels respectively.

Table 4: India's Exports Growth Decomposition for 1996-2000 and 2005-2010

Countries	1996-2000: output growth due to changes in			2005-2010: output growth due to changes in		
	BTBC (%)	IBTBC (%)	EBTBC & CD (%)	BTBC(5) (%)	IBTBC (%)	EBTBC & CD(%)
Australia	-24	77	47	-22	78	44
Canada	-17	71	46	-20	76	44
China	-26	65	61	-28	64	58
Indonesia	-19	62	57	-16	62	54
Japan	-11	72	39	-15	70	45
Malaysia	-15	63	52	-12	60	52
Republic of Korea	-12	76	36	-10	76	34
Singapore	-14	83	31	-12	83	29
Thailand	-16	60	56	-14	67	47
Vietnam	-12	50	62	-13	52	61
United States	-18	70	48	-20	75	45

Notes: BTBC = Behind the border constraints
IBTBC = Implicit behind the border constraints
EBTBC&CD = Explicit behind the border constraints and Core Determinants

1. A positive sign for BTBC means that there is reduction in the 'behind the border' constraints in India between the relevant periods of analysis.
2. A negative sign for BTBC means that there is no reduction in the 'behind the border' constraints in India between the relevant periods of analysis.

Table 5: Maximum Likelihood Estimates of the Stochastic Frontier Gravity model (Dependent variable: India's exports of Environmentally preferable products (EPP), based on end use or disposal characteristics in logarithm)

Category	1996	2000	2005	2010
Constant	2.5562**	2.4622***	2.2646***	2.8975***
	(0.9725)	(0.6995)	(0.6088)	(0.7335)
Ln GDP	0.2132**	0.2324***	0.2476**	0.2568**
	(0.0921)	(0.0636)	(0.1028)	(0.1054)
Ln Population	0.1446*	0.1474*	0.1572**	0.1633*
	(0.0769)	(0.0780)	(0.0767)	(0.0859)
Ln Distance	-0.6795**	-0.6827**	-0.7117**	-0.7316**
	(0.3299)	(0.3236)	(0.3235)	(0.3181)
Ln Exchange rate	-0.2015**	-0.2221**	-0.2462*	-0.2548*
	(0.0876)	(0.0983)	(0.1324)	(0.1341)
Tariff	-0.0843	-0.0968*	-0.0922	-0.0857
	(0.0972)	(0.0538)	(0.1286)	(0.1332)
Trade agreement dummy	0.1587	0.1442	0.1521	0.1592
	(0.1971)	(0.1922)	(0.1954)	(0.1952)
Gamma	0.9011***	0.8876***	0.9112***	0.9185***
	(0.1726)	(0.1737)	(0.1875)	(0.1838)
Log likelihood	-201.56	-218.22	-225.74	-232.98
Number of observations	27	27	27	27

Note:
Figures in parentheses are standard errors of estimates.
***, **, * show the significant level at 1%, 5%, and 10% levels respectively.

Table 6: Maximum Likelihood Estimates of the Stochastic Frontier Gravity model [Dependent variable: India's Environmental monitoring, analysis and assessment equipment (GEM category) exports in logarithm]

Category	1996	2000	2005	2010
Constant	2.4562**	3.1622***	3.4546***	3.7975***
	(1.1725)	(0.7923)	(0.8922)	(0.8456)
Ln GDP	0.1932**	0.2023***	0.2280**	0.2571**
	(0.0921)	(0.0636)	(0.1028)	(0.1054)
Ln Population	0.1521*	0.1572*	0.1686**	0.1692*
	(0.1002)	(0.1032)	(0.0833)	(0.1242)
Ln Distance	-0.7958**	-0.7624**	-0.8137**	-0.8323**
	(0.3235)	(0.3698)	(0.4032)	(0.4118)
Ln Exchange rate	-0.1185**	-0.1427**	-0.1460*	-0.1854*
	(0.0543)	(0.0687)	(0.0955)	(0.1249)
Tariff	-0.0331	-0.0365*	-0.0426*	-0.0438
	(0.0258)	(0.0199)	(0.0286)	(0.0398)
Trade agreement dummy	0.1602	0.1288	0.1434	0.1732
	(0.1878)	(0.1756)	(0.1829)	(0.1837)
Gamma	0.8921***	0.8462***	0.8973***	0.9021***
	(0.2867)	(0.2859)	(0.2866)	(0.2898)
Log likelihood	-198.42	-227.18	-236.52	-240.73
Number of observations	31	31	31	31

Note:
Figures in parentheses are standard errors of estimates.
***, **, * show the significant level at 1%, 5%, and 10% levels respectively.

Table 7: Exports Growth Decomposition for 1996-2000 and 2005-2010: India's Environmentally preferable products (EPP), based on end use or disposal characteristics

Countries	1996-2000: output growth due to changes in			2005-2010: output growth due to changes in		
	BTBC (%)	IBTBC (%)	EBTBC & CD (%)	BTBC(5) (%)	IBTBC (%)	EBTBC & CD(%)
Australia	-19	72	47	-18	74	44
Canada	-21	70	51	-20	72	48
China	-32	60	72	-29	62	67
Indonesia	-22	68	54	-18	65	53
Japan	-17	75	42	-17	75	42
Malaysia	-25	68	57	-22	65	57
Republic of Korea	-18	73	45	-17	70	47
Singapore	-15	85	30	-15	88	27
Thailand	-21	62	59	-20	65	55
Vietnam	-23	60	63	-23	62	61
United States	-20	75	45	-18	75	43

Notes: BTBC = Behind the border constraints
IBTBC = Implicit behind the border constraints
EBTBC&CD = Explicit behind the border constraints and Core Determinants

1. A positive sign for BTBC means that there is reduction in the 'behind the border' constraints in India between the relevant periods of analysis.
2. A negative sign for BTBC means that there is no reduction in the 'behind the border' constraints in India between the relevant periods of analysis.

Table 8: Exports Growth Decomposition for 1996-2000 and 2005-2010: India's Environmental monitoring, analysis and assessment equipment exports

Countries	1996-2000: output growth due to changes in			2005-2010: output growth due to changes in		
	BTBC (%)	IBTBC (%)	EBTBC & CD (%)	BTBC(5) (%)	IBTBC (%)	EBTBC & CD(%)
Australia	-20	70	50	-20	72	48
Canada	-25	68	57	-24	69	55
China	-18	60	58	-21	62	59
Indonesia	-15	60	55	-16	62	54
Japan	-27	78	49	-24	78	46
Malaysia	-20	62	58	-28	74	54
Republic of Korea	-26	78	48	-25	77	48
Singapore	-18	85	33	-18	86	32
Thailand	-18	60	58	-19	65	54
Vietnam	-15	58	57	-16	60	56
United States	-28	80	48	-30	80	50

Notes: BTBC = Behind the border constraints
IBTBC = Implicit behind the border constraints
EBTBC&CD = Explicit behind the border constraints and Core Determinants

1. A positive sign for BTBC means that there is reduction in the 'behind the border' constraints in India between the relevant periods of analysis.
2. A negative sign for BTBC means that there is no reduction in the 'behind the border' constraints in India between the relevant periods of analysis.

Appendix Table

Maximum Likelihood Estimates of the Stochastic Frontier Gravity model in the Panel Data Framework
(Dependent variable: India's total exports of EG in logarithm)

Category	Estimates of coefficients
Constant	3.3769***
	(1.1251)
Ln GDP	0.1821**
	(0.0903)
Ln Population	0.2915**
	(0.1455)
Ln Distance	-0.4854*
	(0.2518)
Ln Exchange rate	-0.0922*
	(0.0482)
Tariff	-0.0341*
	(0.0273)
Trade agreement dummy	0.1108
	(0.0978)
Time trend	0.2842**
	(0.1412)
Gamma	0.9518***
	(0.2165)
Log likelihood	-287.72

Number of observations: 1,156.

Note:
Figures in parentheses are standard errors of estimates.
***, **, * show the significant level at 1%, 5%, and 10% levels respectively.