TRADE COSTS OF INDIA WITHIN ASIA: MEASUREMENT AND ITS DETERMINANTS

by

Sarbjit Singh[1] and S.K. Mathur[2]

ABSTRACT

International trade of an economy is highly affected by the trade costs incurred locally and across the borders. These costs are the difference between marginal cost of a traded commodity and its price paid by the ultimate consumers. The measurement of this price gap is very cumbersome job because it needs the data on each of variable which accumulates the price of a traded commodity from source to destination country. The present study calculates the trade costs of Indian economy within Asia and then also, it attempts to find out the determinants of these calculated trade costs. It is found that the trade costs of India with its Asian trading partners are declining across the study period except the years of Asian financial crisis. Further, the variables, used as determinants of trade costs, are behaving in the proper way as expected. But these determinants are unable to explain the major portion of trade costs, which means that non-included factors, such as, transportation costs, non-tariff barriers and local distribution costs among others, may have an influential role in determining the trade costs.

Keywords: Trade Costs, India, Asia.

JEL Codes: F14, F19.

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1. Introduction

International trade of an economy is highly affected by the trade costs incurred locally and across the borders. These costs are the difference between the marginal cost of a traded commodity and its price paid by the ultimate consumers. Measurement of this price gap is very cumbersome job because it needs the data on each of the variable which accumulates the price of a traded commodity from source to destination country. An attempt in this direction was made firstly by Tinbergen (1962) and he used gravity equation for this. His gravity equation imitates the Newton's gravity equation and describes that international trade between two partner nations is directly linked to their economic sizes and inversely related to the distance between them, the later acts as a proxy for the trade costs. Then after, many economists have started using different proxies for trade costs, such as: common border, common language, tariffs and remoteness among others, which led to the debate over the rationale behind the use of gravity equation in international trade and also, to find out the accurate measure of trade costs.

Anderson (1979) derived the gravity equation from the system of expenditure equations and provided theoretical base to the gravity model of international trade. But McCallum (1995) again estimated the traditional gravity equation for the bilateral trade between U.S and Canada, and assumed distance and border as proxies for the trade costs. He found that the U.S.-Canadian border led to trade between Canadian provinces that is a factor 22 (2,200 percent) times trade between U.S. states and Canadian provinces. But Anderson and Wincoop (2003) challenged the estimated results of McCallum (1995) and proved that he had used the wrong proxies to reflect the international trade costs. Anderson and Wincoop (2003) introduced trade costs exogenously to the model and assumed a particular type of trade cost function to represent these. They were also of the opinion that not only the bilateral trade barriers but multilateral trade barriers too affect the international trade, named as multilateral resistance term, the resistance from the other trading partners.

Novy (2008) used the obtained gravity model of international trade by Anderson and Wincoop (2003) and after applying some manipulations, he derived a micro-founded measure for the international trade costs. His measure overcomes the problem of assuming a symmetric and a particular kind of trade cost function and directly calculates the international trade costs from the observable data. Studies, which have discussed some of the important issues concerning the measurement of trade costs, have conceded that the literature is still in the early stages of understanding and measuring what the real trade costs are (Khan and Kalirajan, 2011).

The present study uses Novy's measure to calculate the trade costs between the India and other Asian countries. After calculating the trade costs, an attempt is made to find out the determinants of measured trade costs. The study is divided into five sections, including the present introductory one. The methodology and database used to fulfill the needs of study are discussed in Section 2. Section 3 calculates the trade costs for India within Asia. In fourth section, the study pin points the determinants of trade costs and last section concludes the study.

1.2 India's Trade with Asia: An Overview

A large portion of Indian trade is with the Asian countries. In fig. 1, the left panel shows that 61 percent of Indian Imports are coming from the Asia and right panel shows that 50 percent of Indian exports are going to Asian nations.

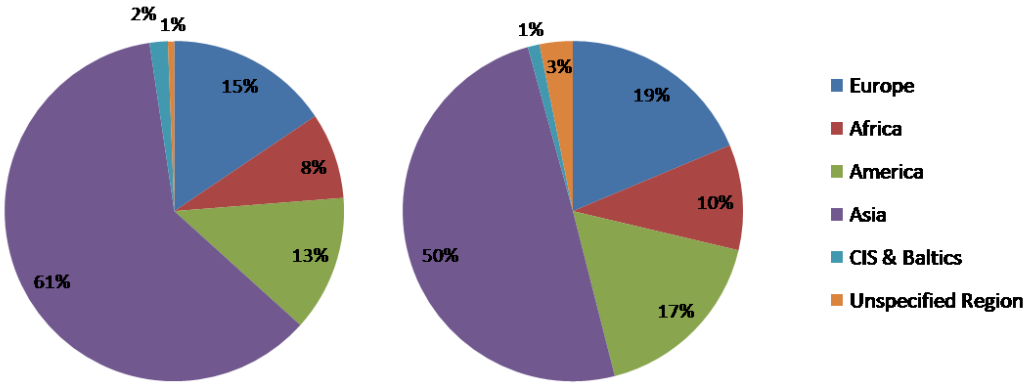

Fig. 1: Region-wise Share of India's Imports and Exports (2013-14)

Source: Compiled from Export-Import Data Bank (Ministry of Commerce and Industry, India)

The detailed trade profile of India with other Asian countries is given in the following table.

Table 1: India's Trade Profile in Asia			
Region	**Major Exports**	**Major Imports**	**Trade Deficit/Surplus 2013-14**
East Asia (comprises Taiwan, China, Hong-Kong, Korea, Macao & Mongolia	Gems and Jewellery, Petroleum (crude and products), Non-Ferrous metals, Iron Ore, Ferro alloys, Cotton raw & Cotton yarn, Fabric, Made ups, Plastic & Linoleum products, Machinery & Instruments and Marine Products.	Electronic Goods, Machinery, Organic Chemicals, Pearls, Precious and Semi-Precious stones, Iron and Steel, Transport Equipment Project goods, Fertilizers and Gold.	**Trade Deficit : US $43.64 bn** Except Hong Kong, North Korea and Mongolia, India has a trade deficit with all other countries in this region. Major trading partners are: China, Hong Kong, South Korea, Japan and Taiwan.
West Asia (comprises 6 GCC countries, Iran, Iraq, Israel, Jordon, Lebanon, Syria, Yemen, Armenia, Azerbaijan, & Georgia.	**To GCC**: Minerals, Pearls and Precious Metals, Cereals, Electrical Machinery and Equipments, Machinery, Articles of Apparel and Clothing, Iron and Steel, Organic Chemicals, Meat (Edible), Fruits, Nuts, Coffee, Tea, Spices, Mate, etc. **To Others**: Minerals, Cereals, Pearls and Precious Stones, Electrical Machinery and Equipments, Organic Chemicals, Meat, Iron and Steel, Machinery, Sugar, Pharmaceutical Products, etc.	**To GCC** : Petroleum Oils, Natural Gas, Liquefied Butanes, Urea, Aluminum Copper, Plastics and Articles thereof, Fertilizers, Inorganic Chemicals, etc. **To Others** : Mineral Fuels, Fertilizers, Organic and Inorganic Chemicals, Electrical Machinery and Equipments, etc.	**Trade Deficit : US$ 53.83 bn (GCC)** Among GCC Countries, India has a trade surplus with UAE and Bahrain. Major trading partners are UAE, Saudi Arabia, Kuwait, Qatar and Oman. **Trade Deficit : US$ 20.54 bn (with Others)** India has a trade deficit only with Iran, Iraq and Azerbaijan. Major trading partners are Iraq, Iran and Israel.
South Asia (comprises Afganistan, Bangladesh, Bhutan, Maldives, Nepal, Sri – Lanka and Pakistan.	Cotton, Mineral and Mineral Products, Vehicles other than Railways, Cereals, Aircrafts and their parts, Iron and Steel, Fodder, Plastic, Vegetables (Edible), Pharmaceutical Products, Electrical Machinery and Equipments, Organic Chemicals, etc.	Petroleum Oils, Edible Fruits and Nuts, Iron and Steel, Coffee, Tea, Mate, Spices, Plastic and Articles thereof, Vegetable Textile Fibres, Paper Yarn, Beverages, Spirits, Vinegar, etc.	**Trade Surplus: US$ 15.04 bn** India has a trade surplus with all countries in this region. Major partner countries are Bangladesh, Sri Lanka, Nepal and Pakistan.
South-East Asia (comprises all ASEAN members)	Petroleum (Crude and Products), Transport Equipments, Machinery and Instruments, Meat and Preparations, Gem and Jewellery, Dyes/ Intermediates & Coal Tar Chemical, Electronic Goods, Ground Nuts, Drugs, Pharmaceuticals & Fine Chemicals; Marine Products, etc.	Vegetable Oils Fixed (Edible), Coal, Coke & Briquettes etc, Petroleum (Crude and Products), Electronic Goods, Organic Chemicals, Machinery except Electrical Machinery and Electronics, Metalliferous Ores and Metal Scrap, Transport Equipments, Wood and	**Trade Deficit: US$ 8.34 bn** Except Singapore, Vietnam, Philippines & Cambodia, India has trade deficit with all other member nations. Main trading partners are Indonesia, Singapore, Malaysia, Thailand and Vietnam.

		Wood Products, etc.	
Central Asia (comprises Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, & Uzbekistan.	Pharmaceutical Products, Apparel and Clothing Accessories, Machinery, Coffee, Tea, Mate, Spices, Electrical Machinery and Equipments, etc.	Mineral Fuels, Inorganic Chemicals, Fertilizers, etc.	**Trade Deficit : US$ 0.17 bn** India has trade deficit with Kazakhstan only. Major trading partners are Kazakhstan and Uzbekistan.
Source: Compiled from Export-Import Data Bank, Ministry of Commerce and Industry, India.			

2. Methodology and Database

2.1.1 Measurement of Trade Costs

Obstfeld and Rogoff (2001) commented that that all the major puzzles of international macroeconomics hang on trade costs. Trade costs include all of those variables which affect the volume of bilateral trade between the trading partners. These variables can be tariff barriers, non-tariff barriers, transportation costs, exchange rate fluctuations etc. In the present study, measurement of trade costs is done by using the measure derived by Novy (2008) (see Appendix I). He assumed Anderson and Wincoop (2003) as the starting point for the derivation of trade costs' measure, but ended up with different findings, which are more realistic one. This measure also has some merits over the Anderson and Wincoop (2003) trade cost function; as it does not assumes bilateral trade costs to be symmetric, trade costs does not depend only on the two variables distance and border and also, these are varying over time. The measure is:

$$\tau_{ij} = \left(\frac{x_{ii} x_{jj}}{x_{ij} x_{ji}} \right)^{\frac{1}{2(\sigma-1)}} - 1 \qquad (1)$$

In the above measure, τ_{ij} represents the tariff equivalents of trade costs. x_{ii} and x_{jj} are the intra-national trade in countries *i* and *j* respectively. x_{ij} is the bilateral trade flow from country *i* to *j* and x_{ji} represents the bilateral trade flow from country *j* to *i*. σ is the elasticity of substitution across goods. Here, trade costs (τ_{ij}) depends upon the ratio of intra-national trade ($x_{ii}x_{jj}$) to international trade ($x_{ij}x_{ji}$). If bilateral trade flow ($x_{ij}x_{ji}$) rises relative to the domestic trade flows

($x_{ii}x_{jj}$), it must have become easier for the two countries to trade with each other. This is captured by a decline in bilateral trade costs and vice versa.

2.1.2 Measurement of Infrastructure

To find out the India's ability to the movement of merchandise, the study used infrastructure Index for India. The study treats infrastructure as a proxy of those costs which are equally responsible for movement of goods across within Indian nation. The Infrastructure Index (II) comprises nine infrastructure variables for India. The *II* is constructed based on Principal Component Analysis (PCA). Briefly, the II is a linear combination of the unit free values of the individual facilities such that:

$$II_{it} = W_{kt} X_{kit} \qquad (2)$$

Where, II_{it} is infrastructure development index of the India in t^{th} time, W_{kt} is weight of the k^{th} facility in t^{th} time, and X_{kit} unit free value of the k^{th} facility for the India in t^{th} time point.

While indexing the infrastructure stock of India, study have considered following nine variables which are directly involved in moving the merchandise among countries: (a) Air transport, freight (million ton-km); (b) Air transport, passengers carried; (c) Air transport, registered carrier departures worldwide; (d) Container port traffic; (e) Electric power consumption (kWh per capita); (f) Fixed broadband Internet subscribers (per 100 people); (g) Mobile cellular subscriptions (per 100 people); (h) Rail lines (total route-km); and (i) Road density (km of road per 100 sq. km of land area).

2.2 Database

Present study calculates trade costs of India within the Asian Region for the era of post liberalization (1991 to 2012). Domestic trade of county *i* (x_{ii}) is the total income minus total exports, $x_{ii} = y_i - x_i$. Total exports x_i are defined as the sum of all exports from country ***i*,** $x_{ii} \equiv \sum_{j \neq i} x_{ij}$. As trade data are only for the merchandise goods, so total GDP data cannot be used for the calculation of y_i, because it takes into account the data on all goods and services produced in a particular year. Therefore, the study took the GDP data only for the agricultural and manufacturing sectors and then added these together to form y_i. All data are taken from World

Development Indicators (WDI) and World Integrated Trade Solution (WITS). The study assumes σ =8, which is the middle range of 5 to 10, found by Anderson and Wincoop (2004)[3]. Due to the limited data availability, study took thirty three partners of India within Asia and then categorized these into five groups; East Asia, West Asia, South Asia, Southeast Asia and Central Asia. Information about number of countries and their names, included in each group is given in Table 2:

Table 2. Region-wise description of Asian countries

East Asia	West Asia	South Asia	Southeast Asia	Central Asia
China	Armenia	Afghanistan	Brunei	Kazakhstan
Japan	Azerbaijan	Bangladesh	Cambodia	Kyrgyz Republic
Korea Rep.	Cyprus	Bhutan	Indonesia	
Mongolia	Georgia	Nepal	Malaysia	
	Iran, Islamic Rep.	Pakistan	Philippines	
	Jordan	Sri Lanka	Singapore	
	Kuwait		Thailand	
	Lebanon		Vietnam	
	Oman			
	Saudi Arabia			
	Turkey			
	United Arab Emirates			
	Yemen			

3 Trade Costs of India within Asia

This section calculates the trade costs for the India with East Asia, West Asia, South Asia, Southeast Asia and Central Asia for the period of 1990 to 2012. The behavior of Indian trade costs with each of these Asian regions is given in the figures 2(a) to 2(e). Figures 2(a) to 2(d) are normalized to 1990 and figure 2(e) is normalized to 1995.

[3] Novy (2008) and Duval and Utoktham (2010) also assumed the same elasticity.

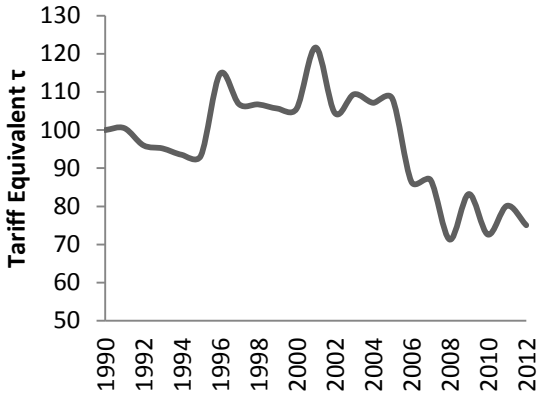

Fig. 2(a): East Asia (1990 = 100)

Fig. 2(b): West Asia (1990 = 100)

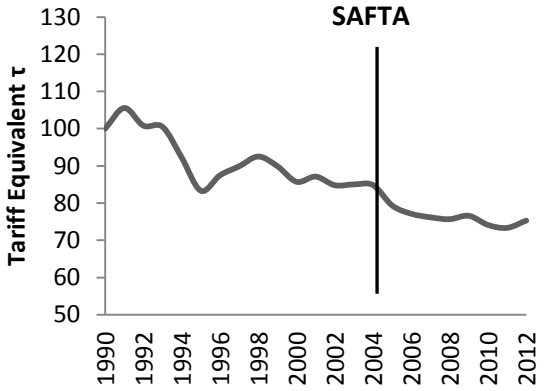

Fig. 2(c): South Asia (1990 = 100)

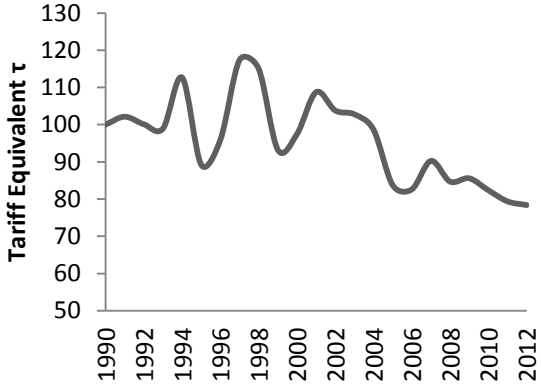

Fig.2 (d): Southeast Asia (1990 = 100)

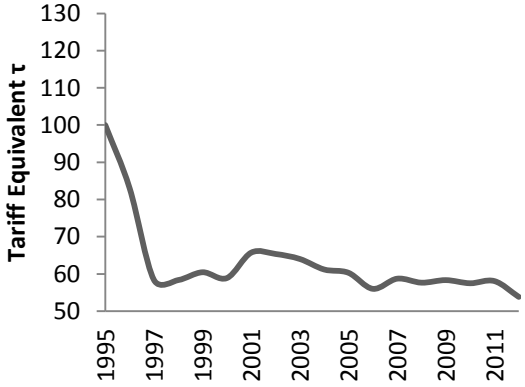

Fig.2 (e): Central Asia (1995 = 100)

In each of the above diagrams the highest peak in the trade costs occurred in the years 1997 to 2000. Among other reasons, one reason of rise in the trade costs between these periods could be the Asian financial crisis, which started in July 1997 in Thailand and soon spread to other Southeast Asian countries including Malaysia, Indonesia and the Philippines. Thereafter, it reaches to South Korea, Hong Kong and China. In 1998, Russia and Brazil's economies also entered in the fall and then also, it affected the stock exchange markets of western world.

3.1 Trade Costs of India with East Asia

Indian trade costs with East Asia are following a downward trend from 1990 to 2012. Fig. 2(a) shows that Indian trade costs declined by almost 25% from the initial year (1990) to final year (2012). After the end of cold war, India in 1991 launched the "look east policy". Under this policy India had signed many trade and non-trade agreements with China, Japan and Republic of Korea, which are the dominant players in the East Asia. These agreements can be a reason of decline in the Indian trade costs with East Asia.

3.2 Trade Costs of India with West Asia

Fig. 2(b) shows that trade costs of India with the West Asia declined by 27 percentage points over the years 1990 to 2012. In the Western Asia most of the countries are the oil and gas producing countries, which are the basic needs of an economy. Some of the West Asian countries stand in the list of top trading partners of India. India has many tie ups with the GCC (Gulf Cooperation Council) countries, due to that the trade costs India are declining with these countries.

3.3 Trade Costs of India with South Asia

As depicted by Fig. 2(c), Indian trade costs with the South Asian countries declined by almost 25% from 1990 to2012. South Asia includes the neighboring countries of India and most of them share a common border with India. Among others, India is a founder member of South Asian Association for Regional Cooperation, which promotes the reduction in trade barriers. In 2004, India signed South Asian Free Trade Area (SAFTA) with other member countries and committed to eliminate the trade barriers and to promote the free trade area, the possible reason causing the trade costs to decline.

3.4 Trade Costs of India with Southeast Asia

The Southeast Asian countries have made concerted attempts to reduce trade costs during the 1990s and 2000s (Pomfret and Sourdin, 2009). Indian trade costs with the Southeast Asian countries are going down over the whole study period, shown by Fig 2(d). India's look east policy is reciprocated by many ASEAN (Association of Southeast Asian Nations) members by expanding their links with the western nations. Since 2002 India is having annual summits with ASEAN and signed the initials of ASEAN–India Free Trade Area (AIFTA) in 2003, which might be a source of declining trade costs of India with Southeast Asian nations.

3.5 Trade Costs of India with Central Asia

Due to less availability of data for the Central Asia, the initial year for the calculation of trade costs is taken as 1995 while in the previous four groups it was 1990. The present study incorporates only two countries from the Central Asia, namely Kazakhstan and Kyrgyz Republic. Indian trade costs with these two are calculated and the Fig. 2(e) shows the trend of trade costs over the time from base year (1995) to final year (2012). It is clear from the diagram that Indian trade costs with Central Asia are falling over time from 1995 to 2012 and fall by 47%.

4. Determinants of Trade Costs

This section is devoted to find out the determinants of calculated trade costs for the Indian economy within Asia. For this, the calculated trade costs are regressed on the average official exchange rate with respect to India (in U.S. dollars), product of tariffs imposed by India and other trading partners, distance between India and partner country, level of infrastructure of India economy and a dummy whether two countries are contagious to each other or not. The regression equation is:

$$\tau_{ijt} = \alpha_{it} - \beta_1 ER_{ijt} + \beta_2 TR_i * TR_j + \beta_3 D_{ij} - \beta_4 Infra_i - \beta_5 Cont_{ij} + \varepsilon_{ijt} \text{.....(3)}$$

The data for the above variables are taken from the World Integrated Trade Solutions (WITS), World Development Indicators (WDI) and CEPII. Here, the Infrastructure Index is constructed with the help of Principal Component Analysis (PCA) (See section 2.2). For the

estimation purpose, all of the above given variables are taken into log forms and then panel data estimation techniques applied. To make a choice between the different panel data estimation techniques, Hausman test and Breusch-Pagan Lagrange Multiplier (LM) tests are done and these tests favored the application of random effects model. Table 3 reports the results obtained by estimating the random effects model.

Table 3 : Determinants of Trade Costs		
Dependent Variable: Trade Costs		
Independent Variables	**Coefficient Values**	**P-values**
Constant	6.984**	0.00
Exchange Rate (ER_{ijt} **)**	-0.020**	0.00
Tariffs ($TR_i * TR_j$ **)**	0.024*	0.04
Distance (D_{ij} **)**	0.011	0.74
Infrastructure ($Infra_i$ **)**	-1.685**	0.00
Contagious ($Cont_{ij}$ **)**	-0.168**	0.00
R^2 = .32 **No. of Observations = 498**		
Note: * and ** represents the coefficient is significant at 5 and 1 percent level of significance respectively.		
Source: Authors' Calculations.		

Here, the exchange rate is defined terms of India, so if exchange rate rises it leads to the depreciation of Indian currency. Due to depreciation, Indian exports will increase and imports will go down, if the increase in exports outweighs the decline in imports (Only if MLR conditions are satisfied). Hence, total trade goes up, which also means that trade costs are declining because of inverse relationship between trade costs and trade. In the present study, Official exchange rate is inversely and significantly affecting the trade costs. In other words, we can say that due to the depreciation of Indian currency leads to rise in the volume of total trade. Tariffs applied by India and other partner countries leads to the aggravation of trade costs and it is confirmed by the positive and significant value of the $TR_i * TR_j$ variable. The distance variable is positively affecting the trade costs which mean that India is facing high trade cots from its far located trading partners.

For a traded good, some costs are incurred from the exporter's side to move it from the originating place to the sea port and then on the same good, some costs are incurred from the importer's side to move it from the sea port to distributor/consumer. These costs are a part of total costs incurred on the traded commodity. If the infrastructure facilities are improved, then these local costs will go down and ultimately the trade costs will decline. The same event is happening in case of India, which is depicted by the negative and significant value of the infrastructure variable. So if the level of Indian infrastructure is improved, it will lower down the trade costs of India with its Asian partners. The last variable (i.e., contagious) is negatively and significantly affecting the trade costs of India with its trading partners, which means that India is facing low level of trade costs from its contagious countries.

The value of the coefficient of determination (R^2) of estimated equation is low, i.e. R^2 = .32. It means that the above determinants of trade costs are explaining only the one third portion of the calculated trade costs and still two third portion of the trade costs is remained unexplained. So distance, tariffs, border, exchange rate and infrastructure are not the suffice proxies for the trade costs because other variables like non-tariff barriers, transportation costs and local distribution costs etc. are also playing their role in determining the trade costs of India.

5. Conclusions

The literature of the measurement of trade costs is at very early stage of its developments. This study calculated the trade costs of Indian economy within Asia and then also, it attempted to find out the determinants of these calculated trade costs. For the calculation of trade costs the study used trade costs measure developed by Novy (2008). It is found that trade costs of India with its all Asian partners are declining over the whole study period except the years of Asian financial crisis. Further, the variables, used as determinants of trade costs, are behaving in the proper way as expected. But these determinants are unable to explain the major portion of trade costs, which means that other factors, such as, transportation costs, non-tariff barriers and local distribution costs among others, may have an influential role in determining the trade costs.

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References

Anderson, J.E. (1979). A Theoretical Foundation for the Gravity Equation. American Economic Review, 69, 106-116.

Anderson, J.E. and Wincoop, E.V. (2003). Gravity with Gravitas: A Solution to the Border Puzzle. American Economic Review, 93 (1), 170-192.

Anderson, J.E. and Wincoop, E.V. (2003). Trade Costs. Journal of Economic Literature, 42 (3), 691-751.

Annual Report (2013). Annual Report 2012-13. Department of Commerce, Ministry of Commerce and Industry, Government of India.

De, P. (2006). Empirical Estimates of Trade Costs for Asia. Third LAEBA Annual Meeting Seoul, South Korea. http://www10.iadb.org/intal/intalcdi/PE/2012/11144a03.pdf

Duval, Y. and Utoktham, C. (2011). Intraregional Trade Costs in Asia: A Premier. UNESCAP, Trade and Investment Division, Staff Working Paper 01/10.

Duval, Y. and Utoktham, C. (2011). Trade Costs in the India-Mekong Sub-region: Identifying Policy Priorities for Trade Facilitation. UNESCAP, Trade and Investment Division, Staff Working Paper 04/11.

Jacks, D. S., Meissner, C. M. and Novy, D. (2006). Trade Costs in the First Wave of Globalization. NBER Working Paper 12602.

Jacks, D. S., Meissner, C. M. and Novy, D. (2008). Trade Costs, 1870-2000. The American Economic Review: Papers and Proceedings, 98 (2), 529-534.

Jacks, D. S., Meissner, C. M. and Novy, D. (2009). Trade Booms, Trade Busts and Trade Costs, NBER Working Paper No. 15267.

Khan, I. U. and Kalirajan, K. (2011). The impact of trade costs on exports: An empirical modeling. Economic modeling, 28, 1341-1347.

McCallum, J. (1995). National Borders Matter: Canada-U.S. Regional Trade Patterns. American Economic Review, 85(3), 615-623.

Novy, D. (2008). Gravity Redux: Measuring International Trade Costs with Panel Data. University of Warwick. http://economics.uwo.ca/conference/thechangingglobal_apr08/novy.pdf

Obstfeld, M. and Rogoff, K. S. (2001). The Six Major Puzzles in International Macroeconomics: Is There a Common Cause. in NBER Macroeconomics Annual 2000, ed. Ben S. Bernanke and Kenneth S. Rogoff, 339-89. Cambridge, MA: MIT Press.

Pomfert, R., and Sourdin, P. (2010). Trade Facilitation and Measurement of Trade Costs. Journal of International Commerce, Economics and Policy, 1 (1), 145-163.

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

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Appendix I

Derivation of Trade Costs of Novy (2008)

Anderson and Wincoop (2003)'s framework

$$x_{ij} = \frac{y_i y_j}{y^w}\left(\frac{t_{ij}}{\pi_i p_j}\right)^{1-\sigma} \qquad (1)$$

and

$$\pi_i{}^{1-\sigma} = \sum_j p_j^{1-\sigma}\theta_j t_{ij}^{1-\sigma} \quad \forall_i \qquad (2)$$

$$p_j{}^{1-\sigma} = \sum_i \pi_i^{1-\sigma}\theta_i t_{ij}^{1-\sigma} \quad \forall_j \qquad (3)$$

By using gravity equation (1) to find the expression for country *i*'s intranational trade:

$$x_{ii} = \frac{y_i y_i}{y^w}\left(\frac{t_{ii}}{\pi_i p_i}\right)^{1-\sigma} \qquad (4)$$

Where t_{ii} represents intranational trade costs, for example domestic transportation costs. Equation (4) can be solved for the product of outward and inward multilateral resistance as:

$$\pi_i p_i = \left(\frac{x_{ii}/y_i}{y_i/y^w}\right)^{\frac{1}{(\sigma-1)}} t_{ii} \qquad (5)$$

The explicit solution for the multilateral resistance variables can be exploited to solve the general equilibrium model bilateral trade costs. Gravity equation (1) contains the product of outward multilateral resistance of one country and inward multilateral resistance of another country, $\pi_i p_j$, whereas equation (5) provides a solution for $\pi_i p_i$. It is therefore useful to multiply gravity equation (1) by the corresponding gravity equation for trade flows in the opposite direction, x_{ji}, to obtain a bidirectional gravity equation that contains both countries' outward and inward multilateral resistance variables:

$$x_{ij}x_{ji} = \left(\frac{y_i y_j}{y^w}\right)^2\left(\frac{t_{ij}t_{ji}}{\pi_i p_i \pi_j p_j}\right)^{1-\sigma} \qquad (6)$$

Substituting the solution from equation (5) yields,

$$x_{ij}x_{ji} = \left(\frac{y_i y_j}{y^w}\right)^2\left(\frac{t_{ij}t_{ji}}{\left(\frac{x_{ii}/y_i}{y_i/y^w}\right)^{\frac{1}{(\sigma-1)}} t_{ii}\left(\frac{x_{jj}/y_j}{y_j/y^w}\right)^{\frac{1}{(\sigma-1)}} t_{jj}}\right)^{1-\sigma}$$

$$x_{ij}x_{ji} = \left(\frac{y_i y_j}{y^w}\right)^2 \left(\frac{t_{ij}t_{ji}}{t_{ii}t_{jj}} \left(\frac{x_{ii}/y_i}{y_i/y^w}\right)^{\frac{1}{(1-\sigma)}} \left(\frac{x_{jj}/y_j}{y_j/y^w}\right)^{\frac{1}{(1-\sigma)}}\right)^{1-\sigma}$$

$$x_{ij}x_{ji} = \left(\frac{y_i y_j}{y^w}\right)^2 \left(\frac{x_{ii}/y_i}{y_i/y^w}\right)^{\frac{1-\sigma}{(1-\sigma)}} \left(\frac{x_{jj}/y_j}{y_j/y^w}\right)^{\frac{1-\sigma}{(1-\sigma)}} \left(\frac{t_{ij}t_{ji}}{t_{ii}t_{jj}}\right)^{1-\sigma}$$

$$x_{ij}x_{ji} = \left(\frac{y_i y_j}{y^w}\right)^2 \left(\frac{x_{ii}}{y_i}\frac{y^w}{y_i}\right)\left(\frac{x_{jj}}{y_j}\frac{y^w}{y_j}\right)\left(\frac{t_{ij}t_{ji}}{t_{ii}t_{jj}}\right)^{1-\sigma}$$

$$x_{ij}x_{ji} = \left(\frac{y_i y_j}{y^w}\right)^2 \left(\frac{y^w}{{y_i}^2}\right)\left(\frac{y^w}{{y_j}^2}\right)(x_{ii}x_{jj})\left(\frac{t_{ij}t_{ji}}{t_{ii}t_{jj}}\right)^{1-\sigma}$$

$$x_{ij}x_{ji} = \left(\frac{y_i y_j}{y^w}\right)^2 \left(\frac{y^w}{y_i y_j}\right)^2 (x_{ii}x_{jj})\left(\frac{t_{ij}t_{ji}}{t_{ii}t_{jj}}\right)^{1-\sigma}$$

$$x_{ij}x_{ji} = (x_{ii}x_{jj})\left(\frac{t_{ij}t_{ji}}{t_{ii}t_{jj}}\right)^{1-\sigma}$$

$$x_{ij}x_{ji} = (x_{ii}x_{jj})\left(\frac{t_{ii}t_{jj}}{t_{ij}t_{ji}}\right)^{\sigma-1} \qquad (7)$$

The size variables in the gravity equation (7) are not total income $y_i y_j$as in traditional gravity equations but intranational trade $x_{ii}x_{jj}$. Intranational trade does not only control for the countries' economic size, but according to equation (5) it is also directly linked to multilateral resistance. (7) can be rearranged as:

$$\frac{t_{ij}t_{ji}}{t_{ii}t_{jj}} = \left(\frac{x_{ii}x_{jj}}{x_{ij}x_{ji}}\right)^{\frac{1}{\sigma-1}} \qquad (8)$$

As shipping costs between *i* and *j* can be asymmetric $(t_{ij} \neq t_{ji})$ and as domestic trade costs can differ across countries$(t_{ii} \neq t_{jj})$, it is useful to take the geometric mean of the barriers in both directions. It is also useful to deduct one to get an expression for the tariff equivalent. The resulting micro-founded trade cost measure is denoted as τ_{ij}:

$$\tau_{ij} = \left(\frac{t_{ij}t_{ji}}{t_{ii}t_{jj}}\right)^{\frac{1}{2}} - 1 = \left(\frac{x_{ii}x_{jj}}{x_{ij}x_{ji}}\right)^{\frac{1}{2(\sigma-1)}} - 1 \qquad (9)$$

τ_{ij} measures bilateral trade costs $t_{ij}t_{ji}$ relative to domestic trade costs $t_{ii}t_{jj}$. It therefore does not impose frictionless domestic trade and captures what makes international trade more costly over above domestic trade.

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