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Abstract

Specialization models are important in providing a solid theoretical ground for gravity equation in bilateral trade. Some research papers try to improve specialization models by adding imperfect specialization to them, but we believe it is unnecessary complication. We provide a perfect specialization model based on the phenomenon that we call tradability, which overcomes the problems with simpler models. We provide empirical evidence using estimations on panel data of bilateral trade of 40 countries over 10 years that support the theoretical model.

Keywords: bilateral trade, gravity equation, perfect specialization, tradability.

JEL classification: F11, F14, C23, E23.

Introduction

Studying trade is one of the most important branches of economics. Although it is as old as economics itself (since Ricardo [1819]), it is gaining much more importance as international trade has been growing tremendously. Gravity equation is a form of empirical relation explaining the flow of bilateral trade by the size of two engaging countries and negatively by distance between them usually in a form resembling the law of gravity in Physics. The traditional relationship did not have a theoretical basis, but theories of trade have tried to explain this equation (Deardorff 1998).

There are a lot of theories, which try to explain the pattern of international trade. A branch of these theories are based on relative factor abundance. One of the common relative-factor-abundance models is the Heckscher-Ohlin model. This theory predicts that trade patterns would be based on relative factor advantages. Those countries with a relative abundance of one factor are expected to produce goods that require a comparatively large amount of that factor in their GDP. Although this model generally is accepted as the theory of trade but does not satisfy empirical results (Bergstrand 1989).

A study by Wassily Leontief indicates that the exports of United States as the most capital endowed country included more labour intensive commodities, which suggests the opposite result. This contradiction is known as the Leontief paradox. The Leontief paradox makes doubt about that Heckscher-Ohlin works in the real world.

An alternative theory, first proposed by Linder (1961), claims that the pattern of trade is determined by similarity of two country's preferences (Bohman and Nilson 2007). Countries with similar demand develop similar industries that result in producing similar goods and services. These countries continue trade in differentiated but similar goods. Linder (1961) writes, "The more similar the demand structure of the two countries the more intensive potentially is the trade between these two countries." Importance of Linder's hypothesis considering demand part is what departs it from neoclassical theories of trade, which pay attention only to production features' part. Linder suggests that per capita income can be used as a proxy for preferences. The hypothesis can then be tested by comparing per capita income between trading partners. It means the more similar two country's GDP's are, the more they trade. That result is consistent with the gravity equation.

Helpman and Krugman (1985) develop the Lender's idea. They observed that countries with similar levels of income trade more (Bohman and Nilson 2006). This is not supported by Heckscher-Ohlin model of trade and comparative advantage theory. They introduced Increasing Returns to Scale as the fundamental factor that account for part of trade known as intra-industry trade. They relax the neoclassical assumption, perfect competition market. Substantial theoretical progress has been made using three different approaches. First is the Marshallian approach, where the economies of scale is assumed external to firms; second is the Chamberlinian approach, where imperfect competition takes the relatively tractable form of monopolistic competition; and the third one is the Cournot approach of non-cooperative quantity-setting firms.

The reciprocal dumping model – in which both countries export the same good to each other to gain higher profits by supplying their product to the other country with lower prices than their own market (Krugman and Obstfeld 2009) – also explains gravity equation. Feenstra, Markusen, and Rose (1998) provided evidence for reciprocal dumping by assessing the “home market effect” in separate gravity equations for differentiated and homogeneous goods. The home market effect showed a relationship in the gravity estimation for differentiated goods, but showed the inverse relationship for homogeneous goods. The authors show that this result matches the theoretical predictions of reciprocal dumping playing a role in homogeneous markets.

At all, the literature about the gravity model of trade includes two debates: first what model is the theoretical base of gravity equation and second what factors account for deviation of actual bilateral trade from gravity form. To answer the first question, Deardorff (1998) claims that the basic gravity model can be derived from Heckscher-Ohlin as well as the Linder and Helpman-Krugman hypotheses. Deardorff (1998) concludes that, considering how many models can be tied to the gravity model equation; it is not useful for evaluating the empirical validity of theories. Barriers, Demand structure, and imperfect specialization are three factors, which were noticed as basic factors for deviation from gravity equation.

To answer the second question Evenett and Keller (2002) suggest that relaxing the perfect specialization assumption produces much better results. They support an imperfect specialization based on a model identification approach consisting of two conditions, first the model should provide a regression coefficient less than one, i.e. can match the real-world data; and second the model should be consistent with the correlation of specialization index and the regression coefficient. As we mentioned the first condition is a kind of gravity-equation-support-identification and the second one checks if the model can provide an explanation for actual bilateral trade deviations from traditional gravity equation. We provide a perfect specialization model based on the phenomenon that we call tradability, which explains the less-than-one coefficient by non-tradeable share of GDP rather than levels of specialization. We provide empirical evidence using estimations on panel data of bilateral trade of 40 countries over 10 years that support the theoretical model. We also provide some empirical evidence on how imperfect specialization might not address the fundamental deviation factor since high correlation of specialization index with other important deviation factors like trade cost and barriers. The remainder of the paper is structured as follows. In the section 2, we review Evenett and Keller's model identification approach. Then we introduce our model of perfect specialization based on the tradability phenomenon in section 3. Section 4 provides information about data used for the study and also the tradability index we calculated for 40 countries. Section 5 gives the empirical test results. And section 6 concludes.

Model Identification Approach

Evenett and Keller's identification approach consists of two steps based on a regression of this type:

$$X_{ab} = \alpha\left(X_{ab}^{Model}\right) + \varepsilon_{ab} \tag{1}$$

where X_{ab}^{Model} is the trade predicted based on gravity equation.

If we ignore the theoretic base of each specialization model, Evenett and Keller suggest that all perfect specialization models will lead in a gravity equation as in follows:

$$X_{ab} = \frac{Y_a \times Y_b}{Y_w} \tag{2}$$

in which X is export volume, Y is the gross domestic product and a, b, and w indices are respectively indicators of exporting country, importing country, and the world. As obvious in eq. 2, the coefficient of the fraction is equal to one, i.e. if this is the true model, estimated α in regression in eq. 1 will be not be significantly different from one. Evenett and Keller (2002) give gravity equations in form of eq. 3 and eq. 4 based on two different imperfect specialization models.

$$X_{ab} = (1 - \gamma_a) \frac{Y_a \times Y_b}{Y_w} \tag{3}$$

$$X_{ab} = (\gamma_b - \gamma_a) \frac{Y_a \times Y_b}{Y_w} \tag{4}$$

in which γ is the specialization index (a number between 0 and 1). As obvious, the coefficient of the fraction in these models is less than one. Evenett and Keller has shown that this coefficient is indeed less than one in bilateral trade data. They conclude thus that perfect specialization models are incapable of explaining the data regarding this coefficient.

The second criteria in Evenett and Keller (2002) is that the model should provide reasons why the coefficient departs from 1. They run different regressions to estimate the coefficient of the fraction from data using five different levels of specialization, and claim that specialization index they use correlates reversely with the estimates of coefficient of the fraction. Their results are summarized in panels (a) to (d) of Figure 1, and shows a weak relationship.

A Model of Gravity with Perfect Specialization based on Tradable/Non-tradable Product Distinction

Assume that there are three goods in world named as *s*, *t* and *z*. Assume that *s* is not tradeable and so to be precise we should use different notation for product *s* of each country. Assuming that there are two countries *a* and *b*, we call the *s* produced and consumed in country *a*: s_a, and the *s* produced and consumed in country *b*: s_b. Either reason of perfect specialization, namely IRS forces or H-O model forces, can be assumed as the reason for perfect specialization in tradable goods in model. Perfect specialization leads to each country to produce either of *t* or *z*. We assume that *a* is producing *t* and *b* is producing *z*.

So these countries GDP's are:

$$Y_a = t + s_a \tag{5}$$

$$Y_b = z + s_b \tag{6}$$

and so letting λ's denote tradable share of GDP we have:

$$\lambda_a = \frac{t}{Y_a} = \frac{t}{t+s_a} \tag{7}$$

$$\lambda_b = \frac{z}{Y_b} = \frac{z}{z+s_b} \tag{8}$$

Supposing identical homothetic preferences, we have that each country's share in consumption of each commodity is equal to its share of world GDP, i.e.

$$X_{ab} = \frac{Y_a}{Y_w} z = \lambda_b \frac{Y_a \times Y_b}{Y_w} \tag{9}$$

To simplify the perfect specialization model, Evenett and Keller (2002) assume that the share of non-tradable goods in GDP is identical for all countries. We do not simplify further as we believe that the idea of tradeable share of GDP plays a great role in forming gravity equation and any simplification might lead to unreasonable results. Thus our model leads in a gravity equation with a coefficient of the ratio less than 1. To support the second criteria we shall show that the deviation of estimate of coefficient of the ratio is related to the share of non-tradable production in GDP. To show this we take logarithms of eq. 9 to get:

$$\ln(X_{ab}) = \beta_0 + \beta_1 \ln \lambda_a + \beta_2 \ln(\frac{Y_a \times Y_b}{Y_w}) + \varepsilon \qquad (10)$$

Which is in fact the logarithm of eq. 11:

$$X_{ab} = e^{\beta_0} \times \lambda_a^{\beta_1} \times \left(\frac{Y_a \times Y_b}{Y_w}\right)^{\beta_2} \qquad (11)$$

Thus $\hat{\beta}_1 = \hat{\beta}_2 = 1$ shows complete accordance of the model to the data. On the other hand tradable production share in GDP is important only if $\hat{\beta}_1$ is statistically significant.

Data

World commodity trade data are gathered from UN ComTrade and UN Service Trade data set provides the data on trade of services. National account data are from World Development Indicators data set. 40 countries are selected that constitute a large part of world GDP (about 90%) and world trade. Saudi Arabia and Israel are dropped because of technical problems such as missing data. Table 2 lists the countries used for this study. The data form a panel of 1600 (40x40) export relationship over 10 years (2000-2009).

Calculating Tradable Productions Share

Model proposed in this paper is based on the tradeable production share in GDP, so we shall provide some data on this phenomenon. However, in reality, no data are gathered for tradability. We only observe traded goods and services, not what was potentially tradable. We study sectors of production and compare the shares of each sector in world production and world trade and decide if that section is tradable. For example, agriculture constitutes about 5.61 percent of the world trade, but only 3.35 percent of world GDP, thus we can say that agriculture is tradeable. Adding up tradable sectors, we can calculate the tradability index of each country. Even so, these calculations are not precise because of absolute decision on tradability of sectors. Textiles' share, as an example, is less than 0.5 percent of world GDP, yet more than 6 percent in world trade, so in fact textile is much more tradable than agriculture. So we use relative tradability with comparing the shares with the most tradable sector (textiles). So if 100 percent of textile is considered tradable, 81% of chemical and 12.36% of agricultural products are tradable. On the other hand, only 2.31 percent of services (which is considered a non-tradable sector) are tradable.

We use the data from Table 1 to calculate the tradability index for each country in each year. Table 2 reports the average tradability index for countries of the study from 2000 to 2009. As shown in this table, Indonesia, Singapore, Malaysia, and South Korea had the highest indices. This means that these countries have production structures that are able to export more. The calculated index is not based on trade data of these countries and is only based on the production structure. Data in Table 2, is plotted on the map of the world in Figure 2.

The Results

Equation 10 is estimated on the bilateral trade data which is a 1560x10 panel. This panel is unbalanced by nature (not all countries have exported to all countries in every year). 6624 observations are available. We estimated the equation using both fixed effect model and random effect model. Testing the null hypothesis that no panel effects exits (thus recommending use of pooled estimates) is rejected. Hausman (1978) test indicates that panel effects are fixed effects, and random effects estimations leads to biased estimates of the equation (Baltagi 2008). Table 3 reports the results of the both models and Hausman test results are reported in Table 4. As we can see in Table 3, both coefficients of interest $\hat{\beta}_1$ and $\hat{\beta}_2$ are statistically not different than 1, thus the theoretic model is supported with data. $\hat{\beta}_2 = 1$ means that the core part of the gravity equation, i.e. that trade is positively related to the multiplication of GDP of both partners is modelled in a way that is completely compatible with data. $\hat{\beta}_1 = 1$ means that the tradability index is the sole reason for deviations of data from basic perfect specialization models.

Conclusion

We provided a perfect specialization model based on the tradability phenomenon, which does not have the problems indicated by Evenett and Keller (2002), namely that our perfect specialization model totally explains the deviations of data from simpler perfect specialization models without entrapment in the complexities of imperfect specialization models (which we do not believe are doing any good in explaining the data). Empirical evidence using estimations on panel data of bilateral trade of 40 countries over 10 years totally and fully supports the theoretical model. In the process of providing empirical evidence, we built and reported an index of tradability, which is a measure of the potentials of a country to be an exporter.

References

Bergstrand, J.H (1989). "The Generalized Gravity Equation, Monopolistic Competition and the Factor-Proportions Theory in International Trade." *The Review of Economics and Statistics.* **71**(1): 143-153.

Bohman H, & Nilson, D. (2007) "Market Overlap and the Direction of Exports: A New Approach of Assessing the Linder Hypothesis." *Working Paper Series in Economics and Institutions of Innovation.* **86.** Royal Institute of Technology.

Deardorff, A. (1998). "Determinants of Bilateral Trade: Does Gravity Work in a Neoclassical World?", in *The Regionalization of the World Economy*, edited by J.A. Frankel. Chicago: Univ. Chicago Press for National Bureau of Economic Research. 7-32.

Evenett, S. J., & Keller, W. (2002). "On Theories Explaining the Success of the Gravity Equation." *Journal of Political Economy*, **110** (2): 281-361.

Feenstra, R. C., Markusen, J. A., & Rose, A. K. (1998). *Understanding the home market effect and the gravity equation: The role of differentiating goods* (No. w6804). National Bureau of Economic Research.

Hausman, J. A. (1978). "Specification tests in econometrics," *Econometrica,* **46**(6): 1251-1271.

Helpman, E., & Krugman, P. R. (1985). *Market structure and foreign trade: Increasing returns, imperfect competition, and the international economy*. MIT press.

Krugman, P. R., & Obstfeld, M. (2009). *International Economics: Theory and Policy*. Pearson Education.

Linder S.B. (1961). *An Essay on Trade and Transformations.* Stockholm: Almqvist & Wiksell.

Ricardo, D., (1819). *The principles of political economy and taxation*.

Table 1: Tradability of Each Economic Sector

Sector	Share in (%) World GDP	World Trade	Ratio	Result	Relative Tradability
Agriculture	3.35	5.61	1.67	Tradable	12.36
Non-manufacturing industry	10.00	7.20	0.72	Non-tradable	5.32
Chemicals	1.68	18.40	10.95	Tradable	80.84
Food, beverages and tobacco	1.87	1.12	0.60	Non-tradable	4.42
Machinery and transport equipment	4.57	32.99	7.21	Tradable	53.25
Other manufacturing	7.77	7.08	0.91	Non-tradable	6.73
Textiles and clothing	0.46	6.17	13.55	Tradable	100.00
Services	68.37	21.43	0.31	Non-tradable	2.31

Source: Authors.

Table 2: Average of 2000-2009 Tradability Index for 40 Countries

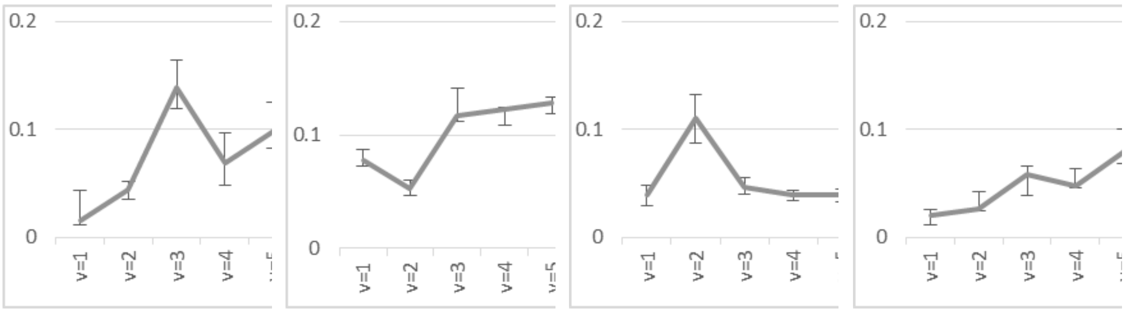
Country	Tradability	Country	Tradability
Argentina	7.31	Japan	9.57
Australia	4.83	Malaysia	13.56
Austria	7.77	Mexico	8.12
Belgium	8.03	Netherlands	6.27
Brazil	8.25	Norway	5.93
Canada	7.56	Poland	6.86
China	6.19	Portugal	7.45
Colombia	8.00	Rep. of Korea	13.24
Czech Rep.	8.92	Russian Federation	6.70
Denmark	5.27	Singapore	13.67
Egypt	11.24	South Africa	7.02
Finland	9.21	Spain	7.50
France	7.04	Sweden	7.63
Germany	9.99	Switzerland	6.99
Greece	5.25	Thailand	10.59
India	10.35	Turkey	10.60
Indonesia	13.74	United Arab Emirates	11.94
Iran	8.45	United Kingdom	6.69
Ireland	11.40	USA	7.10
Italy	9.13	Venezuela	11.76

Source: Authors.

Table 3: Estimating the Gravity Equation based on Imperfect Specialization Model of Bilateral Trade; Fixed and Random Effect Models

Coefficient	Fixed Effects Model	Random Effects Model
$\hat{\beta}_0$	-4.4434*** (0.3798)	-3.7589*** (0.3354)
$\hat{\beta}_1$	0.9573*** (0.1039)	0.7117*** (0.0861)
$\hat{\beta}_2$	1.0178*** (0.0130)	1.0098*** (0.3355)
No. of Observations	6624	6624
F Test (Degrees of Freedom)	3077.41	
Degrees of Freedom of F Test	2, 5067	
Prob > F	0.0000	
Wald Chi-squared Test		7523.48
Degree of Freedom of Wald Test		2
Prob > Chi2		0.0000

Source: Authors.



(a) (b) (c) (d)

Figure 1. Estimates of Coefficients of Gravity Equation versus Specialization Level.

Source: based on estimations provided by Evenett & Keller (2002)

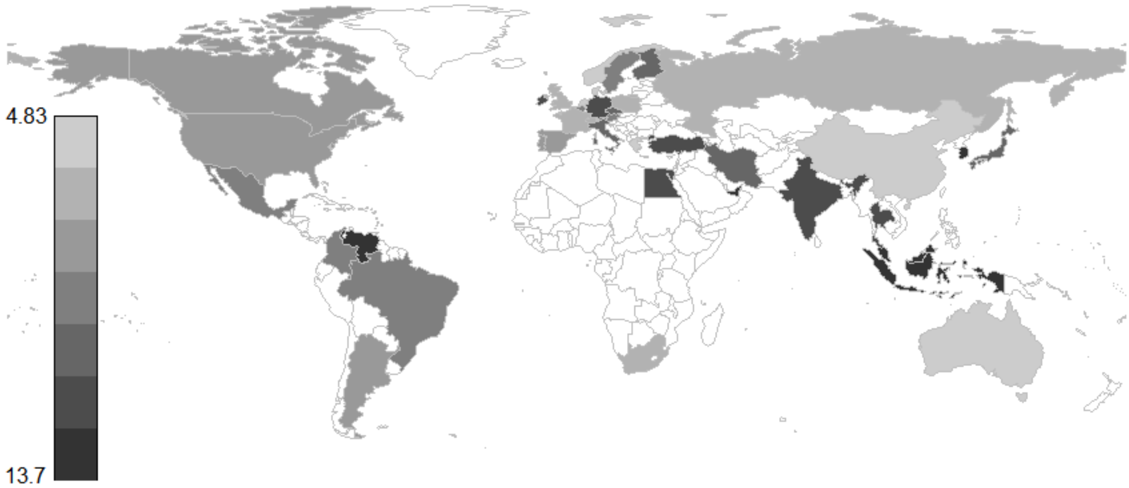


Figure (2) Average of 2000-2009 Tradability Index for 40 Countries

Source: *Authors*