Homework

The Gravity Equation

ECO-13101 Economia Internacional I (International Trade Theory)*

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In this homework, we will depict, graphically, the central themes of the gravity equation: (i) a larger country exports and imports more than a smaller country; (ii) trade between two countries decreases as the distance between the two countries increases. We will carry out this exercise for the OECD countries (though not all of them).

Download the excel file named "DataforGravityEqn.xlsx" from my website. The file has three worksheets: (i) Absorption 1996, (ii) Biateral Trade 1996, and (iii) Distance.

In *Absorption 1996* you will find data on total Absorption (denoted by X_n) in U.S. dollars, where n is a country. Total Absorption is defined as

$$X_n = X_{nn} + \sum_{i \neq n} X_{ni} \quad , \tag{1}$$

where X_{nn} is the amount of goods country n buys from its own producers and X_{ni} ($i \neq n$) is the imports of country n from country i. We will denotes total imports of country n by

$$I_n = \sum_{i \neq n} X_{ni} \quad . \tag{2}$$

In *Bilateral Trade 1996* you will find data on bilateral imports. Each row is an exporting country (i), while each column is an importing country (n). Value in each cell, denoted by X_{ni}, represents the imports of country n (importer - the country for that column) from country i (exporter - the country for that row). The values are expressed in U.S. dollars. Notice that this matrix includes what each importing country buys from itself, i.e. X_{nn}.

Lastly, *Distance* gives data on the distance between trading partners. Each row is an exporting country (i), while each column is an importing country (n). Value in each cell, denoted by τ_{ni}, represents the distance between country n (importer - the country for that column) and country i (exporter - the country for that row). It is obvious that the distance between two countries is the same irrespective who the exporter or importer is, i.e. $\tau_{ni} = \tau_{in}$. Distance is measured in kilometers (Km).

Exercise 1: Imports versus Size

Plot (scatter plot) natural logarithm of total imports $\ln(I_n)$ against natural logarithm of total absorption $\ln(X_n)$, across countries. Let absorption be on the X axis and imports be on the Y axis. Label each axis carefully. This graph should (hopefully!) look similar (qualitatively) to the graph on slide 6 of the lecture notes on Gravity Equation. Interpret the graph.

Exercise 2: Market Share and Size

Plot (scatter plot) country i's market share in each destination n, X_{ni}/X_n (on Y axis), against country i's total production, Y_i (on X axis). Note that the figure will also include observations on country i's penetration of its own domestic market, X_{ii}/X_i. Choose a different symbol to represent this observation (say a + rather than a circle). This graph will, (again hopefully!), look like the one on slide 7 of the lecture notes on Gravity Equation. Interpret the graph.

Exercise 3: Distance and Trade Volume

To isolate the role of geography construct an index of bilateral trade defined as, $B_{ni} = \sqrt{(X_{ni}.X_{in})/(X_{ii}.X_{nn})}$. This index appropriately adjusts for the effect of size by normalizing with the home sales of each country in the pair, and treats the countries in the pair symmetrically. Plot B_{ni} against distance τ_{ni}, across all country pairs, excluding the country pairs in which importer and exporter are the same.

Question 2

Consider a world with two countries - home (h) and foreign (f). Both countries produce two goods - a traded good (T) and a non-traded good (N). Good N produced in the two countries is exactly identical. However, good T produced by home country is not identical to good T produced by foreign country. Think of this as each country producing a unique variety of good T. The utility function of the representative consumer in country $i = \{h, f\}$ is given by:

$$U_i = \left[\left\{T_{ii}^{\rho} + T_{ij}^{\rho}\right\}^{1/\rho}\right]^{\theta} N_i^{1-\theta} \quad , j \neq i \quad , and \;\; 0 < \theta, \rho < 1 \quad .$$

T_{ii} is the consumption, in country i, of good T produced in country i. T_{ij} is the consumption, in country i, of good T produced in country j ($j \neq i$). N_i is the consumption of good N in country i. Production of goods takes place with only factor - labor. The outputs of good T and good N produced in country i are given by:

$$Y_i^T = \alpha_i L_i^T \quad ,$$

$$Y_i^N = \beta_i L_i^N \quad .$$

The endowment of labor in both countries - $\overline{L}_h, \overline{L}_f = 1$. Goods as well as factor markets are perfectly competitive. Let the wage rate in country i be denoted by w_i, the price of good T produced in country i be denoted by p_i^T and the price of good N produced in country i be denoted by p_i^N, where $i = \{h, f\}$. Suppose, transporting 1 unit of good T produced in country j to country i incurs a cost of τ_{ij} % ($j \neq i$) on the value of 1 unit of the good.

1. Set up the firms' profit maximization problem for the traded good sector and the non-traded good sector in country i. Use the first-order conditions to obtain expressions for p_i^T and p_i^N. What are the terms-of-trade of home and foreign country.

2. Set up the utility maximization problem of the consumer in country i. Use the first-order conditions to obtain a relationship between T_{ii} and T_{ij}, and T_{ii} and N_i. Use the relationship between T_{ii} and T_{ij}, and the expressions for prices derived above, to obtain the following expression for the ratio of the expenditure of i on goods produced in i (X_{ii}) and expenditure of i on good imported from j (X_{ij}):

$$\log\left(\frac{X_{ii}}{X_{ij}}\right) = \frac{\rho}{1-\rho}\log\left(\frac{w_j}{w_i}\right) + \frac{\rho}{1-\rho}\log\left(\frac{\alpha_i}{\alpha_j}\right) + \frac{\rho}{1-\rho}\log(1+\tau_{ij}) \quad .$$

   Interpret this expression by explaining the effect of wages, labor productivities, and trade costs on $\log(X_{ii}/X_{ij})$.

3. Normalize $w_h = 1$, and use the Cobb-Douglas form of the utility function and the balanced trade condition for h (revenue from exports is equal to the expenditure on imports) to obtain an equation to characterize the wage in f. In other words, obtain an equation in terms of w_f, trade costs and parameters of the model.

4. Suppose, initially, $\theta = 0.5$ for both h and f. Now, consider the case where f is a rich country, and it spends a larger fraction of its income on the non-traded good (services

like restaurants, movies, etc.). h, on the other hand, is a developing economy that spends an equal fraction of its income on the traded good (food products, consumer durables) and the non-traded good. So, when θ of f is 0.25 and that of h remains unchanged at 0.5, explain, intuitively, what would be the affect on the volume of trade and the gains from trade.