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Gravity Model: South Korea

Introduction:

This paper explores trade of South Korea based on gravity model. When we hear the word 'gravity', first thing that comes to mind is an apple falling on Newton's head. This is a classic story told to generations after generations for centuries. The gravity model that I apply here is indeed derived from physics and applied to international trade. I determined through my gravity model that trade is positively related to the economic size of the country. Every country isn't same, even though they might have the same economic size, thus I will factor in population through per capita GDP in the model. Furthermore, I will analyze how geographical factor such as distance would impact the trade between these countries within the model.

I will analyze the relationship between economic size (GDP), per capita income and geographical factor (distance) with bilateral trade by using a natural log regression model. I illustrate that further through line fit plot and residual charts between the predicted points through model and actual data collected.

The paper will also review other factors that might have impact on the trade such as trade restrictions, tariffs and embargos. I will also analyze how these factors would impose errors in my results. I will further analyze how the quality of the data might have been compromised.

Trade is defined as the action of buying and selling goods and services. As humans, we have been doing this from early civilization. Even when there wasn’t any currency through barter of different commodities. The trade was mostly local in early civilizations, but it has flourished through innovation in transportation making it faster, affordable and global.

Analytical Model:

According to newton's gravity theory, $F = Gm_1m_2/r^2$. Where F is the force of the gravity. G is gravitational constant. The mass of two objects are represented by m_1 and m_2. The distance between them is illustrated by r. In the formula, as m_1 and m_2 goes up so does the gravity force. However, when r goes up it inversely effects the gravity force as it goes down. We use similar logic for the international trade theory. In our case, the bilateral trade volume is regarded as the gravity force. The mass of the objects are regarded as the economic size of two countries. The distance between two objects are similarly modeled as distance between two countries. This would give us a formula of:

$$T_{ij} = X \cdot (Y_i \; Y_j \; / \; D_{ij} \;)$$

T_{ij} = bilateral trade flows (exports + imports)

X = Constant

Y_i = GDP of country i Y_j = GDP of country j

D_{ij}= Distance between country i and j

In addition, we will add population (or per capita GDP) in our gravity model as proxies for economic size. The gravity model was first applied to the international trade field by

Tinbergen (1962) and Pöynöhen (1963) in the early 1960s. They conducted the first econometric analyses of bilateral trade flows based on gravity-type equations, but they only provided empirical evidence without supplying any theoretical justification. Following their analyses, for a period of almost 20 years, the gravity model, in spite of its perceived empirical success, did not receive much attention from economists due to its weak theoretical foundation. There are two models that are mostly recognized by economic community. They are Differentiated Products Model and Heckscher-Ohlin Model. Differentiated Products Model was established by Anderson(1979) and Krugman & Helpman (1985). They identified the relationship between bilateral trade flows and the product of two countries GDPs by utilizing the Differentiated Products Model. Evenett & Keller (1998) work also recognized that gravity prediction constitutes the most important result regarding the volume of international trade. On the other hand, Hummel & Levinsohn (1995) conducted a similar empirical test with a set of non-OECD countries where monopolistic competition was not so plausible. Many scholars have used gravity model as a base to analyze the volume of trade with custom factors on their model.

However, my model would be simple. I will take natural log of the gravity formula and add population (or per capita GDP) to it.

Gravity Model for trade with South Korea :

$$\text{Ln } T_{ij} = \alpha + \beta_1 \text{Ln } [Y_i \cdot Y_j] + \beta_2 \text{ Ln}[(Y/N)_i \cdot (Y/N)_j] + \beta_3 \text{ Ln } D_{ij} + \varepsilon_{ij}$$

T_{ij} = Bilateral trade flow (exports + imports) between Korea (i) and country j

Y_i = GDP of country South Korea (i)

Y_j = GDP of country j

N = population of the given country

D_{ij} = distance between country Korea (i) and its trading partner (country j)

Data Collection:

I gathered the data for South Korea's trade volume from www.imf.org in section "Direction of Trade Statistics (DOTS): exports and imports by trading partner". I downloaded the file in excel for year 2016 and then added the import and export between South Korea and it's 188 trading nations to get the total volume for the trade between them. Similarly, I used IMF Data and Statistics of "World Economic Outlook Databases (WEO): GDP in USD" to collect GDP of South Korea's trading partners. Then I used www.worldbank.org to gather data about population of Korea and it's trading partner for the year 2016. In order to get per capita GDP of these nations, I divided the GDP that I collected from WEO by its respective nation's population. To calculate the distance between South Korea and its trading partners, I used www.distancefromto.net. It didn't have any option to download a spreadsheet and I could only check distance between two countries at a time. I manually did that for 188 trading partners for South Korea. I triple checked to make sure that I didn't collect wrong data. The distance was collected in miles.

Empirical Results

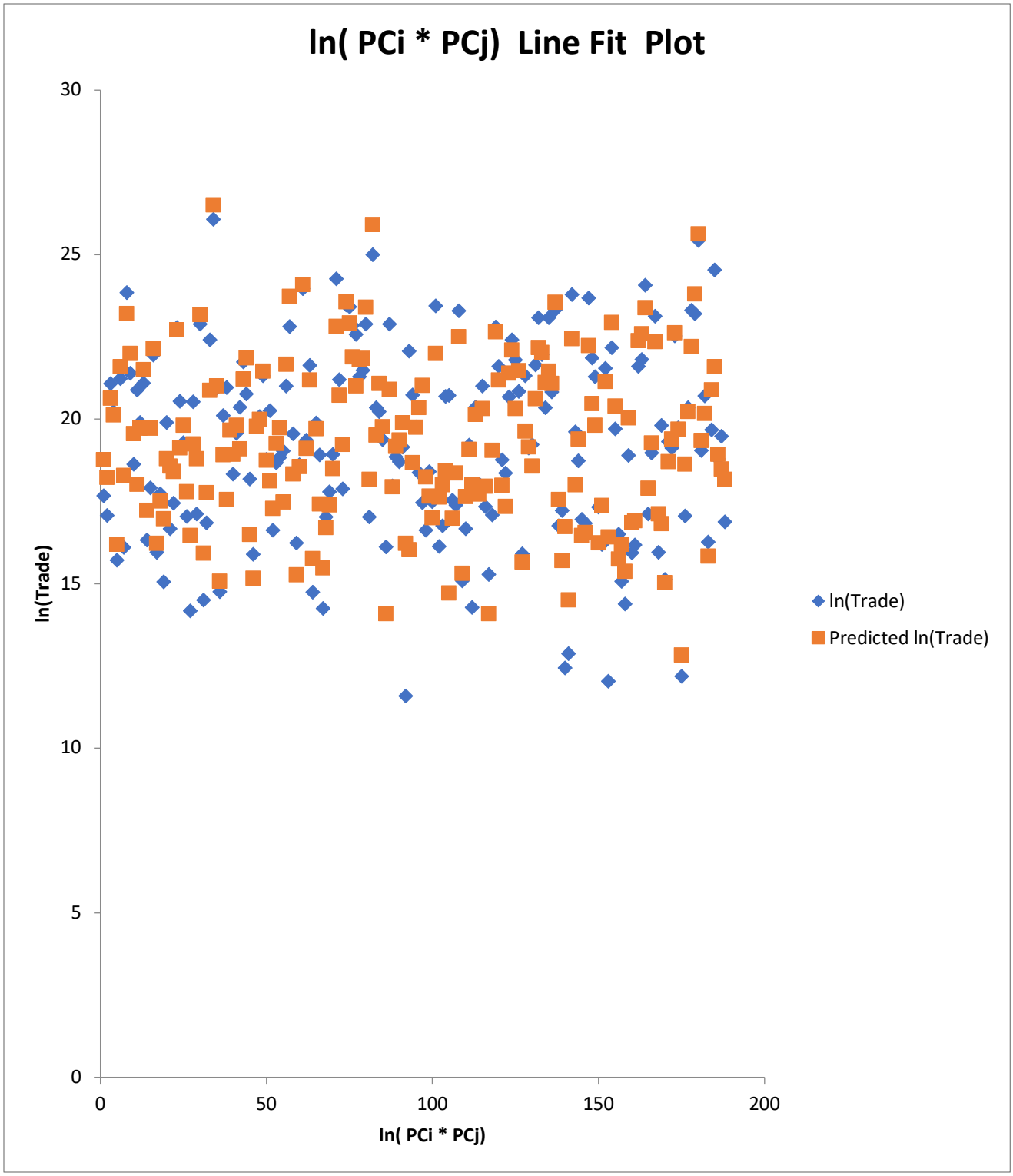
After running regression on natural log of trade volume as an explained variable and natural logs of GDP, per capita GDP and distance as an explanatory variable. We get following results:

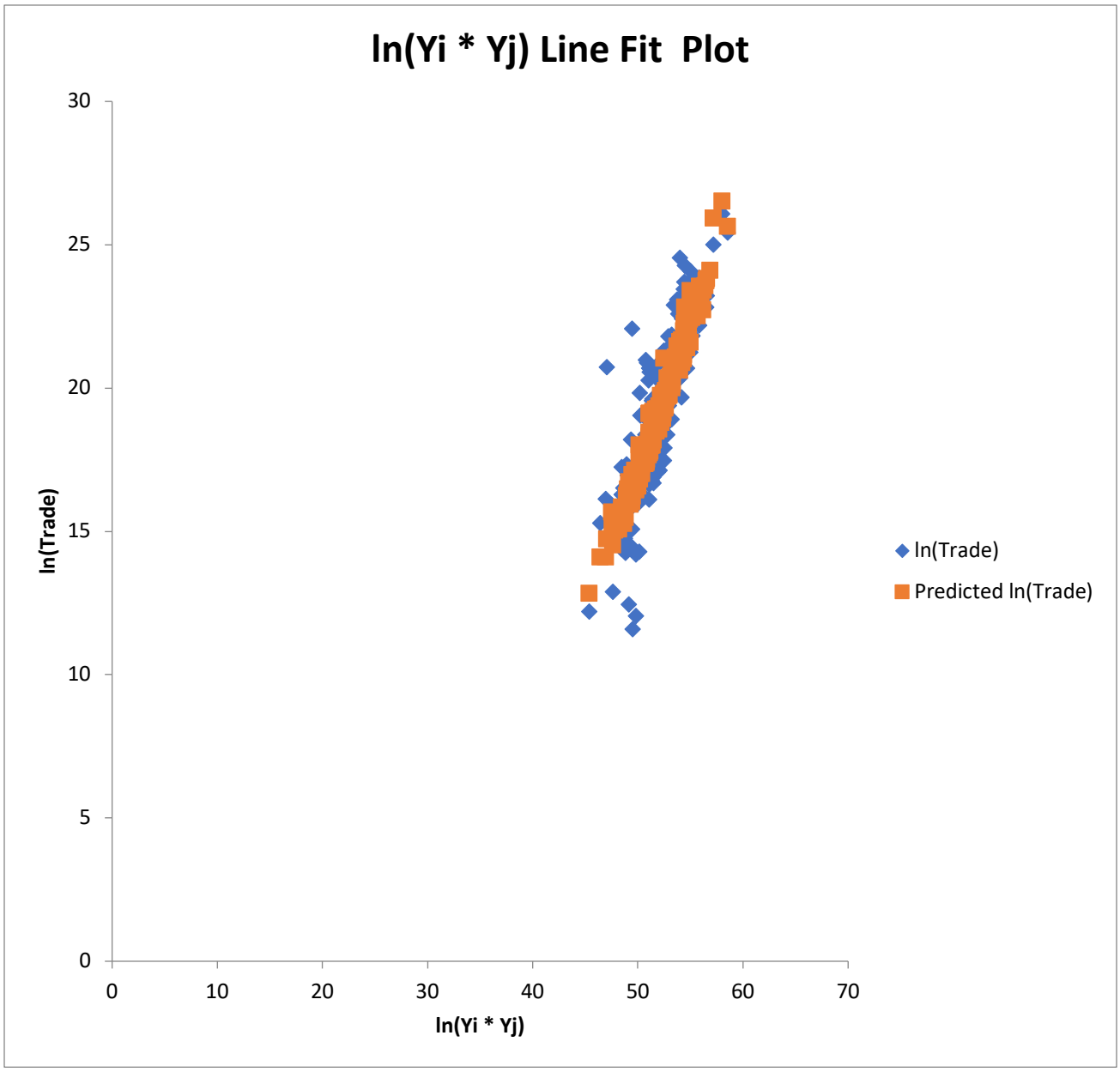
Regression Statistics	
Multiple R	0.87
R Square	0.76
Adjusted R Square	0.76
Standard Error	1.42
Observations	188

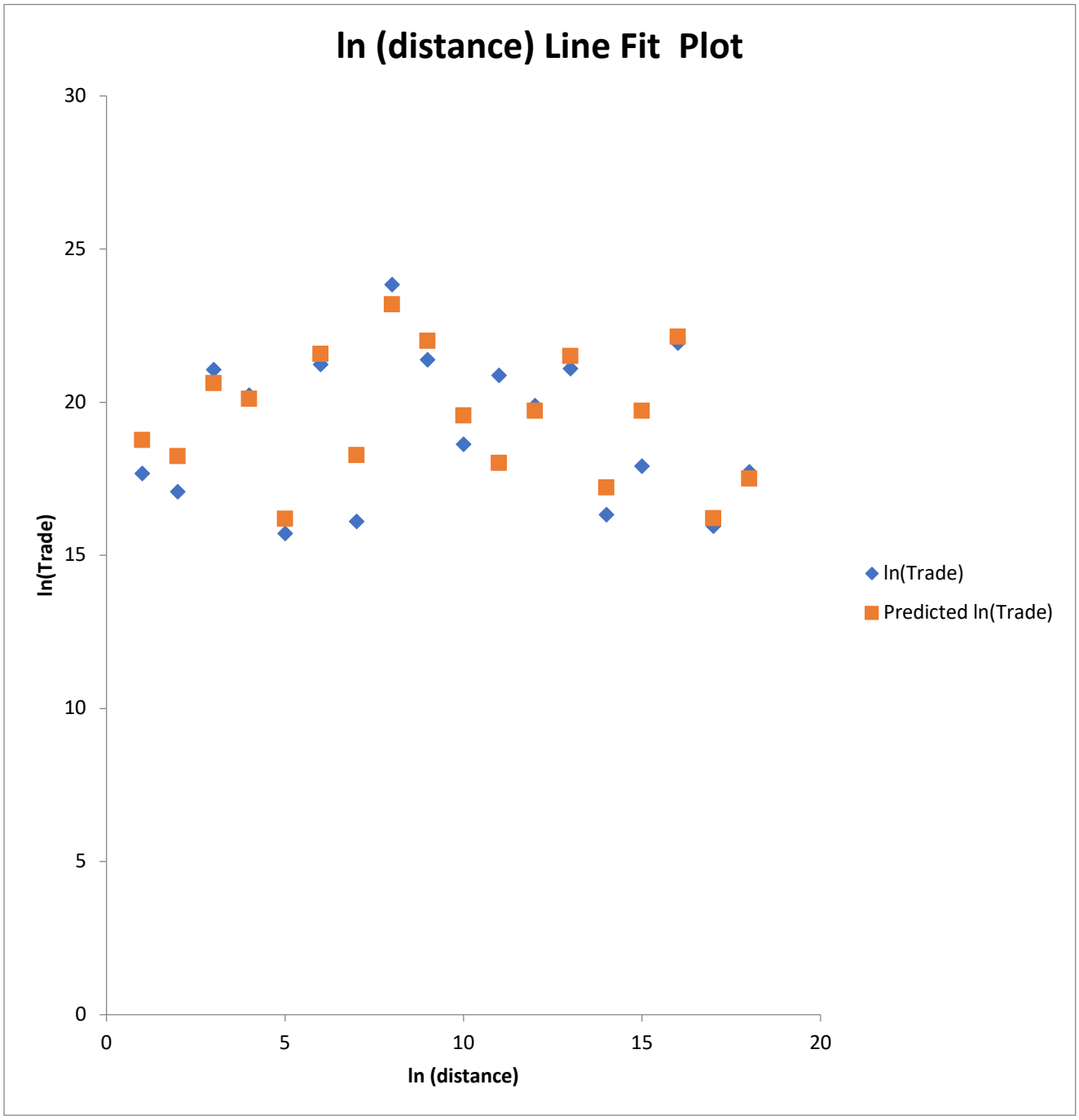
	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	-27.683	3.212	-8.619	0.000
51.67	0.960	0.049	19.471	0.000
16.58	0.151	0.079	1.904	0.058
8.12	-0.689	0.204	-3.384	0.001

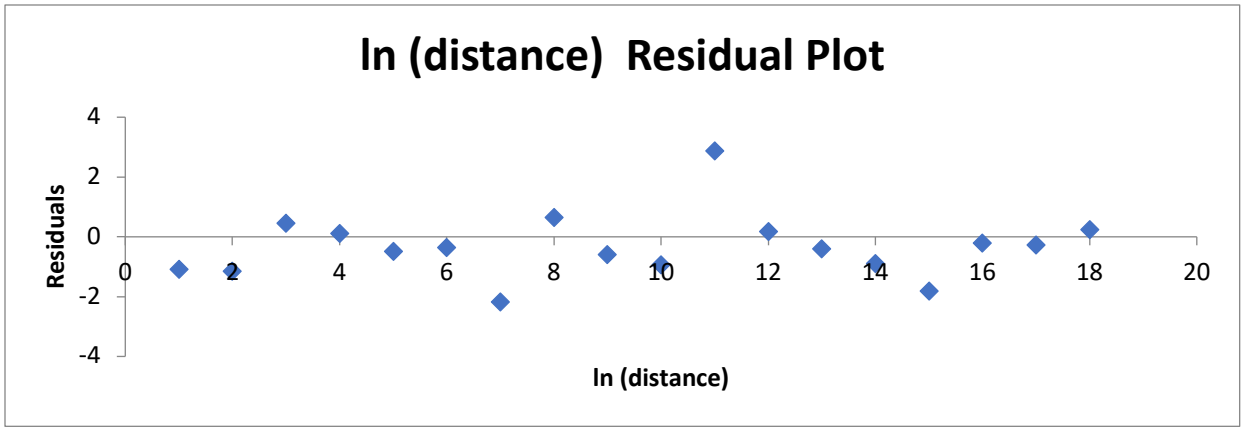
From our regression result, we can observe that, the amount of trade and distance between them are negatively related with coefficient of -0.689(negative). However, the GDP size and the trade amount are strongly positively related with positive coefficient of 0.96. We observed here that per capita of foreign country doesn’t have much impact in the amount of trade that happens with a smaller coefficient with 0.151.

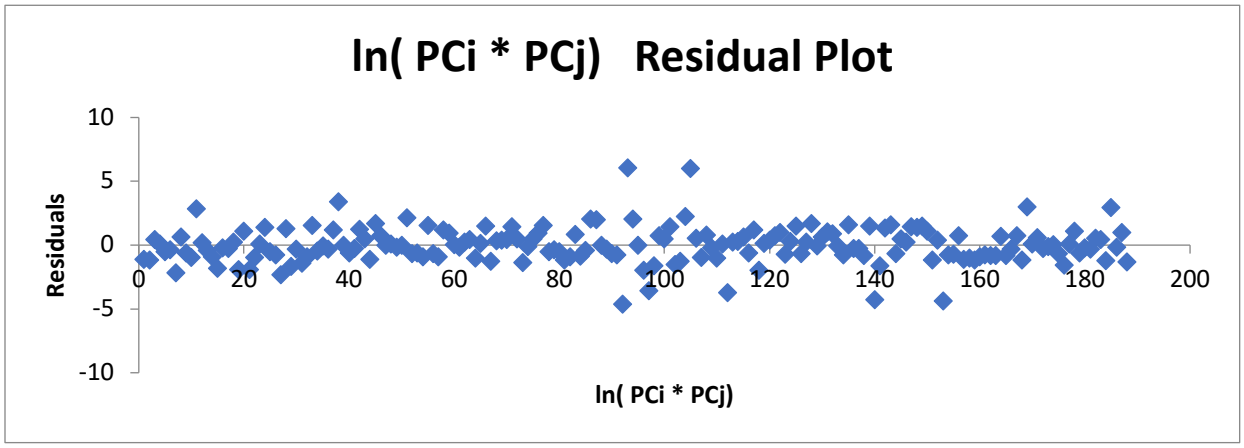
From the gravity equation and the result, it says that the R square is 0.76. R square is a statistical measure of how close the data are to the fitted regression line. And Multiple R was 0.87. Multiple R is the correlation coefficient. We further analyze the model’s result with charts of residual plots, line fit plot and normal probability plot of the explained variable (ln (Bilateral trade volume)) and it’s explanatory variables (GDP (USD) , per capita GDP (USD) and distance (miles)).

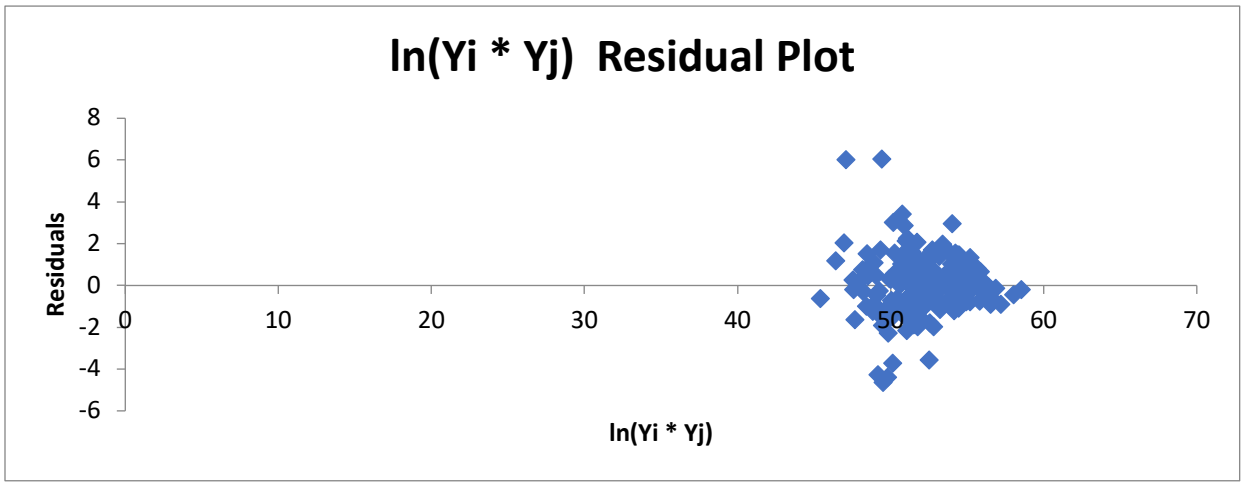

ln(PCi * PCj) Line Fit Plot
30
25
20
15
10
5
0
ln(Trade)
0
50
100
150
200
ln(PCi * PCj)
ln(Trade)
Predicted ln(Trade)

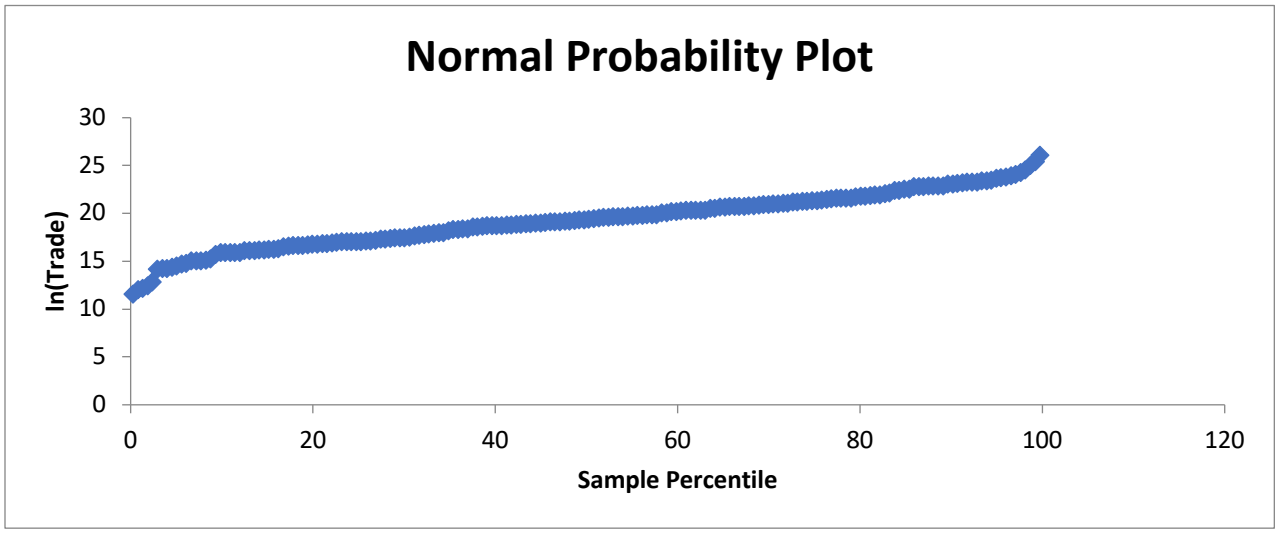

ln(Yi * Yj) Line Fit Plot
30
25
20
15
10
5
0
ln(Trade)
0
10
20
30
40
50
60
70
ln(Yi * Yj)
ln(Trade)
Predicted ln(Trade)


ln (distance) Line Fit Plot
30
25
20
15
10
5
0
ln(Trade)
0
5
10
15
20
ln (distance)
ln(Trade)
Predicted ln(Trade)


ln (distance) Residual Plot
Residuals
4
2
0
-2
-4
0
2
4
6
8
10
12
14
16
18
20
ln (distance)


ln(PCi * PCj) Residual Plot
Residuals
10
5
0
-5
-10
0
20
40
60
80
100
120
140
160
180
200
ln(PCi * PCj)


ln(Yi * Yj) Residual Plot
Residuals
8
6
4
2
0
-2
-4
-6
0
10
20
30
40
50
60
70
ln(Yi * Yj)



My model did a good job on predicting the trade volume. However, there were few outliers having high residuals and deviating further in Line Fit Plot chart in comparison to the predicted ln(Trade).

These outliers and deviations could be result of embargos on the trading partners. Countries like Venezuela and Iran could have been affected due to these embargos as they have lower trade volume with South Korea in comparison with similar GDP trading partners. Korea's actual trade volumes with countries like Japan and China which, in terms of economic size and distance, present greater advantages, seem to fall short of the trade volumes predicted by the gravity model. This implies that

there are significant trade barriers between Korea and these countries.

In addition, errors might have been caused in the distance calculation of the countries. When gathering the distance between two countries from www.distancefromto.net, it calculated the distance between two capitals and not the transportation distance between them. I could have established a better model if I had found the location of major hub of international trade for each trading nations and calculate the distance between them and the transportation hub of South Korea that would have been most likely used. My model would be further improved by adding trade complementarity(TCI). The TCI would measure the degree of trade complementarity between two countries ranging from 0(perfect trade competition) to 1(perfect trade complementarity). We could also consider explanatory variable that checks whether trading nations being members of organization such as APEC membership and its impact on trade.

CONCLUSION:

In today's world economy, South Korea is as a major producer and exporter. They have had strategic development of export industries such as car and electronics to gain on comparative advantage. Our model shows how South Korea has positively related trade flows to their trading partners' GDP

and per capita GDP. However, it is negatively related to the distance between them. According to the regression analysis, the Korean’s bilateral trade patterns fit the basic gravity model well. Therefore, in order to expand bilateral trade volumes, it appears to be more desirable for Korea to promote bilateral trade with countries in close proximity and having large economies. We observed that trade volume with countries like Japan and China were below the predicted trade volumes by gravity model. These might be due to trade barriers between these countries given the economic size and proximity of these countries. By promoting a deeper form of trade freedom with both Japan and China, Korea would to improve its trade potentials and maximize the gains from trade. We can also further conclude that other countries becoming more developed and richer would mean that their economic size will grow and as a result so would the trade volume between them. By analyzing Korea’s trade pattern based on gravity model, we can suggest possible ways to expand trade by identifying important factors determining Korea's bilateral trade flows.

References

Anderson, James E. 1979. "A Theoretical Foundation for the Gravity Equation." *The American Economic Review.* 69.1:106-116.

Direction of Trade Statistics (DOTS) & World Economic Outlook Databases (WEO)
http://www.imf.org/en/Data#data

Distance Statistics www.distancefromto.net

Helpman, E. and P. Krugman (1985) "Market Structure and Foreign Trade: Increasing Returns, Imperfect Competition and the International Economy." MIT Press, Cambridge, MA.