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# Employing Gravity Model to Measure International Trade Potential

Aldon MHP Sinaga<sup>\*1</sup>, Masyhuri<sup>2</sup>, Dwidjono Hadi Darwanto,<sup>2</sup> and Sri Widodo<sup>2</sup>

<sup>1</sup>Tribhuwana Tunggal University – Jl. Telaga Warna, Malang, Indonesia

<sup>2</sup>Gadjahmada University – Jl. Flora, Bulaksumur, Yogyakarta, Indonesia

\*email: a\_sinaga@hotmail.com

**Abstract.** Starting from the analogy of gravitational forces to explain the volume of bilateral trade, the Gravity model has become a very popular model in international trade research. The Gravity Model has also been widely developed by adding various independent variables. Instead to measuring trading volume and various factors that influence the volume of trade, there is not much utilization of the gravity model to measure trade potential. This research is intended to implement a gravity model to measure the potential of Indonesian fruit trade. The measurement of trade potential is carried out by using data on the three main group of Indonesian exported fruits (based on 6 digits HS Code) which traded in 16 years. The classical gravity model, employed in this research contains independent variables, such as the amount of tariffs, the existence of free trade agreements, population, GNP of each country, distance and share of trade. The method of analysis used refers to the gravity model applied by Susanto, et al (2007) and regression analysis method applied by Arita et al (2014). Since its easily fits with some important stylized facts, it is easy to use real data, and also easily estimates using Ordinary Least Square (OLS), the Gravity Model can be a comprehensive instrument for managing big data to present rapid and dynamic estimates of international trade in line with the demands of the Revolution Industry 4.0.

## 1. Background

The gravity model was the first model Tinbergen blazed in 1962 [1]. As the name suggests, the gravity trading model assumes that trade applies as Newton's law of universal gravitation. Its utilizing the gravitational force concept and analysis to explain the volume of bilateral trade flows. Specifically, the gravity model is implemented to explain various variables that affect trade costs and their impact on trade flows. [2].

### Gravity Force Equation

$$F_{ij} = G \frac{M_i M_j}{D_{ij}^2} \dots\dots (1)$$

### Gravity for Trade Equation

$$X_{ij} = C \frac{Y_i Y_j}{t_{ij}} \dots\dots (2)$$

$F_{ij}$  = Force between i and j,  $G$  = Gravity,  $M$  = Mass,  $D_{ij}$  = Distance between i and j.

$X_{ij}$  = Trade flows between i and j,  $C$  = Constant,  $Y$  = Economic Mass (GDP),  $t_{ij}$  = Trade Cost between i and j

**Figure 1.** Gravity force equation and gravity for trade equation analogy

In principle the gravity model states that the gravity force between two objects depends on their mass and inversely proportional to the square of distance between them. While the analogy of the



theory of gravity in trade states that Export (or trade) between two countries depends on their economic access and negatively related to trade costs between them. Comparison of these two principles can be described in Figure 1.

Based on the gravity for trade equation, simple linear empirical equations can be derived as follows:

$$\ln X_{ij} = \beta_0 + \beta_1 \ln Y_i + \beta_2 \ln Y_j + \beta_3 \ln t_{ij} + e_{ij} \dots\dots\dots (3)$$

Where:  $\beta_1, \beta_2 > 0; \beta_3 < 0$

Equation (3) allows the gravity model to be developed flexibly to contain various proxies for trade costs ( $t_{ij}$ ) that affect trade flows ( $X_{ij}$ ). The flexibility of the gravity model causes this equation to be very popularly used in research to explain the various effects of trade cost variables on trade flows. Various trade cost variables that have been implemented in research using gravity equations include; distance [3], adjacency, common language or ethnicity [4], common currency [5], migration [6] and tariff and non tariff barriers [7,8].

As the equation easily fits with some important stylized facts, gravity model has become a popular model to measure an elasticity of trade volumes. Some fact also shown that the model is can be easily implemented to use real data in order explain trade flows with respect to policy factors. It also noted that the model is easily estimates using Ordinary Least Square (OLS). This fact shown by many research [9,10,11].

Gravitational equations have proven to be very effective used as linear equations that can be used to measure elasticity. As an equation estimated by OLS, the estimation of OLS analysis will produce estimates at the average level. This provides an opportunity to estimate the gap between the average value and the actual value. The gap between actual value and estimation is basically a trading potential. This research is intended to study the use of gravity models to predict Indonesia's trade potential, in the case of fruit commodity trading.

## 2. Methodology and Data Analysis

This research is exploratory research carried out by following stages (a) the compilation of gravity models to empirically estimate trade operations, (b) testing models with actual data, (c) interpreting the results of analysis and (d) comparing results interpretation with other scheme or models on trade potential measurement which commonly known. Modeling steps has done by modifying the applied gravity model by Susanto, et al (2007) [7]. Model testing has done by conducting ordinary least square regression analysis procedures (OLS). Interpretation of results then has been compared with trade potential estimation which measured and published at <https://exportpotential.intracen.org/#/home> by the International Trade Center.

The measurement of trade potential is carried out by using panel data on the three main group Indonesian exported fruits (based on 6 digits HS Code) which traded along 16 years. The classical gravity model, employed in this research contains independent variables as: the amount of tariffs, the existence of free trade agreements, population, GNP of each country, distance and share of trade.

Data in this study were obtained from various sources. Most data sources are statistical data obtained electronically through the internet. Volume and value of trade data are obtained from the International Trade Center database through <https://trademap.org>. GNP and average household income data was obtained from the World Bank data base through <https://data.worldbank.org>. Data on tariff rates applied and the existence of trade agreements are obtained from the Asean secretariat data and Indonesia Ministry of Finance data.

The model developed and used in this study refers to the model introduced by Susanto, et.al (2007) similar models are also applied by Plummer, Cheong and Hamanaka (2010) [11]. Susanto, et. Al (2007), uses this model to measure the sectoral impact of international trade in the agricultural sector. The specifications of the gravity model used in this study are as follows:

$$\ln Q_{ij}^t = G + \beta_1 \ln \text{DISTANCE}_{ij} + \beta_2 \ln \text{GDP}_i + \beta_3 \ln \text{GDP}_j + \beta_4 \ln \text{Income}_i + \beta_5 \ln \text{Income}_j + \beta_6 \text{DFTA}_i + \beta_7 \text{DFTA}_j + \beta_8 \text{Tariff}_{ij} + \beta_9 \text{Intrade}_{ij} + \beta_{10} \text{ROWShare}_{ij} \dots \dots \dots (4)$$

$\ln Q_{ij}^t$  : import value of particular commodity to country i originated from j at year of t, in US\$  
 $\ln \text{DISTANCE}$  : average distance among country i to j; in km  
 $\ln \text{GDP}$  : gross domestic product of i and j  
 $\ln \text{Income}$  : per capita incomes of i and j  
 $\text{DFTA}_{ij}$  : dummy on relation status between importer country (i) and exporter (j). DFTA=0 there is no FTA and DFTA=1 if both country was bound in FTA

Ordinary least square (OLS) data analysis has conducting by using IBM-SPSS statistics, version 21.

### 3. Result and Discussion

#### 3.1. Model Implementation and Interpretation

Based on the data obtained, adjustments were made to the model presented in equation (4). The panel data used is based on 3 Indonesian fruit export products classified in 6 digits HS Code i.e: (a) **080450** - Fresh or dried guavas, mangoes and mangosteens; (b). **081090** - Fresh tamarinds, cashew apples, jackfruit, lychees, sapodillo plums, passion fruit, carambola, edible fruit and other edible fruits (excluding nuts, bananas, dates, figs, pineapples, avocados, guavas, mangoes, mangosteens, papaws "papayas", citrus fruit, grapes, melons, apples, pears quinces, apricots, cherries, peaches, plums, sloes, strawberries, raspberries, mulberries, blackberries, loganberries, cranberries, fruits of the genus Vaccinium, kiwifruit, durians, persimmons, black-, white - and redcurrants and gooseberries); (c) **080590** - Fresh or dried citrus fruit (excluding oranges, lemons "Citrus limon, Citrus limonum", limes "Citrus aurantifolia, Citrus latifolia", grapefruit, mandarins, incl. tangerines and satsumas, clementines, wilkings and similar citrus hybrids) . The model in equation (4) is then adjusted to be an operational model which can be presented as follows:

$$\ln Q_{ij}^t = G + \beta_1 \ln \text{DISTANCE}_{ij} + \beta_2 \ln \text{GDP}_{id} + \beta_3 \ln \text{GDP}_{prt} + \beta_4 \ln \text{Income}_{id} + \beta_5 \ln \text{Income}_{prt} + \beta_6 \text{DFTA\_CHISE} + \beta_7 \text{DFTA\_KORSE} + \beta_8 \text{DFTA\_JPSE} + \beta_9 \text{DFTA\_SE} + \beta_{10} \text{REDUC\_MFN} + \beta_{11} \text{REDUC\_CEPT} + \beta_{12} \text{INTRADE\_CHI} + \beta_{13} \text{INTRADE\_KOR} + \beta_{14} \text{INTRADE\_JAP} + \beta_{15} \text{INTRADE\_ROW} \quad (5)$$

Adjustments from equation (4) to equation (5) include adjusting the proxy tariff, becoming the difference between FTA tariffs and the Most Favor Nation (MFN) tariff and the Asean common effective preferential tariff (CEPT). The results of OLS analysis provide the following results:

**Table 1.** OLS analysis result for gravity model

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	-75.367	131.277		-0.574	.566		
DFTA_CHISE	2.490	.738	.258	3.372	.001 **	.407	2.455
DFTA_KORSE	-2.369	.966	-.177	-2.453	.015 *	.461	2.169
DFTA_SEA	.469	.466	.087	1.006	.316 ns	.320	3.130
DFTA_JAPSE	-.452	.999	-.029	-0.453	.651 ns	.570	1.756
GDP_id	5.474	7.117	1.423	0.769	.443 ns	.001	1431.999
GDP_prt	-.688	.270	-.613	-2.552	.011 *	.041	24.184
INCOME_id	-4.771	7.861	-1.115	-0.607	.545 ns	.001	1414.209
INCOME_part	.073	.213	.058	0.342	.733 ns	.082	12.182
DISTANCE	-1.999	.540	-.828	-3.703	.000 **	.048	20.916
REDUC_MFN	.076	.041	.103	1.859	.064 ns	.785	1.274
REDUC_CEPT	-.148	.038	-.216	-3.897	.000 **	.778	1.285
INTRADE_CHI	5.131	.930	.727	5.519	.000 **	.138	7.263
INTRADE_KOR	2.771	1.040	.287	2.664	.008 **	.205	4.870
INTRADE_JAP	8.042	2.094	.834	3.841	.000 **	.051	19.739
INTRADE_ROW	5.064	1.218	.939	4.158	.000 **	.047	21.367
Rsquare	0.653						

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F 11.906

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\*: Significant at  $\alpha$  0,05, \*\*: Significant at  $\alpha$  0,0, ns : Non Significant

The results of OLS analysis show that the gravity model provides an estimate of the elasticity of each factor that influences trade flows. Negative and positive notations in each of the coefficients that are estimated clearly also illustrate the relationship of each proxy for trade costs to Indonesia's main fruit exports.

Assuming that OLS estimation gives a prediction of average trade level value, where actual trading can occur above or below the average, then error term from OLS analysis on gravity model can describe predictions of trade probabilities. OLS analysis will produce predictive values. By using the estimated coefficient to measure trade flows ( $\ln Q_{ij}^t$ ) there will be a prediction of export value ( $\ln \hat{Q}_{ij}^t$ ).

The difference between the actual average value of exports and the predicted value of exports ( $\ln \bar{Q}_{ij}^t - \ln \hat{Q}_{ij}^t$ ) can indicate the presence or absence (size) of trade potential. The calculation results of  $\ln \bar{Q}_{ij}^t - \ln \hat{Q}_{ij}^t$ , has shown below :

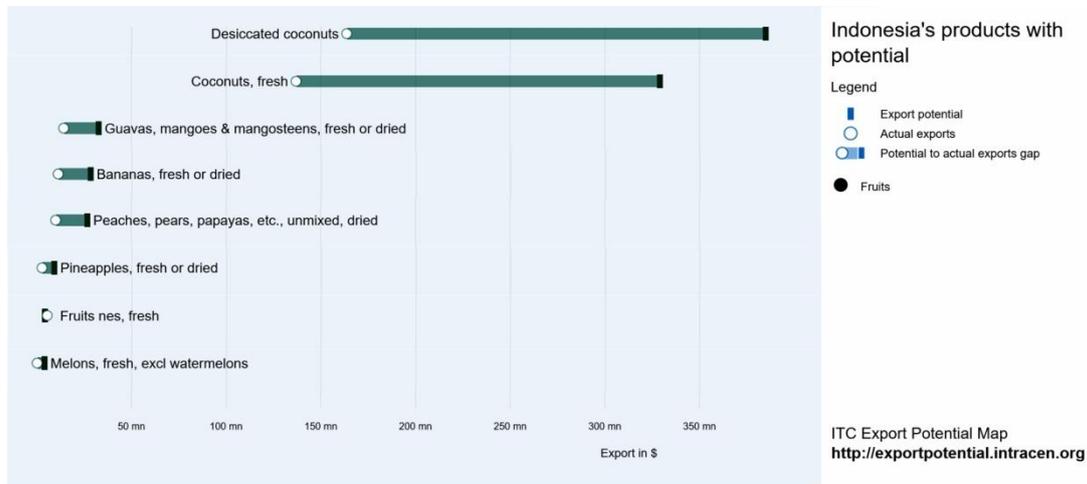
**Table 2.** Measurement of Trade Potential

Variable	Coefficient	$\ln \bar{Q}_{ij}^t$	$\ln \hat{Q}_{ij}^t$
(Constant)	-75.367		-75.367
DFTA_CHISE	2.490	0.063	0.156
DFTA_KORSE	-2.369	0.031	-0.074
DFTA_SEA	0.469	0.250	0.117
DFTA_JAPSE	-0.452	0.023	-0.011
GDP_id	5.474	26.908	147.295
GDP_prt	-0.688	27.257	-18.753
INCOME_id	-4.771	7.623	-36.370
INCOME_prt	0.073	9.876	0.721
DISTANCE	-1.999	7.951	-15.894
Reduc MFN	0.760	0.670	0.509
Reduc CEPT	-0.148	-0.629	0.093
INTRADE_CHI	5.131	0.125	0.641
INTRADE_KOR	2.771	0.063	0.173
INTRADE_JAP	8.042	0.063	0.503
INTRADE_ROW	5.064	0.250	1.266
Total		4.541	5.007
	$\ln \bar{Q}_{ij}^t - \ln \hat{Q}_{ij}^t$		<b>-0.466</b>

The trade potential calculation shows a negative value where the actual value is lower than the predicted value. This indicates that there is a trade potential that cannot be fulfilled. In the other way it can be concluded that there are still import requests that still have the potential to be filled by Indonesian export products. This situation is in line with the records of Anukoonwattaka (2016) [12] which states that the results are negative ( $\ln \bar{Q}_{ij}^t - \ln \hat{Q}_{ij}^t < 0$ ), indicates an obstacle in (export) trade. The recommendation for this model is, Indonesia should be trading more fruit product which based on its economic, geographical fundamentals and comparative advantages.

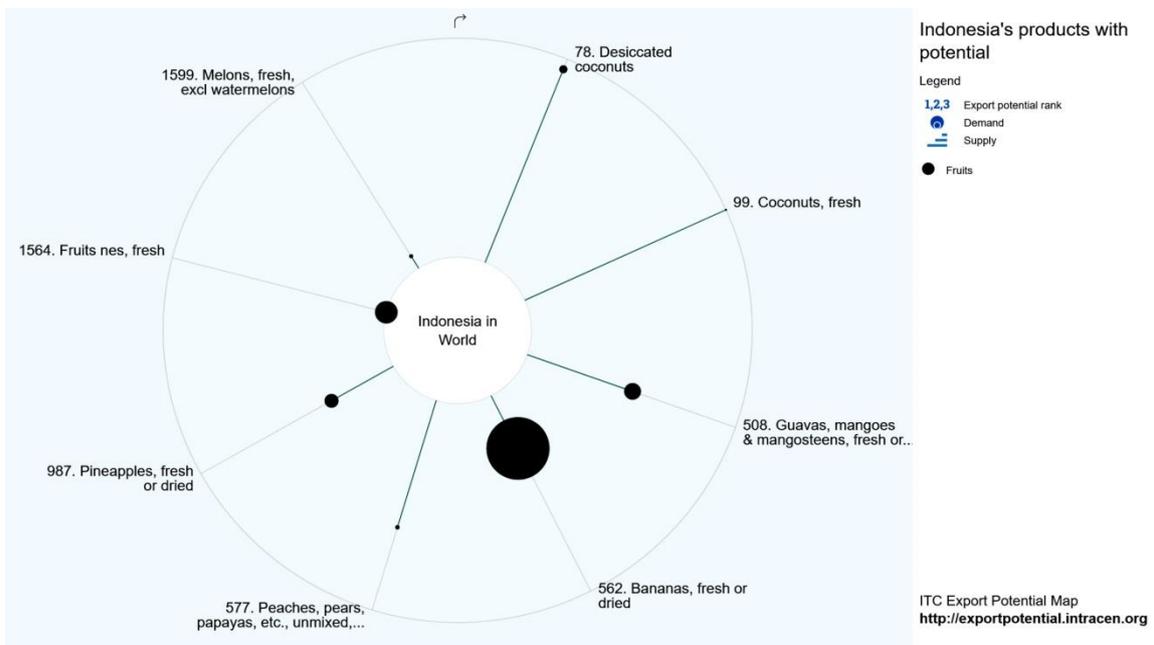
### 3.2. Comparing with ITC estimation

The International Trade Center (ITC) is one of the institutions that has an analysis of trade potential. Comparing the results obtained from OLS analysis and the interpretation of the gravity model with the analysis conducted by ITC can provide a detailed opportunity for the gravity model to predict trade potential. Assuming 3 main commodities of Indonesian fruit exports based on 6 digits HS Code, Indonesian trade potential is obtained as follows:



**Figure 2.** Indonesia fruits potential export (source: <https://trademap.org>)

The map of potential exports of fruit products displayed by ITC shows the same essence. There is enormous potential to encourage Indonesian fruit products to enter the export market.



**Figure 3.** Indonesia fruits potential export by rank (source: <https://.trademap.org>)

As suggested, the analysis of export potential maps based on commodity rankings that shown the potential to be prioritized to be developed is as presented in Figure 3. Clockwise the highest priority is (1) Fresh or dried guavas, mangoes and mangos teens, (2). Fresh bananas, (3) papayas papaws, pears, peaches, (4) fresh or dried pineapple and (5) melons and watermelons. Fruits recommended through the ITC analysis have also shown compliance with the suggestion of developing commodities that have comparative advantages in addressing large trade potential.

**4. Conclusion**

This study shows that by using an electronically available data base, the gravity model is empirically proven to be implemented to (1) estimate future trade flow, (2) estimate the elasticity of

trade driving and inhibiting factors against trade flows and (3) predict the existence of trading potential. These three things are important proxies in establishing international trade policies.

As the character easily fits with some important stylized facts, it is easy to use real data and estimates using Ordinary Least Square (OLS), this model has the potential to be widely used in rapid decision-making systems in international trade at the future. The availability in employing big data on relatively complete trading variables will be an advantage for the models to easily utilized in the determination of more dynamic international trade policies. The gravity model will potentially become a comprehensive instrument for managing big data to present dynamic international trade estimation align with the demands of the Industrial Revolution 4.0.

The character of the gravity model can be used to compile a more comprehensive application of international trade information systems. In addition, this model can also be implemented as a platform for making international trade decision making applications that always dynamically keep abreast of real data developments available online. This opens the opportunity for application developers to be able to build applications that are highly needed by international trade actors and international trade policy makers.

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