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### Application of a gravity model in the evaluation of the determinants of intraindustrial trade in Colombia

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**Abstract:** This paper estimated a gravity model of trade to evaluate the determinants of intra-industry trade between Ecuador, USA, Mexico, Panama, Venezuela, Peru, Brazil and Colombia for the period of 2000-2014. It was found that potential economies of scale, the variety of differentiated products and a larger market size, are positively related to the degree of this kind of trade; while countries' income, transportation costs and dissimilarity in market size between Colombia and the partner country, show a negative relation with intra-industry trade.

**Keywords:** Trade, intra-industry trade, gravity model, economies of scale, factor endowment

#### 1. INTRODUCTION

Nowadays, the economic growth of countries in a global context is frequently analyzed in the literature. It is argued that with the right policies, foreign competition to which the countries are subject to, forces them to be much more competitive and leads to a greater economic growth [1]. Precisely, in recent years most of the world's economies have promoted free trade, seeking to improve their indicators of economic activity, by exploiting their external sector [2].

In that sense, it is necessary to distinguish between different types of trade. Trade can be divided into two types: the inter-industry trade, in which goods of different sectors of economic activity are exchanged. And the intra-industry trade in which the same product, slightly differentiated, is traded [3].

The gains from intra-industry trade (IIT) are generally higher than those arising from inter-industry trade (NIT) because they include benefits related to economies of scale, technological externalities and positive linkages with the rest of the economy, dynamic returns to scale, among others [4]. This trading pattern favors the value added and has a strong impact on the growth of these economies [5].

The IIT goes beyond the explanatory scope of neoclassical theory on trade. According to [6], traditional economic theory cannot adequately model or explain the IIT, since the international commercialization of goods is only explained by the comparative advantages between nations.

As a result, economists have tried to explain the growing importance from different approaches, particularly among economies with similar levels of development [7]. In a context in which simultaneous exports and imports within industries between countries with similar levels of development, are one of the most important empirical findings of the 1960s, in relation to international trade. The concentration of trade flows within branches of the same sector rather than between industries, has been a recurrent pattern of the European integration process [8].

In this context, the purpose of this paper is to develop a gravity model to evaluate the determinants of intra-industry trade in Colombia between the years of 2000 and 2014.

## **2. METHODOLOGY**

An exploratory exercise was conducted to analyze the national determinants of the IIT between Ecuador, USA, Mexico, Panama, Venezuela, Peru and Brazil, which were the countries with the highest Fontagné and Freudenberg Index (IFF) for the different economic sectors analyzed. A gravity model was used to conduct this analysis because models of bilateral trade flows are commonly used when explaining trade volumes between countries. This model bilateral trade is determined by the economic size, population size, price levels and other dichotomous variables, seeking to explain bilateral trade relations. Distance is also included to account for transportation costs, among others [7].

The dependent variable that was used for IIT measurement is the Greenaway and Milner Index (GMI) that was calculated at a three-digit International Standard Industrial Classification (ISIC) disaggregation level, to eliminate Grubel-Lloyd index (GL) aggregation bias. IFF is not used since the GMI calculation was done at bilateral level and there is no risk of geographical bias.

The explanatory variables used correspond to:

YD: the difference of GDP per capita of the two countries. This variable is taken as proxy for the difference in relative factor endowments [9, 10] because is expected that a country with higher labor-capital ratio would have higher income per capita as a result of higher labor productivity. The expected sign differs according to the type of IIT. While for the vertical IIT, a positive sign is expected, in the case of horizontal IIT a neutral effect or a negative sign is estimated [11].

PPP: is the average GDP per capita between Colombia and the partner country. Generally, studies used this proxy to evaluate possible economies of scale and variety of differentiated products and a positive sign is expected [12].

ED: is in the difference of the human development index. It is considered as an indicator of the difference in development. Several factors such as income per capita, market size and industrial structure, allow to expect the IIT to be highly related, positively, to the degree of economic development and industrialization. Therefore, the IIT is less likely in countries with developmental differences, then a negative impact of this variable is expected [11].

D: This is the geographical distance between Colombia and the partner country. Hence there is a negative relation between the proportion of IIT in industry and geographical distance [12] because a longer distance will increase costs. However, transportation costs do not necessarily increase with geographical distance since postal charges may present little variance between destinations [14].

DC: Trade imbalance: [15] the trade imbalance is approached as:

$$DC_j = \frac{|X_j - M_j|}{(X_j + M_j)} \quad (1)$$

Trade imbalance will be used as a control variable to avoid estimation bias. This variable represents the net trade as a percentage of trade. It takes a value of zero at the lower end, if there is no trade imbalance, and a value of one if there are neither exports nor imports. According to the theory, a negative correlation is expected between this control variable and IIT [14].

P: The population serves as a market size proxy. The greater the population, the greater the chances of taking advantage of economies of scale, thus increasing their productive specialization [16]. In addition, it is expected that the larger the size of a country's domestic market, the greater the quantities consumed of the different goods, consequently, the IIT will increase.

Dgdp: The GDP disparity between Colombia and the partner country, serves as a proxy for the difference in the relative market size. A negative sign is expected [17] as a result of an assumption of negative correlation between the proportion of IIT and the dissimilarity in the GDP. The greater the similarity between the countries, the larger the IIT between them.

PP, PPC and the GDP per capita correspond to Colombia and the partner country respectively. It is expected that the flow of IIT is positively related to the income level of each country, due to a more differentiated demand attributable to quality and variety [10].

The model is specified as follows:

$$\log GYM_{jt} = \beta_0 + \beta_1 \log |YD_{jt}| + \beta_2 \log PPP_{jt} + \beta_3 \log |ED_{jt}| + \beta_4 \log D_{jt} + \beta_5 \log DC_{jt} + \beta_6 \log P_{jt} + \beta_7 \log |Dgdp_{jt}| + \beta_8 \log PP_{jt} + \beta_9 \log PP_{ct} + \eta_j + \varepsilon_{jt} \quad (2)$$

$\log GYM_{jt}$  is the logarithm of Colombia's GMI with the country j to 3 digits of the ISIC.  $\log |YD_{jt}|$  is the logarithm of the absolute value of the difference between Colombia and country j income per capita.  $\log PPP_{jt}$  is the logarithm of the average GDP of Colombia and country j.  $\log |ED_{jt}|$  is the logarithm of the absolute value of the difference Colombian and country j human development index.  $\log D_{jt}$  is the logarithm of the distance between Colombia and the country j.  $\log DC_{jt}$  is the logarithm of the trade imbalance between Colombia and country j.  $\log P_{jt}$  is logarithm of the population of the country j.  $\log |Dgdp_{jt}|$  Is the logarithm of the absolute value of the difference of the GDP of Colombia and country j.  $\log PP_{jt}$  Is the logarithm of GDP per capita of the country j.  $\log PP_{ct}$  is the logarithm of GDP per capita of Colombia.  $\eta_j$  is the changing effects over time not observed.  $\delta t$ , is a common deterministic trend.  $\varepsilon_{jt}$  Is a random shock that is assumed by  $\varepsilon_{jt} \sim N(0, \sigma^2)$ .

### 3. RESULTS AND DISCUSSION

In gravity models especial attention should be paid to the heterogeneity of the countries under study. Not taking into account this aspect introduces a bias in the study [7]. To avoid this bias econometric techniques of panel-data were used, since it reduces the problems related to the identification of the models.

The Hausman test determines a Chi Square of 29.49 and a Prob> chi<sup>2</sup> equal to 0.0003, which leads to reject the null hypothesis, that is, one must select the estimator for fixed country specific effects. This confirms the argument of [12], [13] and [7] who suggest using the fixed effects model, because the IIT is subject to a relatively limited number of pre-conditions that are constant over time.

The application of the Wald tests for heteroscedasticity, Wooldridge test for autocorrelation and Breusch-Pagan test for Contemporaneous Correlation, indicated that these three problems appear in the proposed model.

To rectify these problems, the Panel-Corrected Standard Error was used. As no direct effects were calculated directly, dichotomous variables of time were introduced, so that they captured the effects common to all the individuals during a period of time. Lastly, a calculation was made to prove the joint significance of these dichotomous variables used.

The results obtained from the application of a gravitational model for the evaluation of the determinants of the IIT in Colombia with Ecuador, USA, Mexico, Panama, Venezuela, Peru and Brazil are shown in Table 1.

The sign of the average GDP per capita between Colombia and the partner country was expected and this variable is significant in the model at a level of 1%. This indicates that economies of scale and variety of differentiated products have a positive IIT relation between Colombia and the countries analyzed.

It was expected that the trade disequilibrium index had the negative sign because the trade imbalance may skew the IIT indicator down. Additionally, the significant variable in the model was at a 5% level of significance.

The geographic distance between Colombia and the partner country shows a negative sign and is significant in the model at a level of 1%, confirming the hypothesis that longer distance increases transportation costs and presents a negative relation with the IIT.

The difference in GDP between Colombia and the partner country shows in the model the expected sign and 1% level of significance. This validates that the IIT in Colombia has a negative correlation between the proportion of this type of trade and the dissimilar market size of the countries analyzed.

Population serves as a proxy for the partner country market size; is a variable that was found significant in the model at a 5% level of significance. Population also has a positive sign proving that there is a positive correlation between the size of the partner country market and the levels of IIT.

The partner country GDP per capita is significant in the model at a 5% level of significance, yet, it has a negative sign. One possible explanation may be that a higher income level is associated with a greater complexity of demand; therefore, it correlates with a more diversified production, making the country more self-sufficient and induces less IIT. However, another possible explanation is that the demand for non-tradable services increases when there is a higher income level.

The difference in Colombian human development index, the GDP per capita, and the difference in GDP per capita of the two countries, served as proxies of the differences in development, in the structure of demand and the factor endowments, respectively, are not significant in the model. There is no evidence that these variables affect the degree of IIT between Colombia and the countries analyzed.

When testing the joint significance of these temporal dichotomous variables (Table 4) the hypothesis that the temporal dichotomous variables are jointly significant and belong to the model, cannot be rejected. In addition, each of them are significant at 1% level of significance. It was demonstrated that the common effects between Colombia and the trading partners analyzed over a period of time, are related to the IIT levels.

The model shows a  $R^2$  of 0.83, implying that the explanatory variables explain by 83% the levels of IIT in Colombia and the analyzed trading partners.

The model for assessing the determinants of the IIT between Colombia and Ecuador, USA, Mexico, Panama, Venezuela, Peru and Brazil concludes that the opportunities for intra-industry trade increase to the extent that countries are similar; there are economies of scale and variety of differentiated products. As anticipated by economic theory, it decreases as transportation costs and the size of the partner country are larger. Given the benefits provided by the IIT and to take advantage of the IIT's economic growth opportunities, it is important for Colombia to develop economies of scale and trade with countries who have economical similarities and are geographically close.

**Table 1**  
**Gravity model for the evaluation of the determinants of the**  
**IIT in Colombia with Ecuador, USA, Mexico, Panama, Venezuela, Peru and Brazil**

	<b>GYM</b>		
		<b>_Iao_2005</b>	<b>-0.095</b>
<b>yd</b>	<b>-0.014</b>		<b>(11.95)**</b>
	<b>(0.11)</b>	<b>_Iao_2006</b>	<b>-0.078</b>
<b>ppp</b>	<b>3.593</b>		<b>(6.64)**</b>
	<b>(2.74)**</b>	<b>_Iao_2007</b>	<b>-0.075</b>
<b>d</b>	<b>-0.586</b>		<b>(4.09)**</b>
	<b>(2.65)**</b>	<b>_Iao_2008</b>	<b>-0.052</b>
<b>ed</b>	<b>0.031</b>		<b>(2.46)*</b>
	<b>(0.97)</b>	<b>_Iao_2009</b>	<b>-0.066</b>
<b>dc</b>	<b>-0.072</b>		<b>(3.90)**</b>
	<b>(2.56)*</b>	<b>_Iao_2010</b>	<b>-0.113</b>
<b>dpib</b>	<b>-0.220</b>		<b>(5.48)**</b>
	<b>(4.85)**</b>	<b>_Iao_2011</b>	<b>-0.175</b>
<b>p</b>	<b>0.602</b>		<b>(6.93)**</b>
	<b>(2.49)*</b>	<b>_Iao_2012</b>	<b>-0.193</b>
<b>ppc</b>	<b>-0.103</b>		<b>(6.66)**</b>
	<b>(0.22)</b>	<b>_Iao_2013</b>	<b>-0.168</b>
<b>pp</b>	<b>-3.059</b>		<b>(4.69)**</b>
	<b>(2.97)**</b>	<b>_Iao_2014</b>	<b>-0.185</b>
<b>_Iao_2001</b>	<b>0.039</b>		<b>(4.25)**</b>
	<b>(11.10)**</b>	<b>R2</b>	<b>0.83</b>
<b>_Iao_2002</b>	<b>-0.032</b>	<b>N</b>	<b>101</b>
	<b>(5.73)**</b>		
<b>_Iao_2003</b>	<b>-0.063</b>		
	<b>(7.91)**</b>		
<b>_Iao_2004</b>	<b>-0.062</b>		
	<b>(9.06)**</b>		

\* p<0.05; \*\* p<0.01

#### 4. CONCLUSION

When applying a gravity model for the evaluation of the determinants of IIT between Ecuador, the USA, Mexico, Panama, Venezuela, Peru, Brazil and Colombia, it is found that the possible economies of scale, the variety of differentiated products and a larger market size are associated with higher levels of specialization and have a positive relationship in the IIT. Whereas, transportation costs and dissimilarity in the market size between Colombia and the partner country, have a negative relation with the IIT level. A negative relationship between the income level of the partner countries and the IIT is found in When applying a gravity model for the evaluation of the determinants of IIT between Ecuador, the USA, Mexico, Panama, Venezuela, Peru, Brazil and Colombia, it was found that the possible economies of scale, the variety of differentiated products and a larger market size are associated with higher levels of specialization and have a positive relationship in the IIT. Whereas, transportation costs and dissimilarity in the market size between Colombia and the partner country, have a negative relation with the IIT level. A negative relationship between the income level of the partner countries and the IIT is found in the model specified. This is because higher income levels are correlated with more diversified production, making the country more self-sufficient. Also, it can be due to higher demand for non-tradable services and less IIT.

Trade with countries in similar economical condition that are geographically close, represents a great opportunity for the IIT. This would help to develop economies of scale, lower manufacturing costs, provides

availability of better technology and the potential development of for the manufacture of products with high added value. Since the IIT is composed of products with high growth potential, Colombia is a situation of particular concern because of the IIT's lack of existence, considering that some of the existing free trade agreements have been signed with countries with which there is a considerable degree of asymmetry in regards to the size of their economies. Therefore, it is more difficult for these agreements to encourage this type of trade in the country. In this context, economic integration with Andean Community of Nations (CAN), which promotes the development of IIT, as predicted by economic theory.

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