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Research Article

GMM Estimator: An Application to Intraindustry Trade

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This paper investigates the determinants of intraindustry trade (IIT), horizontal IIT (HIIT), and Vertical IIT (VIIT) in the automobile industry in Portugal. The trade in this sector between Portugal and the European Union (EU-27) was examined, between 1995 and 2008, using a dynamic panel data. We apply the GMM system to solve the problems of serial correlation and the endogeneity of some explanatory variables. The findings are consistent with the literature. The difference between per capita incomes and factor endowments present a positive sign. These results are according to Heckscher-Ohlin predictions. The economic dimension has a positive impact on trade. A negative effect of the distance on bilateral trade was expected and the results confirm this, underlining the importance of neighbour partnerships for all trade.

1. Introduction

The intraindustry trade (IIT) or two-way trade is explained by product differentiation and the existence of products belonging to the same category. The big push in the literature emerged with the work of Grubel and Lloyd [1]. The pioneering models of IIT, especially the horizontal differentiation as in Krugman [2], Lancaster [3], and Helpman and Krugman [4], explained this type of trade based on monopolistic competition and economies of scale. In fact, the models of horizontal intraindustry trade (HIIT) do not predict the advantages theory as explanatory factor. HIIT is explained by consumers with similar characteristics and similar types of income.

In this respect, the vertical intraindustry trade (VIIT) admits different types of quality, that is, different types of preferences. The consumers have different types of income per capita, which emphasize the theoretical models of Falvey and Kierzkowski [5] and Shaked and Sutton [6].

In 1990s the intermediate goods led to interest in the academic community [7]. In recent years, the empirical studies [8–11] have focused primarily on vertical specialization, and this linked to the concept of fragmentation or outsourcing. This paper evaluates the vertical intraindustry trade as well as the horizontal intraindustry trade and intraindustry trade.

This paper presents two contributions. First we use the GMM system estimator because we intended to evaluate the long-term effects. Second, this study contributes to the discussion of the development of automobile industry and fragmentation theory.

The results presented in this paper for this specific industrial sector are generally consistent with the expectations of intraindustry trade studies. The remainder of the paper is organised as follows: Section 2 presents the theoretical background; Section 3 presents the indexes of intraindustry trade used in this study. Section 4 displays the econometrical model; Section 5 presents the estimation results, and the final section provides the conclusions.

2. Literature Review

In recent years, emerged in the literature an explanation of international trade based on the transaction of intermediate goods. Fragmentation also called outsourcing of production has received attention from many scholars especially starting in the 1990s.

In fact, the conceptual model of Jones and Kierzkowski [7] demonstrated that the location of multinational firms was associated with economies of scale and factor endowments. In other words, a multinational company may have several branches located in several regional blocks. As Faustino and Leitão [11] referred, the term fragmentation has taken various forms (outsourcing by Feenstra and Hanson [12] and vertical specialization by Hummels and Skiba [13].

Globalisation promotes regional clusters in the international economics. As Eiteam et al. [14] demonstrated, we have some countries as India, Russia, and Mexico that developed highly efficiently. The sector of parts and components for vehicles, aircraft, and software are generally referenced in the literature. According to Kol and Rayment [15] the exchange of intermediate goods may take two forms: horizontal intraindustry trade and vertical intraindustry trade. In fact horizontal intraindustry trade in intermediate goods cannot be explained by different types of quality. However, vertical intraindustry trade helps to explain the various stages of international production, since there are economies abundant in capital (K) and other factors in labour (L). Thus, it is understood that the vertical intraindustry trade is explained by different types of quality. The application of the index of Grubel and Lloyd [1] and the methodology of Abd-el-Rahman [16] and Greenaway et al. [17] have allowed validating the conceptual model of Jones and Kierzkowski [7]. Empirical studies [8–11] have focused primarily on vertical products differentiation (vertical intraindustry trade).

The research of Ando [8] and Kimura et al. [9] validated the fragmentation and vertical intraindustry trade (VIIT) in East Asian countries. Leitão et al. [10] used a static panel data (OLS with time dummies and Tobit model) to explain the phenomena of fragmentation. The article of Leitão et al. [10] concluded that vertical specialization is explained by dissimilarities of per capita GDP, factor endowments and geographical distance. The last few years in the literature is emerging new and important developments on the intraindustry trade (IIT). The dynamic analysis (GMM system) for intraindustry trade was introduced by Faustino and Leitão [18]. This analysis was also used by Faustino and Leitão [18] and Leitão [19].

The study of Faustino and Leitão [18] examined the determinants of VIIT in the automobile components between Portugal and European Union countries and BRIC (Brazil,

Russia, India, and China) for the period 1995–2006. The authors applied a dynamic panel data (GMM System). Faustino and Leitão [18] demonstrated that the differences in per capita and transaction costs are the main determinants of fragmentation.

Leitão [19] examines the long-term effects of IIT and its components—horizontal and vertical IIT, applied to the study case of the United States. Using GMM system, the study shows a negative correlation between factor endowments, and IIT. The findings also illustrate that there is no positive correlation between HIIT and HO (Heckscher-Ohlin) model.

3. Grubel and Lloyd Indexes

Grubel and Lloyd [1] define IIT as the difference between the trade balance of industry i and the total trade of this same industry. In order to make comparisons easier between industries or countries, the index is presented as a ratio, where the denominator is total trade:

$$\mathrm{IIT}_{\mathrm{it}} = 1 - \frac{|X_i - M_i|}{(X_i + M_i)} \Longleftrightarrow \mathrm{IIT}_{\mathrm{it}} = \frac{(X_i + M_i) - |X_i - M_i|}{(X_i + M_i)}, \tag{3.1}$$

where X_i and M_i are export and import to partner country i.

The index is equal to 1 if all trade is intraindustry. If $\mathrm{IIT}_{\mathrm{it}}$ is equal to 0, all trade is inter-industry trade.

Grubel and Lloyd [1, page 22] proposed an adjustment measure to the country IIT index (IIT calculated for all individual industries), introducing the aggregate trade imbalance.

Aquino [20, page 280] also considered that an adjustment measure is required, but to a more disaggregated level, but for this, the Grubel and Lloyd method is inadequate. Following Aquino, we require an appropriate imbalance effect. The imbalancing effect must be equi-proportional in all industries. So, the Aquino at the 5-digit level estimates "what the values of exports and imports of each commodity would have been if total exports had been equal to total imports."

3.1. HIIT and VIIT Indexes

To determine the horizontal ($\mathrm{HIIT}_{\mathrm{it}}$) and vertical intraindustry trade ($\mathrm{VIIT}_{\mathrm{it}}$), Grubel and Lloyd [1] indexes and the methodology of Abd-el-Rahaman [16] and Greenaway et al. [17] are used, that is, the relative unit values of exports ($\mathrm{UV}_{\mathrm{it}}^{X}$), and imports ($\mathrm{UV}_{\mathrm{it}}^{m}$).

Where $\mathrm{HIIT}_{\mathrm{it}}$:

$$1 - \alpha \leq \frac{\mathrm{UV}_{\mathrm{it}}^{X}}{\mathrm{UV}_{\mathrm{it}}^{m}} \leq 1 + \alpha \tag{3.2}$$

and $\mathrm{VIIT}_{\mathrm{it}}$ is

$$\frac{\left(\mathrm{UV}_{\mathrm{it}}^{X}\right)}{\left(\mathrm{UV}_{\mathrm{it}}^{m}\right)} \leq 1 - \alpha \quad \text{or} \quad \frac{\left(\mathrm{UV}_{\mathrm{it}}^{X}\right)}{\left(\mathrm{UV}_{\mathrm{it}}^{m}\right)} > 1 + \alpha, \tag{3.3}$$

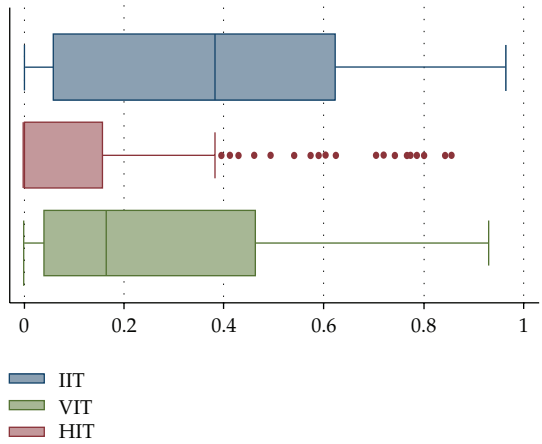

Figure 1: Trade between Portugal and European Countries for the period 1995–2008.

where $\alpha = 0.15$. When the relative unit values of exports and imports are less than 15%, the trade flows are horizontally differentiated (HIIT). The HIIT and VIIT indexes are also calculated with disaggregation at 5-digit Portuguese Economic Activity Classification from INE-Trade Statistics.

In Figure 1, the intraindustry trade between Portugal and the European Union (EU) is over 50% for the period 1995–2008. For all of the period in analysis, the VIIT is much higher than the HIIT. These values are in accordance with the fragmentation theory.

4. Econometric Model

The dependent variable used is the IIT Grubel and Lloyd [1] index, HIIT and VIIT indexes at five-digit level of the Standard International Trade Classification (SITC). The explanatory variables are country-specific characteristics. The data sources for the explanatory variables are the World Bank Development Indicators (2011). The source used for the dependent variable was data from INE, the Portuguese National Institute of Statistics.

This study uses a dynamic panel data (GMM system). In static panel data models, Pooled OLS, fixed effects (FEs), and random effects (REs) estimators have some problems like serial correlation, heteroskedasticity, and endogeneity of some explanatory variables.

The estimator GMM system (GMM-SYS) permits the researchers to solve the problems of serial correlation, heteroskedasticity and endogeneity for some explanatory variables. These econometric problems were solved by Arellano and Bond [21], Arellano and Bover [22], and Blundell and Bond [23, 24], who developed the first-differenced GMM (GMM-DIF) estimator and the GMM system (GMM-SYS) estimator. The GMM-SYS estimator is a system containing both first differenced and levels equations. The GMM-SYS estimator is an alternative to the standard first differenced GMM estimator. To estimate the dynamic model, we applied the methodology of Blundell and Bond [23, 24] and Windmeijer [25] to small sample correction to correct the standard errors of Blundell and Bond [23, 24]. The GMM system estimator is consistent if there is no second-order serial correlation in the residuals (m2 statistics). The dynamic panel data model is valid if the estimator is consistent and the instruments are valid.

4.1. Hypotheses and Definition of Explanatory Variables

Hypothesis 1. There is a negative (positive) correlation between differences in per capita income and IIT and HIIT (VIIT).

LogDGDP is the logarithm of absolute difference in per capita GDP (PPP, in current international dollars) between Portugal and the trading partner. Loertscher and Wolter [26] suggested a negative sign for the IIT model. Hypothesis 1, was formulated based the Linder [27] theory. Linder [27] considers that countries with similar demands have similar products. So, the Linder hypothesis suggests a negative sign for the IIT model (Helpman [28]; and Hummels and Levinsohn [29]).

Regarding Hypothesis 1, Loertscher and Wolter [26] and Balassa [30] estimated a negative coefficient. The recent study of Leitão [19] also found a negative sign. The model of Falvey and Kierzkowski [5] suggests a positive impact between income difference and VIIT. The empirical works of Loertscher and Wolter [26] and Greenaway et al. [17] provide empirical support for a negative relation between difference in per capita income and HIIT.

Hypothesis 2. IIT and HIIT occurs more frequently among countries that are similar in terms of factor endowments.

(a) VIIT predominate among countries that are dissimilar in terms of factor endowments.

LogEP is a proxy for differences in physical endowments. It is the logarithm of the absolute difference in electric power consumption (Kwh per capita) between Portugal and its partners. Considering Hypothesis 2, the models of Helpman and Krugman [4] and Hummels and Levinsohn [29] suggest a negative effect of physical endowment on IIT. Zhan et al. [31] use the absolute difference in electric power consumption in examining IIT for China. Zhang et al. [31] found a negative sign to IIT. The findings of Leitão [19] show a positive sign to VIIT.

Hypothesis 3. The economic dimension influences the volume of trade positively.

LogDIM is the logarithm of average GDP of the two trading partners. Usually the studies utilized this proxy to evaluate the potential economies of scales and the variety of differentiated product. A positive sign is expected for the coefficient of this variable (see, e.g, Greenaway et al. [17], Hummels and Levinsohn, [29], and Leitão et al. [10]).

Hypothesis 4. Trade increases when partners are geographically close.

LogDIST is the logarithm of geographical distance between Portugal and the partner country. Following the most empirical studies, we use kilometres between the capital cities of the trading partners. According to the literature, we expect a negative sign (Badinger and Breuss [32], Blanes [33], Cieślik [34], and Faustino and Leitão [11]).

4.2. Model Specification

We consider that

$$\mathrm{IIT}_{\mathrm{it}} = \beta_0 + \beta_1 X_{\mathrm{it}} + \delta t + \eta_i + \varepsilon_{\mathrm{it}}, \tag{4.1}$$

where IIT_{it} stands for IIT, HIIT, or VIIT, meaning Total, Vertical, or Horizontal Portuguese IIT index, and X is a set of explanatory variables. All variables are in the logarithm form; η_i is the unobserved time-invariant specific effects; δt captures a common deterministic trend; ε_{it} is a random disturbance assumed to be normal, and identically distributed with $E(\varepsilon_{it}) = 0$; Var $(\varepsilon_{it}) = \sigma^2 > 0$.

Following the empirical work of Hummels and Levinsohn [29], we apply a logistic transformation to IIT, HIIT, and VIIT because these indexes vary between zero and one. LOGISTIC IIT = Ln[IIT/(1 − IIT)]. The same transformation is made for HIIT and VIIT.

The model can be rewritten in the following dynamic representation:

$$IIT_{it} = IIT_{it-1} + \beta_0 + \beta_1 X_{it} - \rho\beta_1 X_{it-1} + \delta t + \eta_i + \varepsilon_{it}. \tag{4.2}$$

5. Estimation Results

Table 1 presents summary statistics for each variable. LogDGDP, LogEP, LogDIM, and LogDIST appear to have only little differences. However, this is not the case for the indexes of LogIIT, LogHIIT and LogVIIT.

Before estimating the panel regression model, we have conducted a test for unit root of the variable. Table 2 presents the results of panel unit root test (ADF-Fischer Chi square).

The most important variables such as the intraindustry trade (LogIIT), horizontal intraindustry trade (LogHIIT), vertical intraindustry trade (LogVIIT), electric power consumption (LogEP), economic dimension (LogDIM) do not have unit roots, that is, are stationary with individual effects and individual specifications.

In Figure 2 we can observe the distribution of intraindustry trade.

Table 3 reports the determinants of IIT using a GMM system estimator. All explanatory variables are significant at 1% level ($LogIIT_{t-1}$, LogDGDP, LogEP, LogDIM, and LogDIST). Our model presents consistent estimates, with no serial correlation (m2 statistics). The specification Sargan test shows that there are no problems with the validity of instruments used. As expected for the Lagged dependent variable ($LogIIT_{t-1}$) the result presents a positive sign, showing the changes in IIT have a significant impact on long-term effects. The difference between per capita incomes, in logs (LogDGDP), presents a positive sign. We can infer that countries have dissimilar demand. Following Falvey and Kierzkowski [5], we introduced one proxy for the difference in factor endowments (electric power). The variable, electric power in logs (LogEP) presents a positive sign. As Portuguese IIT is mainly vertical intraindustry trade (VIIT), this is consistent with the neo-Heckscher-Ohlin trade theory, that is, the differences in physical endowments promote the IIT.

The coefficient economic dimension (LogDIM) has a significant and a positive effect on IIT. This result confirms the importance of scale economy and product differentiation. We can conclude that economic dimension influences the volume of intraindustry trade. The geographical distance (LogDIST) has been used as a typical gravity model variable. A negative effect of the distance on bilateral IIT was expected and the results confirm this, underlining the importance of neighbour partnerships for all trade.

The Table 4 presents the results using the horizontal intraindustry trade equation. The model presents consistent estimates, with no serial correlation (m2 statistics). The specification Sargan test shows that there are no problems with the validity of instruments used. As expected for the Lagged dependent variable ($LogHIIT_{t-1}$) the result presents

Table 1: Summary statistics.

Variables	Mean	Std. dev	Min	Max
LogIIT	−0.56	0.56	−2.56	−0.01
LogHIIT	−2.22	1.42	−6.14	−0.07
LogVIIT	−0.92	0.63	−2.87	−0.05
LogDGDP	4.13	0.38	2.18	4.93
LogEP	3.37	0.46	1.60	4.12
LogDIM	4.31	0.20	3.77	4.82
LogDIST	3.33	0.18	2.70	3.59

Table 2: Panel unit root test results.

	Intercept and trend	
ADF-Fischer Chi square	Statistic	Probability
LogIIT	131.19	0.0000
LogHIIT	65.31	0.0319
LogVIIT	97.67	0.0000
LogEP	88.60	0.0006
LogDIM	65.63	0.0682

a positive sign. So we can infer that the changes in horizontal intraindustry trade have a a significant impact on the long-term effects.

The absolute difference in electric power consumption (LogEP) is statistically significant, with positive sign. We can conclude that countries have dissimilar factor endowment. As expected, the variable LogDIM (average of per capita GDP) between Portugal and the partner consider) has a significant and positive effect on trade. Therefore, the intensity of HIIT is positively correlated with the similarity in per capita income between trading partners. The coefficient of LogDIST (geographical distance) is negative as expected. The studies of Balassa and Bauwens [35], Badinger and Breuss, [32], Blanes [33], Cieślik [34], H. Egger and P. Egger [36] also found a negative sign.

In Figure 3 we present the distribution of horizontal intraindustry trade.

Vertical intraindustry trade estimates are report in Table 5. All explanatory variables are significant. The results are according to previous studies. The model present consistent estimates, with no serial correlation and Sargan test validates the instruments used.

The hypothesis for economic differences between countries (DGDP) in logs presents a positive sign and is significant at 1% level. Falvey and Kierzkowski [5] suggest a positive effect of income difference on VIIT model. Kimura et al. [9] found positive relationship between income difference and VIIT for parts and components trade. We can conclude that VIIT occurs more frequently among economies that are dissimilar, that is, differentiation by quality of products.

In Figure 4 we can observe the distribution of vertical intraindustry trade.

The coefficients electric power consumption (EP) and the economic dimension (DIM) are consistent with the expected sign. The result confirms that VIIT can be explained by Heckscher-Ohlin theory.

The difference in electric power consumption per capita (LEP) reflects the difference in endowments between Portugal and its trade partners. Regarding the hypothesis for

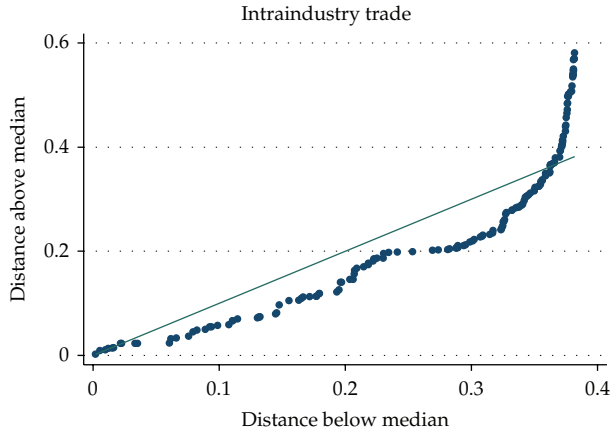

Figure 2: Distribution of intraindustry trade (IIT).

Table 3: Determinants of intraindustry trade.

Variables	GMM system	t-statistics	Significance	Expected sign
LogIIT_{t-1}	0.10	(6.25)	***	(+)
LogDGDP	0.29	(3.55)	***	(−)
LogEP	0.38	(10.49)	***	(−)
LogDIM	0.21	(3.09)	***	(+)
LogDIST	−1.53	(−3.09)	***	(−)
C	2.59	(1.69)	*	
Ar(2)	−0.69 [0.49]			
Sargan Test	20.96 [1.00]			
Observations	289			

The null hypothesis that each coefficient is equal to zero is tested using one-step robust standard error. t-statistics (heteroskedasticity corrected) are in round brackets. P values are in square brackets; ***/*statistically significant at the 1 percent and 10 percent levels. Ar(2) is tests for second-order serial correlation in the first-differenced residuals, asymptotically distributed as $N(0,1)$ under the null hypothesis of no serial correlation (based on the efficient two-step GMM estimator). The Sargan test addresses the overidentifying restrictions, asymptotically distributed X^2 under the null of the instruments' validity (with the two-step estimator).

Table 4: Determinants of Horizontal Intraindustry Trade.

Variables	GMM system	t-statistics	Significance	Expected sign
LogHIIT_{t-1}	0.33	(21.1)	***	(+)
LogDGDP	2.06	(2.44)	*	(−)
LogEP	1.09	(3.33)	***	(−)
LogDIM	2.69	(4.19)	***	(+)
LogDIST	−1.92	(−1.79)	*	(−)
C	3.94	(0.90)		
Ar(2)	2.09 [0.36]			
Sargan Test	18.54 [1.00]			
Observations	138			

The null hypothesis that each coefficient is equal to zero is tested using one-step robust standard error. t-statistics (heteroskedasticity corrected) are in round brackets. P values are in square brackets; ***/*statistically significant at the 1, and 10 percent levels. Ar(2) is tests for second-order serial correlation in the first-differenced residuals, asymptotically distributed as $N(0,1)$ under the null hypothesis of no serial correlation (based on the efficient two-step GMM estimator). The Sargan test addresses the overidentifying restrictions, asymptotically distributed X^2 under the null of the instruments' validity (with the two-step estimator).

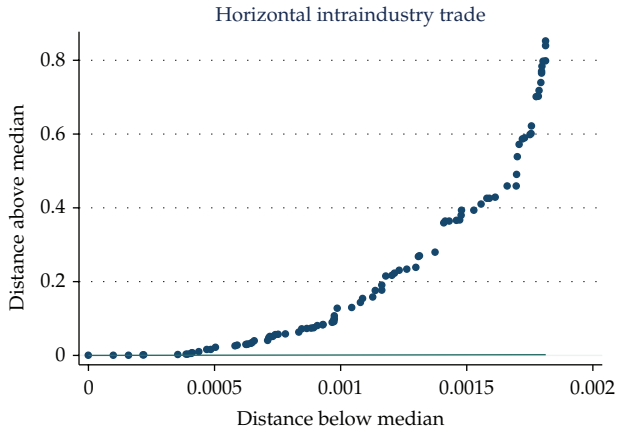

Figure 3: Distribution of horizontal intraindustry trade (HIIT).

Table 5: Determinants of vertical intraindustry trade.

Variables	GMM system	t-statistics	Significance	Expected sign
LogVIIT$_{t-1}$	0.32	(15.63)	***	(+)
LogDGDP	0.19	(4.18)	***	(+)
LogEP	0.01	(1.78)	*	(+)
LogDIM	0.55	(5.13)	***	(+)
LogDIST	−0.44	(−4.25)	***	(−)
C	0.24	(0.69)		
Ar(2)	0.39 [0.70]			
Sargan Test	21.14 [1.00]			
Observations	267			

The null hypothesis that each coefficient is equal to zero is tested using one-step robust standard error. t-statistics (heteroskedasticity corrected) are in round brackets. P values are in square brackets; ***/*statistically significant at the 1 percent, 5 percent, and 10 percent levels. Ar(2) is tests for second-order serial correlation in the first-differenced residuals, asymptotically distributed as $N(0,1)$ under the null hypothesis of no serial correlation (based on the efficient two-step GMM estimator). The Sargan test addresses the overidentifying restrictions, asymptotically distributed X^2 under the null of the instruments' validity (with the two-step estimator).

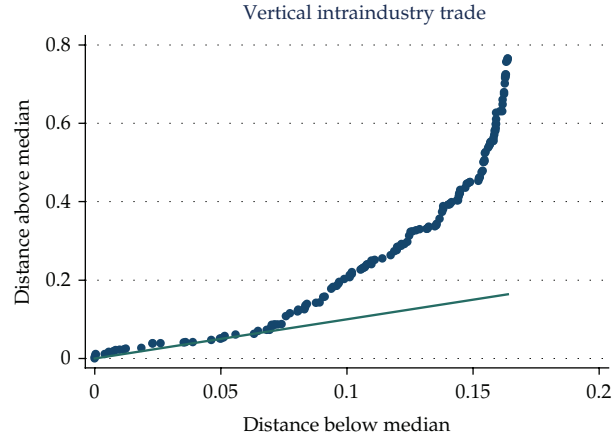

Figure 4: Distribution of vertical intraindustry trade (VIIT).

the geographical distance on VIIT, the empirical result support the idea that the gravity model is important to explain vertical intraindustry trade between partners.

6. Conclusion

The objective of this paper was to analyze the main determinants of intraindustry trade in automobile sector. The IIT between Portugal and the European Union countries is over 50% for the period 1995–2008. For all of the period in analysis, the VIIT is much higher than the HIIT. These values are in accordance with the fragmentation theory.

The Lagged dependent variables (LogIIT_{t-1}, LogHIIT_{t-1}, and LogVIIT_{t-1}) are positive and less than one. So we can infer that the changes in intraindustry trade, horizontal and vertical IIT have a significant impact on the long-term effects.

The Linder theory considers that a difference in per capita incomes explains intraindustry trade and their components (HIIT and VIIT). The variable (LogDGDP) used to evaluate the relative factor endowments presents a positive impact on IIT, HIIT and VIIT. In fact the decision of multinational corporations is associated with different factors as in localization, skilled labour and economies of scales.

In relationship to the variable differences in physical capital endowments (LogEP), our results validate the hypothesis: VIIT occurs more frequently among countries that are dissimilar in terms of factor endowments. Our research confirms that fragmentation of production in the automobile sector is explained by the Heckscher-Ohlin. The difference in factor endowment allows showing that fragmentation is associated with vertical differentiation of products. This reveals that the decision-making of multinational corporations are based in reducing production costs; showing the importance of globalization to explain the phenomenon of fragmentation or outsourcing.

For the variable size of the market (average of GDP), the study suggests that Portugal has size to attract this type of industry. In fact, the Euro Zone countries considered in the econometric analysis show that the removal of tariff and nontariff barriers promoted the increase of intraindustry trade with special focus on the VIIT. In future studies it will be interesting to extend our sample.

According to the literature we expected a negative sign to geographical distance. Usually the literature attributes a negative sign to geographical distance, that is, trade increases if the partners are geographically close. The findings support this hypothesis, that is, the gravity model are important to explain the composition of trade (IIT, HIIT and VIIT) within partners.

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