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INTRA-INDUSTRY TRADE IN THE MEDICAL AND OPTICAL INSTRUMENTS INDUSTRY: A PANEL DATA ANALYSIS

Nuno Carlos Leitão [a], Horácio Crespo Faustino[b]

[a] Professor at Polytechnic Institute of Santarém, Portugal,nunoocarlosleitao@gmail.com
, [b] Professor at ISEG, Technical University of Lisbon, Portugal, faustino@iseg.utl.pt

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ABSTRACT

This paper analyses the determinants of intra-industry trade (IIT) in the Portuguese medical and optical sector using a static and dynamic panel data analysis. The results suggest that IIT in medical and optical instruments occurs more frequently among countries that are similar in terms of relative factor endowments and are members of the same regional integration agreement. Moreover, this trade increases if the partners are geographically close.

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I. INTRODUCTION

This paper estimates the determinants of intra-industry trade (IIT) in the medical and optical instruments industry. We examine the IIT in this sector between Portugal and the European Union (EU-27). We also consider two BRIC countries (Brazil and China) and the United States, as these countries are also of particular relevance to Portuguese bilateral trade in this industry. The methodology applies a static and a dynamic panel data analysis in order to resolve the problems of endogeneity and autocorrelation (see, for example Arellano and Bond, 1991; Arellano and Bover, 1995; Blundel and Bond, 1998, 2000). The panel is unbalanced due to the lack of information on some countries in all of the years analyzed.

Usually, the empirical studies of intra-industry trade (IIT) focus on a range of industries or countries (see, for example Aquino, 1978; Balassa 1986; Greenaway et al. 1984; Hummles and Levinsohn, 1995). Few empirical works analyze the IIT that occurs in one specific industry (see Tharakan and Kerstens, 1995; Sharma, 2002, Kimura et al. 2007; Clark 2006, Majkovič and Turk, 2007).

The recent trend of globalisation has given rise to a new paradigm in international economics, i.e. the fragmentation theory (see Jones and Kierzkowski, 1990). The trade in medical and optical instruments between different units of multinational corporations is a good example of the fragmentation of the production and of the emergence of IIT through the multinational firms. In the empirical studies about fragmentation of production the dependent variable commonly used is the vertical IIT index. However, as Portuguese IIT is mainly of the vertical IIT (VIIT) type, this variable can also be used as variable proxy measuring the trade between parts and components (see, Leitão and Faustino, 2009; Kierzkowski, 2009).

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

II. LITERATURE REVIEW

The traditional trade theories are based on constant returns to scale, homogenous product and perfect competition (Ricardian and Heckscher-Ohlin trade theory). These theories could explain inter-industry trade based on comparative advantages. The pioneering works on IIT (Krugman, 1979, 1980, 1981; Lancaster 1980; Helpman 1981) exclude the idea that traditional theories could explain IIT.

The models of IIT (Krugman, 1979; Lancaster, 1980; Helpman, 1981; Brander and Krugman, 1983; Eaton and Kierzkowski, 1984) are based on monopolistic competition and increasing returns. The Neo-Chamberlinian models, such as the Krugman models, consider the assumption that all varieties enter the utility function symmetrically. By contrast, the neo-Hotelling model, for example, the Lancaster model, assumes asymmetry.

In these models, each variety is produced under decreasing costs and when the countries engage in trading, the similarity of the demands leads to intra-industry trade. This hypothesis of similarity of demands to explain trade between similar countries was first considered by Linder (1961). When product differentiation is considered, we have two types of differentiation and different models of IIT. Horizontal differentiation, or differentiation by attributes other than quality, gives rise to the horizontal IIT models, whereas vertical differentiation – differentiation by quality – originates the vertical IIT models. These models have different underlying determinants (Greenaway et al., 1994, 1995). Vertical IIT can be explained by traditional trade theories (see Davis, 1995). Falvey (1981), Falvey and Kierzkowski (1984), Shaked and Sutton (1984) and Flam and Helpman (1987) introduced the vertical differentiation models. The vertical IIT indexes are also used to measure the fragmentation of the production.

Horizontal differentiation is more likely between countries with similar factor endowments and horizontal IIT cannot be explained by traditional trade theories. The pioneering Krugman models consider that the products are horizontally differentiated. Brander and Krugman (1983) used a Cournot formulation to explain the intra-industry trade. The authors demonstrated that it is possible to explain IIT by reciprocal dumping.

As IIT encompasses both vertical IIT and horizontal IIT, we can test if the factors that explain comparative advantages – differences in relative factor endowments – also explain IIT(Buturac and Rajh, 2006).

III. MEASUREMENT OF INTRA-INDUSTRY TRADE

The level of IIT is generally measured by the so-called Grubel and Lloyd (1975) index. They defined IIT as the difference between the trade balance of industry i and the total trade of this same industry. In order to make the comparison easier between industries or countries, the index is presented as a ratio in which the denominator is total trade.

$$IIT_i = 1 - \frac{\left|X_i - M_i\right|}{\left(X_i + M_i\right)} \Leftrightarrow IIT_i = \frac{\left(X_i + M_i\right) - \left|X_i - M_i\right|}{\left(X_i + M_i\right)} \quad (1)$$

The index is equal to 1 if all trade is of the intra-industry trade type. If IIT is equal to 0, all trade is inter-industry trade.

IV. ECONOMETRIC MODEL

The dependent variable used is the IIT Grubel and Lloyd (1975) index in medical and optical instruments. It is calculated with the disaggregation of five digits CAE (Economic Activities Classification) of the medical and optical instruments. The data sources for the explanatory variables are the World Bank, World Development Indicators (2008). The source used for the dependent variable was INE, which is the Portuguese National Institute of Statistics.

A. EXPLANATORY VARIABLES AND HYPOTHESIS

Linder (1961) considers that countries with similar demands will trade similar products. So, the Linder (1961) hypothesis suggests a negative sign for the coefficient of the variable GDP (differences in per capita GDP). Linder (1961) uses per-capita income differences as a proxy for consumer tastes and preferences. It has been argued that as per capita incomes of two countries become equal, the tastes and preferences of their respective consumers also become similar. Hence, the share of IIT rises as the difference in per-capita income declines. Helpman and Krugman (1985) consider differences in per-capita income as a proxy for differences in the capital-labour ratio. As per-capita income reflects both the demand and supply sides, Hummels and Levinshon (1995) alternatively employ per-capita income and factor ratios. In this paper, we consider different variables for demand and supply sides.

Hypothesis 1: There is a negative correlation between differences in per-capita and IIT

This is the Linder (1961) hypothesis. Linder did not consider the concept of IIT. However, his theory may be used to explain this type of trade.

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 (1980) suggest a negative sign for the IIT model.

Hummels and Levinshon (1995) and Greenaway,et al. (1994) found a negative sign. The studies of Fertö and Soós (2008) also found a negative sign.

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

This hypothesis is based on Krugman (1979, 1980), Bergstrand (1983), Helpman and Krugam (1985), Helpman (1987) and Hummles and Levinsohn (1995).

LogEP is a proxy for differences in physical capital endowments. It is the logarithm of the absolute difference in electric power consumption (Kwh per capita) between Portugal and its partners.

Zhan et al. (2005) and Blanes (2006) found a negative relationship between differences in endowments and intra-industry trade.

We also use EUx EP as a multiplicative dummy variable to distinguish between European partners and other countries. EU is a dummy variable that equals 1 if the country is a European trading partner and 0 otherwise. A negative sign is expected.

Hypothesis 3: There is a positive relationship between the lowest value of GDP per capita and IIT.

The variables (LogMinGDP, and LogMaxGDP) are included to control for relative size effects. The theoretical models of Helpman and Krugman (1985), Flam and Helpman (1987) indicate s suggest a negative (positive) sign for LogMinGDP (LogMaxGDP).

LogMinGDP is a proxy to control for relative size effects. It is the logarithm of lowest value of GDP per capita (PPP, in current international dollars) between Portugal and trading partner.

Helpman (1987), Hummels and Levinsohn (1995), Egger et al. (2007), and Leitão (2011a) found a positive sign, as is theoretically expected.

Hypothesis 4: There is a negative relationship between the highest value of GDP per capita and IIT.

LogMaxGDP is also a proxy to control for relative size effects. It is the logarithm of highest value of GDP per capita (PPP, in current international dollars) between Portugal and trading partner. A negative sign is consistent with the hypothesis that the more similar countries are in economic dimension, the greater the IIT between them (see Hummels and Levinsohn, 1995).

Hypothesis 5: IIT will be greater when trading partners are geographically close.

LogDIST is the logarithm of geographical distance between Portugal and the partner country.

The theoretical models of Krugman (1979), Lancaster (1980), Helpman (1981), Brander and Krugman (1983) can be used to justify the geographical proximity between countries as an explanatory variable of IIT. However, is the gravitacional model that is often used to introduce distance between countries as an important determinant of the IIT (see, Anderson 1979). Following the empirical studies, we use the number of kilometres between the capital cities of trading partners. This proxy is usually as transport cost, or market access barriers. In accordance with the literature the empirical studies, we expected a negative sign (Cieslik 2005; Blanes 2006; Badinger and Breuss, 2008, Leitão 2011b).

B. MODEL SPECIFICATION

Considering these hypotheses, we decided to specify the following econometric model:

$$IIT_{it} = \beta_0 + \beta_1 X_{it} + \delta t + \eta_i + \varepsilon_{it} \quad (2)$$

Where IIT is the Portuguese IIT index, X is a set of countries and industry-specific explanatory variables in logs; 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 (IID) with E (ε_{it}) =0 and Var(ε_{it})= ^{2} >0.

The model can be rewritten in the following dynamic representation:

$$IIT_{it} = \rho IIT_{it-1} + \beta_1 X_{it} - \rho\beta_1 X_{it-1} + \delta t + \eta_i + \varepsilon_{it} \quad (3)$$

Since IIT is an index varying between zero and one, we apply a logistic transformation to IIT, as in Hummels and Levinsohn (1995). We decided against using the fixed-effects estimator, because some relevant variables such as distance do not vary along the time. We control for time effects by including a time dummy variable, while the regression coefficients in the static model are estimated using OLS with time dummies.

V. EMPIRICAL STUDIES

In the empirical study, we present the results with country characteristics as explanatory variables. Table 1 shows the results of panel unit root test (ADF- Fischer Chi-square). The main variables such as the intra-industry trade (LogIIT), electric power consumption (LogEP), the lowest value of GDP per capita (LogMinGDP), and the higher value of GDP per capita (LogMaxGDP) do not have unit roots, i.e are stationary with individual effects and individual specifications.

TABLE 1 – PANEL UNIT ROOT TEST RESULTS (INTERCEPT AND TREND)

ADF- Fischer Chi-square	***Statistic***		***Prob***
LogIIT	93.32		0.00
LogEP	151.79		0.00
LogMinGDP	238.59		0.00
LogMaxGDP	211.39	0.00	

Source: Authors calculation

In Table 2, we present the OLS estimator with time dummies. Our analysis is intended to evaluate the signs of the coefficients and the statistical significance of the explanatory variables. The differences between per-capita incomes (LogDGDP), the difference in electricity consumption (LogEP) in Kwh per capita, the higher value of GDP per capita (LogMaxGDP), the geographical distance (LogDIST) and the multiplicative dummy variables (EUxEP) are all statistically significant and their coefficients have the expected sign, except the variable LogDGDP. The model presents five statistically significant variables (LogDGDP, at 5%), electric power consumption (LogEP, at 10%), the higher value of GDP per capita (LogMaxGDP, at 5%), the geographical distance (LogDIST, at 10%), and EUxEP (at 1%).

The difference between per-capita incomes (LogDGDP) presents a positive sign. This result suggests that the higher the difference in GDP per capita (PPP, in current international dollars) between Portugal and the European trading partner, the higher will be IIT in the medical and optical instrument sector. As Portuguese IIT is mainly of the vertical IIT (VIIT) type, this can explain the positive sign coefficient of this variable. The IIT encompasses both horizontal IIT(HIIT) as VIIT. When VIIT is predominant the effect on VIIT is similar to the effect on IIT. Following Falvey and Kierzkowski (1987), the paper introduces a variable proxy for the difference in factor endowments (electric power, LogEP). This variable presents a negative sign, confirming the theoretical forecast suggested by Hummels and Levinsohn (1995). Our results validate the hypothesis: IIT in this industry occurs more frequently among countries that are similar in terms of factor endowments.

Based on Helpman and Krugman (1985) and Hummels and Levinsohn (1995), this paper also includes two variables to control for relative size effects. Only the higher value of GDP per capita (LogMaxGDP) has the expected negative sign.

The geographical distance (LogDIST) presents a negative correlation, confirming the results of Badinger and Breuss (2008). The greater the distance between partners, the lower will be the IIT in the industry. For the proxy EUxEP, we expected a negative coefficient and the estimated sign is negative. We can consider that IIT in this specific industry occurs more frequently among countries that belong to the same integration area. Thus, the integration process reinforces the IIT in the medical and optical instrument sector.

TABLE 2 – INTRA-INDUSTRY TRADE : OLS ESTIMATOR WITH TIME DUMMIES

Variables	*Coef.*	*Signs*
LogDGDP	0.646 (2.27)**	(-)
LogEP	-0.716 (-1.80)*	(-)
LogMinGDP	2.193 (0.826)	(+)
LogMaxGDP	-4.914 (-2.06)**	(-)
LogDIST	-1.296 (-1.91)*	(-)
EUxEP	-0.554 (-3.52)***	(-)
C	5.070 (0.567)	
N	146	
$\overline{R^2}$	0.18	

T-statistics (heteroskedasticity corrected) are in round brackets.
***/**/*-statistically significant at the 1%, 5% and 10% levels

Source: Authors calculation

As in the studies of Faustino and Leitão (2006, 2007), we decide to present the determinants of intra-industry trade using the GMM-System estimator, because the dynamic analysis resolve the problems of endogeneity and serial correlation.

The equation presents consistent estimates, with no serial correlation (M1, M2 statistics). The specification Sargan test shows that there are no problems with the validity of the instruments used. For equations in first differences the instruments in levels used are: (LogIIT

(2,7), Log DGDP(2,7), LogEP(2,7). For levels equations, the instruments used are first differences of all variables lagged t-1.

The equation presents five significant variables (IIT_{t-1}, LogDGDP,LogEP, LogDIST, UExEP). As expected, the lagged dependent variable is positive.

The proxy LogDGDP presents a positive sign and is significant at the 1% level. This positive coefficient result was not expected.

The electric power consumption (LogEP) presents a negative sign, confirming the other empirical studies (see, for example, Zhan et al. 2005).

TABLE 3 – INTRA-INDUSTRY TRADE : GMM-SYSTEM

Variables	*Coef.*	*Signs*
IITt-1	0.324 (3.57)***	(+)
LogDGDP	0.8194 (3.27)***	(-)
LogEP	-1.175 (-2.21)**	(-)
LogMinGDP	0.839 (0.430)	(+)
LogMaxGDP	-1.893 (-1.03)	(-)
LogDIST	-2.853 (-1.97)*	(-)
EUxEP	0.627 (2.39)**	(-)
C	-6.292 (-0.554)	
N	125	
M1	[0.302]	
M2	[0.952]	
Sargan	[1.000]	

Source: Authors calculation

T-statistics (heteroskedasticity corrected) are in round brackets. ***/**/*-statistically significant at the 1%, 5% and 10% levels. P-values are in square brackets. Year dummies are included in specification (this is equivalent to transforming the variables into deviations from time means. M1 and M2 are tests for first-order and 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). Sargan is a test of over-identifying restrictions asymptotically distributed as χ^2, under the null of instruments' validity (with two-step estimator).

The geographical distance variable (LogDIST) - a typical gravity model variable- is used as a proxy for transport cost. The negative sign of this coefficient was expected and the results confirm the static result. Badinger and Breuss (2008) and Clark (2006) also found a negative sign.

EUxEP is a multiplicative dummy variable used to stress the role of economic integration. A negative effect of difference in factor endowments on bilateral intra-industry trade was expected for the European partners and the results do not confirm this expectation. This deserves further research considering separation between HIIT and VIIT, because these two types of trade in optical and medical instruments may have different determinants.

VI. CONCLUSIONS

The objective of this study was to estimate the determinants of intra-industry trade in the medical and optical instruments sector and to analyse whether the results for this specific industry confirm previous results for all industries. Econometric estimations support the hypotheses formulated and confirm that the IIT for the medical and optical instrument sector is well explained by the differences in per-capita income, differences in factor endowments and distance.

Our results are robust with static and dynamic panel data. IIT in medical and optical instrument occurs more frequently among countries that are similar in terms of relative factor endowments and are members of the same regional integration agreement. Moreover, this trade increases if the partners are geographically close. However, the relevance of economic integration deserves more investigation EUxEP is a multiplicative dummy variable used to stress the role of economic integration. This deserves further research considering separation between HIIT and VIIT, because these two types of trade in optical and medical instruments may be different determinants.

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INTRAINDUSTRIJSKA TRGOVINA U INDUSTRIJI MEDICINSKIH I OPTIČKIH INSTRUMENATA: ANALIZA PANEL PODATAKA

SAŽETAK

Rad analizira determinante intraindustrijske trgovine u medicinskom i optičkom sektoru u Portugalu koristeći analizu statičkih i dinamičkih panel podataka. Rezultati sugeriraju da se intraindustrijska trgovina medicinskih i optičkih instrumenata češće događa među zemljama koje su slične po pitanju relativnih proizvodnih faktora te su članovi istog regionalnog ugovora o integraciji. Osim toga, ova trgovina raste ako su partneri geografski blizu.

Ključne riječi: intraindustrijska trgovina, dinamički panelni podaci, panelni test jediničnog korijena