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The Intra-Industry Trade between Portugal and European Union: A Static and Dynamic Panel Data Analysis (1996-2000)

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ABSTRACT

One of the objectives of this paper is to confront the estimated models of intra-industry trade (IIT), horizontal intra-industry trade (HIIT) and vertical intra-industry trade (VIIT) using a static and a dynamic panel data.

The second objective is to test the relationship between HIIT, VIIT and comparative advantages.

The third objective is to analyse the results of IIT, HIIT and VIIT with the system GMM(GMM-SYS) estimator and with the standard first-differenced GMM(GMM-DIF) estimator. To estimate the models it will be used the methodology of Blundell and Bond (1998, 2000).

Key words: intra-industry trade, horizontal intra-industry trade, vertical intra-industry trade, comparative advantage, dynamic panel data, GMM-SYS estimator, GMM-DIF estimator.

JEL Classification: F12, C2, C3, L1.

I. INTRODUCTION

On types of trade flows intra-industry trade (IIT) can be measured on three distinct bases: (i) on a multilateral basis\(^1\); (ii) on a specific group of countries (i.e. with other industrial countries or with developing countries) and (iii) on a bilateral basis. This paper examines IIT, horizontal IIT (HIIT) and vertical IIT (VIIT) between Portugal and European Union using a balanced panel with twenty one industries for the period 1996-2000.

In static panel data models are used Pooled OLS, Fixed Effects (FE) and Random Effects (RE) estimators. The problems with these kind of applied work arise because in
these models there are serial correlation, heteroskedasticity and endogeneity of some explanatory variables and the estimators used do not take this into account. The solution for these econometric problems was found by Arellano and Bond (1991), Arellano and Bover (1995), Blundell and Bond (1998, 2000) that developed the first-differenced GMM (GMM-DIF) estimator and the system GMM (GMM-SYS) estimator. The GMM-SYS estimator is a system containing both first-differenced and levels equations. In addition to using instruments in levels for equations in first differences it uses instruments in first differences for equations in levels (Arellano and Bover, 1995). The GMM-SYS estimator is an alternative to the standard first-differenced GMM estimator. As Blundell and Bond (1998, 2000) proved, with GMM-SYS estimator there is virtually no sample bias and much better precision, even in the smaller sample size in contrast to the GMM-DIF estimator.

In dynamic panel data models the GMM-SYS estimator eliminates the unobserved industry-specific effects through the equations in first-differences. The GMM-SYS estimator also controls for the endogeneity of the explanatory variables. A standard assumption on the initial conditions allows the use of the endogenous lagged variables for two or more periods as valid instruments if there is no serial correlation (Cf. Blundell and Bond, 1998, 2000). If we assume that the first differences of the variables are orthogonal to the industry-specific effects, this allows in addition the use of lagged first differences of variables for one or two periods as instruments for equations in levels (Cf. Arellano and Bover, 1995, Blundell and Bond, 1998, 2000). The validity of instruments is tested using a Sargan test of the over-identifying restrictions and serial correlation. First-order and second-order serial correlation in the first-differenced residuals is tested using m1 and m2 statistics (Arellano and Bond, 1991). The GMM system estimator is consistent if there is no second-order serial correlation in residuals (m2 statistic). The dynamic panel data model is valid if the estimator is consistent and the instruments are valid.

In empirical studies of IIT is not be usual the dynamic panel data analysis. However, in recent studies of intra-industry, production functions, firms’ growth, productivity spillovers from foreign direct investment or from multinational corporations, most of them use a dynamic panel data model (see, for example, Arellano and Bond, 1991, Blundell and Bond, 2000, Goddard et. al., 2002). The results presented in this paper are generally consistent with the predictions of the theory of intra-industry trade. It is demonstrated that better results can be achieved using a GMM-SYS estimator, rather
than OLS, Fixed Effects or Random Effects estimators. The GMM-SYS estimator has the comparative advantage based on the potential for obtaining consistent parameter estimates even in the presence of measurement errors, omitted variables and endogenous right-hand-side variables. The GMM-SYS estimator is also preferable to the standard GMM-DIF estimator. With the GMM-SYS estimator there is an improvement in performance because it reduces finite-sample biases associated with GMM-DIF estimator. So GMM-SYS estimator yields much more reasonable parameter estimates.

The remainder of the paper is organized as follows. Section 2 reviews the theoretical literature of IIT models. Section 3 presents the indexes, the explanatory variables and the sources. Section 4 reports the evolution of the ITT, HIIT and VIIT between Portugal and European Union over 1995-2002. Section 5 presents the static and dynamic panel data models of IIT HIIT and VIIT and analyzes the estimation results. The final section concludes.

2. Previous Literature

Essentially we have two types of trade: inter-industry trade and intra-industry trade (mainly trade of differentiated products). We used to accept that only traditional theories of comparative advantage (Ricardian trade theory and Heckscher-Ohlin trade theory), based on constant returns to scale, homogeneous product and perfect competition could explain inter-industry trade. The IIT was explained by scale economies, product differentiation and imperfect competition. There was also a wide acceptance of the idea that IIT was a phenomenon more intense between countries with similar income levels, a similarity reinforced by the economic integration process.

The pioneering work in intra-industry models is due to Krugman (1979,1980), Lancaster (1980), Helpman(1981) and Eaton and Kierzkowski(1984). All these models consider that products are horizontally differentiated – different varieties of a product are of a similar quality - although the varieties of the same product may be distinguished in terms of their actual characteristics or perceived characteristics. Neo-Chamberlinian models, such as Krugman models, consider the assumption that all varieties enter the utility function symmetrically. By contrast, the neo-Hotelling model, for example the Lancaster model is, assumes asymmetry. In the former, the consumers are assumed to endeavor to consume as many different varieties of a given product as possible (“love of
variety approach”). In the latter, different consumers have different preferences for alternative varieties of a given commodity and each consumer prefers one variety to all others (“favorite variety approach”). But no unique ranking would be agreed to by all consumers.

In these models each variety is produced under decreasing costs and when the countries open to the trade the similarity of the demands leads to intra-industry trade. So, HIIT is more likely between countries with similar factor endowments and can not be explained by traditional trade theories.

In the vertical differentiation, different varieties are of different qualities and it is assumed that consumers rank alternative varieties according to product quality. Falvey (1981), Falvey and Kierzkowski (1984), Shaked and Sutton (1984) and Flam and Helpman (1987) introduced the vertical differentiation models. It is generally accepted that VIIT can be explained by traditional theories of comparative advantage. (See, for theoretical and empirical work, Greenaway and Milner, 1986, Greenaway, Hine and Milner, 1994, 1995, Tharakan and Kerstens, 1995, Blanes and Martin, 2000). The relative labor abundant countries have comparative advantage in labor-intensive products (lower quality varieties) and relative capital abundant countries have comparative advantage in capital-intensive products (higher quality varieties). So, according to comparative advantage law, the first countries will export the labor-intensive varieties and the other countries will export the capital-intensive varieties. Or in terms of the factor content version of Heckscher-Ohlin theorem for n goods and factors: the capital content of the net exports of the relative capital abundant country will be higher in relation to the net exports of the other country (see Vanek, 1968). As Davis (1995, p. 205) stressed, there is an assumption that “goods are distinguished on the demand side according to perceived quality, and on the production side by the fact that high quality goods are produced under conditions of greater capital intensity”. So, we exclude from vertical IIT goods (varieties) produced under the same factor proportions. Otherwise, horizontal IIT may assume identical factor intensity.

Greenaway, Hine and Milner (1995) refers to four types of model of IIT in differentiated products “(i) large numbers case of vertical IIT (e.g. Falvey, 1981); (ii) small numbers case of vertical IIT (e.g. Shaked and Sutton, 1984); (iii) large numbers case of horizontal IIT (e.g. Helpman, 1981); (iv) small numbers case of horizontal IIT (e.g. Eaton and Kierzkowski, 1984)”.

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Falvey (1981) explains the simultaneous existence of vertical IIT and inter-industry trade. Helpman and Krugman (1985) build up a model which generates both inter and intra-industry trade. The model incorporates factor endowments, decreasing costs and horizontal product differentiation. So, it is known as the Chamberlin-Heckscher-Ohlin model. More recently, Davis (1995) provides a Heckscher-Ohlin-Ricardo framework that gives a unified account of inter-industry and intra-industry trade and where decreasing costs are not necessary for intra-industry trade. There are also some models of IIT in homogeneous products (e.g. Brander, 1981; Brander and Krugman, 1983).

3. Presentation of the Indexes and the Explanatory Variables

Grubel and Lloyd indexes

Grubel and Lloyd (1975) define ITT 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 where the denominator is total trade.

\[ B_i = 1 - \frac{|X_i - M_i|}{(X_i + M_i)} \]

\[ \Leftrightarrow B_i = \frac{(X_i + M_i) - |X_i - M_i|}{(X_i + M_i)} \]  

(1)

The index is equal to 1 if all trade is intra-industry trade one. If Bi is equal 0 all trade is inter-industry trade.

Source: INE- National Institute of Statistics (Trade Statistics)

The HIIT and VIIT indexes

To determine the horizontal and vertical intra-industry trade it is used the Grubel and Lloyd indexes and the methodology of Abel-el-Rahaman (1991), and Greenaway et. al. (1994)

\[ HIIT = \frac{RH}{(X_i + M_i)} \]

(2)

HIIT- Horizontal intra-industry trade index

RH- Total horizontal intra-industry trade

\[ TT_y \] - Relative unit values of exports and imports is used to disentangle HIIT and VIIT 4
If \( TT_{ij} \in [0.85;1.15] \), we have horizontal IIT

\[
VIIT = \frac{RV}{(X_i + M_i)}
\]

(3)

VIIT- Vertical intra- industry index

RV- Total vertical intra-industry trade.

If \( TT_{ij} < 0.85 \) we have vertical IIT, \( TT_{ij} > 1.15 \) we have inferior VIIT (lower quality). \( TT_{ij} > 1.15 \), we have superior VIIT (higher quality).

The HIIT and VIIT are calculated with desegregation of 5 digits CAE (Economic Activities Classification. The CAE classification is similar to NACE classification).

Source: INE (Trade Statistics)

**Explanatory variables**

PD1(*Horizontal Product Differentiation*): the variable proxy is the Hufbauer index, i.e. variation of export unit values. \( H = \frac{\sigma_{ij}}{\bar{x}_{ij}} \) where \( \sigma_{ij} \) = standard deviation of export unit values, and \( \bar{x}_{ij} \) = unweighted mean of those unit values (see Greenaway and Milner,1986 pp.116-117)

PD2 (*Horizontal Product Differentiation*): the second variable proxy is the number of five digit CAE categories in each two digit industry;

HC (*Human Capital*): weight of professionals with qualification plus professionals with semi-qualification in total employment of industry;

L*(*Non-Qualified Labor*): weight of non-qualified workers in total employment;

K/L (*Intensity of Physical Capital*): the variable proxy is the ratio between the non-salaries returns and total employment of industry ( Cf. Hirsch, 1974 and Balassa, 1978);

HCS/L (*Intensity of Human Capital*): the variable proxy is the difference between salaries and medium salary of non-qualified workers, divided by the opportunity cost of capital (Cf. Branson and Monoyios,1977);

VPD (*Vertical Product Differentiation*): % of the professionals with qualification;

PROD (*Productivity*): is the value added by employer
MES1 (Minimum Efficient Scale): The first variable proxy is a measure of relative value added by the four largest firms. Instead of value added we used the sales of the firms.  

MES2 (Minimum Efficient Scale): the second variable proxy is the average size of establishment;  

CONC (Industrial Concentration): it is a percentage of industry sales of the four largest firms in total sales plus imports of industry.  

Sources:  
Ministry of Labor (Quadros de Pessoal)  
INE-Statistics of firms  
Bank of Portugal  

4. The IIT, HIIT and VIIT between Portugal and the European Union over 1995-2002  

As shown in figure 1 the IIT between Portugal and European Union (EU) is over 50% for the period 1996-2002. In 2002 IIT reaches the value of 59% of total trade between Portugal and EU. For all period in analysis the VIIT is, generally, much higher than the HIIT. These values are in accordance with the values expected for a developed country as Portugal. In 2002 VIIT accounts for 73% of total IIT with EU. For the more developed countries VIIT usually accounts for 80 to 90 percent of total IIT (see Aturupane et. al., 1999).  

As it can be seen in figure 2 the VIIT is not homogeneous. The weight of inferior VIIT (low quality products) and superior VIIT (high quality products) is not similar for the all period. Despite the values of years 2000 and 2002 the inferior VIIT is clearly predominant. This suggests that in future econometric estimations it is useful to distinguish inferior VIIT from superior VIIT.
5. Static and Dynamic panel data models

The static panel data models were estimated with Pooled OLS, fixed effects (FE) and random effects (RE) estimators. The F statistic tests the null hypothesis of the same specific-effects for all industries. If we accept the null hypothesis we could use the OLS estimator. The Hausman test can decide which model is better: random effects (RE) versus fixed effects (FE). For purposes of comparison with the dynamic models it was selected the FE model, because it avoids the inconsistency due to correlation between the explanatory variables and the industry-specific effects. In the FE model all explanatory variables are potentially correlated with the effects and therefore only estimators based on deviations of the observations can be consistent (Arellano and Bover, 1995). OLS and RE estimations are also available in the tables.

The paper also estimate the dynamic panel data models using two alternative GMM estimators. The first-differenced GMM estimator (GMM-DIF) was proposed by Arellano e Bond (1991) and the system GMM estimator (GMM-SYS) was proposed by Arellano and Bover (1995), and Blundell e Bond (1998, 2000). This last estimator is an alternative to the standard GMM-DIF estimator. As Blundell and Bond (1998, 2000) proved, with GMM-SYS estimator there is virtually no sample bias, even in the smaller sample size in contrast to the GMM-DIF estimator.

The GMM estimators permit to obtain efficient estimates. It was considered an individual effects autoregressive panel data model with endogenous explanatory variables\(^{10}\). We used \(m1\) and \(m2\) statistics to test for first-order and second-order serial correlation and the Sargan statistic to test the null hypothesis of instruments validity. Identification of the model requires restrictions on the serial correlation properties of the error term and on the properties of the explanatory variables, that may or may not be correlated with industry-specific effects. The paper considers that explanatory variables are not strictly exogenous with respect to error term.

5.1. Intra-industry Trade Model

Model [1]

\[ IIT_{it} = \beta_0 + \beta_1 (PD_{it}) + \beta_2 (MES_{it}) + \beta_3 (CONC_{it}) + \beta_4 PROD_{it} + \delta_t + \eta_i + \epsilon_{it} \]
Where $\eta_i$ is the unobserved time-invariant industry-specific effects; $\delta_t$ captures a common deterministic trend; $\epsilon_{it}$ is a random disturbance assumed to be normal, independent and identical distributed (IID) with $E(\epsilon_{it}) = 0$ and $\text{Var}(\epsilon_{it}) = \sigma^2 > 0$.11

The model 1 can be rewritten in the following dynamic representation:

$$IIT_a = \rho IIT_{a-1} + \beta_1 (PD)_a + \beta_2 (MES)_a + \beta_3 (CONC)_a + \beta_4 (PROD)_a + \delta \eta_i + \epsilon_{it}$$

The expected signs are:

$IIT_{it-1}$: The expected sign is positive;

PD1, (Horizontal Differentiation): Gray(1988), Greenaway and Milner(1986) considered a positive relation of this variable with IIT. Ethier (1982) considers the existence of a negative relation.;

MES1 (Minimum Efficient Scale): Ethier(1982) and Harrigan (1995) questioned the positive relation. The sign could be positive or negative depending on the market structure. The dominant paradigm considers a large number of firms and a negative sign. If we consider the hypothesis of a small number of firms the expected sign is positive;

CONC (Industrial Concentration): The sign could be positive or negative depending on the market structure. With the hypothesis of a large number of firms the expected sign is negative, otherwise the expected sign is positive (hypothesis of a small number of firms);

PROD (Productivity): if we assume that productivity is associated with differentiation of products, the sign should be positive.

5.2. Horizontal Intra-industry Trade Model

Model [2]

$$HIIT_a = \beta_0 + \beta_1 (PD_2)_a + \beta_2 (HCS / L)_a + \beta_3 (MES_2)_a + \beta_4 (CONC)_a + \beta_5 (PROD)_a + \delta \lambda^* + \beta_6 (K / L)_a + \delta \eta_i + \epsilon_{it}$$

The model 2 can be rewritten in the following dynamic representation:
\[\begin{align*}
HIT_{t} &= \rho HIT_{t-1} + \beta_1 (PD_2)_{t} - \rho \beta_1 (PD)_{t-1} + \beta_2 (HCS / L)_{t} - \rho \beta_2 (HCS / L)_{t-1} + \beta_4 (MES_2)_{t} \\
& \quad - \rho \beta_4 (MES_2)_{t-1} + \beta_4 (CONC)_{t} - \rho \beta_4 (CONC)_{t-1} + \beta_3 (PROD)_{t} - \rho \beta_3 (PROD)_{t-1} + \beta_6 (K/L)^* - \rho \beta_6 (K/L)_{t-1} \\
& \quad + \beta_5 (K/L)_{t} - \rho \beta_5 (K/L)_{t-1} + \delta + \eta_t + \varepsilon_t
\end{align*}\]

The expected signs are:

\(HIT_{t-1}\): the expected sign is positive;

\(PD2\) (Horizontal Differentiation): the expected sign is positive;

\(HCS/L\) (stock intensity of human capital): this variable is associated with the neo-factorial theory (neo-factor proportions theory). So, the expected sign is negative or the coefficient is not significantly different from zero (there is no statistical association between HCS/L and HIIT);

\(MES2\) (Minimum Efficient Scale): the sign could be positive or negative. The dominant paradigm considers the hypothesis of a large number of firms, and, so, the expected sign will be negative. Otherwise the expected sign is positive (hypothesis of a small number of firms);

\(CONC\) (Industrial Concentration): the sign could be positive or negative depending on the market structure. With the hypothesis of a large number of firms, the expected sign is negative, otherwise the expected sign is positive (hypothesis of a small number of firms);

\(PROD\) (Productivity): if we consider that the productivity is associated with the differentiation of products, so the expected sign is positive.

\(L^*\) (Non-Qualified Labor), \(K/L\) (Intensity of Physical Capital): these are variables of the HO factor proportions theory used in the empirical studies of comparative advantages. So, the expected signs are negative or the coefficients are not significantly different from zero at any conventional statistical level (non statistical association between these variables and HIIT)

### 5.3. Vertical Intra-industry Trade Model

Model [3]

\[\begin{align*}
VIT_{t} &= \beta_0 + \beta_1 VPD_{t} + \beta_2 (HCS / L)_{t} + \beta_4 (CONC)_{t} + \beta_3 (HCS)_{t} + \beta_5 (K/L)^* + \beta_6 (K/L)_{t} + \eta_t + \varepsilon_t
\end{align*}\]

The model 3 can be rewritten in the following dynamic representation:
\[ \text{VIIT}_{it} = \rho \text{VIIT}_{it-1} + \beta_1 (\text{VPD})_{it} - \rho \beta_2 (\text{VPD})_{it-1} + \beta_2 (\text{HCS} / L)_{it} - \rho \beta_2 (\text{HCS} / L)_{it-1} + \beta_3 (\text{CONC} )_{it} \\
- \rho \beta_3 (\text{CONC } )_{it-1} + \beta_4 (\text{HC})_{it} - \rho \beta_5 (\text{HC})_{it-1} + \beta_5 L^* - \rho \beta_5 L^*_{it-1} + \beta_6 (K / L)_{it} - \rho \beta_6 (K / L)_{it-1} + \delta + \eta_i + \epsilon_{it} \]

The expected signs are:

\( \text{VIIT}_{it-1} \) : the expected sign is positive;

\( \text{VPD} \) (Vertical Product Differentiation): the expected sign is positive;

\( \text{HCS/L} \) (Intensity of Human Capital): as neo-factorial theory can explain the VIIT, the expected sign is positive;

\( \text{HC} \) (Human Capital): the expected sign is positive;

\( \text{CONC} \) (Industrial Concentration): the sign could be positive or negative. According to the dominant paradigm of a large number of firms the expected sign is negative, otherwise the sign will be positive (hypothesis of a small number of firms);

\( L^* \) (Non-Qualified Labor), \( K/L \) (Intensity of Physical Capital): the expected signs are positive. Additionally if we make the distinction between superior quality and lower quality products, we can expect that Portugal exports lower quality varieties (products) if \( L^*>0 \) and \( K/L<0 \) and exports higher quality varieties (products) if \( L^*<0 \) and \( K/L>0 \).

5.4. Analysis of the static panel data estimations

For purposes of comparison to the dynamic models we select the FE model, but we also report in tables OLS and RE estimations.

In table 1 it can be observed the determinants of IIT. With FE estimator the model presents two significant variables: industrial concentration(CONC) and productivity (PROD). It was expected a negative (positive) sign for CONC (PROD) and the results are positive for CONC and negative for PROD.

In table 2 it can be observed the determinants of HIIT. With FE estimator the model presents four significant variables: economies of scale (MES2), industrial concentration(CONC), productivity (PROD), non-qualified workers (L*).

Other considerations relating to HIIT model:

- MES2: the dominant paradigm of large number of firms expects a negative sign and the coefficient estimated is positive;
- CONC: the dominant paradigm of a large number of firms expects a negative sign, and the coefficient, statistically significant, is positive;
- PROD: it was expected a positive sign, and the coefficient is negative;
- L*: the expected sign is negative or the coefficient is not significantly different from zero and the theory is confirmed;
- intensity of physical capital (K/L): the expected signs is negative or the coefficient is not statistically significant. The theory is confirmed.

In table 3 it is shown the determinants of VIIT. With FE estimator the model presents one significant variable: non-qualified workers (L*).

Other considerations relating to VIIT model:
- L*: the expected sign can be positive (negative) if Portugal exports low (high) quality differentiated products. The coefficient is positive which means that Portugal, relative to European Union, has comparative advantages in lower quality products;
- K/L: the expected sign can be positive (negative) if Portugal exports high (low) quality differentiation products. The coefficient, although not statistically significant, is negative, which confirms that Portugal, relative to European Union, has comparative advantages in lower quality products.

5.5. Analysis of the dynamic panel data estimations

As shown in table 4 the IIT dynamic model presents consistent estimates with no serial correlation for GMM-DIF and GMM-SYS estimators (m1, m2 statistics). The specification Sargan test shows that there are no problems with the validity of instrument used for both estimators. The model presents four significant variables (IITt-1, CONC, PROD, PRODt-1) for both estimations. As the significant variables and coefficients signs are the same, it can be said that, apparently, both estimators have equal performance. However, the standard deviations are generally higher in GMM-DIF estimator than in GMM-SYS estimator. So, despite both estimators require restrictions on the initial conditions process and the first-differenced GMM estimates are closer to the system GMM, it is recommendable the system GMM approach, because the additional moment restrictions exploited by the GMM-SYS estimator appear to be
useful in reducing finite sample biases associated with GMM-DIF estimator (see Blundell and Bond, 1998, 2000)

Other results relating to IIT dynamic model:
- lagged intra-industry trade (IITt−1): it was expected a positive sign, and the results confirm this;
- industrial concentration (CONC): the dominant paradigm of a large number of firms predicts a negative sign. However, the results gave a positive one which confirms the paradigm of a small number of firms;
- productivity (PROD) and lagged productivity (PRODt−1): the expected signs are positive, which is not confirmed by the estimations.

Table 5 reports HIIT dynamic estimations. Both differenced and system GMM estimators present consistent estimates with no serial correlation (m1,m2 statistics) but only GMM-SYS estimator have not problems with the validity of instrument used (Sargan test). The GMM-SYS gives reasonable results with four significant variables: (HIITt-1, HCS/Lt-1, CONC, L*t-1).

Other considerations relating to GMM-SYS estimation:
- lagged horizontal intra-industry trade (HITTt−1): The expected sign is positive and the estimate is positive;
- lagged intensity of human capital (HCS/Lt−1): the expected sign is negative or the coefficient is not significantly different from zero and the estimate is positive;
- industrial concentration (CONC): the dominant paradigm with a large number of firms expects a negative sign and the result confirms this;
- non-qualified labor (L*) and intensity of physical capital (K/L): the expected signs are negative or there are non statistical association between these variables and HIIT. The coefficients of these variables are all not significantly different from zero at any conventional level, which confirm the theory;
- lagged non-qualified labor (L*t−1): the expected sign is negative or the coefficient is not significantly different from zero, but the estimate is positive;
- lagged intensity of physical capital (K/Lt−1): the expected sign is negative or the coefficient is not significantly different from zero, and the results confirm the theory.
Table 6 reports VIIT dynamic estimations. Both differenced and system GMM estimators present consistent estimates with no serial correlation (m1,m2 statistics) and both have no problems with the validity of instrument used (Sargan test). However the results are very different The differenced GMM estimation has three significant variables (VIITt-1, HCS/L, K/Lt-1) that are completely different from those ones obtained through the GMM system estimator (HC, Hct-1, L*, Lt-1).

Other results relating to GMM-SYS estimation:
- human capital (HC), lagged human capital (HC_{t-1}): the expected signs are positive and the estimate is positive for HC and negative for HCT-1
- non-qualified labor (L*) and lagged non-qualified labor (L*_{t-1}): the expected signs are positive (negative) if Portugal exports products of low (high) quality. The sign is positive for L* and negative for L*_{t-1}. Despite the sign of L*_{t-1} it is correct to say that Portugal has comparative advantages in low quality differenced products;
- intensity of physical capital (K/L) and lagged intensity of physical capital (K/L_{t-1}): the expected signs are positive (negative) if Portugal exports high (low) quality differentiated products. The coefficients are negative (although the are not statistically significant), which confirms that Portugal, relative to European Union, has comparative advantages in lower quality products.

6- Conclusions and further research

Our main conclusions are: (i) The IIT between Portugal and European Union (EU) is over 50% for the period 1996-2002. For all period in analysis the VIIT is, generally, much higher than the HIIT and the weight of inferior VIIT (low quality products) is predominant relative to superior VIIT (high quality products. This suggests that in future econometric estimations it is useful to distinguish inferior VIIT from superior VIIT. It is our further research; (ii) As was expected the results given by the static and dynamic models are different as well as the results given by both GMM estimators; (iii) In general there is no statistical association between HIIT and comparative advantages variables. This was expected by theory; (iv) The results obtained suggest that Portugal, relative to EU, has comparative advantages in lower quality differenced varieties(products); (v) Although the use of more sophisticated econometric techniques should not be an end in itself, and it would be dangerous to generalize from this one
empirical study, it may be preferable to use the GMM approach in empirical intra-industry trade rather than pooled OLS, fixed effects or random effects estimators. At least we should check their results; (vi) Finally, for comparison to first-differenced GMM estimator, the system GMM estimator has the comparative advantage based on the potential for obtaining much more reasonable parameter estimates, reducing large finite-sample biases associated with the usual first-differenced estimator.

7. NOTES

1. The most empirical studies of IIT use a multilateral measure of it. The idea is that «… one may expect to generate IIT on a multilateral basis with or without two-away trade on a bilateral basis» (Greenaway and Milner, 1986, p.128). However «The possibility that multilateral measured IIT may be an expression of geographical aggregation, analogous to categorical aggregation, may be greater and of grater significance…» (idem).

2. The GMM system estimator that we report was computed using DPD for OX(see Doornik, Arellano, and Bond 2002).

3. If variables are measured without error the number of moment conditions increases and first differences lagged t-2 become valid instruments for the equations in levels. Further lagged differences can be shown to be redundant if all available moment conditions for the equations in first differences are exploited (Cf. Blundell and Bond, 2000)

4. \[ TT_{ij} = \frac{X_{ij}}{M_{ij}} \]

\[ X_{ij} \] - Values of exports of sub sector j of sector i; \[ M_{ij} \] - Values of imports of sub sector j of sector i; \[ QX_{ij} \] - Quantities of exports of sub sector j of sector i; \[ QM_{ij} \] - Quantities of imports of sub sector j of sector i

5. Intensity of Human Capital (Stock) :

\[ \frac{HCS}{L_i} = \frac{W_i - W_i^*}{r} \]

\[ W_i \] = Average salary of industry; \[ W_i^* \] = Average salary of non-qualified workers; \[ r \] = opportunity cost of capital.

6. \[ MES1 = \frac{VA}{L_i} \]

\[ VA \] = Value added of the four firms; \[ L_i \] = Employment of the four firms; \[ V_i = Value added of the industry \]

\[ L_i \] = Employment in industry
7. \( MES_2 = \frac{VBP_i}{E_i} \)

\( VBP_i \) = Value of production of industry i; \( E_i \) = number of firms in industry i.

8. \( CONC = \frac{V_d}{V_j + M_j} \)

9. Quadros de Pessoal is a data set based on a standardized questionnaire that all firms with wage earners must answer every year.

10. The assumption of no serial correlation in the error term is essential for the consistency of estimators. It is assumed that if the error term was originally autoregressive, the model has been transformed so that the coefficients of explanatory variables satisfy some set of common factor restrictions. Thus only serially uncorrelated or moving average errors are allowed.

11. The \( \varepsilon \) are assumed to be independently distributed across industries with zero mean, but arbitrary forms of heteroskedasticity across units and time are possible.
8. TABLES AND FIGURES

TABLE 1

Determinants of IIT (Static Models)

<table>
<thead>
<tr>
<th>Models</th>
<th>C</th>
<th>PD1</th>
<th>MES1</th>
<th>CONC</th>
<th>PROD</th>
<th>Adjusted R²</th>
<th>N</th>
<th>Hausman Test (H0:REV-SFE)</th>
</tr>
</thead>
<tbody>
<tr>
<td>OLS</td>
<td>0.323</td>
<td>-0.810</td>
<td>0.044</td>
<td>0.567</td>
<td>-0.0001</td>
<td>0.275</td>
<td>105</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.042)</td>
<td></td>
<td>(3.167)</td>
<td>(3.360)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fixed Effects</td>
<td>-</td>
<td>0.010</td>
<td>-0.008</td>
<td>0.763</td>
<td>-0.0099</td>
<td>0.8111</td>
<td>105</td>
<td>CHISQ(2)=0.722</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(1.436)</td>
<td></td>
<td>(2.105)</td>
<td></td>
<td></td>
<td></td>
<td>P-value=0.696</td>
</tr>
<tr>
<td>Random Effects</td>
<td>0.384</td>
<td>0.011</td>
<td>0.010</td>
<td>0.485</td>
<td>-0.0009</td>
<td>0.226</td>
<td>105</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(6.683)</td>
<td>(0.761)</td>
<td>(6.642)</td>
<td>(3.217)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* b statistically significant, respectively, at the 10%, 5% and 1% level.
* In parentheses are t-statistics (White-heteroscedasticity corrected).
* F test of A, B= Ai, B; F(20,80)=15.168 ; P-Value=0.000

TABLE 2

Determinants of HIIT (Static Models)

<table>
<thead>
<tr>
<th>Models</th>
<th>C</th>
<th>PD2</th>
<th>HCS/L</th>
<th>MES2</th>
<th>CONC</th>
<th>PROD</th>
<th>L*</th>
<th>K/L</th>
<th>Adjusted R²</th>
<th>N</th>
<th>Hausman Test (H0:REV-SFE)</th>
</tr>
</thead>
<tbody>
<tr>
<td>OLS</td>
<td>0.286</td>
<td>0.0001</td>
<td>0.0019</td>
<td>0.0008</td>
<td>-0.0165</td>
<td>-0.0032</td>
<td>-0.497</td>
<td>0.0003</td>
<td>0.069</td>
<td>105</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(3.768)</td>
<td></td>
<td>(0.150)</td>
<td>(1.519)</td>
<td>(-0.098)</td>
<td>(-1.645)</td>
<td>(-2.239)</td>
<td>(0.238)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fixed Effects</td>
<td>-</td>
<td>-</td>
<td>-0.001</td>
<td>0.0003</td>
<td>1.179</td>
<td>-0.092</td>
<td>-0.773</td>
<td>0.0001</td>
<td>0.546</td>
<td>105</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(-2.244)</td>
<td>(2.071)</td>
<td>(2.379)</td>
<td>(-2.127)</td>
<td>(-1.748)</td>
<td>(0.109)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Random Effects</td>
<td>0.287</td>
<td>0.0004</td>
<td>-0.0003</td>
<td>0.0001</td>
<td>-0.112</td>
<td>-0.0037</td>
<td>-0.540</td>
<td>0.0009</td>
<td>0.051</td>
<td>105</td>
<td>CHISQ(1)=0.49</td>
</tr>
<tr>
<td></td>
<td>(2.678)</td>
<td></td>
<td>(-0.007)</td>
<td>(2.753)</td>
<td>(-0.443)</td>
<td>(-3.127)</td>
<td>(-1.512)</td>
<td>(0.271)</td>
<td></td>
<td></td>
<td>P-value=0.483</td>
</tr>
</tbody>
</table>

* F test of A,B= Ai, B; F(20,77)= 6.1043 ; P-Value=0.000

TABLE 3

Determinants of VIIT (Static Models)

<table>
<thead>
<tr>
<th>Models</th>
<th>C</th>
<th>VPD</th>
<th>HCS/L</th>
<th>CONC</th>
<th>HC</th>
<th>L*</th>
<th>K/L</th>
<th>Adjusted R²</th>
<th>N</th>
<th>Hausman Test (H0:REV-SFE)</th>
</tr>
</thead>
<tbody>
<tr>
<td>OLS</td>
<td>0.453</td>
<td>0.039</td>
<td>0.007</td>
<td>0.209</td>
<td>-0.340</td>
<td>0.497</td>
<td>-0.0006</td>
<td>0.125</td>
<td>105</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(1.915)</td>
<td></td>
<td>(0.246)</td>
<td>(1.423)</td>
<td>(-1.405)</td>
<td>(1.478)</td>
<td>(-3.651)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fixed Effects</td>
<td>-</td>
<td>-0.107</td>
<td>-0.004</td>
<td>0.246</td>
<td>1.288</td>
<td>1.608</td>
<td>-0.0003</td>
<td>0.566</td>
<td>105</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(-0.675)</td>
<td>(-0.881)</td>
<td>(0.643)</td>
<td>(1.448)</td>
<td>(1.726)</td>
<td>(-1.321)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Random Effects</td>
<td>0.244</td>
<td>0.039</td>
<td>-0.001</td>
<td>0.139</td>
<td>-0.065</td>
<td>0.599</td>
<td>-0.0004</td>
<td>0.102</td>
<td>105</td>
<td>CHISQ(3)=6.533</td>
</tr>
<tr>
<td></td>
<td>(0.863)</td>
<td></td>
<td>(-0.418)</td>
<td>(0.957)</td>
<td>(-0.210)</td>
<td>(1.445)</td>
<td>(-2.462)</td>
<td></td>
<td></td>
<td>P-value=0.088</td>
</tr>
</tbody>
</table>

* F test of A,B= Ai, B; F(20,78) = 5.9878 ; P-value = 0.000
### TABLE 4

Determinants of IIT (Dynamic Models)

<table>
<thead>
<tr>
<th>Variables</th>
<th>GMM-DIF</th>
<th>GMM-SYS</th>
</tr>
</thead>
<tbody>
<tr>
<td>IIT(_{t-1})</td>
<td>0.586</td>
<td>0.859</td>
</tr>
<tr>
<td></td>
<td>(6.96)(b)</td>
<td>(8.04)(b)</td>
</tr>
<tr>
<td>PD1</td>
<td>-0.022</td>
<td>-0.072</td>
</tr>
<tr>
<td></td>
<td>(-0.758)</td>
<td>(-0.936)</td>
</tr>
<tr>
<td>PD1(_{t-1})</td>
<td>-0.009</td>
<td>0.063</td>
</tr>
<tr>
<td></td>
<td>(-0.206)</td>
<td>(1.17)</td>
</tr>
<tr>
<td>MES1</td>
<td>-0.016</td>
<td>-0.004</td>
</tr>
<tr>
<td></td>
<td>(-0.330)</td>
<td>(-1.50)</td>
</tr>
<tr>
<td>MES1(_{t-1})</td>
<td>-0.013</td>
<td>0.052</td>
</tr>
<tr>
<td></td>
<td>(-0.399)</td>
<td>(1.36)</td>
</tr>
<tr>
<td>CONC</td>
<td>0.971</td>
<td>0.522</td>
</tr>
<tr>
<td></td>
<td>(2.05)(b)</td>
<td>(1.82)(a)</td>
</tr>
<tr>
<td>CONC(_{t-1})</td>
<td>0.793</td>
<td>-0.041</td>
</tr>
<tr>
<td></td>
<td>(1.29)</td>
<td>(-0.124)</td>
</tr>
<tr>
<td>PROD</td>
<td>-0.0005</td>
<td>-0.0003</td>
</tr>
<tr>
<td></td>
<td>(-3.88)(b)</td>
<td>(-3.85)(b)</td>
</tr>
<tr>
<td>PROD(_{t-1})</td>
<td>-0.0006</td>
<td>-0.0004</td>
</tr>
<tr>
<td></td>
<td>(-7.35)(b)</td>
<td>(-3.96)(b)</td>
</tr>
<tr>
<td>C</td>
<td>0.012</td>
<td>-0.0011</td>
</tr>
<tr>
<td></td>
<td>(0.778)</td>
<td>(-0.017)</td>
</tr>
<tr>
<td>M1</td>
<td>-0.3465</td>
<td>-0.888</td>
</tr>
<tr>
<td></td>
<td>[0.729]</td>
<td>[0.374]</td>
</tr>
<tr>
<td>M2</td>
<td>1.044</td>
<td>0.468</td>
</tr>
<tr>
<td></td>
<td>[0.296]</td>
<td>[0.639]</td>
</tr>
<tr>
<td>W(_{JS})</td>
<td>2586 [0.000]</td>
<td>2692 [0.000]</td>
</tr>
<tr>
<td></td>
<td>df=9</td>
<td>df=9</td>
</tr>
<tr>
<td>Sargan</td>
<td>2.072 [0.913]</td>
<td>5.236 [0.990]</td>
</tr>
<tr>
<td></td>
<td>df=6</td>
<td>df=15</td>
</tr>
<tr>
<td>Observations</td>
<td>63</td>
<td>84</td>
</tr>
<tr>
<td>Parameters</td>
<td>12</td>
<td>13</td>
</tr>
<tr>
<td>Individuals derived from year</td>
<td>21</td>
<td>21</td>
</tr>
</tbody>
</table>

The null hypothesis that each coefficient is equal to zero is tested using one-step robust standard error. In round brackets are t-statistics (heteroskedasticity corrected).

a/b/c- statistically significant, respectively at the 10%,5% and 1% level.

P-values are in square brackets.

Year dummies are included in all specifications (it is equivalent to transforming the variables into deviations from time means, i.e the mean across the n industries for each period).

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)

W\(_{JS}\) is the Wald statistic of joint significance of independent variables (for first-steps, excluding time dummies and the constant term)

Sargan is a test of the over-identifying restrictions, asymptotically distributed as \(\chi^2\) under the null of instruments validity (with two-step estimator)
For the GMM-DIF the instruments in levels used are MES2(2,3), CONC(2,3), HIIT(2,3).

In the case of GMM-SYS and for equations in first differences the instruments in levels used are MES1(2,2), CONC2(2,2), HIIT(2,2). For levels equations the instruments used are first differences of all variables lagged t-1.

### TABLE 5
Determinants of HIIT (Dynamic Models)

<table>
<thead>
<tr>
<th>Variables</th>
<th>GMM-DIF</th>
<th>GMM-SYS</th>
</tr>
</thead>
<tbody>
<tr>
<td>HIIT _t-1</td>
<td>-0.109</td>
<td>0.604</td>
</tr>
<tr>
<td>PD2</td>
<td>-0.0005</td>
<td>(-0.584)</td>
</tr>
<tr>
<td>PD2 _t-1</td>
<td>-0.0006</td>
<td>(-0.424)</td>
</tr>
<tr>
<td>HCS/L</td>
<td>-0.029</td>
<td>(-1.95)</td>
</tr>
<tr>
<td>HCS/L _t-1</td>
<td>0.009</td>
<td>0.022</td>
</tr>
<tr>
<td>MES2</td>
<td>0.0001</td>
<td>(-0.447)</td>
</tr>
<tr>
<td>MES2 _t-1</td>
<td>0.0008</td>
<td>0.0002</td>
</tr>
<tr>
<td>CONC</td>
<td>-0.002</td>
<td>(-0.733)</td>
</tr>
<tr>
<td>CONC _t-1</td>
<td>-0.007</td>
<td>(-0.430)</td>
</tr>
<tr>
<td>PROD</td>
<td>-0.010</td>
<td>(-1.08)</td>
</tr>
<tr>
<td>PROD _t-1</td>
<td>-0.020</td>
<td>(-1.50)</td>
</tr>
<tr>
<td>L*</td>
<td>-0.003</td>
<td>(-0.178)</td>
</tr>
<tr>
<td>L* _t-1</td>
<td>0.004</td>
<td>(0.387)</td>
</tr>
<tr>
<td>K/L</td>
<td>0.005</td>
<td>(1.22)</td>
</tr>
<tr>
<td>K/L _t-1</td>
<td>-0.003</td>
<td>(-1.03)</td>
</tr>
<tr>
<td>C</td>
<td>-0.031</td>
<td>(-0.833)</td>
</tr>
<tr>
<td>M1</td>
<td>0.2293</td>
<td>(0.819)</td>
</tr>
<tr>
<td>M2</td>
<td>0.7277</td>
<td>(0.467)</td>
</tr>
<tr>
<td>W_JS</td>
<td>30.69</td>
<td>[0.010]</td>
</tr>
<tr>
<td>Sargan</td>
<td>1271</td>
<td>[0.000]</td>
</tr>
<tr>
<td>Observations</td>
<td>63</td>
<td>84</td>
</tr>
<tr>
<td>Parameters</td>
<td>18</td>
<td>19</td>
</tr>
<tr>
<td>Individuals derived from year</td>
<td>21</td>
<td>21</td>
</tr>
</tbody>
</table>

For GMM-DIF the instruments in levels used are CONC \((1, 2)\), MES2\((1,2)\), HIIT\((1, 2)\).

For GMM-SYS the instruments in levels used in first differences are MES2\((2,2)\), CONC\((2,2)\), HIIT\((2,2)\).

For equations in levels the instruments used are first differences of all variables lagged t-2.
## TABLE 6

### Determinants of VIIT (Dynamic Models)

<table>
<thead>
<tr>
<th>Variables</th>
<th>GMM-DIF</th>
<th>GMM-SYS</th>
</tr>
</thead>
<tbody>
<tr>
<td>VIIT ( t-1 )</td>
<td>-0.731 (-2.38)</td>
<td>0.085 (0.151)</td>
</tr>
<tr>
<td>VPD</td>
<td>-0.096 (-0.328)</td>
<td>-1.649 (-1.17)</td>
</tr>
<tr>
<td>VPD ( t-1 )</td>
<td>0.160 (0.476)</td>
<td>0.979 (0.885)</td>
</tr>
<tr>
<td>HCS/L</td>
<td>-0.3002 (-1.97) ( a )</td>
<td>-0.032 (-0.196)</td>
</tr>
<tr>
<td>HCS/L ( t-1 )</td>
<td>0.331 (0.9989)</td>
<td>-0.012 (-0.054)</td>
</tr>
<tr>
<td>CONC</td>
<td>-1.873 (-1.18)</td>
<td>0.1339 (0.054)</td>
</tr>
<tr>
<td>CONC ( t-1 )</td>
<td>-0.162 (-0.175)</td>
<td>0.659 (0.242)</td>
</tr>
<tr>
<td>HC</td>
<td>-0.096 (-0.328)</td>
<td>5.153 (1.98) ( a )</td>
</tr>
<tr>
<td>HC ( t-1 )</td>
<td>0.160 (0.476)</td>
<td>-7.716 (-4.99) ( b )</td>
</tr>
<tr>
<td>L*</td>
<td>3.146 (1.23)</td>
<td>6.125 (2.42) ( b )</td>
</tr>
<tr>
<td>L* ( t-1 )</td>
<td>1.136 (0.513)</td>
<td>-6.307 (-2.33) ( b )</td>
</tr>
<tr>
<td>K/L</td>
<td>-0.0002 (-1.32)</td>
<td>-0.006 (-1.25)</td>
</tr>
<tr>
<td>K/L ( t-1 )</td>
<td>-0.001 (-2.93) ( b )</td>
<td>-0.0006 (-0.672)</td>
</tr>
<tr>
<td>C</td>
<td>-1.817 (-2.03)</td>
<td>2.044 (0.626)</td>
</tr>
<tr>
<td>M1</td>
<td>-0.0182 [0.985]</td>
<td>-1.498 [0.134]</td>
</tr>
<tr>
<td>M2</td>
<td>0.069 [0.945]</td>
<td>0.038 [0.969]</td>
</tr>
<tr>
<td>( W_{JS} )</td>
<td>167.1 [0.000] df=13</td>
<td>649.5 [0.000] df=13</td>
</tr>
<tr>
<td>Sargan</td>
<td>4.905 [0.428] df=5</td>
<td>3.306 [0.855] df=7</td>
</tr>
</tbody>
</table>

For the GMM-DIF the instruments in levels used are CONC (1,2), HC(1,2), VIIT(1,2).
For the GMM-SYS the instruments used are CONC (3,3), HC2(3,3), KL(3,3), VIIT(3,3) for the equations in differences. For the equations in levels the instruments used are first differences of variables lagged \( t-2 \).
FIGURE 1

Trade between Portugal and European Union in the Period 1995-2002

Source: Own calculations from INE database.

FIGURE 2

Weight of VIIT inf and VIITsup in Total VIIT between Portugal and European Union

Source: Own calculations from INE database.
REFERENCES


