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Intra-Industry Trade: A Static and Dynamic Panel Data Analysis

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Abstract This study examines the features and determinants of intra-industry trade (IIT), horizontal IIT (HIIT) and vertical IIT (VIIT) between Portugal and the European Union in the period 1996–2002, using a static and a dynamic panel data analysis. The findings indicate that Portuguese VIIT increased significantly during the period in accordance with the values expected for a developed country. The regression results show that there is evidence supporting the explanation of VIIT by Heckscher–Ohlin's (HO) theory and that Portugal has comparative advantages in low-quality differentiated products. The findings support the theory that, in general, there is no positive statistical association between HIIT and HO variables. The central theme of this paper is to show that it may be preferable to use the GMM approach in empirical studies of IIT rather than pooled OLS, fixed effects or random effects estimators. The results also suggest that the GMM system estimator obtains more reasonable parameter estimates than the first-differenced GMM estimator.

Keywords Intra-industry trade · Horizontal intra-industry trade · Vertical intra-industry trade · Comparative advantage · Dynamic panel data · GMM-SYS Estimator · GMM-DIF Estimator

JEL Classification C20 · C30 · F12 · L10

Introduction

In a multi-country, multi-product and multi-factor world, one may expect to generate intra-industry trade (IIT) on a multilateral basis. Indeed, the majority of the empirical

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studies are on a multilateral basis, although a number of such studies are based on bilateral trade (Loertscher and Wolter 1980; Bergstrand 1983; Greenaway et al. 1995).The empirical work is used to "test" industry-specific and/or country-specific determinants of IIT. These studies have generally found more empirical support for country characteristics (factor endowments, income levels, level of development, trade imbalance, distance) than for industry characteristics (i.e., market structure, minimum efficient scale, product differentiation and foreign direct investment). Estimated coefficients on proxies for product differentiation and scale economies have often been insignificant or have had the wrong sign. Greenaway et al. (1994, 1995) argue that this may be the result of not separating horizontal differentiated from vertical differentiated trade. Theoretical literature suggests that horizontal and vertical IIT have different determinants, particularly that vertical IIT can be explained by the traditional Heckscher–Ohlin (HO) factor proportions theory.

This study examines IIT, horizontal IIT (HIIT) and vertical IIT (VIIT) between Portugal and the European Union(EU15), using a balanced panel with 21 industries for the period 1996–2000 (for other features of empirical work, namely the evolution of IIT, HIIT and VIIT indexes, the period is 1996–2002). By making the distinction between HIIT and VIIT, this study is expected to perform a more targeted testing of the industry hypotheses.

In static panel data models, Pooled OLS, fixed-effects (FE) and random-effects (RE) estimators are used (Hummels and Levinshon 1995; Zhang et al. 2005). The problems with this type of applied work arise because in these models, serial correlation, heteroskedasticity and endogeneity of some explanatory variables occur 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) and Blundell and Bond (1998, 2000), who developed the first-differenced GMM (GMM-DIF) estimator and the GMM system (GMM-SYS) estimator.[1] 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.

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 (Blundel and Bond 1998, 2000). If we assume that the first differences of the variables are orthogonal to the industry-specific effects, this additionally allows the use of lagged first differences of variables for one or two periods as instruments for equations in levels (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

[1]The GMM system estimator that we report was computed using DPD for OX (Doornik et al. 2002).

Bond 1991). The GMM system estimator is consistent if there is no second-order serial correlation in the residuals (m2 statistic). The dynamic panel data model is valid if the estimator is consistent and the instruments are valid.

As far as we know, dynamic panel data analysis as not been used in empirical studies of IIT. However, in recent intra-industry studies, production functions, firms'growth, income growth and exports, economic growth, productivity spillovers from foreign direct investment or from multinational corporations, most of the researchers use a dynamic panel data model (Arellano and Bond 1991; Blundell and Bond 2000; Goddard et al. 2002; Agiomirgianakis et al. 2002; Badinger and Breuss 2004; Cuaresma and Worz 2005).

To estimate the dynamic models, we apply the methodology of Blundell and Bond (1998, 2000). The results presented in this paper are generally consistent with the predictions of the theory of intra-industry trade. The regression results demonstrate that there is strong statistical evidence supporting the explanation of VIIT by HO theory. Furthermore, the evidence suggests that Portugal has comparative advantages in low-quality products, as was expected. The results also suggest that HIIT is not explained by comparative advantage determinants (non-qualified labor and physical capital intensity). This was also expected, in accordance with the theory.

The central theme of this paper is to apply the new methodology to IIT studies and to show that better results can be achieved using the GMM approach, rather than OLS, fixed-effects or random-effects estimators. The GMM estimators have the comparative advantage, based on their potential for obtaining consistent parameter estimates even in the presence of measurement errors, omitted variables and endogenous right-hand-side variables. Moreover, our results confirm that compared to the first-differenced GMM estimator, the GMM-SYS estimator obtains more reasonable parameter estimates. The GMM-SYS estimator is preferable to the standard GMM-DIF estimator because it reduces finite-sample biases associated with the latter.

The remainder of the paper is organized as follows. The second section reviews the theoretical literature of IIT models. The third section presents the indexes, the explanatory variables and the sources. The fourth section reports the evolution of the ITT, HIIT and VIIT between Portugal and the European Union over the period 1995–2002. The fifth section presents the static and dynamic panel data models of IIT, HIIT and VIIT and analyzes the estimation results. The final section concludes.

Theoretical Literature

The literature on IIT began to appear in the 1960s with Verdoorn (1960) and Balassa (1965, 1966). These authors became aware that certain developed countries exported and imported products in the same product categories. This phenomenon occurred in the years following the formation of the European Economic Community (EEC). However, it only started to receive increasing attention after Grubel and Lloyd (1975) had introduced an index to measure IIT. After these studies, there was a wide acceptance of the idea that IIT was a more intense phenomenon between countries with similar income levels, a similarity reinforced by the economic integration process. Thus, the traditional HO model could not explain this trade between similarly endowed countries.

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). Neo-Chamberlinian models, such as Krugman's models, consider the assumption that all varieties enter the utility function symmetrically. By contrast, the other models, such as the Lancaster model, assume asymmetry.

In these models, each variety is produced under decreasing costs, and when the countries open up to trade, the similarity of the demands leads to intra-industry trade. So, HIIT is more likely between countries with similar factor endowments and cannot 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), Shaked and Sutton (1984), Falvey and Kierzkowski (1987), and Flam and Helpman (1987) introduced the vertical differentiation models.

The Falvey and Kierzkowski (1987) and Flam and Helpman (1987) models have a similar framework. Following the Linder Hypothesis, Falvey and Kierzkowski (1987, p.144) consider that "a significant element in explaining vertical product differentiation will be unequal incomes." Inequalities in income distribution ensure that both countries will demand all the available qualities. Although all consumers have the same preferences, each individual demands only one variety of the differentiated product, which is determined by his/her income. This is on the demand side. On the supply side, the model considers technology differences (labor productivity) and product quality linked to capital intensity of production. It is assumed that high- (low-) quality varieties are relatively capital (labor) intensive. Therefore, it is expected that technologically advanced countries (with higher productivity and higher wages) will have comparative advantages in capital-intensive products (higher-quality set of varieties) and export them. These countries are capital-abundant, where capital is relatively cheaper. Symmetrically, the labor-abundant country (low-wage country) will have comparative advantages in low-quality varieties that are labor-intensive.

The framework of the Flam and Helpman (1987) model is similar, but this model contains the differences in technology (labor productivity) that explain VIIT. The conclusion is similar: the most productive country, which has higher wages, exports the higher-quality varieties. To summarize, the Neo-HO theory shows that VIIT takes place between countries with different factor endowments (supply-side differences) and with differences in per-capita income (demand-side differences). Helpman (1987) considers that we can use income differences as a proxy for factor-endowment differences because here is a positive correlation between the capita-labor ratio and per-capita income. This is controversial.

Falvey (1981) explained the simultaneous existence of VIIT and inter-industry trade. In this model, a capital-abundant (labor-abundant) country specializes in, and exports, high-quality (low-quality) products. The differences in factor intensity determine the difference in the quality of the products.

Helpman and Krugman (1985) surveyed the various attempts to model IIT and built up a general equilibrium model which generates both HO trade (inter-industry trade) and HIIT. The model incorporates factor endowments, decreasing costs and horizontal product differentiation. This model is known as the Chamberlin–Heckscher–Ohlin model (CHO model). Davis (1995) provides a HO–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.

Today, it is generally accepted that VIIT can be explained by traditional theories of comparative advantage. The relatively labor-abundant countries have a comparative advantage in labor-intensive products (lower-quality varieties) and relatively capital-abundant countries have a comparative advantage in capital-intensive products (higher-quality varieties). Hence, according to comparative advantage law, the former countries will export the labor-intensive varieties and the latter countries will export the capital-intensive varieties. Or in terms of the factor content version of the Heckscher–Ohlin theorem for *n* goods and factors: the capital content of the net exports of the relatively capital-abundant country will be higher in relation to the net exports of the other country (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." Therefore, we exclude from vertical IIT goods (varieties) produced under the same factor proportions. Otherwise, horizontal IIT may assume identical factor intensity (Greenaway and Milner, 1986; Greenaway et al. 1994, 1995; Tharakan and Kerstens, 1995; Blanes and Martin, 2000; Crespo and Fontoura, 2004).

Greenaway et al. (1995) refer to four types of model of IIT in differentiated products: "(1) large numbers case of vertical IIT (e.g. Falvey 1981); (2) small numbers case of vertical IIT (e.g. Shaked and Sutton 1984); (3) large numbers case of horizontal IIT (e.g. Helpman 1981); (4) small numbers case of horizontal IIT (e.g. Eaton and Kierzkowski 1984)." There are also some models of IIT in homogeneous products (Brander 1981; Brander and Krugman 1983).

Some relevant theoretical implications for our empirical work should be stressed from this literature. Firstly, it is generally accepted that scale economies, product differentiation and industrial concentration explain IIT. The exception is Davis' (1995) HO–Ricardo model. Based on Davis (1995), we introduced productivity as an explanatory variable into the IIT model. Secondly, as discussed above, we have different market structures and the relationship between IIT and market structure is ambiguous. So, the expected sign of the explanatory variables' coefficients depends on the dominant paradigm (large number or small number of firms). Furthermore, IIT encompasses both HIIT and VIIT, which have different determinants. This justifies the ambiguity of some expected signs. Thirdly, HIIT measures the share of trade between products that are produced by the same factor proportions, but with different characteristics. So, HIIT cannot be explained by traditional HO trade theory. Finally, Neo-HO theory explains VIIT and the relevant theoretical models consider that factor endowments and differences in income levels (country-specific hypotheses) are essential to this explanation. However, in the OH model, as well as in the Neo-HO theory, there is a linkage between relative factor endowments of the countries and the factor-proportions of the goods.

Although the usual way of stating the HO theorem involves countries' relative factor endowments on the one hand and relative factor proportions (factor-intensities) of products on the other hand, the econometric studies make the distinction between country-characteristics hypotheses and industry-characteristics hypotheses. See, for example, Greenaway et al. (1995), who used the same explanatory variables (industry-characteristics) for IIT, HIIT and VIIT models, with different expected signs. In this way, they seek to emphasize the importance of separating HIIT from VIIT, due to the fact that they have different determinants.

We follow the Greenaway et al. (1995) methodology, but with slight differences. Considering the hypothesis that VIIT (HIIT) has (has not) a factor-endowment and a factor-proportion basis (Neo-HO theory), we decided to add in to the HIIT and VIIT models some factor-proportions variables (stock intensity of human capital, human capital, non-qualified labor, intensity of physical capital) in order to test this assumption. In accordance with Falvey (1981), we considered that differences in relative factor endowments determine the differences in goods factor proportions and that there is a positive relationship between quality and the capital–labor ratio. In this study, we only use the industry-specific characteristics as explanatory variables.[2]

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.

$$B_i = 1 - \frac{|X_i - M_I|}{(X_i + M_i)} \Leftrightarrow B_i = \frac{(X_i + M_i) - |X_i - M_i|}{(X_i + M_i)} \tag{1}$$

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

Grubel and Lloyd (1975, p. 22) proposed an adjusted measure to the country IIT index (IIT calculated for all individual industries), introducing the aggregate trade imbalance. They had considered that their measure would be biased downward when there is an overall trade imbalance.

Aquino (1978, p. 280) also considered that an adjusted measure is required, but to the more disaggregated level and, for this, the Grubel and Lloyd method is inadequate. Following Aquino, we need 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."

Greenaway and Milner (1986) and Helpman (1987) argued against the Aquino adjustment on both theoretical and empirical grounds. Although, following Greenaway and Milner (1986), we did not consider trade imbalance as a control variable,

[2] As we point out in the concluding part of this paper, our projected future research will be to test the country-specific hypothesis and, following Hummels and Levinshon (1995), use factor endowments and differences in per-capita income as explanatory variables in both the HIIT and VIIT models.

we feel that this merits further investigation[3] [INE – Portuguese National Institute of Statistics (Trade Statistics)].

HIIT and VIIT Indexes

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

$$\mathrm{HIIT} = \frac{\mathrm{RH}}{(X_i + M_i)} \tag{2}$$

HITT – horizontal intra-industry trade index;
RH – total horizontal intra-industry trade;
TT_{ij} – relative unit values of exports and imports are used to disentangle HITT and VIIT;
If $\mathrm{TT}_{ij} \in [0.85;1.15]$, we have horizontal IIT;

$$\mathrm{VIIT} = \frac{\mathrm{RV}}{(X_i + M_i)} \tag{3}$$

VIIT – Vertical intra-industry index;
RV – Total vertical intra-industry trade;
If $\mathrm{TT}_{ij} \prec 0.85$ V $\mathrm{TT}_{ij} \succ 1.15$, we have vertical IIT. When $\mathrm{TT}_{ij} \prec 0.85$, we have inferior VIIT (lower quality). When $\mathrm{TT}_{ij} \succ 1.15$, we have superior VIIT (higher quality). The HIIT and VIIT are calculated with disaggregation of five digits CAE (Economic Activities Classification. The CAE classification is similar to the NACE classification) [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 σ_{ij} = standard deviation of export unit values, and $\bar{x}_{ij}$ = unweighted mean of those unit values (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 qualified professionals, plus semi-qualified professionals in the total employment of industry;

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

K/*L* (*Intensity of Physical Capital*): the variable proxy is the ratio between the non-salaried returns and the total employment of industry (Hirsch 1974; Balassa 1979);

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[3]As the referee suggested, one of the major problems with an IIT index is the trade imbalance. As IIT is biased by the degree of trade imbalance, it is expected that the greater the imbalance, the larger the share of ITT. The consideration of the trade imbalance as a variable to control for bias in estimations should be taken into account. We are giving consideration to including it in the next paper.

Table 1 Trade between Portugal–European Union by types

YEARS	IIT	HIIT	VIIT	Inferior VIIT	Superior VIIT
1995	0.491	0.224	0.267	0.158	0.109
1996	0.521	0.224	0.297	0.206	0.091
1997	0.544	0.256	0.288	0.195	0.093
1998	0.537	0.264	0.273	0.179	0.094
1999	0.540	0.212	0.328	0.176	0.152
2000	0.543	0.087	0.456	0.212	0.244
2001	0.507	0.118	0.389	0.227	0.162
2002	0.589	0.159	0.430	0.162	0.268

HCS/*L* (*Intensity of Human Capital*): the variable proxy is the difference between salaries and the average salary of non-qualified workers, divided by the opportunity cost of capital (Branson and Monoyios 1977);
VPD (*Vertical Product Differentiation*): the percentage of workers with qualifications;
PROD (*Productivity*): is the value added by the 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 the enterprise. It is the value of production divided by the number of firms;
CONC (*Industrial Concentration*): this is a percentage of industry sales of the four largest firms in the total sales plus imports of the industry;
Sources: Ministry of Labor (Quadros de Pessoal);[4] INE – Statistics of Firms; Bank of Portugal.

IIT, HIIT and VIIT between Portugal and the European Union (1995–2002)

As shown in Table 1, the IIT between Portugal and the European Union (EU) is over 50% for the period 1996–2002. In 2002, IIT reached the value of 59% of total trade between Portugal and the EU. For all of the 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 like Portugal. In 2002, VIIT accounted for 73% of the total IIT with the EU. For the more developed countries, VIIT usually accounts for 80 to 90% of total IIT (Aturupane et al. 1999)

As can be observed in Table 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 entire period. Despite the values of years 2000 and 2002, the inferior VIIT is clearly predominant. This suggests that in future econometric estimations, it would be useful to distinguish inferior VIIT from superior VIIT.

[4]Quadros de Pessoal is a data set based on a standardized questionnaire to which all firms with wage earners must respond every year.

Table 2 VIIT by types (percent)

Years	1995	1996	1997	1998	1999	2000	2001	2002
Inferior VIIT	59.1	69.5	67.6	65.5	53.6	46.5	58.4	37.6
Superior VIIT	40.9	30.5	32.4	34.5	46.4	53.5	41.6	62.4

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, the FE model was selected 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.

In addition, this paper estimates the dynamic panel data models using two alternative GMM estimators. The first-differenced GMM estimator (GMM-DIF) was proposed by Arellano and Bond (1991), while the system GMM estimator (GMM-SYS) was proposed by Arellano and Bover (1995) and Blundell and Bond (1998, 2000). The GMM estimators permit efficient estimates to be obtained. An individual-effects autoregressive panel data model with endogenous explanatory variables was considered.

Intra-Industry Trade Model

As we have seen earlier, despite the theoretical effort, we do not yet have a clear-cut IIT model on which all empirical studies can be based. This has led empirical work to take an eclectic approach, gathering different theories in the same regression equation. Another limitation is the use of the adequate proxy variable. In this IIT model, we had two proxies to measure the scale economies and industrial concentration. The foreign direct investment (FDI) was also considered as an explanatory variable, but the regression results show that this variable, with a positive coefficient, was not statistically significant. Therefore, we choose the best specification.

Model [1]

$$\mathrm{IIT}_{it} = \beta_0 + \beta_1(\mathrm{PD}_1)_{it} + \beta_2(\mathrm{MES}_1)_{it} + \beta_3(\mathrm{CONC})_{it} + \beta_4\mathrm{PROD}_{it} + \delta t + \eta_i + \varepsilon_{it}$$

where η_i is the unobserved time-invariant industry-specific effects; δt captures a common deterministic trend; ε_{it} is a random disturbance assumed to be normal, independent and identically distributed (IID) with $E(\varepsilon_{it})=0$ and $\mathrm{Var}(\varepsilon_{it})=\sigma^2>0$.[5]

[5]The ε_{it} are assumed to be independently distributed across industries with zero mean, but arbitrary forms of heteroskedasticity across units and time are possible.

Model 1 can be rewritten in the following dynamic representation:

$$IIT_{it} = \rho IIT_{it-1} + \beta_1(\mathrm{PD}_1)_{it} - \rho\beta_1(\mathrm{PD})_{it-1} + \beta_2(\mathrm{MES}_1)_{it} - \rho\beta_2(\mathrm{MES}_1)_{it-1} + \beta_3(\mathrm{CONC})_{it} - \rho\beta_3(\mathrm{CONC})_{it-1} + \beta_4\mathrm{PROD}_{it} - \rho\beta_4(\mathrm{PROD})_{it-1} + \delta t + \eta_i + \varepsilon_{it}$$

The expected signs are:

ITT_{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) considered the existence of a negative relation. The expected sign is ambiguous. This ambiguity arises because the data does not distinguish between HIIT and VIIT. The horizontal product differentiation is positively (negatively) related to HIIT (VIIT) and conversely for vertical product-differentiation;
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.

Horizontal Intra-Industry Trade Model

We include in the HIIT model the HO variables (L* and K/L) and the neo-factorial variable (HCS/L) to test the hypotheses that HIIT is not explained by factor proportions theory. We also considered the FDI, but the regression results show that this variable, with a negative coefficient, was not statistically significant.

Model [2]

$$\mathrm{HIIT}_{it} = \beta_0 + \beta_1(\mathrm{PD}_2)_{it} + \beta_2(\mathrm{HCS}/L)_{it} + \beta_3(\mathrm{MES}_2)_{it} + \beta_4(\mathrm{CONC})_{it} + \beta_5\mathrm{PROD}_{it} + \beta_6 L *_{it} + \beta_7(K/L)_{it} + \delta t + \eta_i + \varepsilon_{it}$$

Model 2 can be rewritten in the following dynamic representation:

$$\mathrm{HIIT}_{it} = \rho\mathrm{HIIT}_{it-1} + \beta_1(\mathrm{PD}_2)_{it} - \rho\beta_1(\mathrm{PD})_{it-1} + \beta_2(\mathrm{HCS}/L)_{it} - \rho\beta_2(\mathrm{HCS}/L)_{it-1} + \beta_3(\mathrm{MES}_2)_{it} - \rho\beta_3(\mathrm{MES}_2)_{it-1} + \beta_4(\mathrm{CONC})_{it} - \rho\beta_4(\mathrm{CONC})_{it-1} + \beta_5\mathrm{PROD}_{it} - \rho\beta_5(\mathrm{PROD})_{it-1} + \beta_6 L_{it} * - \rho\beta_6 L *_{it-1} + \beta_7(K/L)_{it} - \rho\beta_7(K/L)_{it-1} + \delta t + \eta_i + \varepsilon_{it}$$

The expected signs are:

$HITT_{it-1}$: 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). The theory suggests that HIIT is not explained by HO 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 as such, 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, then 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).

Vertical Intra-Industry Trade Model

It used to be accepted that traditional theories of comparative advantage (Ricardian trade theory and HO trade theory), based on constant returns to scale, homogeneous product and perfect competition, only explained inter-industry trade. Nowadays, the recent literature of IIT assumes that the neo-HO model can explain the trade in vertical differentiated products.

We considered the hypotheses of vertical product differentiation, industrial concentration and the neo-HO hypotheses (HCS/*L*, HC, *L**, *K*/*L*). FDI was also considered, but the coefficient, although positive as was expected, was not different from zero.

Model [3]

$$\begin{aligned}\mathrm{VIIT}_{it} = {} & \beta_0 + \beta_1 \mathrm{VPD}_{it} + \beta_2 (\mathrm{HCS}/L)_{it} + \beta_3 (\mathrm{CONC})_{it} + \beta_4 (\mathrm{HC})_{it} + \beta_5 L^*_{it} \\ & + \beta_6 (K/L)_{it} + \eta_i + \varepsilon_{it}\end{aligned}$$

Model 3 can be rewritten in the following dynamic representation:

$$\begin{aligned}\mathrm{VIIT}_{it} = {} & \rho \mathrm{VIIT}_{it-1} + \beta_1 (\mathrm{VPD})_{it} - \rho\beta_1 (\mathrm{VPD})_{it-1} + \beta_2 (\mathrm{HCS}/L)_{it} - \rho\beta_2 (\mathrm{HCS}/L)_{it-1} \\ & + \beta_3 (\mathrm{CONC})_{it} - \rho\beta_3 (\mathrm{CONC})_{it-1} + \beta_4 (\mathrm{HC})_{it} - \rho\beta_5 (\mathrm{HC})_{it-1} \\ & + \beta_5 L^*_{it} - \rho\beta_5 L^*_{it-1} + \beta_6 (K/L)_{it} - \rho\beta_6 (K/L)_{it-1} + \delta + \eta_i + \varepsilon_{it}\end{aligned}$$

The expected signs are:

$VIIT_{it-1}$: the expected sign is positive;
VPD (*Vertical Product Differentiation*): the expected sign is positive;
HCS/L (*Intensity of Human Capital*): as neo-factorial theory can explain the VIIT, the expected sign is positive;
HC (*Human Capital*): the expected sign is positive;
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 $K/L > 0$.

Analysis of the Static Panel Data Estimations

In Table A1, the determinants of IIT can be observed. With the FE estimator, the model presents two significant variables: industrial concentration (CONC) and productivity (PROD). A negative (positive) sign was expected for CONC (PROD), whereas the results are in fact positive for CONC and negative for PROD.

In Table A2, the determinants of HIIT can be observed. With the FE estimator, the model presents four significant variables: economies of scale (MES2), industrial concentration (CONC), productivity (PROD) and non-qualified labor (L^*).

Other considerations relating to the HIIT model:

MES2: the dominant paradigm of a large number of firms expects a negative sign and the estimated coefficient is positive;
CONC: the dominant paradigm of a large number of firms expects a negative sign and the coefficient, statistically significant, is positive;
PROD: a positive sign was expected 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 sign is negative, or the coefficient is not statistically significant. The theory is confirmed.

In Table A3, the determinants of VIIT are shown. With the FE estimator, the model presents one significant variable: non-qualified workers (L^*).

Other considerations relating to the 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 the 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 the European Union, has comparative advantages in lower-quality products.

Analysis of the Dynamic Panel Data Estimations

As shown in Table A4, the IIT dynamic model presents consistent estimates, with no serial correlation for the GMM-DIF and GMM-SYS estimators (ml, m2, and statistics). The specification Sargan test shows that there are no problems with the validity of the instruments used for both estimators. The model presents four significant variables (IIT_{t-1}, CONC, PROD and $PROD_{t-1}$) 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 the GMM-DIF estimator than in the GMM-SYS estimator. Hence, despite the fact that both estimators require restrictions on the initial conditions process and that the first-differenced GMM estimates are closer to the system GMM, the latter approach is recommended because the additional moment restrictions exploited by the GMM-SYS estimator appear to be useful in reducing finite sample biases associated with the GMM-DIF estimator (Blundell and Bond 1998, 2000).

Other results relating to the IIT dynamic model:

Lagged intra-industry trade (IIT_{t-1}): a positive sign was expected 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 sign, which confirms the paradigm of a small number of firms;

Productivity (PROD) and lagged productivity ($PROD_{t-1}$): the expected signs are positive, which is not confirmed by the estimations.

Table A5 reports HIIT dynamic estimations. Both the differenced and system GMM estimators present consistent estimates with no serial correlation (m1, m2, and statistics), but only the GMM-SYS estimator does not have problems with the validity of the instrument used (Sargan test). The GMM-SYS gives reasonable results with four significant variables ($HIIT_{t-1}$, HCS/L_{t-1}, CONC and L^*_{t-1}).

Other considerations relating to the GMM-SYS estimation:

Lagged horizontal intra-industry trade ($HITT_{t-1}$): the expected sign is positive and the estimate is positive;

Lagged intensity of human capital (HCS/L_{t-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 is a non-statistical association between these variables and HIIT. None of the coefficients of these variables is significantly different from zero at any conventional level, which confirms the hypothesis that comparative-advantage variables do not explain HIIT;

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/L_{t-1}): the expected sign is negative, or the coefficient is not significantly different from zero, and the results confirm the theory.

Table A6 reports VIIT dynamic estimations. Both the differenced and GMM-SYS estimators present consistent estimates with no serial correlation (m1, m2, and statistics) and neither have any problems with the validity of the instrument used (Sargan test). However, the results are very different. The differenced GMM estimation has three significant variables ($VIIT_{t-1}$, HCS/L, K/L_{t-1}) that are completely different from those obtained through the GMM-SYS estimator (HC, HC_{t-1}, L^*, L_{t-1}).

Other results relating to the 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 HC_{t-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 they are not statistically significant), which confirms that Portugal, relative to the European Union, has comparative advantages in lower-quality products.

Conclusions and Further Research

The IIT between Portugal and the European Union (EU) is over 50% for the period 1996–2002. The findings indicate that Portuguese IIT attained the value of 59% in 2002 and that VIIT increased significantly during the period, in accordance with the values expected for a developed country. For all of the period in analysis, the VIIT is generally much higher than the HIIT, while the weight of inferior VIIT (low-quality products) is predominant relative to superior VIIT (high-quality products). These results suggest that Portugal can be defined as a non-qualified (or semi-qualified), labor-abundant developed country. To test this hypothesis in future econometric estimations it would be useful to distinguish inferior VIIT from superior VIIT.

Such further research might also include country characteristics into the analysis in order to investigate the impact of country-specific factors. In general, the regression results confirm that changes in non-qualified labor and physical capital intensity are revealed to be significant in influencing VIIT, but not the HIIT. This was as forecast by neo-HO theory. We conclude that Portugal, relative to the EU, has comparative advantages in lower-quality differenced varieties (products).

As was expected, the results emerging from the static and dynamic models are different, as are the results generated by both GMM estimators, which confirms the other empirical studies that find that there is little empirical support for industry-specific hypotheses. Estimated coefficients on proxies for product differentiation and scales economies are insignificant, or have the wrong sign. This is frequently the case in other studies and is confirmed by the static and dynamic panel data estimations. Moreover, the results confirm that disentangling HIIT from VIIT provides the opportunity to discover the underlying determinants of each type of trade, but does not resolve the misspecification problem. Possibly we should disentangle inferior VIIT from superior VIIT in order to resolve this problem.

In the dynamic models, we must stress the positive effects of IITt-1 on IIT. Similarly, the results confirm the positive effect of HIITt-1 (VIITt-1) on HIIT (VIIT). The considerable increases of Portugal's VIIT and the positive effect of VIITt-1 on VIIT indicates that in future, Portugal's VIIT specialization, based on comparative advantages, will be reinforced. Finally, 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 studies, rather than pooled OLS, fixed-effects or random-effects estimators. Their results should at least be compared. In comparison with the first-differenced GMM estimator, the system GMM estimator obtained more reasonable parameter estimates, as was expected by theory.

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Appendix

Table A1 Determinants of IIT (Static Models)

Models	*C*	PD1	MES1	CONC	PROD	Adjusted R^2	*N*	Hausman test (H0:RE VS FE)
OLS	0.323	−0.810	0.044	0.567	−0.0001	0.275	105	
	(7.02)	(−0.56)	(3.17)[a]	(3.36)[a]	(−4.51)[a]			
Fixed effects	–	0.010	−0.008	0.763	−0.0009	0.8111	105	
		(1.44)	(−0.75)	(2.11)[b]	(−2.69)[a]			
Random effects	0.384	0.011	0.010	0.485	−0.0009	0.226	105	CHISQ(2)=0.72,
	(6.68)	(0.76)	(0.64)	(3.22)[a]	(−7.27)[a]			*P* value=0.69

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

Table A2 Determinants of HIIT (Static models)

Models	*C*	PD2	HCS/L	MES2	CONC	PROD	*L**	*K*/*L*	Adjusted R^2	*N*	Hausman test (H0:RE VS FE)
OLS	0.29 (3.8)	0.0001 (0.15)	0.0019 (0.37)	0.0008 (1.52)	−0.017 (−0.09)	−0.0032 (−1.65)	−0.497 (2.24)[b]	0.0003 (0.24)	0.069	105	
Fixed effects	–	–	−0.001 (−0.24)	0.0003 (2.07)[b]	1.179 (2.38)[b]	−0.092 (−2.13)[b]	−0.773 (−1.75)[c]	0.0001 (0.11)	0.546	105	
Random effects	0.29 (2.7)	0.0004 (0.19)	−0.000 (−0.01)	0.0001 (2.75)[a]	−0.112 (−0.44)	−0.0037 (−3.13)[a]	−0.54 (−1.5)	0.0009 (0.27)	0.051	105	CHISQ (1)=0.4, *P* value= 0.48

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

[a,b,c] Statistically significant, respectively, at the 1, 5 and 10% level.

Table A3 Determinants of VIIT (Static models)

Models	*C*	VPD	HCS/L	CONC	HC	*L**	*K*/*L*	Adjusted R^2	*N*	Hausman test (H0: RE VS FE)
OLS	0.45 (1.9)	0.039 (0.25)	0.007 (0.015)	0.209 (1.42)	−0.34 (1.41)	0.497 (1.48)	−0.0006 (3.65)[a]	0.125	105	
Fixed effects	–	−0.107 (−0.68)	−0.004 (−0.88)	0.246 (0.64)	1.288 (1.45)	1.608 (1.73)[c]	−0.0003 (−1.32)	0.566	105	
Random effects	0.24 (0.8)	0.039 (0.23)	−0.001 (−0.42)	0.139 (0.96)	−0.07 (0.21)	0.599 (1.45)	−0.0004 (2.46)[b]	0.102	105	CHISQ(3) =6.53, *P* value= 0.08

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

[a,b,c] Statistically significant, respectively, at the 1, 5 and 10% level.

Table A4 Determinants of IIT (Dynamic models)

Variables	GMM-DIF	GMM-SYS
IIT_{t-1}	0.586 (6.96)[a]	0.859 (8.04)[a]
PD1	−0.022 (−0.758)	−0.072 (−0.936)
$PD1_{t-1}$	−0.009 (−0.206)	0.063 (1.17)
MES1	−0.016 (−0.330)	−0.004 (−1.50)
$MES1_{t-1}$	−0.013 (−0.399)	0.052 (1.36)
CONC	0.971 (2.05)[b]	0.522 (1.82)[c]
$CONC_{t-1}$	0.793 (1.29)	−0.041 (−0.124)
PROD	−0.0005(−3.88)[a]	−0.0003 (−3.85)[a]
$PROD_{t-1}$	−0.0006 (−7.35)[a]	−0.0004 (−3.96)[a]
C	0.012 (0.778)	−0.0011 (−0.017)
M1	−0.3465 [0.729]	−0.888 [0.374]
M2	1.044 [0.296]	0.468 [0.639]
W_{JS}	2586 [0.000], *df*=9	2692 [0.000], *df*=9
Sargan	2.072 [0.913], *df*=6	5.236 [0.990], *df*=15
Observations	63	84
Parameters	12	13
Individuals	21	21

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. a/b/c–statistically significant, respectively at the 1, 5 and 10% level. *P* values are in square brackets. Year dummies are included in all specifications (this is equivalent to transforming the variables into deviations from time means, i.e. the means across the *n* industries for each period). M1 and M2 are tests for the 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 X^2 under the null of instruments' validity (with two-step estimator).

For the GMM-DIF, the instruments in the levels used are: MES2 (2,3), CONC (2,3) and IIT (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) and IIT(2,2). For levels equations, the instruments used are first differences of all variables lagged $t-1$.

Table A5 Determinants of HIIT (Dynamic models)

Variables	GMM−DIF	GMM-SYS
$HIIT_{t-1}$	−0.109 (−0.461)	0.604 (3.36)[a]
PD2	−0.0005 (−0.584)	−0.001 (−0.094)
$PD2_{t-1}$	−0.0006 (−0.424)	−0.001 (−0.094)
HCS/L	−0.029 (−1.95)[c]	−0.006 (−1.10)
HCS/L_{t-1}	0.009 (0.603)	0.022 (3.43)[a]
MES2	0.0001 (0.447)	−0.0002 (−0.093)
$MES2_{t-1}$	0.0008 (1.62)	0.0002 (0.708)
CONC	−0.002 (−0.733)	−0.251 (−1.81)[c]
$CONC_{t-1}$	−0.007 (−0.430)	−0.190 (−1.51)
PROD	−0.010 (−1.08)	0.0004 (0.054)
$PROD_{t-1}$	−0.020 (−1.50)	−0.007 (−0.671)
L^*	−0.0003 (−0.178)	0.043 (1.01)
L^*_{t-1}	0.004 (0.387)	0.111 (2.20)[b]
K/L	0.005 (1.22)	0.0004 (0.379)
K/L_{t-1}	−0.003 (−1.03)	−0.0009 (−1.20)
C	−0.031 (−0.833)	0.294 (3.23)
M1	0.2293 [0.819]	−1.601 [0.109]
M2	0.7277 [0.467]	0.668 [0.438]
W_{JS}	30.69 [0.010], df=15	6306 [0.000], df=15
Sargan	1,271 [0.000], df=3	12.90 [0.610], df=15
Observations	63	84
Parameters	18	19
Individuals	21	21

For the GMM-DIF, the instruments in levels used are: HC2 (1, 2), MES1 (1,2) and IIT (1,2).
For the GMM-SYS, the instruments in levels used in first differences are: MES2 (2,2), CONC (2,2) and HIIT (2,2). For equations in levels, the instruments used are first differences of all variables lagged $t-2$.
[a,b,c] Statistically significant, respectively, at the 1, 5 and 10% level.

Table A6 Determinants of VIIT (Dynamic models)

Variables	GMM-DIF	GMM-SYS
$VIIT_{t-1}$	−0.731 (−2.38)[b]	0.085 (0.151)
VPD	−0.096 (−0.328)	−1.649 (−1.17)
VPD_{t-1}	0.160 (0.476)	0.979 (0.885)
HCS/*L*	−0.3002 (−1.97)[b]	−0.032 (−0.196)
HCS/L_{t-1}	0.331 (0.989)	−0.012 (−0.054)
CONC	−1.873 (−1.18)	0.1339 (0.054)
$CONC_{t-1}$	−0.162 (−0.175)	0.659 (0.242)
HC	−0.096 (−0.328)	5.153 (1.98)[b]
HC_{t-1}	0.160 (0.476)	−7.716 (−4.99)[a]
L^*	3.146 (1.23)	6.125 (2.42)[b]
L^*_{t-1}	1.136 (0.513)	−6.307 (−2.33)[b]
K/*L*	−0.0002 (−1.32)	−0.006 (−1.25)
K/L_{t-1}	−0.001 (−2.93)[a]	−0.0006 (−0.672)
C	−1.817 (−2.03)	2.044 (0.626)
M1	−0.0182 [0.985]	−1.498 [0.134]
M2	0.069 [0.945]	0.038 [0.969]
W_{JS}	167.1 [0.000], *df*=13	649.5 [0.000], *df*=13
Sargan	4.905 [0.428], *df*=5	3.306 [0.855], *df*=7
Observations	63	84
Parameters	16	17
Individuals	21	21

For the GMM-DIF, the instruments in levels used are: CONC (1,2), HC(1,2) and VIIT(1,2). For the GMM-SYS, the instruments used are: CONC (3,3), HC2(3,3), KL(3,3) and VIIT(3,3) for the equations in differences. For the equations in levels, the instruments used are first differences of variables lagged $t-2$.
[a,b] Statistically significant, respectively, at the 1 and 5% level.

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