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Country-Specific Determinants of Intra-Industry Trade in Portugal

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ABSTRACT: Based on the theoretical models of Helpman and Krugman (1985), Falvey and Kierzkowski (1987) and Flam and Helpman (1987) and on the empirical studies of Greenaway, Hine and Milner (1994) and Hummels and Levinsohn (1995), we use a static and dynamic panel data approach to test the country-specific determinants of Portuguese intra-industry trade (IIT). We include income variables together with supply-side variables in order to test the demand similarity and factor endowments difference hypotheses. The results suggest that the Linder hypothesis is confirmed and that differences in income levels have a positive (negative) effect on vertical IIT (horizontal IIT and IIT). However, our findings only partially confirm Helpman and Krugman's theoretical predictions.

Key words: intra-industry trade, horizontal intra-industry trade, vertical intra-industry trade, Linder hypothesis, dynamic panel data.
JEL Classification: F12, C2, C3, L1.

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I. Introduction

In this paper, we analyze the country-specific determinants of intra-industry trade (IIT) , horizontal intra-industry trade (HIIT) and vertical intra-industry trade (VIIT) between Portugal and the European Union (EU-15), using an unbalanced panel data for the period 1995-2003. Furthermore, we seek to test some hypotheses suggested by the theory of monopolistic competition and the Neo-Heckscher-Ohlin theory and to compare our results with those obtained by Greenaway et al. (1994), Hummels and Levinsohn (1995) and Cies´lik (2005).

It is a fact that most of the empirical studies on IIT found more empirical support for country–specific determinants (i.e., income levels, endowments, economic dimension, foreign direct investment) than for industry-specific determinants (market structure, scale economies, product differentiation). Geenaway et al. (1994, 1995) concluded that it was worthwhile separating out HIIT and VIIT because the theory suggests that they have different determinants. So, in this study, we apply the methodology of Abd-el-Rahaman (1991) and Greenaway et al. (1994) in order to separate HIIT from VIIT. The empirical results presented in this paper support the idea that the distinction between the two types of IIT is important.

In this paper, we revisit Helpman´s (1987) empirical tests as well as the empirical studies of Greenaway et al. (1994) and Hummels and Levinsohn (1995). Helpman (1987) and Greenaway et al. (1994) use differences in per-capita income as a proxy for differences in factor endowments. As Hummels and Levinsohn (1995, p.812) note, there are two problems associated with this. First, the proxy is adequate if there are only two factors of production and all goods are traded. In this case, as Helpman (1987) suggests, a higher per-capita income is related to a higher capital-labor ratio. Second, the differences in per-capita income reflect more the demand side phenomenon than the supply side. Following Hummels and Levinsohn (1995), we decided to include supply-side variables to distinguish income effects from factor endowments effects. We found a negative relationship between differences in per-capita income and IIT, which confirms the Linder (1961) hypothesis. We also tested the factor endowments hypotheses (differences in physical and human capital) and obtained statistically significant results. Helpman-Krugman's endowments hypotheses are confirmed in the VIIT and HIIT dynamic models, although in the IIT model, the estimated sign is positive, not as predicted. The static results are also ambiguous and the introduction of Cies´lik's (2005) control variable (the sums of physical capital endowments) did not resolve the problem.

Following Hummels and Levinsohn (1995), we apply a logistic transformation to IIT, HIIT and VIIT and different econometric methods to know if the data still support the theory's country-specific hypotheses. In order to compare the results, we estimate the models using a static and a dynamic panel data. Although the theoretical models of IIT do not suggest a dynamic specification, we decided to introduce a dynamic variant of the static model, because in this model there are serial correlation, heteroskedasticity and endogeneity of some explanatory variables.[1] These econometric problems were resolved by Arellano and Bond (1991), Arellano and Bover (1995) and Blundell and Bound (1988, 2000), who developed the first-differenced GMM and the GMM system estimators. The GMM system estimator, used in this paper, 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. We conclude that it may be preferable to use the GMM system estimator rather than the fixed-effects estimator. Nevertheless, the results obtained from their use should be verified.

The remainder of the paper is organized as follows. Section 2 presents the theoretical background and the revisited empirical work on IIT. Section 3 presents the empirical model. Section 4 analyzes the estimation results. The final section concludes.

II. Theoretical Background and Empirical Work

Linder (1961) considered that consumers' tastes are conditioned by their income levels. These tastes yield demands for products and this demand structure generates a production response. Hence, countries with similar per-capita incomes will have similar demand structures and will export similar goods. The Linder theory of overlapping demands suggests that goods must first be produced for home markets and then exported to similar countries. According to Linder's (1961) hypothesis, a negative relationship between income differences and IIT is to be expected. Linder's (1961) theory can also explain VIIT. The less developed countries with low per-capita incomes specialize in, and export, low-quality products (varieties), whereas the developed countries with high per-capita incomes specialize in, and export, high-quality products (varieties of the same product). So, Linder's theory proposes that the higher the difference in per-capita income, the greater the VIIT.

Linder's theory is consistent with some aspects of the product cycle theory developed by Vernon (1966). Vernon's theory divides the life cycle of the new product into three stages: new product stage, maturing product stage and standardized product stage. The country source of exports shifts throughout the life cycle of the product and the foreign direct investment (FDI) has a decisive role in this dynamic process. In the last product stage, the technology becomes available to the less-developed countries through the FDI. This allows these countries to export low-quality differentiated products to the developed countries, importing at the same time the high-quality product varieties from these countries. So, Vernon's theory suggests a positive relationship between VIIT and per-capita income differences and between VIIT and FDI.

In the theoretical models, the distinction between the two types of IIT is very important. As was stressed by Greenaway et al. (1994, 1995), there are theoretical reasons – different determinants – and empirical evidence that justify separating HIIT from VIIT.

The first theoretical models of IIT were made by Krugman (1979, 1980, 1981), Lancaster (1980) and Helpman (1981). This work was synthesized in Helpman and Krugman's (1985) and Chamberlin-Heckscher-Ohlin's model. This is a model that combines monopolistic competition with the Heckscher-Ohlin (HO) theory, incorporating factor endowments differences, horizontal product differentiation and increasing returns to scale. The model generates both intra- and inter-industry trade and formulates the following country-specific hypothesis: the more different are the factor endowments, the smaller is IIT. As horizontal product differentiation considers that different varieties are of the same quality, but of different characteristics, they may be produced with similar factor intensity. The Helpman and Krugman (1985) model also puts forward the following country-specific hypothesis: the larger the difference in factor endowments, the smaller (larger) the extent of HIIT (VIIT). Cies´lik (2005) re-examines the relationship between IIT and differences in relative factor endowments and considers that "the lack of control for the variation in the sum of capital-labor ratios led to biased estimates of the coefficients in factor proportions across country pairs".

Making the distinction between types of IIT, Linder's theory can also be used to explain HIIT and VIIT. As the similarity of the demand determines the similarity of the goods traded, Linder (1961) proposes the following country-specific hypothesis: the more different the factor endowments, the smaller (greater) the extent of HIIT (VIIT).

The main references in VIIT models are Falvey (1981), Shaked and Sutton (1984), Falvey and Kierzkowski (1987) and Flam and Helpman (1987). The essentials of these models can be summarized as follows. Vertical product differentiation means that different varieties are of different qualities and, on the demand side, it is assumed that consumers rank alternative varieties according to product quality. On the supply side, it is assumed that high- (low-) quality varieties are relatively capital- (labor-) intensive. In the HO theory, as in the Neo-HO theory, there is a linkage between factor endowments of the countries and factor proportions. The relatively labor-abundant countries have comparative advantages in labor-intensive products (lower-quality varieties) and relatively capital-abundant countries have comparative advantage in capital-intensive products (higher-quality varieties).

For example, Falvey and Kierzkowski (1987, p.144), following the Linder hypothesis, 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. So, a large difference in income levels increases the share of VIIT since income differences generate dissimilarity in demand. This is on the demand side. On the supply side, the model considers technology differences and product quality linked to capital intensity of production. Thus, 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), which they will then export. These countries are capital-abundant, since 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 it is the differences in technology (labor productivity) that explain VIIT. The conclusion is similar: the most productive country, where wages are higher, exports the highest-quality varieties.

To sum up, the Neo-HO theory shows that VIIT takes place between countries with different factor endowments (supply-side) and with differences in per-capita income (demand-side).

HO theory has been generalized in two versions: the Jones (1956) commodity content version and the Vanek (1968) factor content version. After the Leontief paradox, the commodity version included a new factor, human capital as a non-homogeneous factor, which became known as neo-factor proportions theory (see Baldwin, 1971, Hirsch, 1974, Stern and Maskus, 1981). We therefore decided to include as an explanatory variable the difference in human capital endowments jointly with the differences in physical capital.

With regard to the empirical studies that we revisited in this paper, they may be synthesized as follows. Helpman (1987) tested three predictions based on the Helpman and Krugman (1985) model, using data from fourteen OECD countries and his results suggest the confirmation of the theory. Hummels and Levinsohn (1995), using a panel data analysis, did the same on Helpman's tests and concluded that the theory is confirmed. However, when country-specific fixed effects (country-pair dummies) were used, they concluded that most of the variation in the share of IIT for all country pairs of OECD countries was explained by factors that were specific to the countries. This result contradicts the results of Helpman (1987). Hummels and Levinsohn (1995) concluded that their results were inconsistent with Helpman and Krugman's (1985) model and questioned the empirical success of the monopolistic competition models. Cies´lik (2005) considers that Hummels and Levinsohn did not derive their estimating equations directly from the Helpman-Krugman framework. Thus, the Hummels – Levinsohn empirical results will fail to provide an exact link between theory and the data. Cies´lik's solution considers a positive relationship between IIT and the sums of capital-labor ratios. The introduction of this control variable by Cies´lik changes the estimation results and confirms a negative relationship between IIT and differences in capital-labor ratios predicted by Helpman and Krugman . Unfortunately, our static and dynamic results, with or without Ciéslik's control variable, do not provide a clear confirmation of Helpman and Krugman's (1985) theoretical predictions, therefore, the problem remains.

Possibly, the solution would be to refine the theory, as Hummels and Levinsohn suggested. However, following Greenaway et al. (1994), considering that IIT encompasses both VIIT and HIIT, it is necessary to separate them since they have different determinants. As we have discrepancies between the data and the predictions of the Helpman-Krugman model, we need to explore simple amendments of the model's assumptions. Another possible solution for the empirical success of these theoretical models would be to use different econometric techniques and specifications.[2] Greenaway et al. (1994) separate HIIT from VIIT, but do not use the panel data framework and, furthermore, use the income variable as a proxy for differences in relative factor endowments. The given assumption is that per-capita income reflects both demand- and supply-side factors. This raises potential problems, as Hummels and Levinsohn (1995) indicated. The use of other, theoretically justified, control variables, similarly to Cies´lik's approach, is another possible solution. Contrary to Cies´lik's conclusion, our results suggest that the performance of the Helpman-Krugman model can be further improved.

III. Empirical Model

The dependent variables used are the IIIT Grubel and Lloyd (1975) index and HIIT and VIIT indexes. The explanatory variables are country-specific characteristics that have been used in others empirical studies (e.g. Greenaway et al., 1994; Hummels and Levinsohn, 1995; Cies´lik 2005; Zhang et al., 2005)**.** The data for explanatory variables is sourced from the World Bank, World Development Indicators (2005). The source used for dependent variables was the INE - Portuguese National Institute of Statistics (Trade Statistics).

III.1. Dependent Variables

The IIT index

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:

$$IIT_i = \frac{(X_i + M_i) - |X_i - M_i|}{(X_i + M_i)}$$

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

In the empirical analysis, we consider all the products at the five-digit level of the Combined Nomenclature (CN). In econometric analysis, the 5-digit product categories were aggregated to the 3-digit industry level, according to the Portuguese Classification of Economic Activities (CAE)[3]. The conversion between CN and CAE is provided by the INE. Our sample comprises the fifteen member states of the European Union (EU15), prior to its enlargement in 2004 (trade data for Belgium and Luxembourg is aggregated).

The HIIT and VIIT indexes

To separate horizontal from vertical intra-industry trade, the Grubel and Lloyd index and the methodology of Abd-el-Rahaman (1991), and Greenaway et al. (1994) are used. Relative unit values of exports and imports of the good i between countries j and k (TTijk) are used to disentangle total IIT into total HIIT (RH) vis-à-vis total VIIT (RV). We use a unit value dispersion of 15 per cent.

If $TT_{ij_k} \in [0{,}85;1{,}15]$, we have RH; otherwise we have RV.

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

HIIT- Horizontal intra-industry trade índex.
Xi, Mi are the exports and imports of the industry i.

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

VIIT- Vertical intra- industry index .
If TTijk < 0,85 or TTijk >1,15 we have VIIT. TTijk < 0,85, we have inferior VIIT (lower-quality varieties). TTijk> 1.15, we have superior VIIT (higher-quality varieties). The HIIT and VIIT are calculated with desegregation of 5 digits CAE from INE-Trade Statistics.

III.2. Explanatory variables and expected sign

In order to analyse the country-specific determinants of the IIT, HIIT and VIIT, we used the following explanatory variables:[4]

- LogDGDP is the logarithm of the absolute difference in GDP per-capita (PPP, in current international dollars) between Portugal and each EU trading partner. Falvey and Kierzkowski (1987) suggest a positive sign for VIIT model and Loertscher and Wolter (1980) and Greenaway et al. (1994) provide empirical support for a negative relation between difference in per-capita income and HIIT. Linder (1961) considers that countries with similar demands will trade similar products. So, the Linder hypothesis suggests a negative sign for the IIT model (See, also, Falvey and Kierzkowski, 1987; Helpman,1987; and Hummels and Levinsohn, 1995). The underlying hypothesis is that the similarity in incomes implies a greater similarity in the demands. So, the more similar are the countries, the larger will be IIT, or the greater the difference in GDP per-capita, the less will be IIT. Based on Helpman (1987), Greenaway et al. (1994) uses this variable to test the effects of factor endowments differences on HIIT and VIIT. This is problematic because per-capita income reflects both the demand and supply sides. Hummels and Levinsohn (1995) alternately employ per-capita income and factor ratios. In this paper, we consider different variables for demand and supply sides and we will use two proxies for factor endowments differences. Bergstrand (1983) also considered supply-side and demand-side variables – factor intensity differences and taste differences – but did not find empirical support for Linder's hypothesis;

- LogEP is a proxy for differences in physical capital endowments.[5] It is the logarithm of the absolute difference in electric power consumption (Kwh per-capita) between Portugal and its EU partners. Based on Helpman and Krugman (1985), we formulated the following hypothesis: the larger the difference in factor endowments, the larger (smaller) the VIIT (HIIT). Bergstrand (1983) found empirical support for a negative relationship between the differences in factor endowments and HIIT. Helpman and Krugman (1985), Helpman (1987), Hummels and Levinsohn (1995) and Cies´lik (2005) all considered a negative relation between IIT and differences in factor endowments. In our opinion, as IIT encompasses both HIIT and VIIT, the expected sign for IIT is ambiguous. It is a matter of empirical evidence;

- LogSUMEP is a proxy for the sums of physical capital endowments between Portugal and each European trading partner. Based on Cies´lik (2005), a positive relationship between this control variable and IIT is expected;

- LogEC is the second proxy for difference in physical capital endowments. It is the logarithm of absolute difference in energy use (kg. of oil equivalent per-capita) between

Portugal and its EU trading partners. A negative (positive) sign for HIIT (VIIT) and an ambiguous sign for IIT is expected;

- LogSUMEC is the second proxy for the sums of physical capital endowments. According to Cies´lik (2005) we should expect a positive effect of this control variable on IIT;
- LogSEC is the proxy for the difference in human capital endowments. It is the logarithmic of the absolute difference in the school enrolment rate in secondary education between Portugal and the European trading partners. According to the literature, the higher the difference in factor endowments between Portugal and its trading partners, the higher (less) will be VIIT (HIIT). So, we expect a positive sign for VIIT, a negative sign for HIIT and an ambiguous sign for IIT;
- LogDIM is the logarithm of the average of GDP (PPP, in current international dollars) between Portugal and its EU trading partners. This is a proxy for economic dimension and a positive sign is expected (Loertscher and Wolter ,1980, Greenaway et al., 1994);
- LogFDI is the logarithm of the foreign direct investment, net inflows, that originate from a trading partner (% GDP). Markusen (1984) and Helpman (1984, 1985) provide an explanation for a positive relation between FDI and IIT, both vertical and horizontal. Greenaway et al. (1995) consider a positive sign for IIT. The product life cycle theory of Vernon (1966) also asserts that FDI is positively associated with VIIT;
- LogMinGDP is the logarithm of the lower value of GDP (PPP, in current international dollars) between Portugal and its EU partners. This variable is included to control for relative size effects. According to Helpman (1987) and Hummels and Levinsohn (1995), a positive sign for IIT, HIIT and VIIT is expected;
- LogMaxGDP is the logarithm of the higher value of GDP (PPP, in current international dollars) between Portugal and its EU partners. This variable is also included to control for relative size effects. A negative sign is expected (Helpman, 1987; Hummels and Levinsohn, 1995).

III.3. Model Specification

$$IIT_{it} = \beta_0 + \beta_1 X_{it} + \delta t + \eta_i + \varepsilon_{it}$$

Where IIT_{it} stands for either IIT, HIIT,or VIIT, meaning Total, Vertical or Horizontal Portuguese IIT index, X is a set of country-specific explanatory variables in logs; ηi is the unobserved time-invariant country-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 (εit) =0 and Var (εit) = σ^2 >0 .

The model can be rewritten in the following dynamic representation:

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

Because IIT is an index varying between zero and one, we apply a logistic transformation to IIT, HIIT and VIIT (see Hummels and Levinsohn, 1995).

$IIT = \ln[IIT/(1-IIT)]$. The same is carried out for HIIT and VIIT.

IV. Estimation Results

We will first present the static and dynamic panel data model without the Cies´lik (2005) control variables. In Paragraph 4.3, we present two different specifications for the IIT model, using Cies´lik's control variables in order to verify whether Helpman-Krugman's predictions are confirmed or not.

IV. 1. Results for the Static Models

We only present the fixed effects estimates, although the random-effects regression results are similar to the fixed-effects results. The fixed-effects estimator was selected, because it avoids the inconsistency due to correlation between the explanatory variables and the country-specific effects (Arellano and Bover, 1995).

The main results of the estimated regressions for IIT, HIIT and VIIT, displayed in Table 1, can be summarized as follows:

(i) The variable LogDGDP (difference in per-capita income) is not statistically significant in all models. The estimated coefficient has a predicted (non-predicted) negative sign for the IIT and HIIT (VIIT) models. So, these static results are ambiguous relative to Linder's hypothesis;

(ii) Both proxy variables for differences in factor endowments are statistically significant in the IIT model. The variable LogEP (difference in electric power consumption) has a negative effect on IIT, as was predicted by the Helpman and Krugman (1985) model. However, the second proxy for differences in factor endowments, the variable LogEC (difference in energy use), has a positive sign. These two variables are not statistically significant in the HIIT and VIIT models. Thus, these empirical results are ambiguous relative to the Helpman-Krugman theoretical predictions;

(iii) The variable LogSEC (difference in school enrolment rate in secondary education), used as proxy for difference in human capital endowments, is not statistically significant in all models;

(iv) The variable LogDIM (average of GDP), used also by Greenaway et al. (1994), has a significant and predicted positive effect on IIT, but it is insignificant in both the HIIT and VIIT models;

(v) The variable LogFDI (foreign direct investment) enters significantly in the IIT model and has a predicted positive sign, but it is insignificant in both the HIIT and VIIT models;

(vi) The variables LogMinGDP and LogMaxGDP, included as size effect controls, are statistically significant in the IIT and VIIT models, although LogMinGDP has a wrong sign;

(vii) The results for the HIIT and VIIT regressions are very poor. In the HIIT equation, only LogEC is significant, whereas in the VIIT regression, only the variables that control for bias are significant. This could be due to a possible misspecification and/or the potential endogeneity of the explanatory variables. These results suggest a dynamic specification to us;

(viii) The explanatory power of the IIT regression is very high ($R^2 = 0.967$). So, we can conclude that in Hummels and Levinsohn's (1995) paper, the fixed effects are picking up the effects of the missing explanatory variables. The R^2 of their fixed effects regression jumps from 0.524 (without country-pair dummies) to 0.96 when country dummies are included in regression. Instead of country-pair dummies, we use country-specific variables.

Table 1– Estimated Regressions for IIT, HIIT, and VIIT Models

	FIXED EFFECTS			EXPECTED SIGN		
Variable	IIT	HIIT	VIIT	IIT	HIIT	VIIT
LogDGDP	-0.089	-0.038	-0.256	(-)	(-)	(+)
	(-0.367)	(-0.054)	(-1.131)			
LogEP	-0.814	-1.474	-1.078	(+/-)	(-)	(+)
	(-2.359)**	(-0.752)	(-1.379)			
LogEC	0.125	0.478	0.043	(+/-)	(-)	(+)
	(1.678)*	(2.057)**	(0.444)			
LogLSEC	0.052	-0.405	0.014	(+/-)	(-)	(+)
	(0.523)	(-0.594)	(0.077)			
LogDIM	1.542	-4.615	2.062	(+)	(+)	(+)
	(1.707)*	(-1.287)	(1.574)			
LogFDI	0.085	-0.016	0.059	(+)	(+)	(+)
	(2.013)**	(-0.54)	(0.673)			
LogMINGDP	-1.900	4.108	-2-234	(+)	(+)	(+)
	(-2.443)**	(1.227)	(-1.654)*			
LogMAxGDP	-0.686	1.484	-0.771	(-)	(-)	(+)
	(-2.542)**	(1.304)	(-1.769)*			
Adj.R^2	0.967	0.639	0.794			
N	88	88	88			

Notes: t-statistics (heteroskedasticity corrected) are in parentheses. ***, **, * indicate significance at the 1% , 5% and 10% levels respectively.

IV. 2. Results for the Dynamic Models

We considered an individual-effects autoregressive panel data model and that the explanatory variables are not strictly exogeneous with respect to error term.[6]

The dynamic panel data model is valid if the estimator is consistent and the instruments are valid. The Sargan test of over-identifying restrictions tests the validity of the instruments. The first- and second-order serial correlation in residuals is tested by M_1 and M_2 statistics. The GMM system estimator is consistent if there is no second-order serial correlation.

According to the specification of the dynamic model, the distinction between the short-run and the long-run effects of the independent variable on the dependent variable is important. The short-run or contemporaneous effect is given by the coefficient of the current dated variables. The long-run effect is given by the coefficient of the current dated variable plus the coefficient of the same lagged variable (current effect plus lagged effect).

The regression results presented in Table 2 can be summarized as follows:

(i) Lagged IIT, HIIT and VIIT variables have an expected positive sign and are significant in IIT and HIIT models;

(ii) Similarly to Greenaway et al.'s (1994) cross-section study, we find evidence in support of Linder's hypothesis in the IIT, HIIT, VIIT panel data dynamic models. However, Greenaway et al. (1994) found an unexpected positive sign for income per-capita differences in the IIT model. In our study, the variable LogDGDP (difference in per-capita income) has a negative and significant sign in the IIT, HIIT and VIIT equations. However, if we consider the joint-effect of LogdGDP and $LogDGDP_{t-1}$ the sign in the VIIT equation is positive (the long-run effect is positive, i.e., -0.983+2.405 >0);

(iii) The signs of the physical capital endowments difference proxies (LogEP and LogEC) are as we had expected in all three models, but LogEP (difference in electric power consumption) is significant only in the HIIT model and LogEC (difference in energy use) is significant only in the VIIT model. Helpman-Krugman predictions are confirmed (not confirmed) relatively to the HIIT and VIIT (IIT) models;

(iv) The human capital endowments difference proxy (LogSEC) is significant in the HIIT and VIIT equations. However, the negative sign in the VIIT equation is contrary to expectations;

(v) The variables LogDIM (dimension) LogFDI and LogMinGDP are not statistically significant in all models;

(vi) The variable LogMaxGDP is significant in all models and has the expected negative sign;

(vii) The Sargan test and M_2 statistics show that the instruments used are valid and the parameter estimates are consistent.

Comparing the GMM estimates with the fixed-effects estimates, we note an improvement in the results for HIIT and VIIT models. However there are variables that are insignificant and/or with the wrong sign. Since we used the same specification for all models, the solution to the problem could be to use different equations for the HIIT and VIIT models. As in our sample VIIT accounts on average for 64 percent of the total IIT, it is acceptable that in the future we use the same regression for IIT and VIIT and a different equation regression for HIIT. Another solution is to use capital stock and labor force from Penn World Tables (if available) and not to use the proxies for the capital-labour ratio.

Another remarkable difference is that the income per-capita differences variable (LogDGDP) is now significant and with the predicted sign in the IIT, HIIT and VIIT models.

Table 2 – Estimated Regressions for IIT, HIIT and VIIT Dynamic Models

	GMM-SYSTEM			EXPECTED SIGN		
Variable	IIT	HIIT	VIIT	IIT	HIIT	VIIT
Constant	26.295	160.03	112.76			
	(2. 03)	(1.58)	(2.62)			
(IIT; HIIT; VIIT)t-1	0.645	0.473	0.134	+	+	+
	(4.29)***	(4.62)***	(0.715)			
LogDGDP	-0.323	-1.262	-0.983	(-)	(-)	(+)
	(-1.77)*	(-1.96)**	(-2.33)**			
LogDGDPt-1	0.362	0.627	2.405			
	(0.898)	(0.831)	(2.12)**			
LogEP	0.270	-4.769	1.496	(+/-)	(-)	(+)
	(0.372)	(-1.89)*	(0.904)			
LogEPt-1	-0.119	5.397	-1.868			
	(-0.14)	(2.12)**	(-1.05)			
LogEC	0.306	-1.003	0.914	(+/-)	(-)	(+)
	(1.43)	(-1.49)	(1.99)**			
LogECt-1	-0.404	0.457	-1.150			
	(-1.94)*	(0.586)	(-2.48)**			
LogLSEC	-0.196	-0.968	-0.934	(+/-)	(-)	(+)
	(-1.28)	(-1.81)*	(-1.84)**			
LogLSECt-1	0.159	0.039	-0.192			
	(0.886)	(0.06)	(-0.444)			
LogDIM	-1.184	-2.77	-8.184	(+)	(+)	(+)
	(-0.255)	(-0.25)	(-0.986)			
LogDIMt-1	-3.033	-9.65	4.115	(+)		
	(-0.778)	(-0.76)	(0.531)			
LogFDI	-0.031	0.496	-0.226	(+)	(+)	(+)
	(-0.195)	(1.01)	(-0.891)			
LogFDIt-1	-0.148	-1.087	-0.025			
	(-1.18)	(-1.77)*	(-0.07)			
LogMINGDP	1.843	-19.95	-8.391	(+)	(+)	(+)
	(0.313)	(-1.18)	(-0.967)			

Table 2 (cont) – Estimated Regressions for IIT, HIIT and VIIT Dynamic Models

	GMM-SYSTEM			EXPECTED SIGN		
Variable	IIT	HIIT	VIIT	IIT	HIIT	VIIT
LogMINGDPt-1	1.535	29.81	12.12			
	(0.285)	(1.56)	(1.61)			
LogMAxGDP	-10.02	-50.75	-50.30	(-)	(-)	(-)
	(-2.14)**	(-2.04)**	(-3.15)***			
LogMAxGDPt-1	8.187	37.26	38.26			
	(2.19)**	(2.28)**	(3.13)***			
M1	-1.181	-1.113	-0.647			
	[0.238]	[0.266]	[0.517]			
M2	0.137	0.916	0.454			
	[0.891]	[0.360]	[0.650]			
W_{JS}	4999	5954	6449			
	[0.000]	[0.000]	[0.000]			
Sargan	-1.9e-15	3.3e-015	1.645e-15			
	[1.000]	[1.000]	[1.000]			
	df=55	df=73	df=45			
N	74	74	74			

Notes: ***, **, * indicate significance at the 1% , 5% and 10% levels respectively.
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).P-values are in square brackets. Year dummies are included in all specifications (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, excluding time dummies and the constant term (two-step estimation). Sargan is a test of the over-identifying restrictions, asymptotically distributed as χ^2 under the null of instruments validity (two-step estimation) . Instruments used in the IIT and HIIT models: LOGIIIT (3, 4) or LOGIHIIT (3, 4), LogMinGDP (3, 4), LogMaxGDP (3, 4) for the equations in first differences and lagged first differences of all variables for the equations in levels. Instruments used in the VIIT model: the instruments used are LOGIVIIT (3, 4), LogMinGDP (3, 4), LogMaxGDP (3, 4) for the equations in first differences and lagged first differences of all variables, except LogMinGDP and LogMaxGDP, for the levels equation. All the dynamic panel data models estimated are valid.

IV.3. Testing Cies´lik's hypothesis

Helpman and Krugman's theoretical framework predicts a negative relationship between differences in relative factor endowments and IIT. Cies´lik(2005) demonstrated that empirical studies confirm this prediction once the sums of relative factor endowments are controlled for. In the estimations presented above, our results suggest that the relation between relative factor endowments and IIT is ambiguous and only partially confirm Helpman and Krugman (1985) hypotheses.

We will now investigate how robust our results are when we expand the set of control variables in the IIT static and dynamic regressions. Specifically, we wish to know if Linder's hypothesis maintains and what happens to Helpman and Krugman's (1985) predictions. We also wish to know if the Cies´lik control variables are significant or not and if they have the correct sign. First, we use the Hummels and Levinsohn (1995) control variables (LogMinGDP and LogMaxGDP) together with Cies´lik's (2005) control variables (LogSUMEP, LogSUMEC). The estimation results are presented in Table 3, columns (1) and (3), for static and dynamic estimates, respectively. Second, we use only the Cies´lik control variables. The estimation results are presented in columns (2) and (4).

With regard to Table 3, we see that in the static model and in the two cases (equations (1) and (2)), the effect of per-capita income differences (LogDGDP) on IIT is, again, negative, although not significant. So, in relation to Linder's hypothesis, the introduction of the Cie´slik control variables in the fixed-effects estimator does not change the previous conclusions. Both of the Cies´lik control variables are statistically insignificant and only LogSUMEP has the estimated coefficient with the correct positive sign. However, when we consider the dynamic results (GMM-estimator), the estimated coefficient of the LogDGDP variable is now positive and this variable becomes statistically insignificant. The results are now inferior and Linder's hypothesis is not confirmed.

Relative to the Helpman-Krugman predictions, the controls of the sums of relative factor endowments in IIT regressions do not improve our results as Cies´lik had predicted. In the fixed-effects regression, we have the same situation: the proxy LogEP continues to be significant with a negative predicted sign in both cases, whereas the other proxy for the difference in relative factor endowments (LogEC) is now insignificant and with the wrong positive sign. Therefore, the Helpman-Krugman prediction is only partially verified in the static fixed-effects estimations. The results are as ambiguous as they were prior to the introduction of the Cies´lik control variables. Regarding the dynamic regressions, the results do not change our previous conclusion. The variables are not significant, although the variable LogEC has now an estimated coefficient with a correct negative sign. The puzzle initially observed by Hummels and

Levinsohn (1995) does not disappear. The Cies´lik control variables are, in general, not significant.

Table 3 – Estimated Regressions for the IIT Model, using the Cies´lik control variables

	Fixed Effects		GMM-System	
Variable	(1)	(2)	(3)	(4)
Constant			-55.3	-4.94
IITt-1			0.629	0.77
			(3.62)***	(6.53)***
LogDGDP	-0.133	-0.045	0.08	0.05
	(-0.57)	(0.83)	(0.35)	(0.26)
LogDGDPt-1			0.09	0.179
			(0.25)	(0.58)
LogEP	-0.825	-1.13	0.63	0.404
	(-2.28)**	(-3.16)***	(1.26)	(0.84)
LogEPt-1			-0.62	-0.40
			(-1.04)	(-0.78)
LogEC	5.12	5.89	-2.61	-4.30
	(0.93)	(0.97)	(-0.20)	(-0.34)
LogECt-1			36.2	21.6
			(4.57)***	(2.89)***
LogLSEC	0.03	0.07	-0.42	-0.79
	(0.328)	(0.82)	(-0.71)	(-1.71)*
LogLSECt-1			0.41	0.49
			(0.48)	(0.42)
LogDIM	1.83	-0.51	0.37	3.17
	(2.19)**	(-2.41)**	(0.09)	(1.86)*
LogDIMt-1			-3.41	-2.70
			(-0.88)	(-1.55)
LogFDI	0.06	0.07	-0.03	0.08
	((1.80)*	(2.01)**	(-0.52)	(0.85)
LogFDIt-1			-0.07	-0.125
			(-0.95)	(-1.79)*
LogMINGDP	-2.08		2.78	
	(-2.82)***		(0.59)	
LogMINGDPt-1			-0.29	
			(-0.06)	
LogMAxGDP	-0.78		9.96	
	(-3.43)***		(1.87)*	
LogMAxGDPt-1			-4.11	
			(-1.19)	
LogSUMEP	2.03	1.37	0.30	0.555
	(0.98)	(0.60)	(0.81	(1.68)*

Table 3 (cont)- Estimated Regressions for the IIT Model, using Cies´lik control variables

	FIXED EFFECTS		GMM-SYSTEM	
Variable	(1)	(2)	(3)	(4)
LogSUMEPt-1			-0.33	-0.36
			(-0.49	(-0.91)
LogSUMEC	-5.05	-5.84	3.08	4.67
	(-0.90)	(-0. 95)	(0.23)	(0.36)
LogSUMECt-1			-37.0	-22.1
			(4.59)***	(-2.9)***
Adj.R^2	0.967	0.965		
M1			-1.01	-0.42
			[0.31]	[0.67]
M2			-0.66	-1.23
			[0.508]	[0.216]
W_{JS}			1523	2402
			[0.000]	[0.000]
Sargan			4.1e-15	-2.8e-16
			[1.000]	[1.000]
N	88	88	74	74

Notes: ***, **, * indicate significance at the 1% , 5% and 10% levels respectively.
Instruments used in GMM-System: equation (1): the instruments used are LOGIIIT (3, 4) , LogMinGDP (3, 4), LogMaxGDP (3, 4), LogDGDP(3, 4), LogSEC(3, 4), LogDIM(3, 4), LogFDI(3, 4), LogSUMEP(3, 4) and LogSUMEC(3, 4) for the equations in first differences and lagged first differences of all variables for the equations in levels; equation (2) :the instruments used are LOGIIIT (3, 4), LogDGDP (3, 4), LogSEC (3, 4), LogDIM(3, 4), LogFDI(3, 4), LogSUMEP(3, 4) and LogSUMEC(3, 4) for the equations in first differences and lagged first differences of all variables for the levels equation. All the dynamic panel data models estimated are valid.

V. Conclusions

In this paper we have tested some hypotheses generated from Linder's and Vernon's international trade theories, and from formal models such as those of Helpman and Krugman (1985) and Falvey and Kierzkowski (1987). We also revisited Greenaway et al.'s (1994) and Hummels and Levinsohn's (1995) empirical studies, which tested some of these hypotheses, although with different econometric specifications and estimators. Following Hummels and Levinsohn (1995), and according to Linder, we considered that demand structure is proxied by the difference in per-capita income and that the supply-side structure is proxied by the factor endowments difference. So, we do not consider that per-capita income difference is an adequate proxy to measure differences in factor composition. Our findings reveals that Linder's hypothesis (the demand similarity hypothesis) is confirmed when we include the supply-side variables. The results present a negative (positive) relationship between income per-capita difference and IIT, HIIT (VIIT) , when we use a dynamic panel data analysis. Our results also suggest that country-pair dummies used by Hummels and Levinsohn (1995) should be replaced by differences in relative factor endowments (physical and human capital) and other country-specific variables such as economic dimension and foreign direct investment. Comparing our static panel data regression (without country-pair dummies) with Hummels and Levinsohn's panel data regression (with country-pair dummies), we conclude that the explanatory power of both regressions is identical (R^2=0.96). Comparing our results with those of Greenaway et al. (1994), we note that both found a negative relationship between per-capita income differences and both types of IIT. However, our dynamic analysis allows us to conclude that the effect on VIIT is positive if we consider the long-run effect. Contrary to the Helpman and Krugman (1985) theoretical framework that predicts a negative relationship between IIT and differences in factor endowments, our results suggest that the sign of the coefficient is ambiguous (it is a matter of empirical evidence) because IIT encompasses both HIIT and VIIT, which have different determinants. Our dynamic results also confirm the Cies´lik (2005) hypothesis of a positive relationship between IIT and the sums of relative factor endowments. However, the introduction of this new control variable does not eliminate the ambiguity relative to Helpman-Krugman's predictions. Thus, the problem raised by Hummels and Levinsohn's (1995) findings remains. Finally, although the use of more sophisticated econometric techniques should not be an end in itself, it may be preferable to use the GMM system estimator in empirical IIT studies rather than pooled OLS, fixed-effects or random-effects estimators. The results should at least be verified. In our opinion, the system GMM estimator has the comparative advantage based on the potential for obtaining consistent parameter estimates, even in the presence of measurement errors and endogenous right-hand-side variables.

Notes

1. The idea of a dynamic variant without a theoretical support was previously introduced by Baier and Bergstand (2001) and Badinger and Breuss (2004). The dynamic approach has been frequently used in studies of firms' growth, growth of trade and productivity spillovers from foreign direct investment
2. In static panel data models, three kinds of estimators are used: pooled OLS, fixed effects and random effects estimators. The results of the empirical studies that use a static panel data approach are questionable due to the difficulty in finding exogenous variables than can be regarded *a priori* as being uncorrelated with the individual effects.
3. At this level of disaggregation, CAE is similar to NACE.
4. We also considered other explanatory variables, such as "Distance", "Differences in school enrolment rate in tertiary education" and "Trade imbalance" (to control for bias in estimation), but the introduction of these variables did not improve the results.
5. In order to compare the results, it would be preferable to use capital-labour ratios from Penn World Tables, as Hummels and Levinsohn (1995) and Cies´lik (2005) did. As the data is not freely accessible, we decided to use these two variable proxies.
6. As reported by Arellano and Bover (1995) and Blundell and Bond (1998), an interesting case arises when the levels of explanatory variables are correlated with the specific effects, but where first differences of these variables (and first difference of the dependent variable) are not correlated with those effects. In this case, the use of suitable lagged first differences as instruments for equations in levels is permitted.

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