

Inter-Industry Specialization and Labor Productivity in the European Union: the Development of the High-Tech Sectors

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ABSTRACT

This paper explores the relationship between inter-industry specialization and labor productivity in the European Union countries in order to indirectly test out the different trade theories and explore the role of labor productivity in achieving a specialization in high-tech industries. Evidence only partially seems to support the close relationship between inter-industry specialization and labor productivity expected from a Ricardian framework. Less developed countries in the European Union, specialized in low-tech industries, do not show comparative higher productivity in these industries. On the contrary, they frequently achieve good performances in the high-tech industries, helped by the foreign direct investment, what only can be understood on the basis of the Heckscher-Ohlin-Vanek framework (HOV), assuming very small factor elasticity of substitution in the technological advanced industries, in opposition to the low-tech ones. As a consequence, high labor productivity in high-tech industries is not a guarantee of specialization in such kinds of industries. Technological capital endowments are required, again in accordance with the HOV model. So, backward countries should have to support the development of their high-tech industries on large expenditures in R&D, even if they want to attract foreign companies.

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I. INTRODUCTION

In spite of the growth of international economic integration and globalization, it still remain significant differences in factor prices among countries, including the most industrialized, that could justify at least partially the differences in labor productivity founded. Those differences do not show a clear tendency to diminish, as is well known from Dollar and Wolff's key contributions (Dollar and Wolff, 1993). Neither does the differences in inter-industry specialization among countries, as also Wolff shows (Wolff, 1999) and other author focusing in the European Union area (Sapir, 1996; WIFO, 1999; Midelfart, Overman, Redding and Venables, 2000; Aiginger and Davies, 2001; Midelfart, Overman and Venables, 2003).

From inside the Heckscher-Ohlin-Vanek (HOV) framework, differences in factor prices among countries will lead them to specialize in those industries using more intensively their cheapest factors of production, achieving relatively lower labor productivity in these factors. On this basis, it is expected for backward countries to exhibit lower labor productivity, given its lower wages. Beside, this result would extend to every manufacturing industry at the same proportion if constant return to scale and identical technologies and wages were assumed. Therefore, when differences in these issues are considered, differences in inter-industry labor productivity will appear. In that case, industries characterized by a higher possibility of substitution between factors of production will use more intensively labor in less developed countries, making this factor to exhibit lower productivity.

Suppose now those industries showing superior capabilities of substitution between factors are the lesser technological advanced ones, what might be expected due to the greater standardization of their products and the higher employment of not skilled labor. Then the less developed countries, that tend to be specialized in those kinds of industries, would exhibit relative lower productivity in them. But this result is contrary to the expected from inside the Ricardian framework. Following that, the more standardize an industry is, the easier to develop for backward countries. Thus, these are supposed to achieve relatively high labor productivity in more standardized manufacturing industries (Gomory and Baumol, 2001).

According with that, an indirect way of testing the two above mentioned theoretical framework is studying the relationship between development, specialization and labor

productivity across countries and industries. This is precisely our main purpose in this paper, taking as a base ten European Union countries (Germany, Belgium, Denmark, Spain, France, Netherlands, Italy, Luxembourg, Portugal and the United Kingdom), what obviously means a limitation for such ambitious subject, but this is only a first approach that has to be completed with more countries and more extended data series.

Another purpose of the paper strongly related with the first one is to explore the role of labor productivity in the achievement of a high-tech industry, as many countries are committed in such a task, what for some of them, as Spain, Italy or Portugal have become very urgent, as they are more threatened by emergent economies.

To these purposes, we use the Groningen Growth and Development Centre database for industrial activities, with 26 industrial sectors classified according to the International Standard Classification (ISIC) revision 3¹. The Groningen Growth and Development Centre take as the point of departure the OECD Structural Analysis (STAN) database, which is largely based on latest official national accounts of OECD countries. We have built up a panel data for the ten above mentioned countries in the ten years of the period 1993-2002.

The paper is structured as follows. In Section II, the differences in specialization across industries and countries are explored. Section III is focus on the relationships between development, inter-industry specialization and labor productivity by industries. Finally, in

¹ Using the ISIC rev.3 classification and mixing the types of manufacturing industries provided by the OECD and the European Commission, focusing on demand growth and technological intensity, we distinguish three kinds of industries: 1) high demand and technological intensity or *advanced manufacturing* (office machines; insulated wire; other electrical machinery and apparatus; electronic valves and tubes; telecommunication equipment; radio and television receivers; scientific instruments; other instruments); 2) medium demand and technological intensity or *medium manufacturing* (chemicals; rubber and plastics; mechanical engineering; motor vehicles; building and repairing of ships and boats; aircraft and spacecraft; railroad equipment and transport equipment); and 3) low demand and technological intensity or *traditional manufacturing* (food, drink and tobacco; textiles; clothing; leather and footwear; wood and products of wood and cork; pulp, paper and paper products; printing and publishing; non-metallic minerals products; basic metals; fabricated metal products; furniture and miscellaneous manufacturing). We define the indexes for the high-tech sectors as those referred to the aggregate of the first group of industries.

Section IV, a deeper analysis about the relationship between specialization and labor productivity by industries is undertaken, although focusing in the high-tech ones. The last section concludes.

II. PRODUCTION SPECIALIZATION PATTERNS BY COUNTRIES AND INDUSTRIES

We begin our study by showing, in *Figure 1*, the specialization indexes (*SSI*) of each of the ten European Union countries considered, in the high-tech industrial manufacturing sectors. These indexes are defined as follows:

$$SSI_{jEU} = s_{ij} / s_{iEU} \quad [1]$$

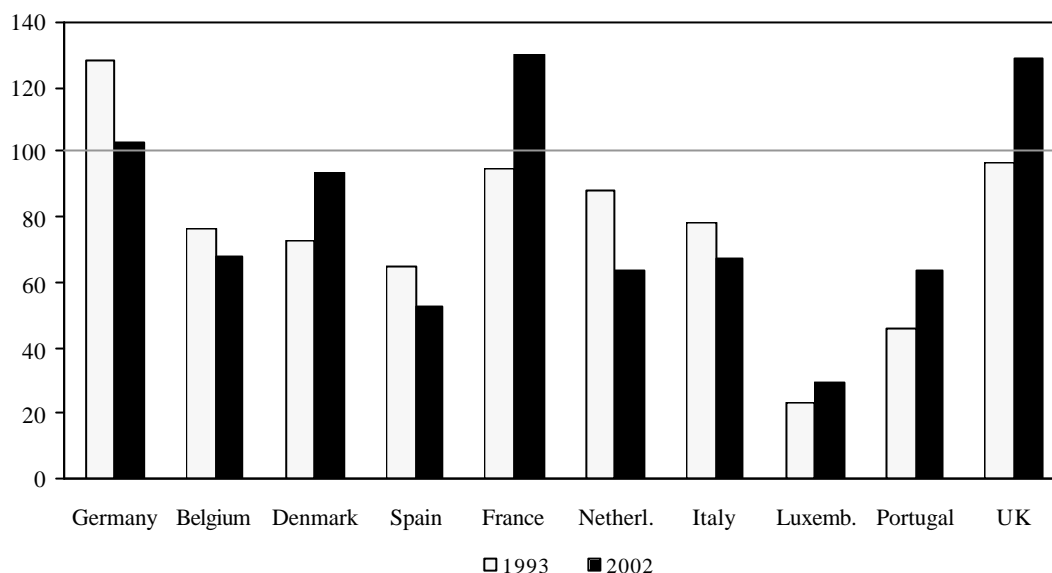
where s_{ij} denotes the share of industry i in country j 's total manufacturing value added and s_{iEU} is the same ratio for the whole European Union². Specifically, when this indicator turns up a value higher than one for a particular sector, it can be said of the country in question in each case that it is comparatively more specialized than the European Union in that sector.

In 2002, there were three countries that were clearly specialized in the high-tech industries, France, the United Kingdom and, to a lesser extent Germany, with some differences between them: Germany produced more electric machinery and other instruments and fewer computers than the other two countries. France was highly specialized in electronic valves and tubes and telecommunication equipment, while the United Kingdom in office machinery.

If we consider not only high but also medium-tech sector, the above picture does not change properly, except by the fact that Germany improves its position because is stronger than France and the United Kingdom in its medium-tech industries, particularly in motor vehicles and mechanical engineering.

² This quotient, used here as an indicator of production specialization, was originally designed by Balassa (1965) to measure the comparative commercial advantage revealed in the economy.

Figure 1
Specialization indexes in the high-tech sectors, 1993-2002



Source : Groningen Growth and Development Centre, 60-Industry Database (2005).

On the other hand, as is a common knowledge, there were other three countries clearly centred on low-tech industries: Portugal, Italy and Spain. However, there were very significant differences among them too, showing Italy and Spain in stronger positions than Portugal in the medium and high-tech industries³. Within the low-tech industries, Portugal and Italy led in textiles, clothing and leather and footwear, while Portugal and Spain were the front runner in non-metallic minerals and products.

Denmark, Belgium and the Netherlands were situated in an intermediate position, between the two aforementioned groups of countries. Denmark, with a specialization pattern similar to that of the European Union as a whole, was the leader in other instruments and scientific instruments, while Belgium led in basic metals and industrial chemicals and the Netherlands in radio and television receivers, furniture and food, drink and tobacco.

³ This means that the relative position of these three countries in the *Figure 1* improve slightly if medium-tech sectors are also included and particularly this of Spain.

These patterns of production specialization underwent some changes since 1993. In the nine years between 1993 and 2002, Germany, the Netherlands and Belgium fell behind from the position their high-tech industries formerly held, while France, the United Kingdom and Denmark advanced rapidly in these sectors replacing low-tech with high-tech manufacturing. Germany reinforced its position in the medium-tech industries and lost industrial weight in the office machinery, while the United Kingdom gained ground in that sector. And respect the latin countries specialized in low-tech industries, only Portugal became more similar to the European Union as a whole, developing their high-tech sectors (and medium-tech), while Italy and Spain surprisingly reinforced their relative position in the low-tech industries, the first of them losing weight in high-tech industries and the second also in medium-tech.

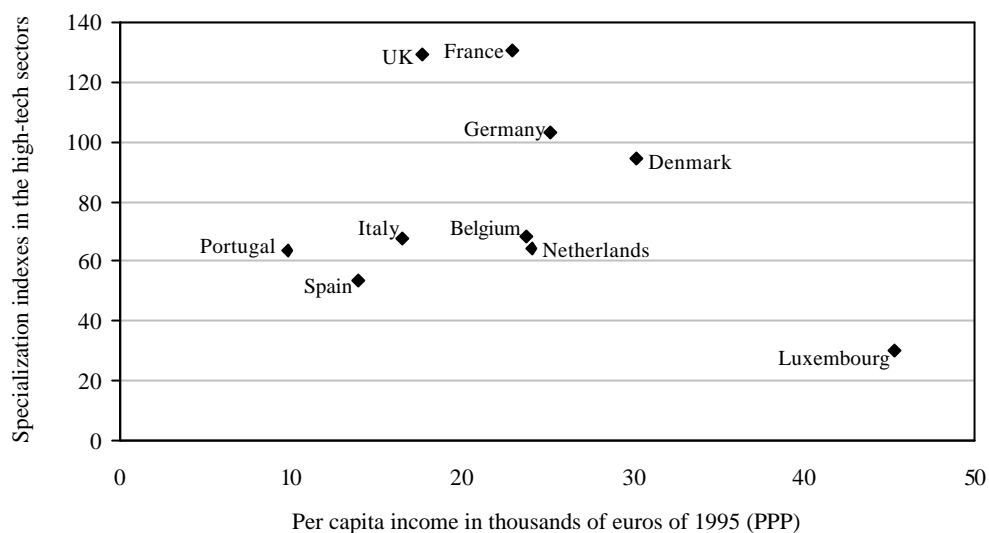
III. SPECIALIZATION AND LABOR PRODUCTIVITY

As *Figure 2* indicates, the specialization of the countries in the high-tech sectors seems to be related to their economic development, measured by their per capita income, what help to explain why it change so little. Only the special case of Luxembourg disturb the correlation that on the contrary would improve if compatible information about Ireland and Finland were available, because these have been the countries growing faster and with a stronger increase of its specialization in the high-tech sectors in the European Union during the period here studied.

From a Ricardian perspective, countries specialized in the high-tech sectors could be expected to reach higher labor productivity levels in those sectors, because they are equipped with the necessary wherewithal. This would also hold for a HOV model if all the industries show the same factor elasticities of substitution and the factor price equalization fails, as the high-tech industries are intensives in physical and human capital, factors more abundant in richer countries.

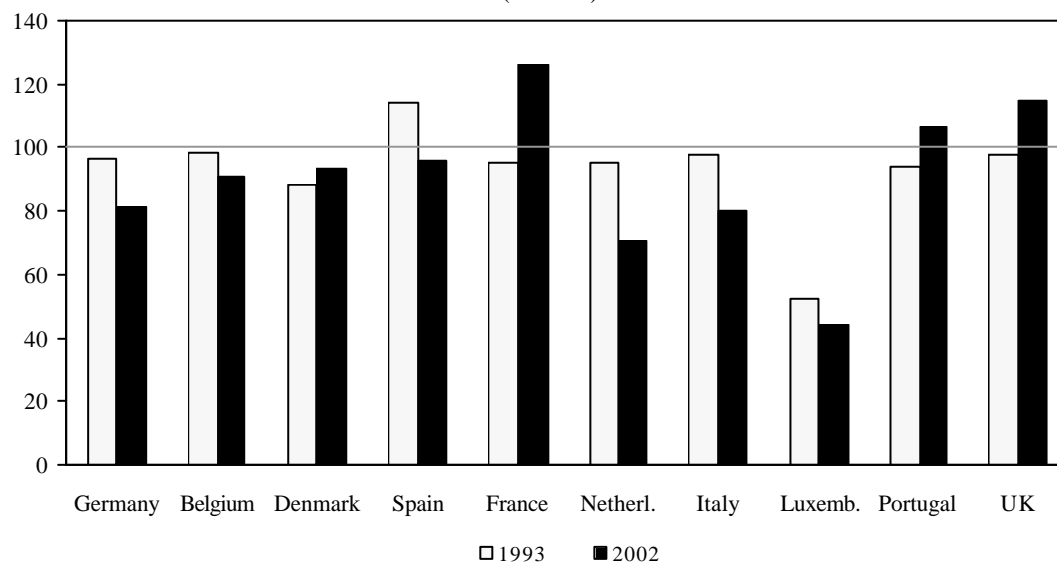
However, we are confronted by the fact that the patterns of sectoral labor productivity do not fit those specialization patterns. *Figure 3* offers a first picture depicting that problem.

Figure 2
Per capita income and production specialization in the European Union, 2002



Source: Groningen Growth and Development Centre, 60-Industry Database and OECD (2005).

Figure 3
Relative labor productivity in the high-tech sectors, 1993-2002
(EU=100)



Source: Groningen Growth and Development Centre, 60-Industry Database (2005).

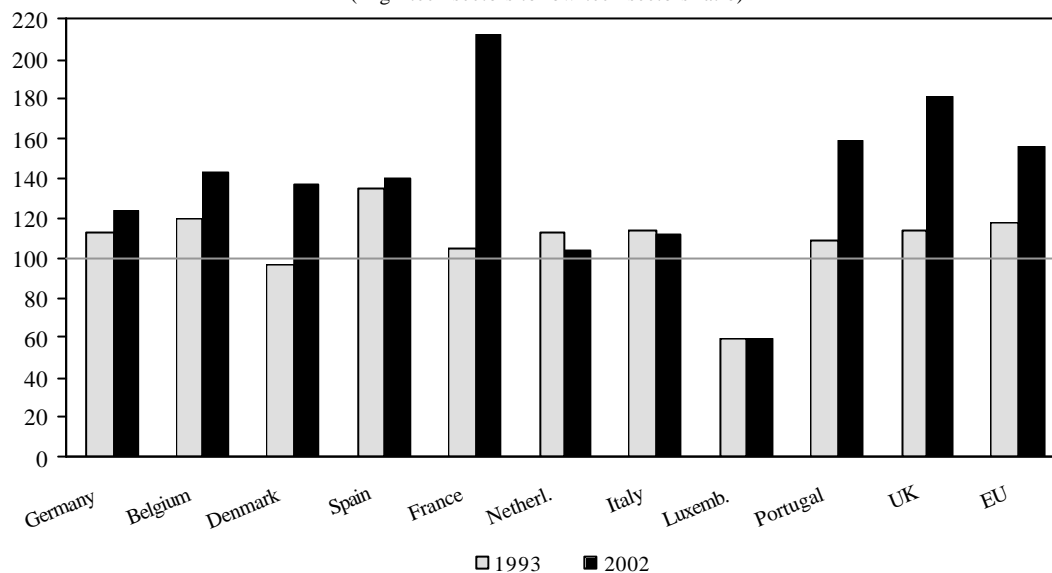
As can easily be observed, the differences among the countries in labor productivity in the high-tech manufacturing sectors in 2002 are not in accord with the mentioned expectations, with Spain, Italy and Portugal registering achievements on a par with Germany's and even better than the United Kingdom's if we go back ten years to 1993. This picture does not change at all if we look at the high and medium-tech sectors taken together. And it would be even more shocking referred to the relative unit labor costs. Thanks to their low wages, even partially corrected by lower prices corresponding to the lower quality of their products, Spain, Italy and Portugal are among the countries with the lowest unit labor costs.

But *Figure 4*, with shows for ten countries the ratio of labor productivity in the high-tech industries to low-tech sectors is even more striking, as it indicates that the less developed countries in the European Union have reached relatively higher labor productivity levels in the high-tech manufacturing sectors, what is mainly due to a very low labor productivity levels in the traditional industries where they specialize. The case of Portugal is particularly striking. Obviously, this is translated into relatively lower unit labor costs in the high-tech sectors. *Figure 5* shows even more clearly that there is a negative correlation between economic development and relative sectoral productivity in the high-tech industries⁴.

Though all these results seem initially surprising, they can be understood on the basis of the HOV model if the marginal rate of substitution in production between labor and capital is much higher in the low-tech sectors and factor price equalization fails. In this case, the differences in labor productivity between countries would be higher in the low-tech sectors. However, similar or higher absolute labor productivity levels in the high-tech industries in countries with diverse levels of development are more difficult to make compatible with this model, although not impossible. They would imply very little factorial possibilities of substitution in the high-tech industries. So, the differences in labor productivity among the countries in such industries would find an explanation in the differences of intra-industry specialization.

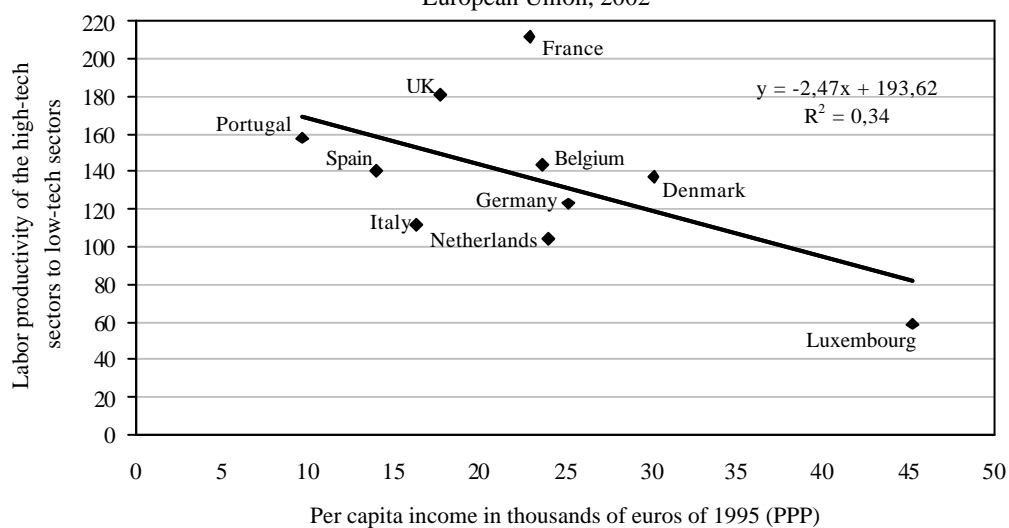
⁴ This is not a result of less relative labor productivity in the high-tech sectors in the countries specialized in those sectors.

Figure 4
 Labor productivity, 1993-2002
 (High-tech sectors to low-tech sectors ratio)



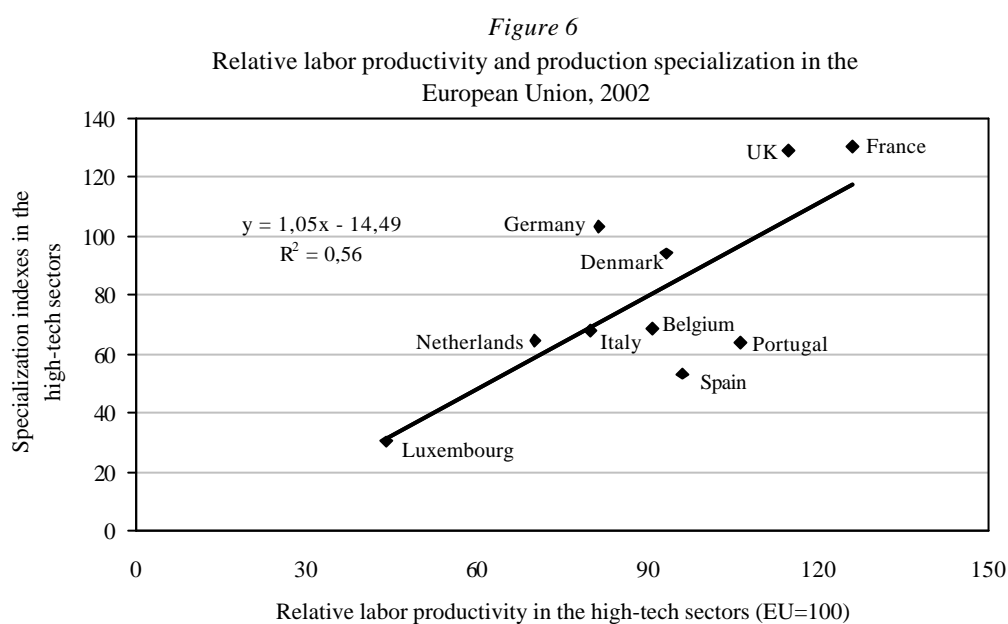
Source : Groningen Growth and Development Centre, 60-Industry Database (2005).

Figure 5
 Per capita income and relative sectoral labor productivity in the
 European Union, 2002



Source : Groningen Growth and Development Centre, 60-Industry Database and OECD (2005).

Anyway, even with so small sample of countries, if we look for the expectations derived of the Ricardian model, we can find out a positive and significant relationship between specialization in high-tech industries and relative labor productivity in them, as *Figure 6* shows. The cases of France and the United Kingdom are keys in that result that could improve if we considered a wider disaggregation of industries⁵.



Source : Groningen Growth and Development Centre, 60-Industry Database (2005).

Therefore, in order to test this relationship in a robust way, we have estimated the following econometric expression:

$$SSI_{ij,t} = a + \beta T_{ij,t} + u_{ij,t} \quad [2]$$

where *SSI* is the specialization index before defined and *T* is relative labor productivity measured in a similar way, that is, labor productivity in industry *i* and country *j* with respect to that in total manufacturing divided by the same ratio for the European Union.

⁵ In fact the result worsen if the medium-tech sector is added.

We used a disaggregation in 26 industries for the ten countries chosen and carried out the estimates for the period 1993-2002 what provided of 2560 observations⁶. The variables were expressed in logarithm in order to better interpret the coefficients, as elasticities. Using the panel data analysis, we found a positive association between specialization and labor productivity, as is expected from the Ricardian framework (*Table 1*). Nevertheless, this association is stronger in the time path than in the cross-section perspective, as can be tested comparing the within-group estimator (WG) with the between-group one (BG) which besides is not a consistent estimator due to the existence of individual effects correlated with the regressors.

*Table 1 . Production specialization and labor productivity
in the European Union
(Regression results with Panel Data)*

Dependent variable: Specialization indexes by industry and by country		
Period	1993-2002	
Number of observations	2560	
Estimator	BG	WG
Labor productivity ⁽¹⁾	0,92144 (6,10)***	0,87573 (29,75)***
Adjusted R ²	0,32	0,90

⁽¹⁾Heteroscedastic-consistent t-values in brackets: *** means significant at 1 per cent, ** at 5 per cent, * at 10 per cent.

However, as endogeneity weakness was detected in the above estimate, the Generalized Method of Moments (GMM) was applied. This procedure controls for the endogeneity of the regressors, through the use of their lagged values as instruments, and also eliminates fixed individual heterogeneity⁷.

⁶ 40 values are missed because of the lacking of the data for four branches to Luxembourg.

⁷ For details of the econometric method, see Arellano and Bover (1990, 1995).

The results shown in *Table 2* confirm the previous ones. Labor productivity has a positive impact on inter-industry specialization, with a elasticity of 0,85. That means that the increase of labor productivity in the industries contributes to reinforce a specialization in them as was expected from the Ricardian framework. But it does not necessarily mean that specialization is based in the labor productivity level reached. The causality of the relationship between these two variables is not clear at all, and hardly can be assured by any econometric method. Although a relative good performance in labor productivity is expected to push specialization in a given industry that is also expected to lead to a steady increase in labor productivity, in a virtuous circle.

Table 2. Production specialization and labor productivity
in the European Union
(GMM estimation. Main results)⁽¹⁾

Dependent variable: Specialization indexes by industry and by country	
Period	1993-2002
Number of observations	2560
Labor productivity ⁽²⁾	0,84744 (35,22)***
χ^2 value, Wald test of significance	1240,09

⁽¹⁾The equation have been transformed in first-differences.

⁽²⁾Heteroscedastic-consistent t-values in brackets: *** means significant at 1 per cent, ** at 5 per cent, * at 10 per cent.

In another words, does our results mean that any country can reach a specialization in high-tech industries soaring labor productivity in them? And if that was the case, would it increase the threat to the developed world coming from new emerging economies, following the fears pointed out recently by Samuelson (2004)? The answer to these questions does not seem clearly affirmative just looking at our data, because the less developed countries in the European Union, Spain and Portugal, showed good performances in labor productivity inside the high-tech sectors without increase their specialization in them. In fact, as was above shown, in the case of Spain, such specialization has decreased from 1993 to 2002. But this seems also to be the case for the Netherlands and Belgium.

IV. EXPLORING THE PATTERNS OF DEVELOPMENT IN THE HIGH-TECH INDUSTRIES

What we see in the *Figures 1* and *2* leads us to ask, firstly, why Belgium, Denmark, Spain, Portugal and Italy had attained in the first year we considered, 1993, such a high relative labor productivity levels in their high-tech sectors; second, why this has not led them to greater degree of specialization in those sectors, on the contrary of what would have been expected on the basis of the Ricardian framework; and thirdly, with the exception of Portugal, is the failure in achieving a stronger specialization in high-tech sector the cause of the decreasing in relative labor productivity or the opposite?

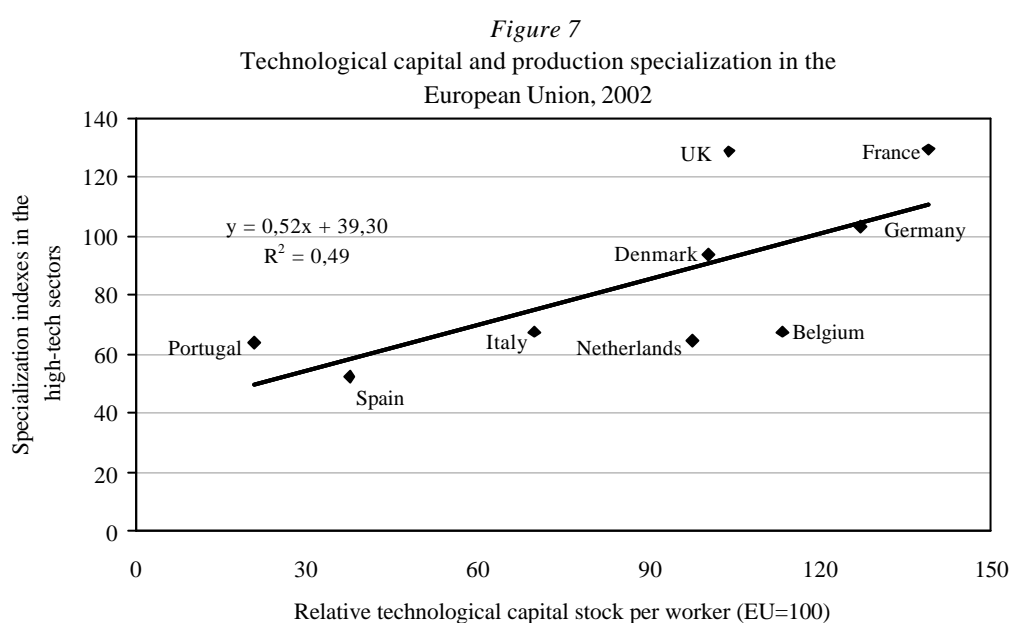
In some cases, the answer to the first question could be that foreign capital has been very helpful in the development of the high-tech sectors. In Spain, for example, foreign capital controlled more than 60 per cent of production in such sectors from the beginning of the 1990s, following the foreign investment boom linked to the integration of Spain in the European Union (Fernández-Otheo, 2000).

The answer to the second question perhaps lies in that these countries may find it difficult to advance in the high-tech industries because of their low technological capacity or small size. A limited base in technological capital may prevent them from moving on to improve and attain more sophistication in the quality of their products. It seems clear, for instance, that all these countries find it difficult to progress in the computer sector. This is a hypothesis we have to test.

If that hypothesis found some evidence we would answer to the third question saying that the decrease of specialization in high-tech sectors of the above mentioned countries led their levels of labor productivity down.

Therefore, one possible answer to these questions resides in the empirical fact that the specialization indexes in the high-tech sectors (*Figure 1*) reveal a clear connection with the degree of development of each particular country and, more specifically, with their base in technological capital, as *Figure 7* shows. Nevertheless, this is not incompatible with a positive influence of labor productivity on specialization. On the contrary, labor productivity in every

industry also depends on technological capital in the whole economy. However, the point here is that countries obtain technology from abroad particularly in the high-tech branches, being then compatible high values of labor productivity in these sectors with poor domestic technological endowment, and this could be the case for the less developed and technologically more dependent economies. Therefore, the specialization in the high-tech industries could be attached to the domestic technological base rather than the increase of labor productivity in those industries.



Source : Groningen Growth and Development Centre, 60-Industry Database (2005) and OECD, MSTI (2005).

In order to test this hypothesis more directly, we regressed the average value of the high-tech sectors indexes in each country over the aggregated endowments of physical, human and technological capital stock per worker, according with the following expression:

$$SSI_{jt} = f(K_{jt}, H_{jt}, TECH_{jt}) \quad [3]$$

where j refers to the country, t is the year ($t = 1993, \dots, 2002$) and K , H and $TECH$ denote the physical, human and domestic technological capital stock per worker in each country relative to the European Union average.

The stocks of physical and technological capital were obtained accumulating the investment data given by EUROSTAT and OECD respectively, assuming depreciation rates of 4 per cent and 10 per cent. The human capital measure is based in the estimates of De la Fuente y Domenech (2001), interpolating annual dates between each five years offered.

According with the HOV framework, these three explanatory variables reflecting the relative capital endowments are supposed to be positively related with the specialization in high-tech industries, allegedly intensives in physical, human and technological capital.

Nevertheless, to approach the Ricardian effect, we have also estimated the expression [3] introducing the labor productivity really achieved in the high-tech industries, not that for the entire economy.

The main results of the econometric estimates with panel data are given in *Table 3*⁸. On one hand, only technological capital per worker proves to be significant in explaining the specialization indexes for countries in the high-tech manufacturing sectors, not only in a cross-sectional comparison, but also in the time path. The results for physical and human capital are omitted because its lack of significance. On the other hand, the significance of labor productivity is severely reduced mainly in the between-group estimate. That means the specialization in high-tech sector depend almost completely on technological capital, and slightly of labor productivity. Evidently, further work must be devoted to finding an explanation for the differences in specialization between countries within the high-tech sectors⁹.

⁸ In both of the estimates included in this table the within-group estimator (WG) is the only consistent estimator, due to the existence of individual effects correlated with the explanatory variables.

⁹ Nevertheless, it is always possible to go into a more complex classification of the manufacturing sectors, introducing several other characteristics, such as scale economies and natural resources. This is the road chosen by Midelfart *et al.* (2000) and frequently used by the OECD and the European Commission.

Table 3 . Production specialization in the high-tech sectors and technological capital in the European Union
(Regression results with Panel Data)

Dependent variable: Specialization index in the high-tech sectors by country				
	1		2	
Period	1993-2002		1993-2002	
Number of observations	90		90	
Estimator	BG	WG	BG	WG
Technological capital ⁽¹⁾	0,30625 (3,18)**	0,52490 (2,47)**	0,32699 (3,59)**	0,53698 (2,54)**
Labor productivity ⁽¹⁾			1,00819 (1,43)	0,00784 (2,04)**
Adjusted R ²	0,53	0,93	0,59	0,93

⁽¹⁾Heteroscedastic-consistent t-values in brackets: *** means significant at 1 per cent, ** at 5 per cent, * at 10 per cent.

Finally, we have to be sure that the significance of technological capital does not capture the effects produced by openness to foreign competition, a crucial variable for explaining differences in specialization indexes across industries and countries, as we have noted in another work (Álvarez and Myro, 2005). To test out this hypothesis, we introduced both variables into the estimate with the result that technological capital proves to be the more powerful of the two.

V. CONCLUSIONS

According with the expectations derived from the Ricardian framework, countries tend to show comparatively high labor productivity levels in the industries where they specialize. But the relationship is far from being accurate, to the point that less developed countries frequently obtain high labor productivity levels not only in the low-tech sector but also in the high-tech sectors, helped by direct foreign investment. This result is in fact more compatible with the HOV framework if factor price equalization fails and the elasticity of factor substitution in the high-tech industries are very small and much lower than in the low-tech industries.

Increasing labor productivity in one industry helps to make stronger the specialization of a country in it, but does not create it. This seems to depend more on endowments, following the HOV model. Therefore, high labor productivity in the more technologically advanced sectors does not seem to guarantee to the less developed countries that they will be able to achieve specialization in those sectors. Higher technological capital endowments are primarily necessary. Without this, apparently more sophisticated or better quality goods cannot be produced, thus limiting the expansion of the high-tech sectors.

That means that less developed countries have to support the development of their high-tech industries on great expenditures on R&D, particularly if the base of high-tech industry is foreign direct investment, as the risk of relocation have increased nowadays. This also means that new emergent economies, as China or India, need to impulse its technological endowment if they want to compete in the field of the high-tech sectors. At the same time, relocation of firms to these new economies must find a limit in the lack of technological endowment.

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