VERTICAL SPECIALIZATION IN PORTUGUESE INTERNATIONAL TRADE*

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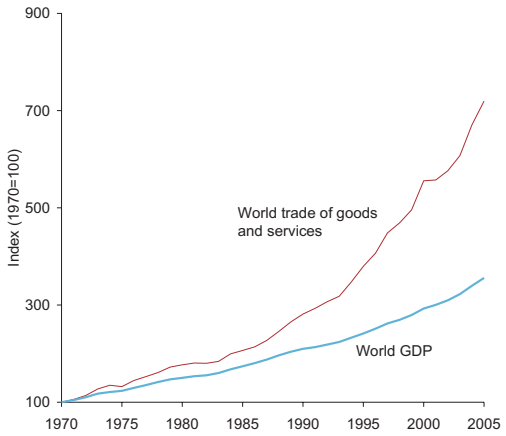
1. INTRODUCTION

One of the significant economic trends of the last decades is the strong growth of international trade flows. World trade volume of goods and services exhibited an average annual growth of 6.0 per cent over the period 1970-2005, well above the real growth rate of world GDP of 3.7 per cent (Chart 1). Another important feature of the current globalization phase is the increase in the stock of foreign direct investment (FDI) and the rising importance of multinational corporations in world production. Several explanations for these trends have been put forward in the literature. Firstly, the recent decades have witnessed substantial progress in the liberalization of international trade and capital flows, with the integration of several emerging market economies in world markets. Secondly, the dissemination of information and marketing strategies tends to increase consumers' taste for variety, intensifying international intra-industry flows of final goods (see Lloyd and Lee (2002)). Thirdly, a new paradigm in the international organization of the productive process has emerged since, for a large share of goods, activity is now vertically decomposed among different countries. Such activities explain part of the increase in world trade because more intermediate goods circulate between countries. The internationalization of production also relates with the increase of FDI because part of these activities are conducted within the structure of multinational corporations as intra-firm trade.

Chart 1

WORLD TRADE AND GDP (REAL)



Source: IMF.

* The authors thank António Rua for making available Input-Output matrices based on Portuguese national accounts, Asier Minondo for supplying the results for Spain, Jorge Correia da Cunha and José Ferreira Machado for their suggestions and comments. The analyses, opinions and findings represent the views of the authors; they are not necessarily those of Banco de Portugal. The usual disclaimer applies.

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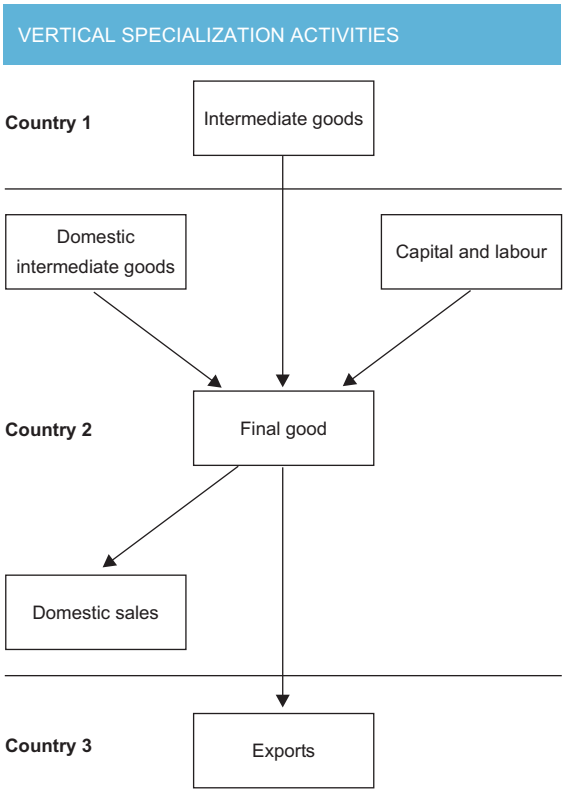
International production sharing has always been part of international trade as countries import manufactured goods to be incorporated in their exports (see Yeats (1998) for a discussion). Nevertheless, the reduction of transport and communication costs, the sharp increase in technical progress and the removal of political and economic barriers to trade exponentiated the opportunities for the internationalization of production, as firms began to offshore many tasks that were previously considered non-tradable. Overall, this new paradigm, named by Baldwin (2006) as the "second unbundling", led to the surge of new countries in world trade depending heavily on outsourced tasks in industries where potential gains of specialization are higher. In geographical terms, this phenomenon has been largely reported in emerging market economies in South East Asia.

In this article, we use the concept of vertical specialization introduced in Hummels *et al.* (1998) and further developed in Hummels *et al.* (2001) to quantify the international vertical linkages for the Portuguese economy from 1980 to 2002. This concept basically considers situations where one country uses imported inputs in the production of goods that are later exported. Therefore, vertical specialization requires that the production is carried out in at least two countries and that the goods cross at least twice the international borders (Chart 2). In this context, countries specialize in particular stages of a good's production. By comparison, as stated in Hummels *et al.* (1998), in a horizontal-specialization scenario, countries trade goods that are produced from start to finish in just one country. This vertical specialization concept has some similarities with the international outsourcing measure proposed by Feenstra and Hanson (1996) that has been widely used to asses the impact of international fragmentation of production on domestic employment and relative wages. Nevertheless, the differences between the two measures are relevant. The Feenstra and Hanson (1996) measure focuses on the foreign content of domestic production as it considers the share of (direct) imported inputs in production or in total

Chart 2



Source: Hummels *et al.* (2001).

inputs, while the Hummels *et al.* (2001) measure of vertical specialization considers the share of (direct and indirect) imported inputs in total exports.

It is relevant to analyse the experience of the Portuguese economy in the context of vertical specialization. Firstly, this new paradigm in world production implies the reconfiguration of the patterns of comparative advantages and FDI flows, making it important to assess the ability of the Portuguese economy to adjust to this reality. In addition, it is important to identify which sectors are more vertically integrated, as well as the geographical links of this phenomenon. Secondly, the calculations provide an accurate measurement of the import content of Portuguese exports, which is useful in macroeconomic analysis.

On a policy perspective, it is important to note that it is not possible to directly link the degree of vertical specialization with the economic performance of a country. In fact, a country can perform well in international markets if it is competitive in productions where vertical specialization is not adopted. Conversely, a country with a high share of vertical specialization activities may not take substantial benefits if it is placed on a segment of the production chain associated with very low value-added goods. Therefore, the participation in vertical specialization activities represents an opportunity but the underlying determinants of comparative advantages remain crucial for economic growth.

The seminal paper by Hummels *et al.* (2001) takes a sample of ten OECD and four emerging market countries and makes use of Input-Output tables to compute an index of vertical specialization. The index measures the share of such activities in total exports and reveals that it accounts for 21 per cent of exports in the countries considered in 1990 with a growth rate of almost 30 per cent between 1970 and 1990. Other studies have applied this methodology, in some cases with minor changes relatively to the original formulation, and have also identified increases in vertical specialization activities in several countries. Some examples are Minondo and Rubert (2002) for Spain, Breda *et al.* (2007) for Italy and six other EU countries, Cadarso *et al.* (2007) for nine EU countries, Dean *et al.* (2007) and Xiaodi and Jingwei (2007) for China, and Chen and Chang (2006) for Taiwan and South Korea. The vertical specialization measure of Hummels *et al*. (2001) is also computed by the OECD as one of its indicators of global economic flows under the name of import content of exports.[1]

The article is organized as follows. In Section 2 we describe the methodology developed by Hummels *et al.* (2001) and the data used to derive the results for the Portuguese economy. Section 3 starts by presenting the overall measure of vertical specialization and then moves to a sectoral analysis of vertical specialization in Portugal. Additionally, we explore the geographical link to Portuguese vertical specialization, focusing on the main trade partners. Finally, Section 4 presents some concluding remarks.

2. MEASUREMENT AND DATA

Vertical specialization in trade involves the use of imported intermediate goods in the production of goods for export. Following Hummels *et al.* (2001), vertical specialization activities (from now on referred as VS activities) in sector *j* can be defined as the contribution of imported inputs to exports of sector *j*, in nominal terms, that is:

(1) See Backer and Yamano (2007) and OECD (2007) for a presentation of several OECD indicators computed using Input-Output data. Although the total import content of exports (or embodied imports) was already computed by the OECD as one of its economic globalization indicators, the link with Hummels *et al.* (2001) concept of vertical specialization had not been established explicitly (see for instance OECD (2005a) and OECD (2005b)).

$$VS_j = \sum_{i=1}^{n}\left(\frac{M_{ij}X_j}{Y_j}\right) = \sum_{i=1}^{n} a_{ij}^{M} X_j \quad (1)$$

where M_{ij} is the value of imported intermediate product i absorbed by sector j, Y_j is the gross output of sector j, X_j is the value of exports of sector j, and a_{ij}^{M} is the proportion of imported input i used to produce output Y_j, for $i, j = 1,2,\ldots,n$. So VS_j measures the total amount of imported intermediate goods required to produce the exports of sector j, *i.e.*, the import content of exports or the foreign value included in the exports of sector j.

For country k total VS is simply the sum of VS across all sectors j:

$$VS_k = \sum_{j=1}^{n} VS_j = \sum_{j=1}^{n}\sum_{i=1}^{n} a_{ij}^{M} X_j \quad (2)$$

In order to facilitate the analysis, it is useful to calculate the VS as a percentage of total exports of the country. The VS share of total exports in country k is given by:

$$\frac{VS_k}{X_k} = \frac{\sum_{j=1}^{n} VS_j}{\sum_{j=1}^{n} X_j} = \sum_{j=1}^{n}\left[\left(\frac{VS_j}{X_j}\right)\left(\frac{X_j}{X_k}\right)\right] = \sum_{j=1}^{n}\left[\left(\sum_{i=1}^{n} a_{ij}^{M}\right)\left(\frac{X_j}{X_k}\right)\right] \quad (3)$$

where $X_k = \sum_{j=1}^{n} X_j$ are total exports of country k. Using equation (3), the total VS share of a country can be decomposed in an export-weighted average of sectoral VS export shares.

One basic element of the methodology proposed by Hummels *et al.* (2001) is the utilization of Input-Output (I-O) matrices to identify the value of the different intermediates used in the production of each sector, specifically the value of those that are imported. The advantages of the utilization of I-O matrices are twofold. Firstly, the value of imported intermediates is properly accounted, in the sense that the I-O approach bases the classification on the use of the good and not on its characteristics. In fact, there are many examples of goods that can be either final or intermediate, thus strong arbitrariness is introduced when the classification is based on the product characteristics. Secondly, the I-O approach allows for a sectoral breakdown of the VS measure. The drawback is that the I-O matrix does not differentiate the import content of a good that is domestically consumed from that of a good that is exported. Therefore, the assumption that the import content is similar in the two cases is necessary.

The VS measure presented in equation (3) is:

$$VS \text{ share of total exports in } k = \frac{VS_k}{X_k} = \frac{uA^{M}X}{X_k} \quad (4)$$

where u is a $1\times n$ vector, n is the number of sectors, A^{M} is the $n \times n$ imports direct input coefficient matrix, where each a_{ij}^{M} element represents the imports of product i absorbed per unit of output of sector j, X is a $n \times 1$ vector of exports of each sector j and X_k is the sum of exports across the n sectors.

Equation (4) measures the value of imported inputs that are used *directly* in total exports, *i.e.*, the direct import content of total exports. Nevertheless, the existence of an I-O matrix makes it possible to consider also the imported inputs used *indirectly* in exports. It is clear that one intermediate good can be initially imported as input of one domestic sector and the production of this latter sector is then used as an intermediate in a second domestic sector and so on, until the imported product is finally embodied in a good that is exported. Therefore, the original intermediate import may circulate in the domestic economy across several sectors before there is an export. Using the example stated in OECD (2005b), suppose that in producing cars for exports, a car manufacturer imports certain components (*e.g.* the

chassis), the direct import contribution will be the ratio of the value of the chassis to the total value of the car. And if the car manufacturer purchases other components from domestic manufacturers, who in turn use imports in their production process, those imports must also be included in the car's final value. Thus, the imported inputs required for the production of a car include not only the direct imports, but also the indirect imports that are used in the production of rounds of domestically produced inputs for cars. These indirect imports should also be included in a measure of the contribution of imports to the production of cars for export (see also Xikang (2007) for a discussion). This indirect effect can only be considered if an I-O matrix is used and it is captured by:

$$VS\ share\ of\ total\ exports\ in\ k = \frac{VS_k}{X_k} = \frac{uA^M \left[I - A^D\right]^{-1} X}{X_k} \qquad (5)$$

where I is the identity matrix and A^D is the $n \times n$ matrix of domestic technical coefficients. The term $\left[I - A^D\right]^{-1}$ can be written as the sum of a converging infinite geometric series with common ratio A^D, that is:

$$\left[I - A^D\right]^{-1} = \left[I + A^D + A^{D^2} + A^{D^3} + \ldots + A^{D^x}\right],\ when\ x \to \infty.$$

Thus, the numerator of equation (5) measures the total imported inputs, iterated over the economy's production structure, that are needed to produce the total exports (see Dean *et al.* (2007) and Xikang (2007) for a discussion). Dividing this by the amount of total exports of a country yields the total (direct and indirect) share of exports attributable to imported inputs, *i.e.*, the total VS share of a country. Therefore, equation (5) is the measure elected to compute the importance of VS activities.

The Hummels *et al.* (2001) concept of VS can be further clarified by using standard concepts of I-O models. The $\left[I - A^D\right]^{-1}$ matrix is the Leontief inverse matrix (see Miller and Blair (1985) for details). The elements of the Leontief inverse matrix are often termed as output multipliers, as they enable the estimation of both direct and indirect impacts of a change in final uses. Each (i, j) element of the inverse indicates by how much the output of sector i increases if final demand for output of sector j increased by one unit. If we multiply the matrix of direct requirements of imported inputs A^M and the Leontief inverse matrix $\left[I - A^D\right]^{-1}$, we obtain the matrix of direct and indirect requirements of imported inputs $A^M \left[I - A^D\right]^{-1}$. In general terms, and as shown by Dietzenbacher *et al.* (2005), the element (i, j) of the matrix $A^M \left[I - A^D\right]^{-1}$ gives the total imports of product i required to satisfy one unit of final demand for sector j. Hence, the sum of the elements in the j^{th} column of the matrix measures the imported inputs from all sectors generated by one unit final demand for output of sector j.[2] In our case, the final demand item considered are total exports, so the sum of j^{th} column of this matrix gives the total imported inputs per unit of exports of sector j, *i.e.*, the VS share or VS intensity of sector j.

In this article the data used for Portugal comes from national accounts for the years 1980, 1986, 1990, 1995, 1999 and 2002. The 1995 and 1999 I-O tables were released by the Department of Foresight and Planning and International Affairs (*DPP*) based on data from Statistics Portugal (*INE*), while the remaining tables are from *INE*. It is also important to notice that, as in Reis and Rua (2006), the import-use matrix for 2002 maintains the import structure of 1999. This fact limits the significance of the results obtained for this last year, but the problem is minimized if the 1980-2002 evolution is considered. All I-O tables are available at current basic prices, and hence not affected by taxes. Neverthe-

(2) Reis and Rua (2006) name this sum as the total backward leakage of sector *j*.

less, from 1995 to 1999 the classification of the sectors changed from ESA79 to ESA95 and the methodology for the allocation of the financial intermediation services indirectly measured (FISIM) was altered. Therefore, in order to assure a minimum comparison basis across the period, we used the adjustments explained in Reis and Rua (2006) and end up with 29 sectors/products arranged according to the 2-digits NACE rev.2 breakdown level. We broadly focus the analysis on the Portuguese manufacturing industry excluding the energy sector, which further reduces the number of sectors considered to 13.[3] Nevertheless, in Section 3, we briefly provide evidence on the non-significance of VS in the services sector and on the impact of the energy sector in Portuguese VS.

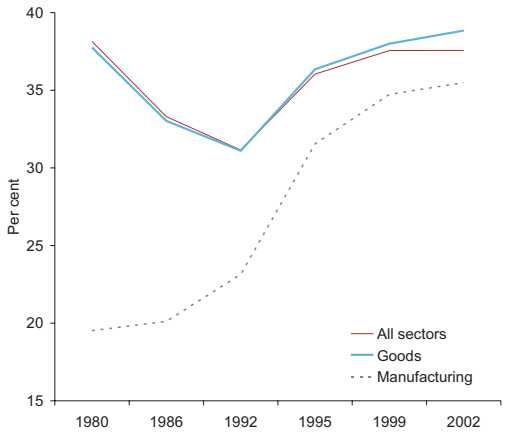
Hummels *et al.* (2001) stressed that the relatively aggregate sectoral data from the I-O tables can lead to measurement biases of the true level of VS. If, within a sector, there is a positive (negative) correlation between exports and the imported inputs to gross-output ratio, this VS calculations will be downward (upward) biased. Supposing that, within one sector, the exported goods do not make use of imported intermediates while non-exported goods do, then the measure would consider some VS in the sector when it does not really exist. On the contrary, if the correlation between exports and the imported gross-output ratio is positive, this VS measure understates the importance of the phenomenon.

3. VERTICAL SPECIALIZATION IN PORTUGAL

The computation of the VS index presented in equation (5) for the Portuguese economy reveals an increase in the importance of these activities, in particular since the mid-nineties (Chart 3). Nevertheless, the results differ depending on the set of sectors considered. When all 29 goods and services sectors are included, the measure of VS is higher than when the analysis is restricted to the 13 manufacturing sectors (the detailed results according to each sectoral classification are included in Appendix A). In addition, the path of the VS measure in these two situations is also different, especially before 1992. Considering the 29 sectors, the VS measure decreases from 38.1 per cent in 1980 to 31.2 per cent in 1992, increasing afterwards to 37.6 per cent in 2002. When the analysis is restricted to the

Chart 3

VERTICAL SPECIALIZATION IN PORTUGAL
As a share of total exports



Sources: DPP, *INE* and authors' calculations.

(3) Hummels *et al.* (2001) and other authors refer that results change substantially when the energy sector is included. This fact derives from its importance as an imported intermediate for most sectors and from the sharp changes in energy prices.

manufacturing industry, it increases from 19.5 per cent to 23.1 per cent from 1980 to 1992, rising sharply afterwards to 35.5 per cent in 2002. Furthermore, the consideration of the 16 sectors associated with the production of goods gives results very similar to the ones obtained with all 29 goods and services sectors. Two main qualifications are worth underlining in this exercise. Firstly, the difference between restricting to the manufacturing industry or to the total goods sector is associated with the "Fuel and mining" sector. Imports of this sector are important inputs in almost all other sectors and Portugal is a net importer of energetic products. In addition, energy prices have fluctuated significantly in the last decades. High energy prices explain the high VS share in 1980 and subsequent falling prices explain the reduction in the VS share in 1986 and 1992. Secondly, VS activities in Portugal do not appear significant in the 13 services sectors, as illustrated by the small difference between the VS measure of all 29 sectors and the VS measure of the goods sector. One exception is the transportation sector, where some VS activities seem relevant, especially in the first period.

The VS measure obtained for Portugal taking the goods sector can be compared with what has been computed for other economies (Table 1). Chen *et al.* (2005) report results for some OECD countries and Minondo and Rubert (2002) study the case of Spain. VS trade in Portugal appears to be more important than in the other countries considered, with the exception of the Netherlands. This fact is probably related to the relatively smaller size of the economy and to its high degree of openness, which favour VS trade, and to the high share of energy imports in Portugal. To avoid biasing the analysis with the effect of the energy sector from here on we focus on the Portuguese manufacturing industry (13 sectors).

One interesting calculation suggested by Hummels *et al.* (2001) is to identify how much does VS trade account for the growth of the total exports to gross output ratio. That is given by:

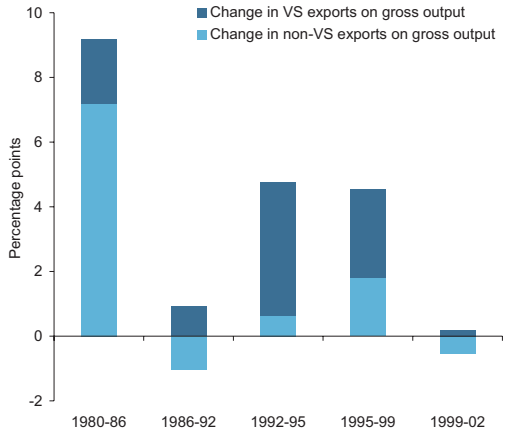
$$\Delta\left(\frac{X_t}{Y_t}\right) = \Delta\left(\frac{VS_t}{Y_t}\right) - \Delta\left(\frac{X_t - VS_t}{Y_t}\right) \qquad (6)$$

where Y_t stands for gross output in period t.

Chart 4

CONTRIBUTIONS TO THE CHANGE OF THE EXPORT-GROSS OUTPUT RATIO

Portuguese manufacturing industry



Sources: DPP, *INE* and authors' calculations.

Table1

VERTICAL SPECIALIZATION OF DIFFERENT COUNTRIES

Vertical specialization exports as share of total exports of goods

	Australia	Canada	Denmark	France	Germany	Italy	Japan	Netherlands	Portugal	Spain	UK	US
1980			33.6	26.1			18.7		37.8	26.4		
1981		23.1						44.6				
1982												8.8
1983												
1984											24.1	
1985			33.5	26.7		26.9	13.5			31.0		9.3
1986	11.5	27.8			19.8			36.9	33.0			
1987												
1988					19.0							
1989	11.2											
1990		27.0	29.5	23.9	19.6		11.0			25.6	25.9	10.8
1991												
1992						22.5			31.1			
1993												
1994										29.0		
1995	15.7			27.1	22.4		9.5	39.2	36.3			
1996							10.5	39.7				
1997			28.2				11.3	41.3				12.3
1998								40.7			27.2	
1999									38.0			
2000												
2001												
2002									38.8			

Sources: Chen *et al*. (2005), Minondo and Rupert (2002) for Spain and authors' calculations for Portugal.

From 1980 to 2002, export-gross output ratio in the Portuguese manufacturing industry increased by 18.0 percentage points (p.p.) and VS exports as a percentage of gross output increased by 9.9 p.p. in the same period, thus accounting for 55.2 per cent of the change in the total export-gross output ratio. In particular, the increase in the total manufacturing exports to gross output ratio in the nineties was mostly due to the rise of VS exports (Chart 4).

3.1. Sectoral vertical specialization in Portugal

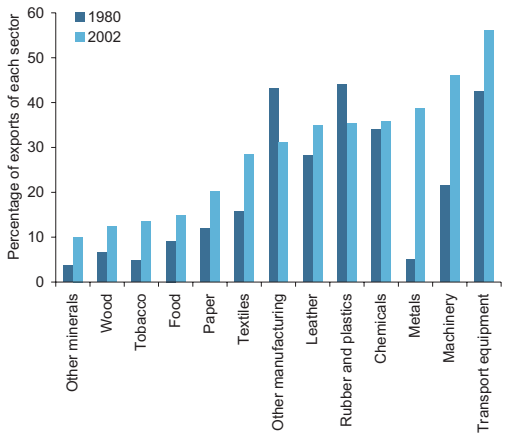
In this section, we analyse the reliance of exports of each manufacturing sector on imported intermediates. Recall that the sum of the elements of column j of the $A^M \left[I - A^D \right]^{-1}$ matrix tells us the intermediate imports of all products that are (directly and indirectly) required to obtain one unit of exports of sector j, that is the VS of sector j as a percentage of exports of the sector.

Between 1980 and 2002, the majority of Portuguese manufacturing sectors showed a growing propensity to use imported inputs in the production of exports (Chart 5). The only two exceptions are "Rubber and plastics" and "Other manufacturing". The most striking increase in VS intensity occurred in the "Metals" sector, increasing from 5.1 per cent in 1980 to 38.7 per cent of the sector's exports in 2002. The VS export share in the "Transport equipment" and "Machinery" sectors also increased strongly. In the more recent period, substantial differences in terms of import content exist between sectors. In 2002, the extent of VS was particularly high in the "Transport equipment" sector, amounting to 56.1 per cent of the sector's exports, well above the average for the manufacturing industry. Due to its highly standardized production process, this is a sector in which VS opportunities tend to be exploited (see Breda *et al.* (2007) for similar results in other countries). The same happens in the Portuguese "Machinery" sector that records an import content of exports of 46.0 per cent in 2002. A second group of industries that displays a high import content of exports includes those that heavily use primary goods, like "Metals", "Chemicals" and also "Rubber and plastics".

Chart 5

VS INTENSITY OF EACH PORTUGUESE MANUFACTURING SECTOR

Total import content of exports of each sector

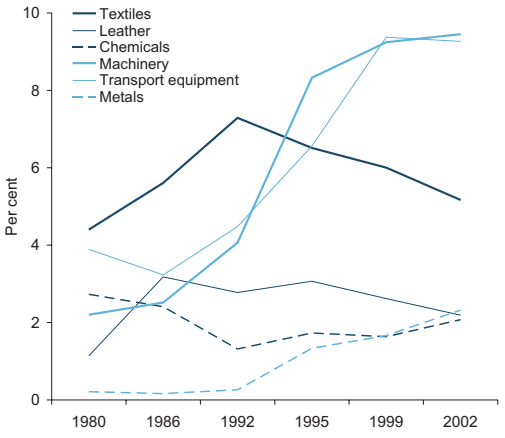


Sources: DPP, *INE* and authors' calculations.

Chart 6

SECTORAL VERTICAL SPECIALIZATION IN PORTUGAL

As a share of total manufacturing exports



Sources: DPP, *INE* and authors' calculations.

The contribution of each sector to total Portuguese VS share of manufacturing exports depends not only on each sector's VS intensity but also on the share of each sector in total exports as shown in equation (3). Chart 6 includes the main sectoral contributions to the Portuguese VS share and the detailed results for each sector are included in Appendix A. The higher contributions in 2002 are given by the "Machinery" and "Transport Equipment" sectors, whose intermediate imports reach, in each case, values above 9 per cent of total Portuguese manufacturing exports. The path of the "Machinery" sector is particularly striking, with its contribution rising 7.3 p.p. from 1980 to 2002. This increase is mainly concentrated between 1992 and 1995. The "Transport Equipment" sector also gives an important contribution in terms of VS in the most recent period, with the increases occurring mainly between 1992 and 1999 and coinciding with the settlement in Portugal of large FDI projects in the automobile sector, whose production is directed to exports and where the import content in output is significant. Conversely, the VS contribution of the "Textiles" sector increased until 1992 but lost some ground in recent periods, reaching values close to 5 per cent of total Portuguese manufacturing exports in 2002.

The contribution of each sector to the change in total VS share can be further detailed using a shift-share analysis to disentangle the contributions coming from changes in each sector's VS intensity and from changes in each sector's share in total exports. This intensive (more VS in the sector) - extensive (higher share of the sector in total exports) breakdown is given by:

$$\Delta \frac{VS_{k,t}}{X_{k,t}} = \sum_j \left[\Delta \frac{VS_{j,t}}{X_{j,t}} \times 0.5 \times \left(\omega_{k,j,t} + \omega_{k,j,t-1} \right) + \Delta \omega_{k,j,t} \times 0.5 \times \left(\frac{VS_{j,t}}{X_{j,t}} + \frac{VS_{j,t-1}}{X_{j,t-1}} \right) \right] \qquad (7)$$

where $VS_{k,t}$ and $X_{k,t}$ stand for total VS and total exports of country k in period t, respectively, and $VS_{j,t}$ and $X_{j,t}$ are the equivalent notions but focusing on sector j. Finally, $\omega_{k,j,t}$ is the share of sector j in total exports of country k in period t.

The breakdown results for the change in the VS share from 1980 to 2002 are presented in Table 2 and Appendix B includes the detailed sectoral contributions for each year. Taking all manufacturing sectors, the contribution of changes in VS intensity represents 73 per cent of the total increase in the VS

Table 2

CONTRIBUTIONS TO THE CHANGE IN PORTUGUESE VS SHARE OF TOTAL MANUFACTURING EXPORTS

Change from 1980 to 2002, in percentage points

	Contribution of change in		Total
	Sector VS intensity	Sector share of total exports	
Food	0.5	-0.5	0.0
Tobacco	0.0	0.0	0.0
Textiles	3.0	-2.2	0.8
Leather	0.3	0.7	1.1
Wood	0.4	-0.6	-0.1
Paper	0.5	-0.2	0.2
Chemicals	0.1	-0.8	-0.7
Rubber and plastics	-0.2	0.9	0.7
Other minerals	0.2	0.1	0.3
Metals	1.7	0.4	2.1
Machinery	3.8	3.5	7.3
Transport equipment	1.8	3.6	5.4
Other manufacturing	-0.4	-0.6	-1.1
Total	11.7	4.3	16.0

Sources: DPP, *INE* and authors' calculations.

measure from 1980 to 2002. The highest sectoral contributions to the total increase in the Portuguese VS share in manufacturing exports came from the "Machinery" and "Transport equipment" sectors. The significant contribution of these two sectors is both attributable to increased VS intensity and to increased shares in total exports. In the "Machinery" sector, the two partial contributions are balanced, but in "Transport equipment" the increase in the share of the sector in total exports is the dominant effect. Interestingly, in the "Textiles" sector, there is a high positive effect of VS intensity and a negative contribution coming from a decrease in the share of this sector in total Portuguese manufacturing exports.

3.2. The geographic links of Portuguese vertical specialization

One interesting dimension to explore is the geographical orientation of Portuguese VS activities. In this article we selected the five main trade partners of Portugal (Spain, Germany, France, UK and US) and the Intra-EU15 and Extra-EU15 blocks. The computation of the share of VS in total Portuguese exports to each of these destinations requires the strong assumption that all products in each sector are homogeneous, so the results should be interpreted carefully. In fact, the differences in the VS results for the main trade partners reflect essentially the different product composition of Portuguese exports by destination, given that the sectoral import content coefficients are the same for all countries.

In each period, the sectoral VS level for each partner is obtained by the product of the VS intensity of each sector and total exports of that sector to the specified partner. That is:

$$VS_{c,j} = \frac{VS_j}{X_j} X_{c,j} \tag{8}$$

where VS_j and X_j stand, as previously, for VS level and exports of sector j and $X_{c,j}$ are the exports of sector j to partner c.

Again, the sectoral results for each partner can be added up to get a total VS level with each partner and the results are easier to interpret if the VS share in total exports to each partner is computed. The VS share of total exports of country k to partner c is given by:

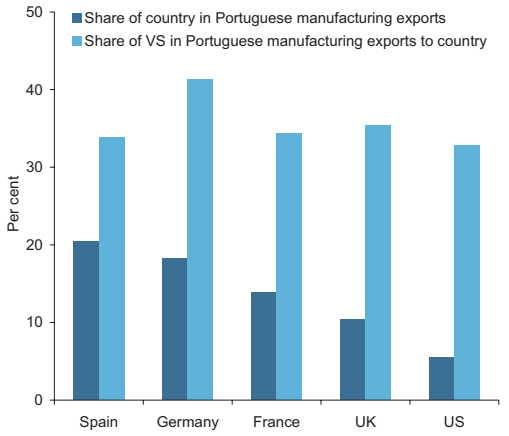
$$\frac{VS_{k,c}}{X_{k,c}} = \frac{\sum_{j=1}^{n} VS_{c,j}}{\sum_{j=1}^{n} X_{c,j}} \tag{9}$$

The share of Portuguese VS manufacturing exports to each destination was computed for 2002 using nominal international trade data from *INE*. The Portuguese export data is available in a bilateral basis and with a detailed product breakdown, which was aggregated to match the I-O data sectoral classification. The results show that Germany, the second major destination of Portuguese manufacturing exports in 2002, is the country where Portuguese VS based trade is more important (Chart 7). In fact, 41.3 per cent of the value of Portuguese exports to Germany in 2002 is associated with imported intermediates. In the cases of Spain, France, UK, US, as well as the Intra-EU15 and Extra-EU15 blocks, the values are around 35 per cent in 2002.

The sectoral breakdown reveals some interesting differences in terms of Portuguese VS exports to these trade partners in 2002 (Table 3). In the case of Germany, VS activities are mainly concentrated in the "Machinery" and "Transport equipment" sectors, which account together for 70.6 per cent of total VS exports to Germany. On the contrary, VS trade with Spain is more dispersed, with sectors like "Metals", "Textiles" and "Chemicals" representing together 38.2 per cent of total. This result points to a broader VS pattern with Spain. In the case of VS trade with US, the striking point is the strong rele-

Chart 7

VERTICAL SPECIALIZATION IN PORTUGUESE MANUFACTURING EXPORTS TO MAIN TRADE PARTNERS, 2002



Sources: DPP, *INE* and authors' calculations.

Table 3

SECTORAL COMPOSITION OF PORTUGUESE MANUFACTURING VS EXPORTS TO SELECTED COUNTRIES/AREAS

Percentage share of each sector in total VS to country/area, 2002

	Spain	Germany	France	UK	US	Intra-EU15	Extra-EU15
Food	4.1	0.5	2.5	2.2	2.8	2.3	4.5
Tobacco	0.0	0.0	0.0	0.1	0.0	0.1	0.0
Textiles	13.2	9.2	18.1	24.2	19.1	15.1	14.5
Leather	1.4	7.6	9.6	10.9	4.8	6.6	4.3
Wood	1.8	0.7	2.3	0.6	4.1	1.3	3.2
Paper	3.4	2.1	2.5	2.3	1.5	2.9	2.8
Chemicals	8.7	2.0	2.2	4.9	4.4	5.2	7.4
Rubber and plastics	4.8	2.6	3.6	1.9	1.3	3.2	3.0
Other minerals	1.5	0.4	1.3	1.1	1.6	1.0	1.4
Metals	16.4	3.3	4.0	3.9	6.2	6.6	6.3
Machinery	18.0	36.3	22.4	19.8	44.7	24.5	36.4
Transport equipment	23.9	34.4	26.6	27.1	8.4	28.7	13.5
Other manufacturing	3.0	1.0	4.9	1.0	1.1	2.5	2.7
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Sources: DPP, *INE* and authors' calculations.

vance of the "Machinery" sector, the highest of all countries considered. On the contrary, the share of "Transport equipment" in VS exports to the US is the lowest of the five countries, indicating that Portuguese direct exports of this sector are not primarily destined to the US. Regarding VS exports to the UK, the "Textiles" and "Leather" sectors make up 35.1 per cent of total, the highest share of the countries selected, which highlights the relevance of the UK as a destination of Portuguese exports of these sectors.

4. CONCLUDING REMARKS

Over the last decades, the nature of trade has changed, as countries increasingly specialize in producing particular stages of a good, rather than making a complete good from start to finish. In this study, we follow Hummels *et al.* (2001) to measure vertical specialization in terms of the total imported intermediate content of exports, considering a multiple-stage input-output circulation among Portuguese industries. We use data from Portuguese Input-Output matrices in 1980, 1986, 1992, 1995, 1999 and 2002 to quantify the total (direct and indirect) import content of Portuguese exports. We conclude that vertical specialization activities in Portugal are important in the manufacturing industry, but not in the services sector. In the Portuguese manufacturing industry, vertical specialization based trade has been steadily increasing and it accounts for 35.5 per cent of total exports in 2002, up from 19.5 per cent in 1980, which is a relatively high figure compared to other OECD countries. Our empirical results also indicate that vertical specialization in trade plays an important role in explaining the increase in Portuguese manufacturing export share of gross output. Around 55 per cent of the growth in total manufacturing exports to gross output ratio between 1980 and 2002 is attributable to the increase in Portuguese vertical specialization.

Two groups of industries show especially high import content of exports in 2002, standing above the manufacturing industry average. The first group includes some technology intensive industries with standardized production processes, like the “Transport equipment” and “Machinery” sectors. In particular, vertical specialization in the “Transport equipment” sector exceeds 55 per cent of the sector’s exports in 2002. The second group of sectors with significant shares of vertical specialization trade are more basic industries, like the “Metals” and “Chemicals” sectors.

The increase in the share of vertical specialization in total Portuguese manufacturing exports between 1980 and 2002 was split into two parts using a shift-share analysis. The first part accounts for the change in the intensity of vertical specialization of each sector and the second for the change in the sectoral composition of exports. The increase in the intensity of sectoral vertical specialization explains 73 per cent of the total change. The manufacturing sectors providing the highest contributions to the growth of the Portuguese vertical specialization measure were the “Machinery” and “Transport equipment” sectors. The contribution of the “Machinery” sector is especially strong and is mainly concentrated between 1992 and 1995. This contribution results both from an increased vertical specialization intensity in the sector and from an increased share of the ‘’Machinery" sector in total exports. In the ‘’Transport equipment" sector, the increase in the share of the sector in total exports is the dominant effect. The stronger contributions of this sector occur mainly between 1992 and 1999 and coincide with the location in Portugal of large FDI projects in the automobile sector, whose production is export-oriented and has a high import content. Conversely, the contribution of the ‘’Textiles" sector increased until 1992 but declined afterwards, reflecting a negative effect coming from the decrease in the share of this sector in total Portuguese exports.

We complemented the input-output analysis with data from international trade to get some indications on the geographic orientation of Portuguese vertical specialization in 2002. We found that vertical specialization activities are especially relevant in Portuguese trade with Germany. Vertical specialization exports to Germany are mainly concentrated in the “Machinery” and “Transport equipment” sectors. In contrast, Portuguese vertical specialization exports to Spain are more widespread across sectors.

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Appendix A

VERTICAL SPECIALIZATION AS A SHARE OF TOTAL PORTUGUESE EXPORTS (DIFFERENT SETS OF SECTORS CONSIDERED)

Contribution of each sector in percentage points

	All sectors (29 sectors)						Goods (16 sectors)						Manufacturing (13 sectors)					
	1980	1986	1992	1995	1999	2002	1980	1986	1992	1995	1999	2002	1980	1986	1992	1995	1999	2002
Agriculture	0.35	0.15	0.26	0.09	0.10	0.15	0.38	0.15	0.26	0.09	0.10	0.14						
Fishing	0.02	0.03	0.04	0.01	0.01	0.02	0.02	0.03	0.04	0.01	0.01	0.02						
Fuel and mining	6.04	3.70	3.18	2.74	1.42	1.48	6.97	4.08	3.48	3.01	1.57	1.71						
Food	2.59	1.35	0.96	1.61	1.58	1.65	2.87	1.36	0.99	1.60	1.58	1.70	0.98	0.38	0.41	0.80	0.94	0.99
Tobacco	0.01	0.00	0.00	0.00	0.02	0.09	0.01	0.00	0.00	0.00	0.02	0.09	0.00	0.00	0.00	0.00	0.00	0.05
Textiles	6.71	7.57	7.74	7.00	6.23	5.10	7.27	7.83	8.12	7.30	6.54	5.44	4.40	5.61	7.29	6.51	6.00	5.17
Leather	1.01	2.84	2.46	2.76	2.38	1.95	1.15	3.13	2.63	2.94	2.56	2.13	1.14	3.18	2.78	3.07	2.62	2.19
Wood	1.72	1.24	1.31	0.86	0.95	1.06	1.81	1.21	1.30	0.84	0.95	1.08	0.72	0.59	0.65	0.33	0.41	0.58
Paper	1.24	1.25	0.86	1.32	1.05	1.08	1.23	1.20	0.74	1.20	0.94	1.09	0.79	0.73	0.64	1.10	0.89	1.04
Chemicals	3.38	3.62	1.54	1.74	1.72	2.15	3.78	3.85	1.62	1.81	1.75	2.31	2.73	2.41	1.32	1.73	1.64	2.08
Rubber and plastics	0.36	0.38	0.51	0.65	0.90	1.05	0.41	0.41	0.56	0.68	0.93	1.14	0.43	0.41	0.59	0.70	0.93	1.14
Other minerals	0.64	0.52	0.53	0.85	0.75	0.81	0.66	0.49	0.48	0.79	0.69	0.77	0.10	0.14	0.21	0.50	0.43	0.38
Metals	1.17	0.92	1.07	1.29	1.62	2.08	1.33	1.00	1.06	1.33	1.69	2.26	0.21	0.16	0.26	1.34	1.66	2.32
Machinery	3.17	3.26	4.12	7.30	8.30	8.21	3.59	3.52	4.55	7.90	8.96	9.14	2.20	2.52	4.07	8.33	9.24	9.45
Transport equipment	3.55	3.52	4.24	5.72	8.17	7.84	4.13	3.91	4.73	6.24	9.10	8.96	3.89	3.23	4.48	6.56	9.37	9.26
Other manufacturing	1.84	0.78	0.48	0.60	0.61	0.82	2.13	0.86	0.53	0.61	0.62	0.88	1.92	0.74	0.45	0.59	0.60	0.85
Electricity, gas and water	0.04	0.00	0.03	0.04	0.09	0.01												
Construction	0.00	0.00	0.00	0.00	0.00	0.00												
Trade	0.30	0.24	0.07	0.07	0.20	0.14												
Hotels and restaurants	0.01	0.00	0.06	0.08	0.12	0.21												
Transportation	3.94	1.90	0.91	0.80	0.85	0.96												
Communications	0.00	0.01	0.06	0.14	0.07	0.13												
Financial intermediation	0.01	0.01	0.02	0.06	0.07	0.07												
Real estate	0.00	0.00	0.00	0.00	0.00	0.00												
Renting and business activities	0.04	0.02	0.66	0.26	0.32	0.43												
Education	0.00	0.00	0.00	0.00	0.00	0.00												
Health	0.00	0.00	0.00	0.00	0.00	0.00												
Public administration	0.00	0.00	0.00	0.00	0.00	0.00												
Other services	0.00	0.00	0.01	0.05	0.04	0.05												
Total	38.1	33.3	31.2	36.0	37.6	37.6	37.8	33.0	31.1	36.3	38.0	38.8	19.5	20.1	23.1	31.6	34.7	35.5

Sources: DPP, *INE* and authors' calculations.

Appendix B

CONTRIBUTIONS TO THE CHANGE IN PORTUGUESE VERTICAL SPECIALIZATION SHARE OF TOTAL MANUFACTURING EXPORTS

Contribution of each sector in percentage points

	Contribution of change in sector's VS intensity						Contribution of change in sector's share of total exports						Total contribution					
	1980-86	1986-92	1992-95	1995-99	1999-02	1980-02	1980-86	1986-92	1992-95	1995-99	1999-02	1980-02	1980-86	1986-92	1992-95	1995-99	1999-02	1980-02
Food	-0.33	0.12	0.23	0.23	0.03	0.49	-0.27	-0.09	0.16	-0.09	0.03	-0.49	-0.60	0.03	0.39	0.14	0.06	0.01
Tobacco	0.00	0.00	0.00	0.00	0.03	0.02	0.00	0.00	0.00	0.00	0.02	0.03	0.00	0.00	0.00	0.00	0.04	0.05
Textiles	0.43	1.80	0.95	0.46	0.09	2.95	0.77	-0.12	-1.72	-0.97	-0.93	-2.19	1.21	1.68	-0.78	-0.51	-0.84	0.77
Leather	0.62	-0.90	0.70	0.01	-0.08	0.35	1.42	0.49	-0.41	-0.45	-0.35	0.70	2.04	-0.40	0.29	-0.45	-0.43	1.05
Wood	0.11	0.13	-0.15	0.09	0.16	0.44	-0.24	-0.07	-0.17	0.00	0.01	-0.57	-0.12	0.06	-0.33	0.09	0.17	-0.13
Paper	-0.10	0.08	0.30	0.10	0.08	0.48	0.04	-0.17	0.16	-0.31	0.07	-0.23	-0.06	-0.09	0.46	-0.21	0.15	0.25
Chemicals	-0.62	-0.03	0.40	-0.02	0.10	0.12	0.30	-1.06	0.01	-0.08	0.34	-0.78	-0.32	-1.09	0.41	-0.09	0.44	-0.65
Rubber and plastics	-0.05	-0.01	-0.02	-0.01	-0.04	-0.19	0.04	0.18	0.13	0.25	0.24	0.89	-0.02	0.17	0.11	0.23	0.21	0.71
Other minerals	0.04	0.02	0.21	0.00	-0.04	0.20	0.01	0.04	0.07	-0.07	-0.01	0.07	0.04	0.07	0.29	-0.07	-0.05	0.28
Metals	0.00	0.04	1.14	0.00	0.28	1.71	-0.05	0.06	-0.06	0.32	0.38	0.40	-0.05	0.10	1.07	0.33	0.66	2.11
Machinery	0.33	0.60	2.71	-0.12	-0.10	3.77	-0.02	0.95	1.56	1.04	0.30	3.48	0.32	1.55	4.26	0.92	0.21	7.25
Transport equipment	-0.58	0.63	1.12	0.49	0.11	1.76	-0.07	0.62	0.96	2.33	-0.22	3.62	-0.66	1.25	2.08	2.81	-0.11	5.37
Other manufacturing	-0.22	-0.16	-0.02	0.00	0.10	-0.43	-0.95	-0.13	0.16	0.00	0.15	-0.63	-1.17	-0.29	0.14	0.00	0.25	-1.07
Total	-0.37	2.34	7.58	1.23	0.73	11.67	0.97	0.69	0.84	1.95	0.04	4.31	0.60	3.03	8.41	3.18	0.77	15.98

Sources: DPP, *INE* and authors' calculations.