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International Fragmentation of Production in the Portuguese Economy: What do Different Measures Tell Us?*

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July 2008

Abstract

This paper analyses the relevance and the characteristics of the international fragmentation of production in the Portuguese economy. The empirical trade literature suggests different measures of fragmentation, changing the scope of the concept and using alternative sets of information. The existing measures can be broadly divided in those that make use of Input-Output matrices together with international trade data and those that look at specific elements of international transactions, namely trade in parts and components and outward-inward processing trade. In this paper, we survey the different measures of international fragmentation of production and apply them to Portuguese data. Our results of Input-Output based measures point to a substantial increase of the vertical linkages in the Portuguese economy, in particular since the nineties. Nevertheless, it seems that the pace of vertical specialization has been somewhat modest in international terms. The share of exports of parts and components in total trade has almost doubled in the last two decades, while the import share of these goods has remained nearly stable. Processing trade represents a very low share of Portuguese international trade.

Keywords: International Trade, International Fragmentation of Production, Vertical Specialization, Globalization

JEL Codes: F1, F14, F15, O52

*The authors thank António Rua for making available Input-Output matrices based on Portuguese national accounts. The usual disclaimer applies. Address: Banco de Portugal, Research Department, R. Francisco Ribeiro 2, 1150-165 Lisboa - Portugal. E-mails: jamador@bportugal.pt and scabral@bportugal.pt

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. One of the reasons that has been put forward to explain this sharp growth of international trade is the emergence of a new paradigm in the organization of the productive processes in the world economy. In fact, for an increasing share of goods, production has become vertically decomposed, i.e. the production of the good is fragmented into different stages, which are then executed in distinct plants, often located in different countries. Therefore, this new paradigm of production and its related activities explain part of the increase in world trade because more intermediate goods circulate between countries.

This phenomenon is not entirely new. 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 East Asia.

Different measures of international fragmentation of production can be found in the empirical trade literature. These measures differ in terms of the scope of the concept and make use of alternative sets of information. The existing measures can be broadly divided in those that combine Input-Output (I-O) tables and international trade data and those that analyse only specific elements of international trade flows, namely trade in parts and components and processing trade. In this paper, we survey the different measures of international fragmentation of production and apply them to Portuguese data. In addition, we detail the analysis in order to identify the products where international fragmentation is more relevant, as well as the major trade partners involved in these activities.

It is relevant to analyse the experience of the Portuguese economy in the current context of international fragmentation of production. In fact, this new paradigm in world production implies a substantial reconfiguration of the patterns of comparative advan-

tages and foreign direct investment (FDI) flows across the world, making it important to assess the ability of the Portuguese economy to adjust to this reality. Part of the debate on the disappointing growth path of the Portuguese economy since the end of the nineties has been centered on the increased competition from new players in world markets, notably from East Asia and Central and Eastern Europe. Nevertheless, on a policy perspective, it is important to note that it is not possible to directly link the degree of fragmentation with the economic performance of a country. In fact, a country can perform well in international markets if it is competitive in productions where the international fragmentation of production is not adopted. Conversely, a country with a high share of activities associated with fragmentation 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 activities associated with the international fragmentation of production represents an opportunity but the underlying determinants of comparative advantages remain crucial for economic growth.

The paper is organized as follows. Section 2 surveys the different measures used in the empirical literature to measure the international fragmentation of production. Section 3 reports the results for the Portuguese economy obtained using the methods based on I-O matrices, namely those proposed by Feenstra and Hanson (1996) and Hummels et al. (2001). In addition, we briefly present the results for Portugal of the relative measure suggested by Amador and Cabral (2008*a*). In Section 4, the evolution of Portuguese trade flows classified as parts and components is examined. Section 5 looks at Portuguese data on outward and inward processing trade. Finally, Section 6 presents some concluding remarks.

2 A Survey of the Literature

The fragmentation of the production chain, with different stages of production located in different countries, is one of the factors underlying the high growth of international trade over the last decades (see Yi (2003) and Jones et al. (2005)). International trade literature has labelled this phenomenon using a set of different terms: "vertical specialization", "slicing up the value chain", "outsourcing", "offshoring", "international production sharing", "disintegration of production", "multi-stage production", "intra-product specialization", "production relocation", "international segmentation of production", etc.[1] Nevertheless, international trade theorists tend to call it "fragmentation", a term originally proposed by Jones and Kierzkowski (1990). In parallel, the concept of middle products was introduced in the early eighties by Sanyal and Jones (1982)

[1] See Hummels et al. (2001) for a discussion.

to incorporate the notion that all internationally traded goods incorporate some domestic value added either through manufacturing and assembly processes or just through local transportation and retailing services. More recently, some important contributions to the theory of international fragmentation of production and trade in intermediate products using Ricardian and Heckscher-Ohlin type models include the works of Arndt (1997), Venables (1999), Yi (2003), Jones and Kierzkowski (2001, 2005), Deardorff (2001*a*,*b*, 2005), Kohler (2004) and Baldwin and Robert-Nicoud (2007), among others. Another branch of the literature on fragmentation focuses on the firm's choice of organizational form, incorporating firm heterogeneity as in the works of McLaren (2000), Antràs and Helpman (2004), Grossman and Helpman (2005) and Antràs et al. (2006). Finally, Grossman and Rossi-Hansberg (2006*a*,*b*) present a formal model of trade in tasks where offshoring acts as technological progress and originates a positive productivity effect that can generate gains for all domestic factors.[2]

The extent of international fragmentation is difficult to measure accurately and assumes a variety of forms. The empirical trade literature suggests a range of different methods and data sources to quantify these activities.[3] Three main methodological approaches have been used to document the international fragmentation of production at the sectoral level: international trade data combined with Input-Output (I-O) tables, international trade statistics on parts and components and customs statistics on processing trade.

Most of the existing systematic evidence on international fragmentation of production focuses on the imported input shares of gross output, total inputs or exports. Typically, such measures use information from I-O tables sometimes complemented with import penetration statistics computed from trade data. The accuracy of the measurement of fragmentation depends crucially on the product breakdown available. A very detailed product classification assures that the characteristics of the production chain are identified and tracked properly, i.e. that a given product is indeed an intermediate good used in the production of another product. However, such data is typically unavailable, making accurate cross-country and/or time-series analysis more difficult to implement. Therefore, the identification of countries with important fragmentation activities and the assessment of its main trends has usually been carried out at a relatively aggregate product breakdown. Nevertheless, I-O tables tend to provide the most appropriate source of information, as they allow the analysis across industries and time, even if they are available only for some countries on a comparable basis and are not updated regularly.

[2]See Arndt and Kierzkowski (2001) and Baldwin and Robert-Nicoud (2007) for a review of different models of fragmentation.

[3]See Molnar et al. (2007) and Baumann and di Mauro (2007) for a discussion.

Two different types of measures based on I-O data have been implemented in the empirical trade literature (see Hijzen (2005) for a discussion). The first type of measure focuses on the foreign content of domestic production as it considers the share of (direct) imported inputs in production or in total inputs. This measure is originally due to Feenstra and Hanson (1996) and has been used widely afterwards in different formats. Horgos (2007) provides a detailed analysis of the design of this type of indices. Generally, these studies find a steady increase of international outsourcing of material inputs over time. Campa and Goldberg (1997) find an increase of the share of imported inputs in production in the US, UK and Canada, but not in Japan. Hijzen (2005) shows that international outsourcing has steadily increased since the early eighties in the United Kingdom, while significant differences persist across industries. In addition, Egger et al. (2001) and Egger and Egger (2003) provide evidence of a significant growth of Austrian outsourcing to Central and Eastern European countries from 1990 to 1998, reflecting the decline of trade barriers and the low wages prevailing there.

This first type of measure has been used to assess the impact of the international fragmentation of production on the labour market (see Feenstra (2007) for a discussion). In fact, most developed countries have witnessed a shift in labour demand towards more-skilled workers. Skill-biased technological change and the international fragmentation of production are commonly examined as the two main factors behind this evolution. International outsourcing tends to have a negative impact on the relative demand for low-skilled labour in developed countries, as some of their tasks become performed by workers abroad. Therefore, the relative wages of domestic skilled workers tend to increase with an impact on wage inequality within the country. Feenstra and Hanson (1996) and Feenstra and Hanson (1999) concluded that the rise of outsourcing accounts for a significant part of the increase in the relative demand for skilled labour in US manufacturing industries during the eighties. For France, Strauss-Kahn (2003) found an increase in the share of imported inputs in production from 1977 to 1993 and concluded that it contributed to the decline in the share of unskilled workers in manufacturing employment. Geishecker (2006) concluded that the significant growth of international outsourcing during the nineties was an explanatory factor for the observed decline in relative demand for manual workers in German manufacturing. In the same period, Geishecker and Görg (2007) also provide evidence of a negative (positive) effect of international outsourcing on the real wage of low-skilled (high-skilled) workers in Germany. As regards the UK, Hijzen (2007) examined the impact of international outsourcing on the increase in wage inequality in the period 1993–98 and his results indicate that skill-biased technological change is the major driving force, but international outsourcing also contributed significantly. Finally, Geishecker et al. (2008)

provide evidence of an increase in outsourcing in Germany, the UK and Denmark with different impacts on individual wages in the three countries, relating it to the existence of distinct types of labour market institutions.

The second I-O based measure of fragmentation focuses on the (direct and indirect) import content of exports and it was initially formulated by Hummels et al. (1998) and Hummels et al. (2001), which labelled it vertical specialization. This measure captures cases where the production is carried out in at least two countries and that the goods cross at least twice the international borders. In comparison with the first I-O based measure, which refers to the direct imported input share of gross output, this measure is narrower as it adds the condition that some of the resulting output must be exported. Conversely, the measure proposed by Hummels et al. (2001) is broader as it considers also the imported inputs used indirectly in the production of the goods exported. Hummels et al. (2001) found that vertical specialization activities accounted for 21 per cent of the exports of ten OECD and four emerging market countries in 1990 and grew almost 30 per cent between 1970 and 1990. Chen et al. (2005) updates the analysis presented in Hummels et al. (2001) by using more recent I-O tables, finding also that trade in vertical specialized goods has increased over time. Other studies have applied this methodology, in some cases with minor changes from the original formulation, and found an increase of vertical specialization activities. Some examples are Amador and Cabral (2008*b*) for Portugal, Minondo and Rubert (2002) for Spain, Breda et al. (2007) for Italy and six other European Union (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. More recently, Koopman et al. (2008) start from the Hummels et al. (2001) formulation and develop a general framework for computing the extent of vertical specialization when processing exports are pervasive, applying it to Chinese data.

The second methodological approach makes use of international trade statistics to measure fragmentation by comparing trade in goods classified as parts and components with trade in final products. In fact, even if trade in intermediate goods as a whole has not risen much faster than trade in final goods, data shows that trade in parts and components has exhibited a dynamism exceeding that of trade in final goods (see Athukorala and Yamashita (2006) and Jones et al. (2005) for a review). The main advantage of this approach is the accessibility of the data and its comparability across countries, allowing the identification of specific trading partner relationships. A drawback is that it relies heavily on the product classification of trade statistics. Typically, the parts and components aggregate is obtained from the Standard International Trade Classification (SITC) at the most detailed level and tends to include

products belonging to SITC 7 (Machinery and transport equipment) and SITC 8 (Miscellaneous manufactured articles). This type of analysis was initiated with the works of Yeats (1998) and Ng and Yeats (1999) and has been used extensively afterwards. Yeats (1998) finds that trade in parts and components accounts for 30 per cent of total OECD exports of SITC 7 in 1995 and that this ratio has been rising in recent years. Several papers focus on specific regions or countries and make use of this type of detailed trade data to analyse the international fragmentation of production. Understandably, the focus is put on East Asia and China's recent experiences. This is the case of Lemoine and Ünal Kesenci (2002, 2004) and Gaulier et al. (2005) that use data on imports of parts and components to complement their analysis of the evolution of trade patterns in East Asia. Gaulier et al. (2006) use a detailed bilateral trade database with information on unit values and show that the emergence of the Chinese economy has intensified the international segmentation of production processes among Asian partners. Kaminski and Ng (2001) analyze the evolution of trade in parts and components of ten Central and Eastern European countries and conclude that all of them engage in this type of trade, especially Estonia, Hungary and Slovakia. Other authors have used this method to measure the importance of fragmentation in specific industries in particular countries or geographical areas, as Lall et al. (2004) study of the electronics and automotive sectors in East Asia and Latin America. They show that electronics is fragmenting faster worldwide than the car industry, in particular in East Asia where electronics networks are more advanced. In the same vein, Ando (2006) study the evolution of machinery trade in East Asia in the nineties and conclude that the strong increase in vertical intra-industry trade was largely due to the expansion of back-and-forth transactions in vertically fragmented cross-border production processes. Finally, Kimura et al. (2007) examine patterns of international trade in machinery parts and components in East Asia and Europe and conclude that the theory of fragmentation is well suited for explaining the mechanics of international networks in East Asia.

The third methodological approach relies on the analysis of customs statistics. These statistics include information on trade associated with customs arrangements in which tariff exemptions or reductions are granted in accordance to the domestic input content of imported goods. The US Offshore Assembly Programme and the EU Processing Trade data sets are examples of such data, which have been used in a number of empirical studies to obtain a narrow measure of international fragmentation. Outward (inward) processing trade is considered a narrow measure of fragmentation because it captures only the cases where components or materials are exported (imported) for processing abroad (internally) and then reimported (reexported). Swenson (2005) exam-

ines the US offshore assembly program between 1980 and 2000 and concludes that these operations grew strongly in that period. Yeats (1998) uses data on offshore assembly processing as a second source of information on international production sharing. He shows that, outside the machinery and transport equipment group, production sharing seems to be also a key factor in the manufacture of textiles and clothing, leather goods, footwear and other labour intensive manufactures. In addition, Clark (2006) examines data on the use of offshore assembly provisions in the US tariff code and concludes that US firms tend to shift the simple assembly operations to unskilled labour abundant countries. Feenstra et al. (1998) also find that the US content of imports, made through the US offshore assembly program, of apparel and machinery and of transportation equipment from industrial countries is characterized by relatively intense use of skilled labour. Görg (2000) using Eurostat data shows that there was an increase in US inward processing trade in the EU countries, in particular in peripheral countries and in the leather and textiles sectors. Baldone et al. (2001) conclude that outward processing trade represents a significant share of trade between the EU15 and Central Europe in the textile and apparel industry. According to Helg and Tajoli (2005), Germany has a higher propensity to use outward processing trade than Italy, especially towards Central and Eastern Europe, and it appears to be concentrated in a few specific sectors. Baldone et al. (2007) also observe that EU processing trade tends to be concentrated in a few industries and regions, while Egger and Egger (2001) find that outward processing trade in the EU is stronger in import-competing industries, which correspond to the EU low-skilled intensive industries. They also show that outward processing in EU manufacturing grew at the relatively rapid pace in the period 1995-1997. Similarly, Egger and Egger (2005) observe that outward processing trade in the EU grew significantly between 1988 and 1999, in particular with Central and Eastern European countries. Processing trade accounts also for a significant share of the total manufactured exports of some developing countries. Lemoine and Ünal Kesenci (2002, 2004) and Gaulier et al. (2005) use detailed data from China´s customs statistics on processing trade and conclude that the preferential treatment granted to international processing activities has fostered production sharing between China and its neighbours and strengthened regional economic integration in East Asia.

Some components of the international fragmentation of production have 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 costs, the sharp increase in technical progress and the removal of political and economic barriers to trade exponentiated the opportunities for fragmentation. Therefore, firms began to offshore many tasks that were previously considered as non-

tradable. As stated by Baldwin (2006), fragmentation is now occurring at a much finer level of disaggregation and international competition – which used to be primarily between firms and sectors in different nations – now occurs between individual workers performing similar tasks in different nations. Overall, this new globalization process, named by Baldwin (2006) "*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 economies in East Asia (see Kimura (2006) for a comprehensive analysis of East Asian production and distribution networks).

In parallel, international fragmentation of production has been associated with vertical foreign direct investment (FDI) flows, as multinational firms adopt the new paradigm and become prominent players in international trade. In this case, trade in intermediate goods takes the form of intra-firm transactions with production stages located in different countries, i.e. vertical production networks in multinationals. A strand of the literature on fragmentation has focused on the activities of multinational corporations. For instance, Hanson et al. (2005) use firm-level data on US multinationals to examine trade in intermediate goods between parent firms and foreign affiliates. They conclude that imports of inputs by the affiliates are higher in host countries with lower trade costs, lower wages for less-skilled labour and lower corporate income tax rates. In the same vein, Borga and Zeile (2004) examine intra-firm trade in terms of the propensity of foreign affiliates to import intermediate goods from their US parent companies. Kimura and Ando (2005) examine the mechanics of international networks in East Asia using highly disaggregated international trade data and micro-data for Japanese firms. The authors find evidence of active trade of parts and components in a combination of intra-firm and arm's length transactions.

At this point two new research avenues on the international fragmentation of production are worth mentioning. The study of fragmentation issues using firm-level data is an interesting approach. Empirical research at the firm level allows for the control of heterogeneity and can give important insights on the impact of outsourcing on productivity. For instance, Görg and Hanley (2005) examine the effect of international outsourcing on productivity at the plant level in the electronics industry in Ireland between 1990 and 1995. The authors provide some evidence that international outsourcing of materials increases productivity in plants with low export intensities.[4] More recently, Görg et al. (2008) investigate the impact of international outsourcing on productivity with plant level data for Irish manufacturing, finding evidence of positive effects from

[4]Girma and Görg (2004) find also a positive effect of outsourcing on productivity in the United Kingdom, though they do not distinguish between domestic and foreign outsourcing.

outsourcing of services inputs for exporters. Tomiura (2005) investigates Japanese manufacturing firms, relating various firm-level characteristics and their choices of foreign outsourcing, and Tomiura (2007), using the same data set, concludes that FDI firms are more productive than foreign outsourcers and exporters, which in turn are more productive than domestic firms. In the same vein, Kurz (2006) uses plant-level US manufacturing data to identify differences in the characteristics of outsourcers and non-outsourcers, finding also that more productive firms are more likely to outsource. However, the empirical evidence on international outsourcing at the firm-level is still limited, mostly due to data limitations and lack of international comparability.

The international outsourcing of services is another area where further investigation seems promising. The empirical evidence is still scarce because only recently technological developments made it possible offshore some services inputs. Amiti and Wei (2005) describe the main world trends in outsourcing of business services and computing and information services. The authors show that service outsourcing has been steadily increasing, though it is still at very low levels. They also examine the impact of service and material outsourcing in the United Kingdom and find no evidence of employment losses. In parallel, Amiti and Wei (2006) estimate the effects of offshoring on the productivity of US manufacturing industries between 1992 and 2000, showing that service offshoring is much lower, though having a stronger positive impact and growing more rapidly, than material offshoring. Finally, Liu and Trefler (2008) study the impact on U.S. labour markets of offshoring in services to China and India and find that the effects are remarkably small.

3 Input-Output Tables and International Trade Data

This section starts the analysis of the international fragmentation of production in the Portuguese economy using the methodological approaches that combine I-O matrices and international trade data. 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 measures. 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 when the Hummels et al. (2001) measure is computed.

The I-O data 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 some results obtained for 2002, 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. Nevertheless, 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.[5]

This section also studies the geographical orientation of Portuguese international outsourcing and vertical specialization activities. For that purpose, we selected the five main trade partners of Portugal (Spain, Germany, France, UK and US) using nominal international trade data from INE in 2002. 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.

3.1 Feenstra's Import Content

Feenstra and Hanson (1996) defined international outsourcing as the import of intermediate goods by domestic firms. The original measure considers the industry-level intermediate imports as a share of total purchases of non-energy inputs. In this paper, we follow Geishecker and Görg (2007) and normalize by the industry-level output instead. This option reduces the impact of an upward trend towards domestic outsourcing, i.e. increased purchases of intermediate goods from domestic suppliers. In fact, in Feenstra and Hanson (1996) higher domestic outsourcing means higher total input purchases in the industry and thus a lower measure, while in Geishecker and Görg (2007) the normalization with the industry's output means that increased input purchases are countered by lower value added. It is obvious that, since the gross output of a sector is bigger than its total inputs, the share of international outsourcing is lower when the

[5] 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.

former aggregate is used for normalization. Additionally, Feenstra and Hanson (1999) distinguish between broad and narrow definitions of outsourcing. The broad definition considers the value of intermediate goods that each manufacturing industry purchases from all the remaining ones. The narrow definition of outsourcing is obtained by considering only the inputs that are purchased from the same industry of the good being produced.

The broad definition of international outsourcing for each sector reflects the direct import content per unit of output, which corresponds to the column totals of the I-O import-use tables.[6] For each sector j, the share of imported inputs in gross output, in nominal terms, is:

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

where M_{ij} is the value of imported intermediate good i absorbed by sector j, Y_j is the gross output of sector j, for $i, j = 1, 2, \ldots, n$, while a_{ij}^{M} is the proportion of imported input i used to produce output Y_j.

Total international outsourcing for country k as a percentage of total output can be decomposed as the output-weighted average of the outsourcing shares of all sectors j:

$$\frac{IOS_k}{Y_k} = \frac{\sum_{j=1}^{n} IOS_j}{\sum_{j=1}^{n} Y_j} = \sum_{j=1}^{n} \left[\left(\frac{IOS_j}{Y_j} \right) \left(\frac{Y_j}{Y_k} \right) \right] = \sum_{j=1}^{n} \left[\left(\sum_{i=1}^{n} a_{ij}^{M} \right) \left(\frac{Y_j}{Y_k} \right) \right] \tag{2}$$

where $Y_k = \sum_{j=1}^{n} Y_j$ is total output of country k.

According to Feenstra and Hanson (1999), the above definition can be considered too broad if one understands international outsourcing to be the result of a "make or buy decision". According to this interpretation, it is not the sum of total imported inputs that constitutes international outsourcing but only the fraction that could be produced within the domestic industry (see Geishecker et al. (2008) for a discussion). Nevertheless, this notion requires the existence of data at a relatively high level of product breakdown, otherwise the criticism remains. In addition, part of manufacturing firms' activities can be related to the production of own inputs that, when outsourced, are included in a neighbouring sector. In this case, the broad measure is preferable, offering also a link with macroeconomic analysis since it identifies the direct import content of domestic output.

Figure 1 plots the broad and narrow measures of international outsourcing in the Portuguese manufacturing sector. The paths of these indicators are fairly parallel at the

[6] Feenstra and Hanson (1999) combine data on total intermediate purchases with trade data in order to obtain the imported intermediate goods, as import-use matrices were not available.

aggregate level, though the broad measure of international outsourcing is obviously higher. International outsourcing in the Portuguese manufacturing industry has grown substantially since 1986, reaching 23.8 percent of total output in 2002 when the broad definition is used (17.4 percent with the narrow definition). In the remaining of this subsection we use the existing data for the Portuguese manufacturing industry, excluding energy, and adopt the broad definition of international outsourcing.

Figure 1: International outsourcing in the Portuguese manufacturing industry
(as a percentage of total output)

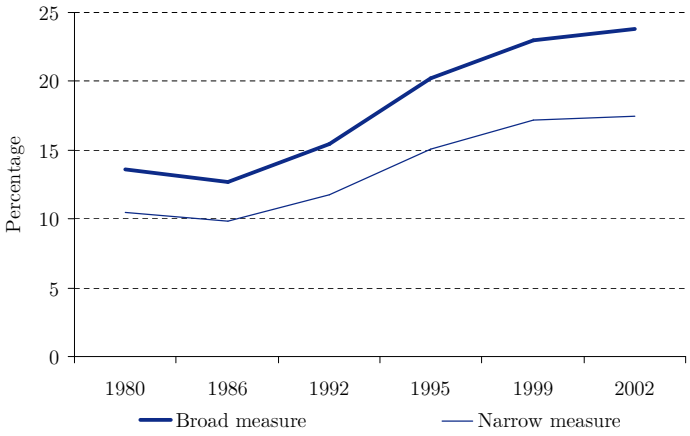
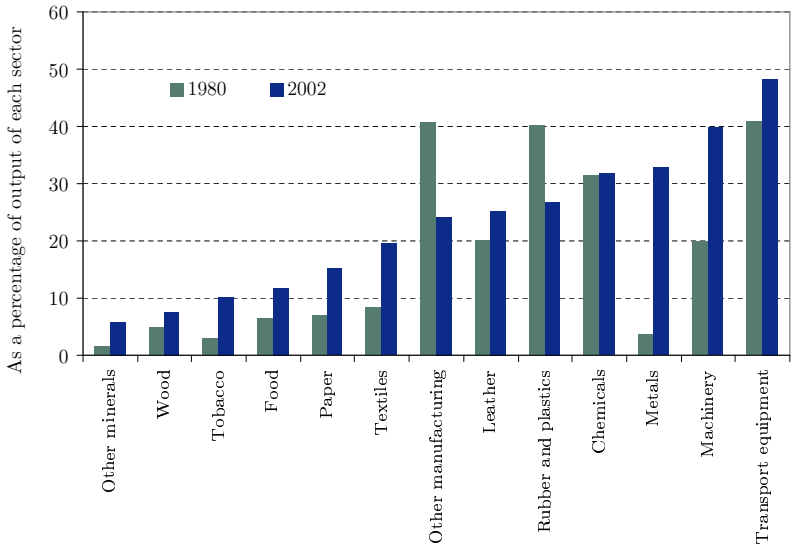


Figure 2 displays the direct import content of output in the different Portuguese manufacturing sectors. Despite the differences in the extent of international outsourcing, most sectors record substantial increases from 1980 to 2002. The two exceptions are the "Other manufacturing" and "Rubber and plastics" sectors. The strongest increase occurs in the "Metals" sector: from 3.8 percent of the sector's output in 1986 to 32.8 percent in 2002. In 2002, the importance of international outsourcing is fairly different across industries. The highest values are found in the "Transport equipment" sector, with an outsourcing intensity of 48.3 percent, and in the "Machinery" sector (39.9 percent of output). In contrast, outsourcing intensity in the "Other minerals" and "Wood" sectors is below 10 percent in 2002.

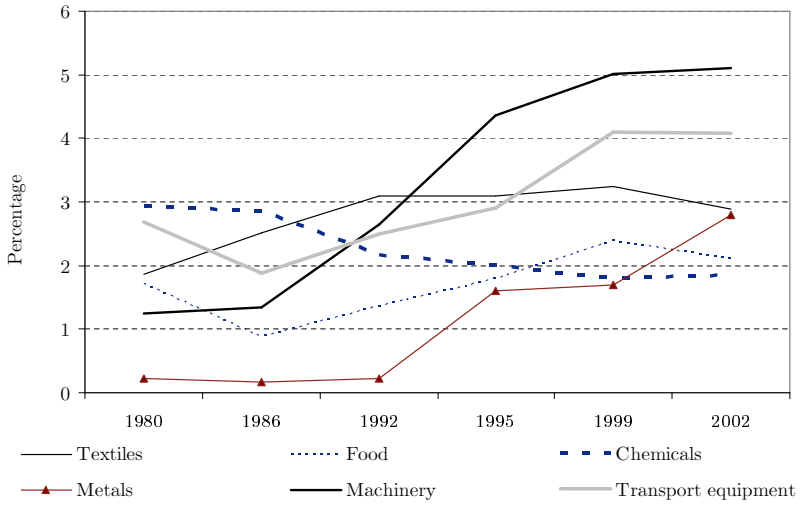
The contribution of each sector to the measure of international outsourcing in total Portuguese manufacturing output depends both on the sector's outsourcing intensity and on the share of each sector in total output as shown in equation (2). Figure 3 includes the main sectoral contributions to the Portuguese outsourcing share and the detailed results for each sector are included in Appendix A. The contribution of the "Machinery" sector has steadily increased over time, in particular during the nineties, reaching the highest value among all sectors analyzed in 2002, 5.1 percentage points (p.p.). The contribution of the "Transport Equipment" sector is also important, with

Figure 2: International outsourcing intensity of each Portuguese manufacturing sector
(direct import content of output by sector)



the increases occurring mostly between 1995 and 1999. The contribution of "Textiles" sector rises until 1992 but stabilizes afterwards, while the contribution of the "Metals" sector increases strongly after 1992, to around 2.8 p.p. in 2002. On the contrary, the contribution of the "Chemicals" sector declines by around 1 p.p. over this period.

Figure 3: Sectoral international outsourcing in the Portuguese manufacturing industry
(as a share of total manufacturing output)



On a dynamic perspective, the contribution of each sector to the change in the output share of international outsourcing can be further detailed using a shift-share analysis to examine the contributions coming from changes in each sector's outsourcing intensity and from changes in each sector's share in total output. This *intensive* (more outsourcing in the sector) - *extensive* (higher share of the sector in total output) breakdown is

given by:

$$\Delta \frac{IOS_{k,t}}{Y_{k,t}} = \sum_j \left[\Delta \frac{IOS_{j,t}}{Y_{j,t}} * 0.5 * (\psi_{k,j,t} + \psi_{k,j,t-1}) \right.$$
$$\left. + \Delta \psi_{k,j,t} * 0.5 * \left(\frac{IOS_{j,t}}{Y_{j,t}} + \frac{IOS_{j,t-1}}{Y_{j,t-1}} \right) \right] \quad (3)$$

where $IOS_{k,t}$ and $Y_{k,t}$ stand for total international outsourcing and total output of country k in period t, respectively, and $IOS_{j,t}$ and $Y_{j,t}$ are equivalent notions for sector j. Finally, $\psi_{k,j,t}$ is the share of sector j in total output of country k in period t.

Table 1 - Contributions to the change in the measure of Portuguese international outsourcing (change from 1980 to 2002, in percentage points)

	Contribution of change in		
	Sector outsourcing intensity	Sector share of total output	Total
Food	1.2	-0.8	0.4
Tobacco	0.0	0.0	0.0
Textiles	2.0	-1.0	1.0
Leather	0.2	0.4	0.5
Wood	0.1	-0.1	0.0
Paper	0.5	0.2	0.7
Chemicals	0.0	-1.1	-1.1
Rubber and plastics	-0.4	0.2	-0.2
Other minerals	0.3	0.1	0.4
Metals	2.1	0.5	2.6
Machinery	1.9	2.0	3.9
Transport equipment	0.6	0.8	1.4
Other manufacturing	-0.5	1.0	0.5
Total	8.0	2.2	10.1

Table 1 includes the breakdown results of the change in the share of international outsourcing from 1980 to 2002 (the detailed sectoral contributions for each year are included in Appendix B). The changes in outsourcing intensity across all manufacturing sectors account for 78.5 percent of the growth in the Portuguese outsourcing share from 1980 to 2002. Looking at the sectoral contributions, the "Machinery" sector accounts for 3.9 p.p. of the growth in the overall outsourcing share. The strong contribution of this sector results both from the increase in its outsourcing intensity and from its higher share in total output. The same occurs in the "Transport Equipment" sector, where both contributions are balanced. In contrast, the "Metals" sector contributes primarily through increases in its outsourcing intensity, the highest of all sectors. The increase in the outsourcing intensity in the "Textiles" sector from 1980 to 2002 gives also an important contribution, but the decline of its share in total manufacturing output reduces its overall contribution. Likewise, the negative overall contribution of the "Chemicals" results exclusively from the decline of its share in total manufacturing

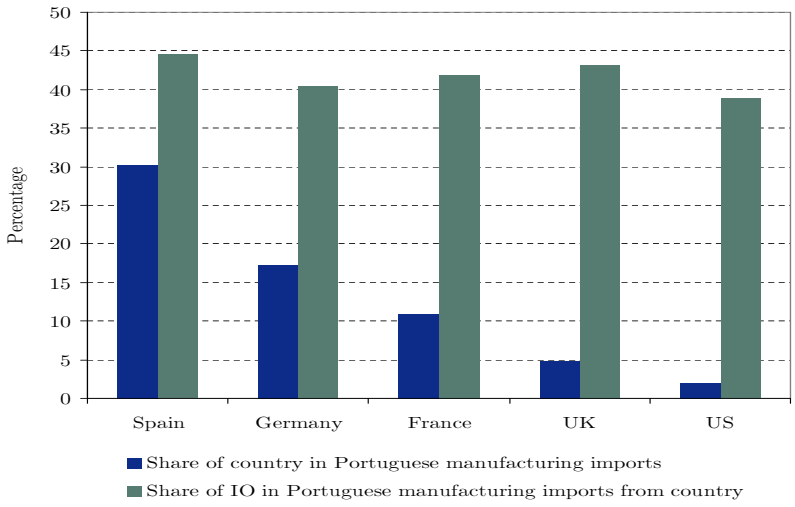
output, as its outsourcing intensity is similar in 1980 and in 2002.

We can disaggregate total Portuguese international outsourcing to identify the different source countries of the imported intermediate goods. In each period, the international outsourcing level of sector j from each source country is computed by multiplying each type of imported input i by the respective country's import share on total imports of product i, obtained from trade statistics. That is:

$$IOS_{c,j} = \sum_{i=1}^{n} \left(M_{ij} \frac{M_{i,c}}{M_i} \right) \tag{4}$$

where $M_{i,j}$ stands, as previously, for imports of product i absorbed by sector j, $M_{i,c}$ are the imports of product i from partner c and M_i are total imports of product i. The underlying assumption in this calculation is that the breakdown by country of origin of intermediate imports of type i is the same for all Portuguese industries j that purchase it.

Figure 4: International outsourcing in Portuguese manufacturing imports from main trade partners, 2002



International outsourcing represents around 40 per cent of total Portuguese imports from its five main trade partners in 2002 (Figure 4). The highest international outsourcing share is the one of Spain (44.6 per cent of total Portuguese imports from Spain) and the lowest the one of the US (38.9 per cent).

Table 2 presents the sectoral breakdown of Portuguese international outsourcing from its main trade parters. In 2002, Portuguese intermediate imports from Germany are mainly absorbed by the "Machinery" and "Transport equipment" sectors, which represent 54.3 per cent of total international outsourcing from that country. Intermediate imports from Spain are more dispersed across sectors, with the "Metals" sector recording the highest outsourcing share in the five countries considered. Concerning France,

the "Textiles" and "Transport equipment" sectors represent 14.0 and 25.0 per cent of total outsourcing from this country, respectively. Regarding the UK, the "Chemicals" sector accounts for 12.3 per cent of total, the highest share in the countries selected. In the case of the US, the share of the "Food" sector is the highest of the five main parters and the share of the "Machinery" sector is also very significant (29.2 per cent).

Table 2 - Sectoral composition of international outsourcing from selected countries/areas
(Percentage share in country/area, 2002)

	Total	Spain	Germany	France	UK	US	Intra-EU	Extra-EU
Food	8.8	11.7	4.2	8.2	9.1	13.1	8.2	11.8
Tobacco	0.2	0.2	0.3	0.1	0.6	0.4	0.3	0.1
Textiles	12.1	12.1	8.8	14.0	11.9	5.7	12.4	10.8
Leather	4.4	4.1	2.7	3.5	3.0	1.6	4.1	5.6
Wood	1.5	1.8	0.7	1.0	0.6	5.7	1.2	2.8
Paper	4.6	6.5	2.9	3.8	5.4	3.7	5.1	2.2
Chemicals	7.7	6.5	7.5	8.2	12.3	8.3	8.1	6.1
Rubber and plastics	3.6	3.4	3.7	3.6	4.7	3.2	3.7	2.8
Other minerals	1.8	2.2	1.5	1.6	1.8	1.4	1.9	1.5
Metals	11.8	13.1	10.2	9.8	10.4	3.6	11.4	13.6
Machinery	21.5	17.5	31.4	17.0	20.6	29.2	21.9	19.5
Transport equipment	17.2	15.4	23.0	25.0	16.2	18.7	17.0	18.0
Other manufacturing	4.8	5.6	3.2	4.3	3.4	5.5	4.7	5.3
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

3.2 Hummels's Vertical Specialization

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:

$$VS_j = \sum_{i=1}^{n} \left(\frac{M_{ij} X_j}{Y_j} \right) = \sum_{i=1}^{n} a_{ij}^M X_j \tag{5}$$

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 amount of imported intermediate goods required to produce the exports of sector j X_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:

$$VS_k = \sum_{j=1}^{n} VS_j = \sum_{j=1}^{n} \sum_{i=1}^{n} a_{ij}^M X_j \tag{6}$$

The VS as a percentage of total exports of the country k is given by:

$$\frac{VS_k}{X_k} = \frac{\sum_{j=1}^{n} VS_j}{\sum_{j=1}^{n} X_j} = \sum_{j=1}^{n} \left[\left(\frac{VS_j}{X_j} \right) \left(\frac{X_j}{X_k} \right) \right] = \sum_{j=1}^{n} \left[\left(\sum_{i=1}^{n} a_{ij}^{M} \right) \left(\frac{X_j}{X_k} \right) \right] \tag{7}$$

where $X_k = \sum_{j=1}^{n} X_j$ are total exports of country k. Using equation (7), the total VS share of a country can be decomposed in an export-weighted average of sectoral VS export shares.

The VS measure presented in equation (7) is:

$$VS \text{ share of total exports in } k = \frac{VS_k}{X_k} = \frac{uA^M X}{X_k} \tag{8}$$

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 (8) 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 (2005), 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. However, 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:

$$VS \text{ share of total exports in } k = \frac{VS_k}{X_k} = \frac{uA^M \left[I - A^D \right]^{-1} X}{X_k} \tag{9}$$

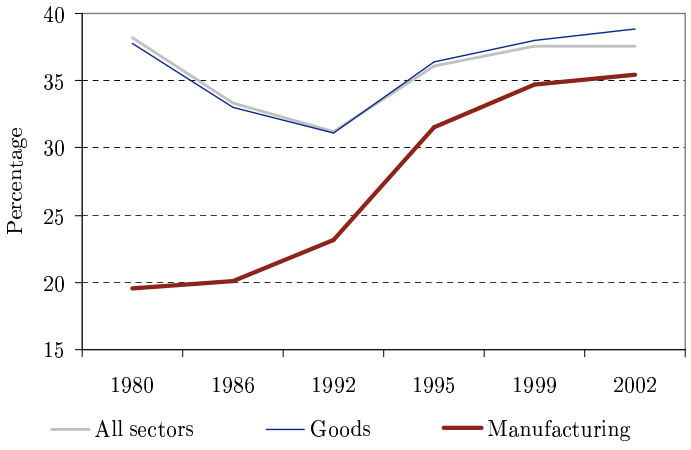
where I is the identity matrix and A^D is the $n \times n$ matrix of domestic technical coefficients. The term $\left[I - A^D\right]^{-1}$ is the Leontief inverse matrix that can be written as the sum of a converging infinite geometric series with common ratio A^D, that is:

$\left[I - A^D\right]^{-1} = \left[I + A^D + A^{D2} + A^{D3} + \cdots + A^{Dx}\right]$, when $x \to \infty$.

Thus, the numerator of equation (9) 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 (9) is the measure elected to compute the importance of VS activities in Portugal.

The VS index suggested by Hummels et al. (2001) has some similarities with the international outsourcing measure proposed by Feenstra and Hanson (1996), in what concerns the connection between imports of intermediate goods and the international fragmentation of production, as well as in terms of the utilization of I-O tables to measure it. Nevertheless, the differences between the two measures are relevant. Firstly, Hummels et al. (2001) takes into account all indirect contributions of imported intermediates in the production of domestic sectors. Secondly, the VS measure is expressed with reference to the total value of exports, as it only takes into account the intermediate imports embodied in the products that are exported.

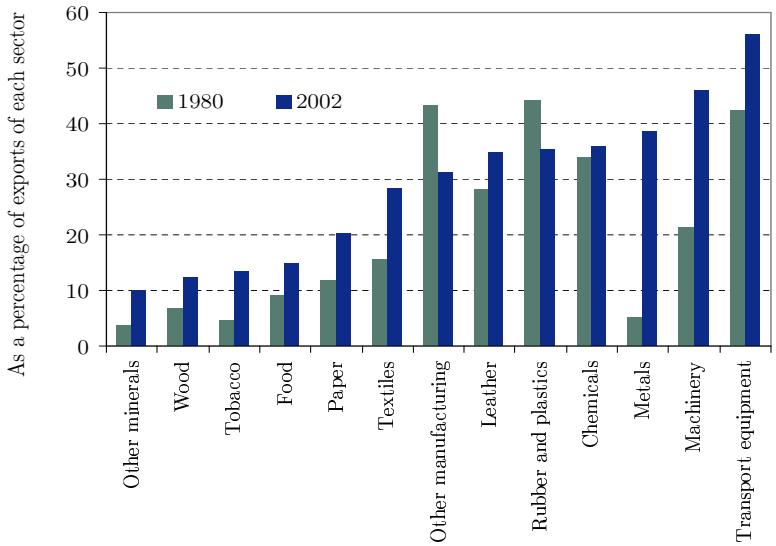
Figure 5: Vertical specialization trade in Portugal
(as a share of total exports)



The computation of the VS index presented in equation (9) for the Portuguese economy reveals an increase in the importance of these activities, in particular since the mid-nineties (Figure 5). 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 C). 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 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.

Figure 6: VS intensity of each Portuguese manufacturing sector
(Total import content of exports by sector)



To avoid biasing the analysis with the effect of the energy sector, from here on we focus on the Portuguese manufacturing industry (13 sectors). Between 1980 and 2002, the majority of Portuguese manufacturing sectors shows a growing propensity to use

imported inputs in the production of exports (Figure 6). The only two exceptions are the "Rubber and plastics" and "Other manufacturing" sectors. The most striking increase in VS intensity happens in the "Metals" sector, rising 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 increases strongly. In the more recent period, substantial differences in terms of import content exist between sectors. In 2002, the extent of VS is 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".

Figure 7: Sectoral vertical specialization in Portugal
(as a share of total manufacturing exports)

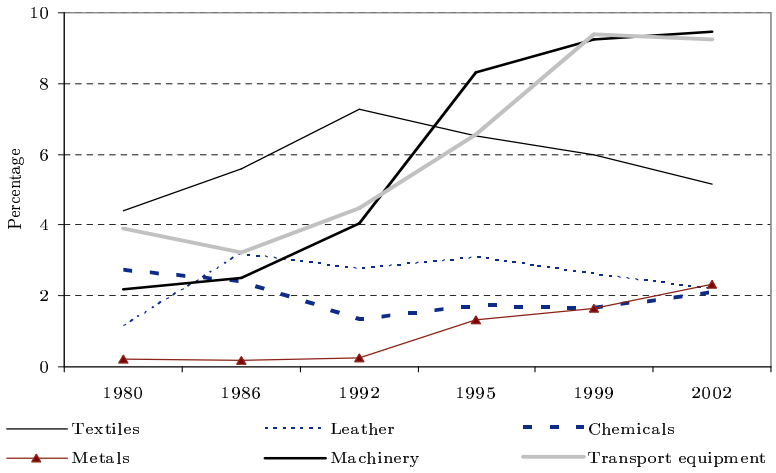


Figure 7 includes the main sectoral contributions to the Portuguese VS share and the detailed results for each sector are included in Appendix C. The higher contributions in 2002 are given by the "Machinery" and "Transport Equipment" sectors, whose intermediate imports reach, in each case, values above 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 Por-

tugal of large FDI projects in the automobile sector, whose production is directed to exports and where the import content is significant. Conversely, the VS contribution of the "Textiles" sector increases until 1992 but loses 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, as in the previous subsection, using a shift-share analysis. The contributions coming from changes in each sector's VS intensity and from changes in each sector's share in total exports are given by:

$$\Delta\frac{VS_{k,t}}{X_{k,t}} = \sum_j \left[\Delta\frac{VS_{j,t}}{X_{j,t}} * 0.5 * (\omega_{k,j,t} + \omega_{k,j,t-1}) + \Delta\omega_{k,j,t} * 0.5 * \left(\frac{VS_{j,t}}{X_{j,t}} + \frac{VS_{j,t-1}}{X_{j,t-1}}\right)\right] \quad (10)$$

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.

Table 3 - 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

The breakdown results for the change in the VS share from 1980 to 2002 are presented in Table 3 and Appendix D 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 measure from 1980 to 2002. The highest sectoral contributions to the total increase in the Portuguese VS share in manufacturing exports come 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.

Similarly to what was done for the Feenstra's approach in the previous subsection, one dimension to explore is the geographical orientation of Portuguese VS activities. 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:

$$VS_{c,j} = \frac{VS_j}{X_j} * X_{c,j} \tag{11}$$

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.

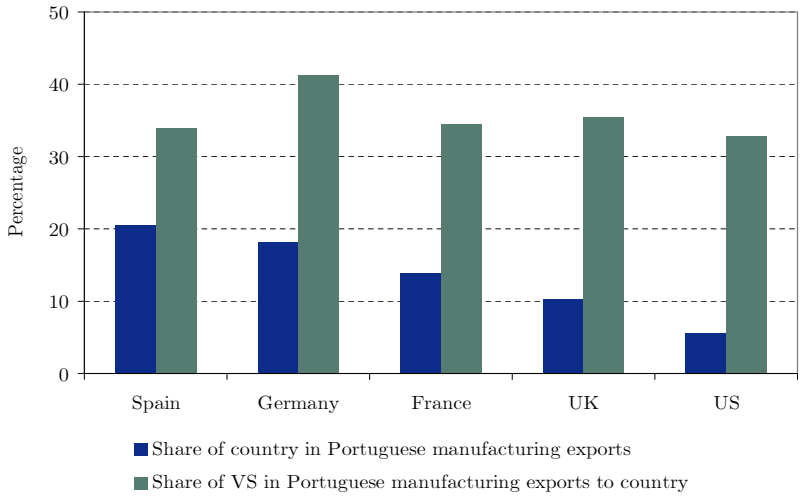
Again, the sectoral results for each partner can be added up to get a total VS level with each partner and the results are easier to interpret if the VS share in total exports to each partner is computed. The VS share of total exports of country k to partner c is given by:

$$\frac{VS_{k,c}}{X_{k,c}} = \frac{\sum_{j=1}^{n} VS_{c,j}}{\sum_{j=1}^{n} X_{c,j}} \tag{12}$$

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 (Figure 8). 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 4). 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.

Figure 8: Vertical specialization in Portuguese manufacturing exports to main trade partners, 2002



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 relevance 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.

Table 4 - Sectoral composition of Portuguese manufacturing VS exports to selected countries/areas
(Percentage share in total VS to country/area, 2002)

	Spain	Germany	France	UK	US	Intra_EU	Extra-EU
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

At this point it is useful to briefly compare the results obtained with the Hummels et al. (2001) and the Feenstra and Hanson (1996) methodologies. The two indicators provide the same qualitative results in terms of the increase of fragmentation in the Portuguese manufacturing industry (Figures 1 and 5). They also give similar results in terms of the ranking of the main sectoral contributions to the international fragmentation of production in Portugal (Figures 3 and 7). These similarities indicate that the common features of the indicators are important for the quantification of the phenomenon, namely the matrix of direct imported input coefficients A^M. However, some differences arise in terms of the magnitude of the results. Firstly, the "Transport equipment" sector shows a stronger increase in its fragmentation intensity when the VS indicator is considered. This evolution is due to the fact that the VS measure takes into account all indirect contributions of imported intermediates in the production of domestic sectors. In fact, the "Transport equipment" sector combines two features. The import content of the inputs coming from the same sector is comparatively high and it takes a substantial share of its inputs from other sectors with high import contents of their own. For instance, in the "Metals" sector the last feature does not apply. Secondly, when the Hummels et al. (2001) indicator is considered, Germany is the partner where Portuguese international fragmentation of production is higher. This result is connected with the fact that this indicator attributes increased significance to the "Transport equipment" and "Machinery" sectors, which are especially important in the structure of Portuguese exports to Germany.

3.3 A Relative Measure of Vertical Specialization

One of the most serious limitations of the previous I-O based methods is the access to up to date matrices and the difficulty to perform accurate cross-country comparisons. In fact, I-O matrices are computed sparsely in time and across countries. Thus, it is difficult to produce an assessment of how dynamic are VS activities comparatively to other countries in the world. In Amador and Cabral (2008*a*) a relative measure of VS is proposed. This relative method requires substantial information on trade flows, but it relies on a generic I-O matrix with zeros and ones that signals the intermediate goods used in the production of each good. The final result can be interpreted as a proxy of the importance of VS activities in each country relatively to the other economies in the world.

The method presented in Amador and Cabral (2008*a*) proceeds in two steps. In the first step of the methodology, information from the I-O tables of the United States is used to identify the intermediate goods used in the production of each sector. Next, conditional

on this information, the identification of relevant VS activities is accomplished by computing an appropriate trade specialization indicator - the $B^{\star}$ index introduced in Amador et al. (2007) - for both exports and imports in the 121 different sectors, for a sample of 79 countries, and by setting a threshold defined as a high percentile of the cross-country distribution of the index. The basic intuition is that if a country simultaneously exports a specific product and imports an intermediate good used in its production much more than the average of the other countries, then international vertical linkages must play a role. In the second step of the methodology, the value of intermediate imports that surpasses the one implied by the threshold percentile (PRC) is considered as trade due to VS activities in period t. That is:

$$VSM_{pi}^{PRC} = m_{pi} - m_{pi}^{PRC} \qquad \text{country } p = 1, 2 \dots N; \text{ product } i, j = 1, 2 \dots S \tag{13}$$

where m_{pi} stands for the imports of country p of product i and m_{pi}^{PRC} is the value of imports of product i by country p that would put it in the percentile PRC of the cross-country distribution of the imports' specialization indicator of product i.

Starting from:

$$B_{Mpi}^{\star} = B_{Mi}^{\star PRC} \Leftrightarrow \frac{\left(\frac{m_{pi}}{M_p}\right)}{\frac{1}{N}\sum_{p=1}^{N}\left(\frac{m_{pi}}{M_p}\right)} = \frac{\left(\frac{m_{pi}^{PRC}}{M_p^{PRC}}\right)}{\frac{1}{N}\sum_{p=1}^{N}\left(\frac{m_{pi}^{PRC}}{M_p^{PRC}}\right)} \Leftrightarrow$$

$$\frac{\left(\frac{m_{pi}}{m_{pi}+\sum_{z\neq i}^{S} m_{pz}}\right)}{\frac{1}{N}\left(\frac{m_{pi}}{m_{pi}+\sum_{z\neq i}^{S} m_{pz}}\right) + \frac{1}{N}\sum_{c\neq p}^{N}\left(\frac{m_{ci}}{M_c}\right)} = \frac{\left(\frac{m_{pi}^{PRC}}{m_{pi}^{PRC}+\sum_{z\neq i}^{S} m_{pz}}\right)}{\frac{1}{N}\left(\frac{m_{pi}^{PRC}}{m_{pi}^{PRC}+\sum_{z\neq i}^{S} m_{pz}}\right) + \frac{1}{N}\sum_{c\neq p}^{N}\left(\frac{m_{ci}}{M_c}\right)} \tag{14}$$

Solving (14) in order of m_{pi}^{PRC}:

$$m_{pi}^{PRC} = \frac{\frac{B_{Mi}^{\star PRC}}{N}\left(\sum_{c\neq p}^{N}\frac{m_{ci}}{M_c}\right)\left(\sum_{z\neq i}^{S} m_{pz}\right)}{1 - \frac{B_{Mi}^{\star PRC}}{N}\left(1 + \sum_{c\neq p}^{N}\frac{m_{ci}}{M_c}\right)} \tag{15}$$

The international trade data used in this subsection comes from the CEPII - CHELEM database, which reports bilateral trade flows for goods in value terms (the unit being the US dollar). The sample period starts in 1967 and ends in 2005. The database comprises 79 countries or country groups (N=79) and 121 different manufacturing products

(S=121), with a product breakdown at the 4-digit level of the International Standard Industrial Classification of economic activities (ISIC), rev.3.1. The I-O matrix comes from the Bureau of Economic Analysis (BEA) 1997 Benchmark Input-Output Accounts for the United States. Several product aggregations had to be made to turn the US I-O classification compatible with the ISIC classification. Finally, a 121 by 121 I-O matrix following the ISIC was obtained, establishing the amount of each intermediate good used in the production of each one of the 121 products. Next, this I-O matrix was turned into a 1/0 pseudo IO_{ij} matrix, according to the following rule: if a product represents more than 1 percent of total inputs of a sector, then the pseudo IO_{ij} matrix takes the value 1; otherwise it takes the value zero. Three other pseudo IO_{ij} matrices were computed with different product compositions. Firstly, energy-related items as coke, refined oil products and nuclear fuel were excluded from the analysis by zeroing the respective input and output elements of the matrix, resulting in 118 active products on both sides. Secondly, the values of some other inputs i were also set to zero to approximate the definition of parts and components that is used in several studies, resulting in a new pseudo IO_{ij} matrix with 45 active products as inputs.[7] Thirdly, a more restrictive definition of parts and components was applied, by zeroing additional products on the input side, leaving 33 active products as inputs.

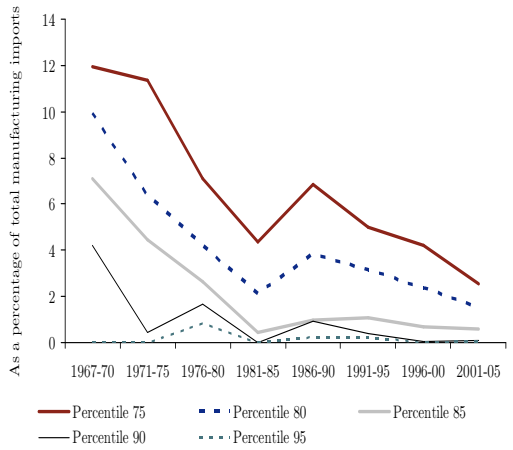
Figure 9 shows the relative evolution of Portuguese VS trade, as percentage of total imports, considering different alternatives in each dimension, i.e. total sample (121 products), excluding energy-related items (118 active products), broad definition of parts and components (with 45 active inputs), strict definition of parts and components (with 33 active inputs); and different threshold percentiles ($PRC = 75, 80, 85, 90, 95$). The results obtained for Portugal with this relative measure are not incompatible with those of the previous subsections. The low levels of this measure indicate that, even if the level of VS activities has been increasing in the Portuguese economy in the past decades, the pace has been slower than in many other countries, notably in East Asia.[8] Thus, since the indicator expressed in equation (13) has a relative nature, it shows a decrease of VS in Portugal in the last decades when the broader categories of goods (121 and 118 products) are considered and a near stabilization when the narrower categories (45 and 33 products) are selected. In fact, this indicator bases the identification and quantification of VS activities on trade flows whose relative dimension in the country is above a restrictive international threshold that is also changing over time. So, in dynamic terms, this measure will only capture the cases where the increase of real VS activities in a country is strong enough to translate into a growth of intermediate

[7] See Amador and Cabral (2008*a*) for further details.

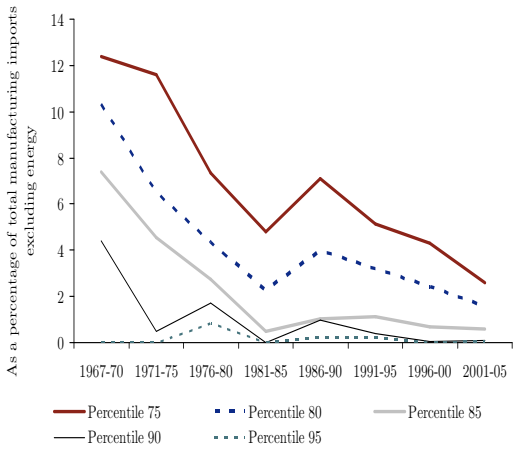
[8] Significant and growing VS activities are identified in East Asia over the last two decades with this relative measure. See Amador and Cabral (2008*a*).

imports above the one implied by the international threshold. Nevertheless, a common feature visible in Figure 9 is the increase of the indicator in all product compositions in the period 1986-90. This results mostly from the increase in medium-high-technology goods, possibly reflecting higher VS-based trade accompanying FDI inflows in the years following Portuguese accession to the European Economic Community in 1986.

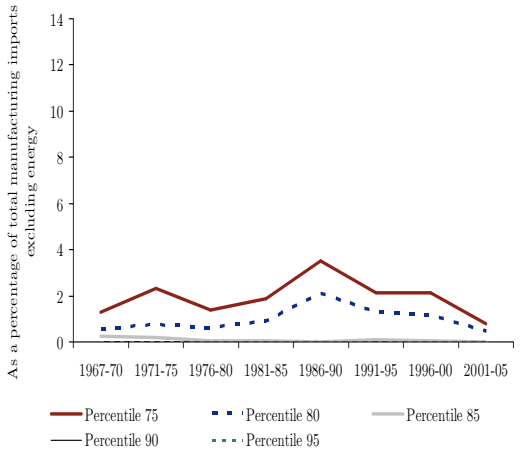
Figure 9: Portugal - Vertical specialization activities(relative measure)



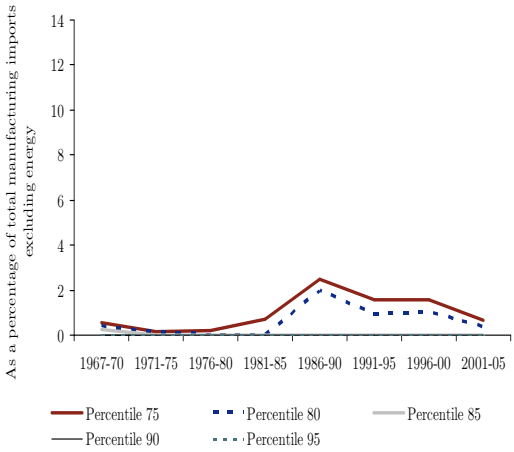
(a) 121 inputs



(b) 118 inputs



(c) Parts and components (45 inputs)



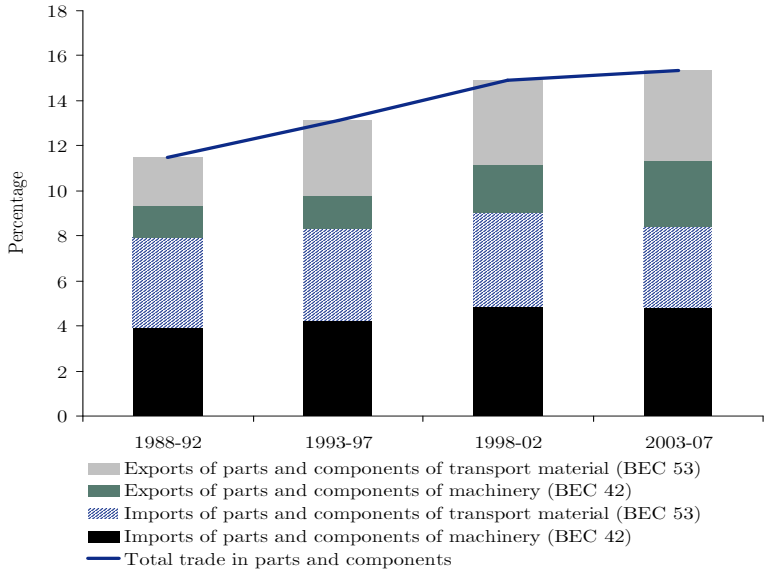
(d) Parts and components (33 inputs)

4 International Trade of Parts and Components

This section makes use of international trade statistics to measure fragmentation by comparing trade in goods classified as parts and components with trade in final products. The United Nations' classification of Broad Economic Categories (BEC) rev.3 groups trade statistics into large classes of goods, basing on the principal use of the products. In this paper, the BEC sub-categories "42 - Parts and accessories of

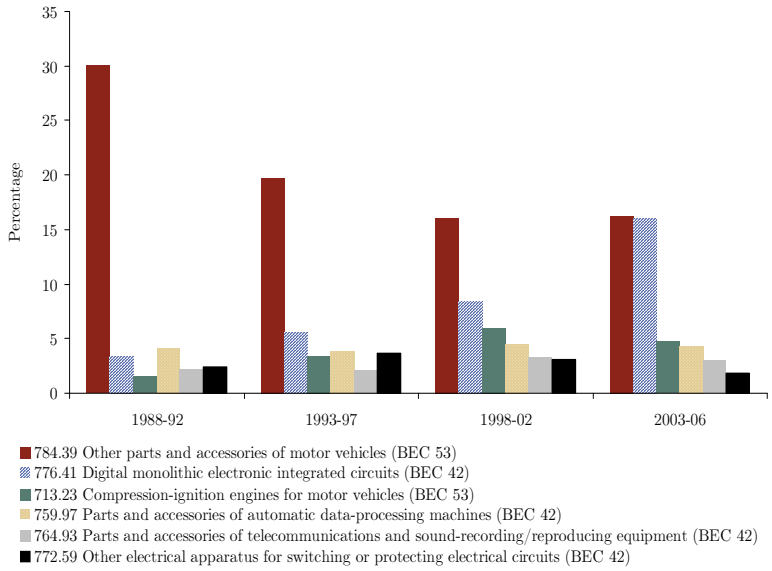
capital goods" and "53 - Parts and accessories of transport equipment" are used to measure Portuguese international trade in parts and components (see, for instance, Gaulier et al. (2006) for a similar definition). The international trade data, in nominal terms, used in this section comes from the Eurostat - COMEXT database and covers the 1988-2007 period.

Figure 10: Portuguese international trade of parts and components
(as a share in total trade)

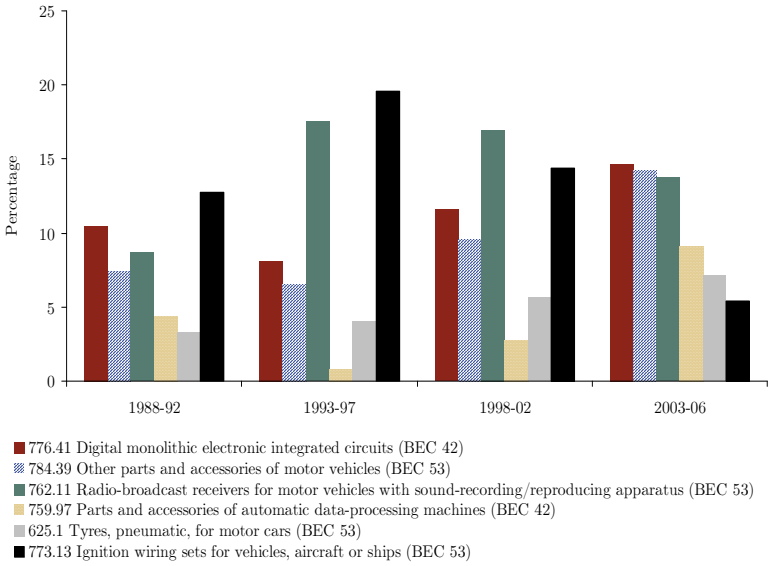


The share of parts and components in total Portuguese international trade exhibits an upward trend over the last twenty years, from 11.5 per cent of total trade in the average of the period 1988-92 to 15.4 per cent in 2003-07 (Figure 10). This increase is significant during the nineties but a nearly stabilization is evident in the average of the most recent period. This recent stabilization is rooted on the decrease of the share of imports of parts and components in total trade since 2004 (the yearly results are included in Appendix E). When taking the whole period, the increase in the share of parts and components in total trade results mostly from the growth of Portuguese exports of these products. In the last two decades, exports of parts and components of transport material rise from 2.2 per cent in 1988-92 to 4.0 per cent of total Portuguese international trade in 2003-2007 (10.2 per cent of total exports in 2003-2007). Exports of parts and components of machinery increase also during the last twenty years, to 2.9 per cent of total trade in the 2003-2007 period (7.5 per cent of total exports). On the import side, the share of parts and components of machinery on total trade increases somewhat over the 1988-2007 period, but imports of parts and components of transport material show a slight decline, especially in the most recent period.

Figure 11: Portuguese international trade of parts and components - main products



(a) Main imported products, as a share in total imports of parts and components



(b) Main exported products, as a share in total exports of parts and components

Note: The names of the items were taken directly, with some abbreviation, from SITC Rev3 .

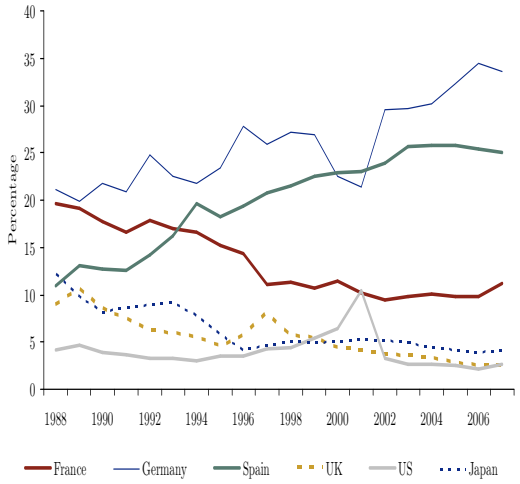
Figure 11 displays the main items of imports and exports of parts and components in the Portuguese economy using the SITC rev.3 at the 5-digit breakdown level.[9] Some results are worth highlighting in this exercise. Firstly, the share of imports of "Other parts and accessories of motor vehicles" (SITC 784.39) in total imports of parts and components declines sharply over the last twenty years, but the reverse happens when

[9] As the BEC rev.3 is defined in terms of SITC rev.3, there is a exact correspondence between the two classifications and the analysis can be done at a detailed breakdown level. The analysis at the product level is done until 2006, as the detailed data for 2007 is only available according to SITC rev.4. and its correspondence with SITC rev.3 is not exact at the 5-digit level.

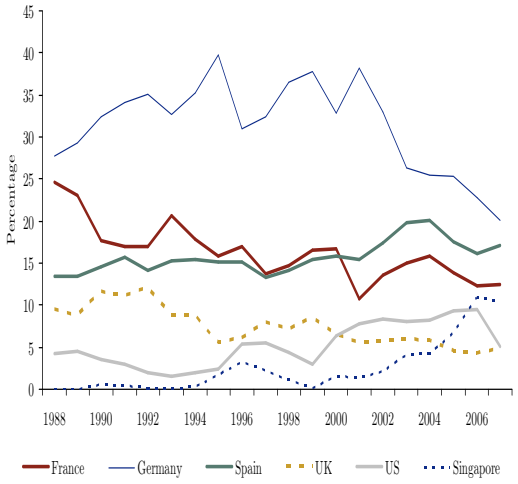
exports of these products are considered. Other items of transport material like "Radio-broadcast receivers for motor vehicles" (SITC 762.11) and "Tyres, pneumatic for motor cars" (SITC 625.1) are also among the main Portuguese exports of parts and components. This reflects the rise of the Portuguese industry of parts and components for automobiles, which not only supplies the domestic industry but also integrates the worldwide supply chain of some car constructors. Nevertheless, over this period, there was a strong decline of exports of components of "Ignition wiring sets for transport material" (SITC 773.13). In addition, "Digital electronic integrated circuits" (SITC 776.41) represent a high and increasing share both on the import and on the export side, signalling the integration of Portugal in international networks of production of these goods. The same happens, though in a lesser extent, with "Parts and accessories of office and automated data-processing machines" (SITC 759.97).

A geographical breakdown of Portuguese trade in parts and components over the last twenty years is included in Figure 12. The share of the five main trade partners in total imports of parts and components increases by around 10 p.p. between 1988 and 2007, reflecting mainly the strong dynamics of imports from Germany (mostly in electronic components) and Spain (more evenly distributed across the different products). In contrast, France and the UK show a declining path, mostly attributable to lower imports of auto-parts. Out of the five main partners, Japan has also a decreasing share in Portuguese imports of parts and components, associated with parts and accessories of motor vehicles. On the contrary, the share of the five main trade partners in total Portuguese exports of parts and components declines by around 20 p.p. over the last two decades. This decrease largely reflects the evolution of exports to Germany and France, predominantly of parts and components of motor vehicles, and to the UK, mainly of parts of electrical machinery. Conversely, Spain and the US increase their share in Portuguese exports of parts and components. In the case of Spain, this evolution results mostly from the growth of exports of parts and components of transport equipment and, in the case of the US, it reflects mainly the growth of exports of electronic components. Finally, there is a strong increase in the share of Singapore in total Portuguese exports of parts and components especially since 2003, reaching 7.2 per cent in the average of the 2003-2007 period, which chiefly reflects exports of digital electronic integrated circuits.

Figure 12: Portuguese international trade of parts and components - main trade partners



(a) Main import origins, as a share in total imports of parts and components



(b) Main export destinations, as a share in total exports of parts and components

5 Outward and Inward Processing Trade

Information on processing trade obtained from customs statistics can be used to construct a very narrow measure of international fragmentation of production, strictly defined as trade flows for reasons of processing. Processing trade in the EU includes both outward and inward processing trade (see Eurostat (2006)). Outward processing trade results from a customs arrangements that allows firms to temporarily export goods to countries outside the EU for processing and to import the resulting products with a full or partial exemption of duties and levies. Inward processing arrangements make it possible to temporarily import goods so that they can be processed in the EU and then exported outside the EU without payment of duties and levies.

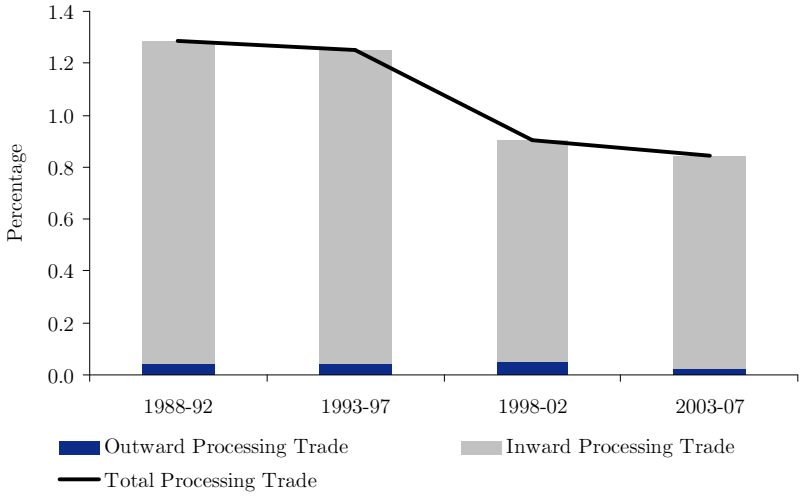
Data on processing trade is available for the EU countries in the COMEXT database, in nominal terms, as the Eurostat collects information on outward and inward processing trade between the EU member states and non-EU countries.[10] The statistical procedures of extra-EU trade concerning processing trade include broadly four different types of trade flows: (1) exports of goods by an EU country to be processed in a non-EU member and (2) imports by the EU of those processed goods; (3) imports of goods to be processed in the EU and (4) exports of those goods to a country outside the EU. The first two flows measure outward processing trade (OPT) and the last two

[10] We refer to inward processing trade (IPT) and outward processing trade (OPT) of EU Member States with the rest of the world, excluding intra-EU trade, since European statistics collect data on intra-EU processing trade only up to December 1992. Given the nature of these operations, it is clear that for EU countries outward-inward processing is currently associated with extra-EU trade. Duties and levies are not applied in intra-EU trade, turning these arrangements unnecessary.

measure inward processing trade (IPT). However, as stated in Eurostat (2006), the application of a statistical procedure is independent of the nature of the transaction concerned (purchase/sale, processing under contract, etc.). Thus, some of the goods traded for processing, in the economic sense of the term, are often registered under normal imports and exports, leading to a underestimation of processing activities using this type of data.

Figure 13 shows the evolution of Portuguese processing trade as a percentage of total international trade between 1988 and 2007. These operations represent a very small share of total trade (always below 2 per cent) and, in terms of composition, IPT is overwhelmingly dominant. This fact means that Portugal seems to be more a destination than an origin of processing activities.

Figure 13: Outward and inward processing trade in Portugal
(as a share in total trade)



In sectoral terms, processing trade in Portugal tends to be concentrated in a few sectors, which is line with the findings of studies on other countries. The "SITC 7 - Machinery and transport equipment" sector accounts for 47.1 per cent of total IPT in the average of the last twenty years, playing a stronger role between 1995 and 2005. In the period 2003-2007, "SITC 2 - Crude materials, inedible, except fuels" and "SITC 5 - Chemicals and related products n.e.s." represent 10.4 and 11.2 per cent of the total, respectively. In what concerns OPT, the share of "SITC 7 - Machinery and transport equipment" is clearly dominant, representing 69.6 per cent of total in the average of the period 1988-2007.

In geographic terms, there are strong similarities between the most important trade partners of Portuguese IPT and OPT over the last twenty years. As regards IPT, 25.2 per cent of Portuguese IPT in the average of 1988-2007 period takes place with

non-EU European countries (Switzerland, Norway between 2000 and 2003, and, in the last four years, Russia), 30.8 per cent is linked with the US and 18.5 per cent with Asian countries (in particular Japan, South Korea, and, since 2000, China and India). Considering OPT, 39.1 per cent of total flows in the 1998-2007 period occur with non-EU European countries, in particular Switzerland and, between 1995 and 2003, Poland. Additionally, the US represent 26.3 per cent of total Portuguese OPT and Asian countries account for 25.5 per cent in the average of the period 1998-2007 (especially Japan).

6 Concluding Remarks

Over the last decades, international trade patterns have evolved significantly, as countries increasingly specialize in producing particular stages of a good. In fact, a new paradigm in the international organization of the productive processes has emerged since, for a large share of goods, the production chain has become vertically decomposed among different countries as firms take advantage of technological progress and trade openness to explore comparative advantages in the assembly and production of parts and components. In this context, it becomes increasingly important to identify and characterize the international fragmentation of production. This paper uses the different methodologies proposed in the empirical literature to quantify these international vertical linkages in the Portuguese economy.

The international fragmentation measures proposed by Feenstra and Hanson (1996) and Hummels et al. (2001) make use of imported input content coefficients included in Input-Output tables and capture both modern fragmentation processes as well as more classical situations where countries import certain intermediate products to produce other goods. Using the methodology proposed by Feenstra and Hanson (1996), international outsourcing in the Portuguese manufacturing industry has grown substantially since 1986, reaching 23.8 percent of total output in 2002. "Machinery" and "Transport Equipment" are the two most important sectors, representing 21.5 and 17.2 of total Portuguese international outsourcing in the manufacturing industry in 2002, respectively.

When the Hummels et al. (2001) methodology is applied to the Portuguese manufacturing industry, vertical specialization increases from 19.5 per cent to 23.1 per cent of total Portuguese exports from 1980 to 1992, rising sharply afterwards to 35.5 per cent in 2002. The highest contributions are also those of the "Machinery" and "Transport Equipment" sectors, which represent together 52.7 per cent of total Portuguese vertical specialization in 2002. Considering the two main trade partners, vertical specializa-

tion exports to Germany are mainly concentrated in the "Machinery" and "Transport equipment" sectors, while exports to Spain are more widespread across sectors.

It should be noted that, although measures based on Input-Output tables show increases in the Portuguese international fragmentation of production over the last decades, other economies have witnessed much stronger dynamics. More specifically, the results of the relative measure proposed by Amador and Cabral (2008*a*) indicate that vertical specialization activities in the Portuguese economy have been increasing at a pace lower than that of other countries, notably in East Asia.

Taking a narrower approach, statistics on international trade in parts and components have been used in the literature to compute a proxy of international fragmentation of production. The share of parts and components in total Portuguese international trade exhibits an upward trend over the last twenty years, from 11.5 per cent of total trade in 1988-92 to 15.4 per cent in the average of the 2003-07 period. This increase is significant during the nineties, resulting mostly from the strong growth of exports of parts and components. However, a nearly stabilization is evident in the most recent period, basically associated with a decrease in the share of imports of parts and components since 2004. In sectoral terms, the industries of parts and components for automobiles and, to a lesser extent, of electronic circuits play the leading roles, supplying not only the domestic industry but also integrating worldwide supply chains. As for the geographical distribution, the share of the five main trade partners in total imports of parts and components increases by around 10 percentage points between 1988 and 2007. Conversely, the share of the same five partners in total exports of parts and components declines by around 20 percentage points in the same period. In addition, there was a substantial increase in the share of Singapore as a destination of Portuguese exports of parts and components in the last five years.

Processing trade stands as a very specific component of the international fragmentation of production. These statistics reflect trade associated with customs arrangements in which tariff exemptions or reductions are granted in accordance to the domestic input content of imported goods. In Portugal, these operations represent less than 2 per cent of total trade over the 1988-2007 period. Inward processing trade is overwhelmingly dominant, indicating that Portugal is more a destination than an origin of processing activities. In sectoral terms, "Machinery" and "Transport equipment" are again the most important sectors.

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Appendices

APPENDIX A
International outsourcing in the Portuguese manufacturing industry as a share of total output
Contribution of each sector in percentage points

	Broad measure						Narrow measure					
	1980	1986	1992	1995	1999	2002	1980	1986	1992	1995	1999	2002
Food	1.71	0.88	1.36	1.79	2.38	2.10	1.17	0.66	0.67	1.54	2.10	1.70
Tobacco	0.01	0.02	0.02	0.00	0.01	0.06	0.00	0.00	0.00	0.00	0.00	0.04
Textiles	1.86	2.51	3.09	3.09	3.24	2.88	1.43	2.12	2.66	2.37	2.49	2.16
Leather	0.49	1.10	1.20	1.22	1.14	1.04	0.23	0.63	0.89	0.90	0.85	0.76
Wood	0.31	0.25	0.34	0.16	0.27	0.36	0.15	0.09	0.20	0.12	0.22	0.27
Paper	0.39	0.44	0.59	1.10	1.13	1.09	0.34	0.33	0.37	0.90	0.91	0.79
Chemicals	2.93	2.84	2.17	2.00	1.79	1.84	2.82	2.73	2.03	1.93	1.70	1.74
Rubber and plastics	1.06	0.78	0.70	0.83	0.91	0.85	0.07	0.06	0.05	0.18	0.26	0.20
Other minerals	0.07	0.13	0.20	0.34	0.45	0.43	0.03	0.07	0.09	0.08	0.15	0.12
Metals	0.22	0.17	0.22	1.61	1.69	2.80	0.19	0.14	0.12	1.53	1.60	2.59
Machinery	1.24	1.35	2.65	4.36	5.01	5.11	1.02	1.16	2.47	3.36	3.88	3.90
Transport equipment	2.69	1.88	2.49	2.91	4.11	4.09	2.43	1.60	1.96	2.01	2.81	2.84
Other manufacturing	0.64	0.33	0.37	0.79	0.89	1.13	0.59	0.25	0.22	0.14	0.23	0.34
Total	13.6	12.7	15.4	20.2	23.0	23.8	10.5	9.8	11.7	15.1	17.2	17.4

APPENDIX B

Contributions to the change in the share of international outsourcing in total Portuguese manufacturing output

Contribution of each sector in percentage points

	Contribution of change in the sector´s outsourcing intensity						Contribution of change in the sector´s share of total output						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	-0.88	0.60	0.62	0.72	0.01	**1.16**	0.05	-0.12	-0.19	-0.13	-0.29	**-0.77**	-0.83	0.48	0.43	0.59	-0.28	**0.39**
Tobacco	0.00	0.00	-0.01	0.00	0.04	**0.03**	0.00	0.01	-0.01	0.00	0.01	**0.01**	0.00	0.01	-0.02	0.00	0.05	**0.05**
Textiles	0.59	1.02	0.23	0.45	-0.07	**2.00**	0.07	-0.44	-0.23	-0.30	-0.28	**-0.97**	0.66	0.57	0.00	0.15	-0.35	**1.03**
Leather	0.30	-0.33	0.10	0.05	-0.02	**0.17**	0.30	0.43	-0.08	-0.14	-0.07	**0.38**	0.60	0.10	0.02	-0.08	-0.10	**0.55**
Wood	0.04	0.05	-0.14	0.09	0.08	**0.15**	-0.10	0.04	-0.04	0.02	0.01	**-0.10**	-0.06	0.09	-0.18	0.11	0.09	**0.05**
Paper	-0.01	0.14	0.29	0.18	0.04	**0.53**	0.07	0.00	0.23	-0.15	-0.07	**0.18**	0.06	0.14	0.52	0.02	-0.03	**0.71**
Chemicals	-0.79	0.05	0.40	0.05	0.08	**0.03**	0.70	-0.73	-0.57	-0.27	-0.02	**-1.12**	-0.09	-0.68	-0.17	-0.22	0.06	**-1.09**
Rubber and plastics	-0.12	-0.02	-0.11	-0.02	-0.09	**-0.39**	-0.16	-0.06	0.23	0.10	0.02	**0.18**	-0.28	-0.08	0.12	0.08	-0.06	**-0.21**
Other minerals	0.07	0.05	0.09	0.07	-0.06	**0.27**	-0.01	0.02	0.05	0.04	0.04	**0.09**	0.06	0.07	0.14	0.11	-0.02	**0.36**
Metals	0.01	0.02	1.33	0.10	0.21	**2.10**	-0.06	0.04	0.06	-0.02	0.90	**0.47**	-0.05	0.05	1.38	0.08	1.11	**2.57**
Machinery	0.17	0.39	1.28	-0.02	-0.05	**1.89**	-0.07	0.92	0.44	0.67	0.15	**1.98**	0.10	1.30	1.71	0.65	0.10	**3.87**
Transport equipment	-0.39	0.24	0.42	0.26	0.00	**0.55**	-0.42	0.37	0.00	0.93	-0.02	**0.84**	-0.81	0.61	0.42	1.20	-0.02	**1.39**
Other manufacturing	-0.09	-0.13	-0.06	0.02	0.10	**-0.52**	-0.22	0.17	0.48	0.08	0.14	**1.01**	-0.31	0.03	0.42	0.10	0.25	**0.49**
Total	-1.10	2.07	4.44	1.97	0.27	**7.97**	0.16	0.64	0.36	0.83	0.51	**2.18**	-0.95	2.71	4.80	2.80	0.78	**10.15**

APPENDIX C

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

APPENDIX D

Contributions to the change in the share of vertical specialization in total Portuguese manufacturing exports

Contribution of each sector in percentage points

	Contribution of change in the sector´s VS intensity						Contribution of change in the 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**

APPENDIX E
Portuguese international trade of parts and components
Share in total trade, percentage

	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
Imports of parts and components	8.5	8.1	7.5	7.8	7.8	7.7	7.5	8.2	9.1	9.0
Imports of parts and components of machinery (BEC 42)	4.0	3.8	3.8	4.0	3.9	3.9	3.9	4.6	4.5	4.3
Imports of parts and components of transport material (BEC 53)	4.5	4.3	3.7	3.8	3.9	3.8	3.6	3.6	4.6	4.7
Exports of parts and components	3.3	3.7	3.5	3.5	3.7	4.1	4.6	5.5	5.1	4.8
Exports of parts and components of machinery (BEC 42)	1.4	1.5	1.4	1.4	1.2	1.0	1.2	1.8	1.5	1.8
Exports of parts and components of transport material (BEC 53)	1.9	2.1	2.1	2.1	2.5	3.1	3.4	3.8	3.5	3.0
Total trade of parts and components	11.8	11.8	11.0	11.3	11.5	11.8	12.1	13.7	14.2	13.8

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Imports of parts and components	9.3	9.1	8.7	9.0	9.1	9.4	8.7	8.3	8.2	7.5
Imports of parts and components of machinery (BEC 42)	5.0	4.9	4.8	4.9	4.9	5.1	4.7	4.9	5.0	4.3
Imports of parts and components of transport material (BEC 53)	4.3	4.2	3.9	4.1	4.2	4.3	4.0	3.4	3.2	3.1
Exports of parts and components	5.3	5.7	5.7	5.9	6.6	7.2	6.9	6.6	7.0	6.9
Exports of parts and components of machinery (BEC 42)	2.0	2.0	1.8	2.3	2.4	2.9	2.8	2.8	3.3	2.9
Exports of parts and components of transport material (BEC 53)	3.3	3.7	3.9	3.6	4.2	4.4	4.1	3.8	3.7	4.0
Total trade of parts and components	14.6	14.9	14.4	14.9	15.7	16.6	15.5	14.9	15.3	14.4

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