

# The Effects of International Fragmentation of Production on Trade Patterns: an Empirical Assessment\*

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## Abstract

Does fragmentation of production affect the trade patterns of different countries in similar ways? In contrast with current theories of vertical specialization, attempts to provide empirical evidence on this question have been based, in the vast majority of cases, only on a statistical analysis of trade flows. I propose a computable general equilibrium model of trade and fragmentation that allows me to capture the effects of vertical specialization on the export performances of different countries in individual sectors. It is a comprehensive framework, which combines comparative advantages (both of the Ricardian and Heckscher-Ohlin type) with other characteristics of the economies (sizes, market structure, investments in R&D) and takes into consideration the role of the employment of domestic and imported intermediates in the production of exported and non-exported final goods. The model is used to explain the differences in French and Japanese exports of manufactured goods (relative to US) toward other OECD countries over the period 1980-1994. In particular, the model highlights the propensity of France to vertically specialize its activities in order to fill possible gaps in terms of innovation and TFP, while the negative impact of fragmentation on Japanese exports shows a disinclination to use imported intermediates in the production of the exported goods.

**Key words:** Fragmentation of production; Vertical specialization; General equilibrium model of trade; Export performances

**JEL classification:** F10; F12; F14.

<< *Figures at the end of the paper* >>

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## 1. Introduction

In the last few decades a rapidly increasing integration of the global economy has been observed. A general increase of trade/GDP ratios has been experienced by all the OECD countries. The reasons for this are usually said to involve the higher and higher share of services traded, the decline of transport cost and tariffs (trade liberalization), the greater similarity of countries' sizes (in the economic sense), etc. But as Jones and Kierzkowski (2001) argue another reason is the fact that a larger part of production activity is now intensively affected by trade.

Increasing competition in the world economy has forced producers to look outside their own borders to reduce costs. As Feenstra (1998) claims «the rising integration of world markets has brought with it a *disintegration* of the production process, in which manufacturing or services activities done abroad are combined with those performed at home». The result of this process has been defined as *fragmentation of production*.

A production process is fragmented when it is split into two or more steps that can be undertaken in different locations but that lead to the same final product. The decision to locate abroad phases of the production process should be determined by the presence of some kind of comparative advantage offered by the country chosen. But a new meaning for comparative advantage is required in this context: when fragmentation takes place, delocalization of production segments is not necessarily induced by differences in technology or in factor endowments as in the orthodox frameworks, but it can occur because of differences in the absolute level of labor cost. In fact, when the role of intermediate goods is considered, a trade flow can be originated by the existence of an absolute cost advantage and by the specific combination of phases of production taking place in different countries.

The ways in which international fragmentation of production takes place are many and that is why the literature the same phenomenon is described in many different ways: delocalization of production, vertical specialization, outsourcing, etc. But, as Hummels et al. (2001) state, the key idea behind fragmentation is that «countries increasingly link sequentially to produce goods». And following strictly their contribution it can be said that it occurs when:

- a) a good is produced in two or more sequential stages;
- b) two or more countries provide value-added during the production of goods;
- c) at least one country must use imported inputs in its stage of the production process and some of the resulting output must be exported.

An import side and an export side are thus involved in the definition, as long as vertical specialization is more than the share of intermediate goods in general trade; it is the subset of imported intermediates that will be embodied in exported goods.

So internationalization of production has made the trade flows change not only quantitatively, but also qualitatively.

According to Yi (2002) vertical specialization is not merely one of the reasons for the increase in the volume of world trade observed in the past half-century, but it is the key-reason. In fact, fragmentation of production «can serve as a propagation mechanism magnifying tariff reductions into large increases of trade», allowing for an explanation of the puzzle of the non-linearity of trade growth with respect to the observed decrease in the level of tariffs.

Fragmentation may be considered as a manifestation of globalization and technology combined. In fact, in some industries the possibility of splitting the process of production and coordinating the resulting parts has been possible only thanks to advances in technology.

But the fragmentation of production does not effect efficiency, leading to cost savings and increases in trade. It has also a strong impact on domestic employment which is significantly different for skilled and unskilled workers. The absolute cost advantage that delocalization offers to developed countries in terms of unskilled wages will cause a movement of activities that intensively use unskilled labor towards developing countries. The domestic relative demand for unskilled workers will then fall in a similar way as replacing these workers with automated production. So as Feenstra (1998) claims: «this means that outsourcing has a qualitatively similar effect on reducing the demand for unskilled relative to skilled labor within an industry as does skill-biased technological change».

In this contribution I strictly focus on the effects of fragmentation on trade patterns. I shall proceed by discussing the main contributions to the theoretical treatment of the phenomenon, and the reliability of the indices used so far to measure it. I shall then present a general equilibrium model of trade and fragmentation that allows me to take simultaneously into account all the main findings of the theory. This framework will be empirically applied to understand how vertical specialization may affect in different ways the exports performances of different countries. Evidence will be provided for French and Japanese exports, relative to the US, to the rest of the OECD.

## **2. Fragmentation and trade patterns: theory and evidence**

Deardorff (1998) tries to explain fragmentation's implications on the basis of the textbook Ricardian framework of comparative advantages. He provides a clear and systematic theoretical treatment of the phenomenon, but he seems to overlook many important aspects both in terms of the causes and effects of fragmentation. In fact, he finds that if the country is specialized in the production of a certain good, X, and there is the possibility for a costly fragmentation of the X industry, the price conditions under which the country moves from one specialization to another might change slightly, but with

non significant changes in trade patterns. Instead, if fragmentation became possible in the import good industry, Y, under special price conditions, a comparative advantage in this good may rise. There will then be room for a significant change in the patterns of trade. But what is missing in the analysis of Deardorff is a clear distinction between exported final goods fully produced domestically and exported final good produced by a fragmented technology. As Baldone et al. (2001) explain, comparative advantages can be derived unambiguously only for the first type of good as long as it fully incorporates the country specific relative endowment, technology and characteristics. In fact, the second type sums up different countries' specific advantages, so it would be misleading to say that the country exporting it is the one with a comparative advantage. Other factors should be taken into account like possible absolute cost advantages (for example, those deriving from a specific combination of phases of production) which makes its export profitable for the country in which it is completed. Thus, with the presence of fragmentation of production the directions of trade will not follow just the suggestions of the standard theory, and comparative advantages are not the only determinants of trade patterns.

In a subsequent paper Deardorff (2001) provides a reorganization of the main results obtained with the preceding analysis and focuses on other features of the phenomenon. One of these is the effect of trade barriers, such as transport costs and tariffs, on fragmentation. In particular, it is not difficult to see that if there is no barrier to trade in a good, X, but there is one to trade in any intermediate input, Z, coming from the fragmented production of X, then fragmentation may become unprofitable even if it would otherwise lower costs. This happens every time a not very large tariff is required to raise the cost above the one resulting from producing X with the old technology. So a tariff may prevent fragmentation from occurring. On the other hand, if there is a barrier to trade in X, but none to trade in Z, then even costly fragmentation can be profitable. To sum up, fragmentation can be both encouraged and discouraged by trade barriers and the presence of obstacles to the transactions and other trade costs cannot be ignored when the phenomenon is studied.

As we depart from the assumptions of orthodox frameworks (perfect competition, homogeneous products, etc.) to encounter the more realistic ones of the new theories (non-competitive markets, differentiated products, etc.) we face a significantly different approach to the theoretical treatment of the phenomenon of outsourcing.

Grossman and Helpman (2002a, 2002b), firstly define a general equilibrium model of industrial structure in which outsourcing and vertical integration (all the activities undertaken within the same firm) are considered as possible outcomes of an organizational process endogenous to a single industry, and then they extend their methodology in order to analyze the possible effects in a global market. The focus is on the so-called "make-or-buy" decision. The dilemma is about incurring the high cost of production faced by a vertically integrated firm, basically due to the large number of divisions to

be managed and to the absence of the learning spillovers deriving from specialization, or to face the costs of outsourcing, represented by the possible frictions in the search for a partner that which will provide suitable intermediate products in the quantities and qualities required and by the imperfect contracting arising descending from the impossibility for a third part to verify the presence in the inputs of all the required attributes. They show that in a multi-industry model with differentiated products of consumption, where the search is modelled as a matching process and where contracting is incomplete, the size of the country matters as long as it affects the "thickness" of its market. Furthermore, innovation in technology plays a crucial role as long as it affects the willingness of a partner to tailor its intermediates to the final product and to undertake investments in a prototype. But there are also some country specific conditions to be taken into account: the effectiveness of the search technology is influenced by the availability of good infrastructures for communication and transportation, and different contracting environments imply different profitabilities of outsourcing in different countries. These findings define a set of conditions for fragmentation to occur that are strictly related to the economic structures of the countries involved in the outsourcing process. Thus they reveal the capability of a country to engage in the international fragmentation of its own production activities and we can expect this capability to be clearly reflected in trade patterns.

Notwithstanding the early stages of the theoretical treatment of the phenomenon, an increasing amount of evidence about the increasing importance of the phenomenon has been provided. Unfortunately, the empirical work has been so far almost entirely based on a strict statistical analysis of trade flows and no relevant attempts to incorporate fragmentation in an empirical general equilibrium model of trade have been done.

Among the others, particularly interesting seems to be the contribution of Baldone-Sdogati-Tajoli (2001) that in order to observe the trends of the fragmentation of production within EU refer to the general concept of Processing Trade (PT)<sup>1</sup>. Processing Trade can be decomposed in two specific components, Inward Processing Trade (IPT) and Outward Processing Trade (OPT), by means of which it can be stated if a country is either a destination of fragmented production activities or an origin of fragmentation activities. The advantage of these kind of measures is represented by the availability of data at high level of merchandise disaggregation allowing for a deep sectoral analysis, but there are two major drawbacks: they tend to underestimate the level of fragmentation that has actually occurred<sup>2</sup>, and data are available just for EU countries because of

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<sup>1</sup>PT is a particular EU's trade regime which consist in a separate registration of flows concerning final goods with respect to those concerning intermediate goods exported (imported) temporarily in order to be processed and then re-imported (re-exported) by the country of origin.

<sup>2</sup>Fabbris and Malanchini (2000) point out that only the firms endowed with a licence and respecting some requirements (among the others, goods exported for processing should originate in the EU) can temporarily send Community's goods outside the EU custom territory under this special trade regime.

the juridical status granted to OPT within the EU trade legislation. Thus, measures like the ones discussed cannot be used for a more general analysis that takes into account Non-EU countries as principals.

A different measure is proposed by Hummels et al. (2001). Their index allows the researcher to capture the amount of vertical specialization for a country that uses imported inputs to produce exported goods. The VS index for a country  $k$  in the sector (good)  $i$  is defined as the imported input content of exports ("share of imported inputs into gross production - IIGP" multiplied by "exports") or as the foreign value-added embodied in exports:

$$VS_{ki} = \left( \frac{\text{imported intermediates}_{ki}}{\text{gross output}_{ki}} \right) \text{exports}_{ki} = \left( \frac{\text{exports}_{ki}}{\text{gross output}_{ki}} \right) \text{imported intermediates}_{ki}.$$

The availability of data, provided by the OECD's Input-Output tables for a large number of countries, is certainly the main advantage offered by the VS measure, but there are at least three more technical advantages of the I-O tables that are worth considering: a) arbitrariness of classification schemes (what is "intermediate"? what is "final"?) is avoided, b) data are available for disaggregated sectors, c) imported inputs used "indirectly" in the production of exported goods are taken into account. The latter feature is very useful as long as it allows us to consider the case in which imported inputs «circulate through several stages of the domestic economy before "exiting" as an export».

On the other hand, it should be noticed that if there is a positive or negative correlation between the two components of the VS (IIGP and exports) within a sector, a computation that involves I-O sector-level data will be respectively downward or upward biased. So the VS measure must be handled carefully. However, this kind of measure tends to consider a large number of the many possible cases of fragmentation (one, two or more border crossing) while the OPT considers just a special case of transactions for processing purpose. Fabbri and Malanchini (2000) underline that OPT is only a subset of vertical specialization defined in this far more general sense.

### 3. A general equilibrium model of trade and fragmentation

From the proposed theoretical and empirical survey I can round up the elements that seem to play the key-roles in the explanation of the effects of international fragmentation of production on trade patterns. Comparative advantages (differences in endowments and technologies) seem to act differently than usual with respect to the determination of trade patterns in a world with fragmentation of production, but they are still effective. So Ricardian and Heckscher-Ohlin theories should not be dismissed. On the other hand, the more realistic frameworks defined in the New Theories approach provide the

instruments to catch significant features of the exchanges: differentiation of products and intra-industry trade, the role of the economies' sizes, the role of innovation in technology. Furthermore, trade barriers can both encourage or discourage fragmentation of production so they should be taken into account and possible country-specific effects cannot be ignored. Finally, in order to measure and evaluate the effect of the phenomenon it is necessary to consider the intermediate goods content of trade, but this should be achieved by means of an index that minimize the possible measurement biases.

It seems clear that in order to consider such a wide range of elements, a very comprehensive framework is required. I believe this can be accomplished through the extension of the model proposed by Chaudhri and Hakura (2000). It is a framework set up on the basis of an integrated Ricardo-Heckscher-Ohlin-New Theories approach, which defines a general equilibrium model of trade with monopolistic competition<sup>3</sup>.

The basic equation is represented by the following relative export relation of two countries ( $j, k$ ) toward a common third country ( $m$ ) for a given sector ( $i$ ):

$$\frac{X_i^{jm}}{X_i^{km}} \equiv \left( \frac{F_i^j}{F_i^k} \right) \left( \frac{B_i^{jm}}{B_i^{km}} \right)^{-\sigma} \left( \frac{C_i^j}{C_i^k} \right)^{1-\sigma} \left( \frac{A_i^j}{A_i^k} \right)^{-(1-\sigma)}. \quad (1)$$

The first component on the right-hand side (relative employment of the composite factor,  $F_i^j/F_i^k$ ) proxies for the ratio of the number of firms in the industry, or the relative size of the two countries. The second component on the right-hand side,  $B_i^{jm}/B_i^{km}$ , accounts for trade barriers and trade costs. The relative cost of the composite factor,  $C_i^j/C_i^k$ , represents the Heckscher-Ohlin part of the model, accounting for endowments. The relative productivity term,  $A_i^j/A_i^k$ , takes into account possible Ricardian explanations in terms of Hick-neutral technical differences across industries and countries.

Further characteristics, such as innovation in technology and country-specific effects, can be introduced in the model's econometric implementation.

### 3.1. The econometric implementation

The model allows one to estimate the relative export,  $\left( \frac{X_{it}^{jm}}{X_{it}^{km}} \right)$ , of two countries ( $j, k$ ) to a third one, of the goods produced in the sector  $i$  at time  $t$ , on the basis of the log-linear form of the equation (1),

$$\ln \left( \frac{X_{it}^{jm}}{X_{it}^{km}} \right) \equiv a_0 \ln \left( \frac{B_{it}^{jm}}{B_{it}^{km}} \right) + a_1 \ln \left( \frac{F_{it}^j}{F_{it}^k} \right) + a_2 \ln \left( \frac{A_{it}^j}{A_{it}^k} \right) + a_3 \ln \left( \frac{C_{it}^j}{C_{it}^k} \right) + e_{it}^m, \quad (2)$$

where  $a_0 = -\sigma$ ,  $a_1 = 1$ ,  $a_2 = \sigma - 1$ ,  $a_3 = 1 - \sigma$ ,  $e_{it}^m$  is a stochastic residual.

This kind of specification does not consider explicitly the effects of trade in intermediates as long as they are incorporated in the definition of the composite factor,  $F_i$ .

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<sup>3</sup>The model is fully described in the Appendix A.

I isolate in the equation the intermediate inputs variable by the assumption that the industry total use of the composite factor in country  $j$  is defined by a Cobb-Douglas function

$$\ln F_{it}^j = k_i \ln K_{it}^j + w_i \ln L_{it}^j + \sum_r \theta_i^{zr} \ln Z_{it}^{jr}, \quad (3)$$

where  $K_{it}^j$  is the quantity of capital used,  $L_{it}^j$  is the amount of labour employed,  $Z_{it}^{jr}$  is an aggregate measure of the intermediate inputs produced in sector  $r$  and employed in sector  $i$ ;  $w_i$ ,  $k_i$  and  $\theta_i^{zr}$  are the shares of the three factors used to form one unit of the output<sup>4</sup>.

The intermediates component of the composite factor can be approximated by the following expression

$$\ln Z_{it}^j = \sum_r \theta_i^{zr} \ln Z_{it}^{jr} \cong \theta_i \ln \tilde{Z}_{it}^j = \theta_i \left( \ln \tilde{I}_{it}^j + \ln \widetilde{VS}_{it}^j \right), \quad (4)$$

where  $\theta_i$  is the overall share of intermediates in the formation of the composite factor,  $\tilde{Z}_{it}^j$  is an aggregate measure of the employment of intermediate inputs that can be decomposed in two parts:  $\tilde{I}_{it}^j$  represents the amount of domestic and imported intermediates employed in the production of goods sold on the domestic market,  $\widetilde{VS}_{it}^j$  represents the imported intermediates content of export (vertical specialization).

Therefore, by means of (4) I can write equation (3) as

$$\ln F_{it}^j = \ln PF_{it}^j + \ln Z_{it}^j = \ln PF_{it}^j + \ln \tilde{I}_{it}^j + \ln \widetilde{VS}_{it}^j, \quad (5)$$

where the contributions of the primary factors,  $\ln PF_{it}^j = k_i \ln K_{it}^j + w_i \ln L_{it}^j$ , and the role of intermediates in the formation of the composite factor,  $\ln \tilde{I}_{it}^j = \theta_i \ln \tilde{I}_{it}^j$  and  $\ln \widetilde{VS}_{it}^j = \theta_i \ln \widetilde{VS}_{it}^j$ , are considered separately.

In order to take into account the possible effects of technological innovation, I provide the equation with a new variable able to act as measure of the R&D effect. The assumption to make is about the form of the value-added function that is supposed to be a Cobb-Douglas of the following type

$$\ln Y_{it}^j = \ln \tilde{A}_{it}^j + (1 - \tilde{w}_i) \ln K_{it}^j + \tilde{w}_i \ln L_{it}^j, \quad (6)$$

where  $Y$  represent the output in the sector  $i$ ,  $K$  is the capital employed,  $L$  is the labor employed,  $\tilde{w}_i$  and  $(1 - \tilde{w}_i)$  are the proportions in which the two factors contribute to the formation of the value-added. Considering a shift of the curve due to the R&D, I can simply define a new function

$$\ln Y_{it}^j = \left( \ln \widetilde{TFP}_{it}^j + \ln \widetilde{R\&D}_{it}^j \right) + (1 - \tilde{w}_i) \ln K_{it}^j + \tilde{w}_i \ln L_{it}^j, \quad (7)$$

where I assume the Solow residual to consist of two components,  $\ln \tilde{A}_{it}^j = \ln \widetilde{TFP}_{it}^j + \ln \widetilde{R\&D}_{it}^j$ , the first accounting for total factor productivity and the second for the effects of investments in research and development activities.

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<sup>4</sup>Of course, the sum of the three coefficients will equal 1.

The total use of the composite factor and the Solow residual are linked by the following output relation

$$\ln Q_{it}^j = \ln A_{it}^j + \ln F_{it}^j, \quad (8)$$

where  $\ln A_{it}^j = y_i \ln \tilde{A}_{it}^j$ ,  $y_i$  being the share of value added in the value of output<sup>5</sup>. It follows that

$$\ln A_{it}^j = y_i \ln \tilde{A}_{it}^j = y_i \left( \ln \widetilde{TFP}_{it}^j + \ln \widetilde{R\&D}_{it}^j \right) = y_i \ln \widetilde{TFP}_{it}^j + y_i \ln \widetilde{R\&D}_{it}^j = \ln TFP_{it}^j + \ln R\&D_{it}^j. \quad (9)$$

I can compute the unit cost for the employment of the composite factor by the relation

$$\ln C_{it}^j = k_i \ln R_t^j + w_i \ln W_t^j + \sum_r \theta_i^{zr} \ln P_{it}^{jr},$$

where  $R_t^j$  is the rental rate in the country  $j$ ,  $W_t^j$  is the wage rate in the same country<sup>6</sup>,  $P_{it}^{jr}$  is the price index for the intermediates. This index is affected by the number of varieties produced in the industry and by their domestic and foreign prices. Anyway, if inter-country differences in prices are assumed to be small, the computation of the unit cost of the composite factor can be simplified by considering the intermediates' prices equal in all the countries ( $P_{it}^{jr} = P_{it}^{kr}$ ) and the inputs traded and produced in monopolistic-competitive sectors. Thus I have

$$\ln \tilde{C}_{it}^j = (1 - \tilde{w}_i) \ln R_t^j + \tilde{w}_i \ln W_t^j, \quad (11)$$

$$\text{and } \ln C_{it}^j = y_i \ln \tilde{C}_{it}^j.$$

The variable accounting for trade barriers should take in consideration all the possible ways in which the obstructions to trade could rise: tariffs, non-tariff barriers, transport cost. Such a composite index cannot be computed because of the extreme variability of trade barriers across country pairs and time. I can then decompose the variable into two elements accounting respectively for specific time and country pair effects in a given market  $m$ ,

$$\ln \left( \frac{B_{it}^{jm}}{B_{it}^{km}} \right) = \beta^{jkm} + \beta_t^m. \quad (12)$$

Through (5), (9) and (12), I can finally restate the export relation as

$$\ln \left( \frac{X_{it}^{jm}}{X_{it}^{km}} \right) \equiv \beta^{jkm} + \beta_t^m + a_1 \ln \left( \frac{PF_{it}^j}{PF_{it}^k} + \frac{I_{it}^j}{I_{it}^k} \right) + a_2 \ln \left( \frac{VS_{it}^j}{VS_{it}^k} \right) + a_3 \ln \left( \frac{TFP_{it}^j}{TFP_{it}^k} \right) +$$

<sup>5</sup>Of course, we can write  $k_i = y_i(1 - \tilde{w}_i)$ ,  $w_i = y_i \tilde{w}_i$ .

Thus,  $\ln Q_{it}^j = \ln A_{it}^j + \ln F_{it}^j = y_i \ln \tilde{A}_{it}^j + \ln F_{it}^j = y_i [\ln Y_{it}^j - (1 - \tilde{w}_i) K_{it}^j - \tilde{w}_i L_{it}^j] + k_i \ln K_{it}^j + w_i \ln L_{it}^j + \sum_r \theta_i^{zr} \ln Z_{it}^{jr} = y_i \ln Y_{it}^j - y_i(1 - \tilde{w}_i) K_{it}^j - y_i \tilde{w}_i L_{it}^j + k_i \ln K_{it}^j + w_i \ln L_{it}^j + \sum_r \theta_i^{zr} \ln Z_{it}^{jr} = y_i \ln Y_{it}^j + \sum_r \theta_i^{zr} \ln Z_{it}^{jr}$ .

<sup>6</sup>The assumption of free mobility of factors ensures that both the rental and wage rates are equal in all sectors.

$$a_4 \ln \left( \frac{R\&D_{it}^j}{R\&D_{it}^k} \right) + a_5 \ln \left( \frac{C_{it}^j}{C_{it}^k} \right) + e_{it}^m.$$

This is the equation that will be tested empirically.

#### 4. A Study Case: The Effects of Fragmentation on the Trade Patterns of France, Japan and US

In order to estimate the general equilibrium model presented in the previous chapter, I have to create a database containing six variables (one dependent, five independent) for the manufacturing sectors of the different economies. The indices are built on the basis of data available for the most of the OECD's members<sup>7</sup>. This gives me the opportunity to focus on the possible different effects of fragmentation of production on the trade patterns of three developed economies that are structurally different: France, Japan, US.

In fact, dissimilarities in endowments, technologies, sizes, innovation as well as different geographical characteristics may raise different opportunities to fragment the production processes and thus affect in a different way the exports.

Being the leading economy in the world, the US is chosen as the benchmark, so I will estimate two relations: the relative export of France with respect to US and the relative export of Japan with respect to US, both toward the rest of the OECD countries.

Some general idea about the ways in which fragmentation of production has been affecting the production process in the three countries over time and whether they present sensible discrepancies regarding their attitude to vertically specialize can be drawn through a closer look to the trends in the employment of domestic and foreign intermediates. I consider a disaggregated manufacturing sector (11 industries) on the basis of OECD's Input-Output Tables data<sup>8</sup>.

##### 4.1. United States

According to Hummels et al. (2001), the US is one of the countries that presents an increase in the overall VS share from 5% to 10% in the three decades that lie between 1970 and 1990. Feenstra (1998) points out that the US's preferred regions for outsourcing activities are Eastern Asia and Central America with Mexico playing a major role in the latter area.

For the manufacturing sectors I observe that the employment of domestic intermediates has been increasing in the early 1970s and then it has remained constant (Fig. 1) while the shares of imported intermediate inputs over gross output present an upward trend for most of the industries (Fig. 2).

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<sup>7</sup>See Appendix C for the construction of the series.

<sup>8</sup>A detailed list of the sectors and the level of aggregation considered can be found in Appendix B.

In Figure 3, the trends of the Vertical Specialization index (imported intermediates content of export) for the manufacturing sectors depict a significant increase over the whole period with the Machinery, Transport equipments and Chemicals sectors giving a major contribution.

#### **4.2. France**

The structures of production and export of France present the typical key features of the developed European economies. Similarly to Germany, Italy and UK, about 70% of the export is toward the rest of the EU. For what concerns fragmentation of production, a common feature for the majority of EU members is the growing share of intermediate goods in total trade flows. This is pointed out by Fabbri and Malanchini (2000) who underline the increasing importance of Outward Processing Trade with respect to total trade. France together with Germany, Italy, the Netherlands and Austria, account for about 90% of total flows generated by European member states toward the Central Eastern Europe Countries (CEECs). Because of historical and economic connections, France was among the first to outsource activities to firms located in the Mediterranean basin (Northern Africa Countries) over last few decades. But its dominance in this region seems to be progressively lost in favor of the upward involvement of Germany. On the other hand, the weight of France's activities in the CEECs has been significantly growing over the 1990s despite the first mover advantage enjoyed by Germany for proximity reasons both in geographical, economic and political terms. Baldone, Sdogati and Tajoli (2001) observe that France displays «a high propensity to international fragmentation of production both in terms of IPT and OPT».

Figures 4 and 5 show that, in the three decades (1970-1990), France experienced a considerable increase in the employment of imported intermediates as opposite to the negative trend in the domestic intermediates/gross output ratio with no significant differences across the manufacturing sectors. As a consequence, in the same time period, a remarkable rise in the VS index can be observed for the whole manufacturing sector with a primary role played by the Chemicals, Machinery and Basic Metal sectors (Fig.6).

#### **4.3. Japan**

Japan represents a notable exception to the general trend. As Hummels et al. (2001) notice «for every country but Japan, the VS share grew between the initial and final year of the sample». In particular, there is a drop in the overall VS share from 7.3% to 6.6%. But for the manufacturing sectors I find a slightly different reality. If the employment of domestic intermediates is generally constant over the all period (Fig.7), the employment of imported intermediates show an upward trend even if substantial differences can be observed across the industries (Fig. 8). However, the VS index is

clearly increasing for the Manufacturing Sector considered as a whole, with sectors like Chemicals, Basic Metal, Food and Machinery being the more vertically specialized (Fig. 9).

On the basis of this first-sight comparison evidence I would say that these three countries present very dissimilar profiles, with the production structure of France being the most affected by the phenomenon of the international fragmentation as opposed to Japan that seems not to consider very attractive the perspective of vertically specializing its activities.

The US presents a profile located somewhere in the middle of the first two: it is not as “closed” as Japan, but it is not as “open” as France either. This is an ideal feature with respect to my intention to use this country as a benchmark case in estimating the model. In fact, I would expect fragmentation of production to have a more substantial effect on the performance of the French exports compared to the one it has in the case of Japan.

#### 4.4. Estimation of Relative Exports and Results

In Table 1, I present the results obtained for France applying a panel data analysis to the data collected for 10 manufacturing sectors over a 15 years period<sup>9</sup>.

**Table 1.** Estimates FRANCE/US toward OECD 1980-1994

Dependent Variable: EXPORT		
10 manufacturing sectors out of 11 (missing Other Manufacturing)		
Estimation Technique:	Model with VS	Model without VS
	Random Effects with Specific Time Effects	Random Effects with Specific Time Effects
FACTOR	0.428478764** (3.58780)	0.507262872** (5.20403)
VS	0.214440617** (5.27190)	
TFP	0.180988133* (2.25984)	0.955967625** (6.39224)
R&D	1.607906292** (7.67777)	1.838467976** (10.30091)
COST	-0.269833034** (-3.61618)	-0.162864669* (-1.99328)
R-squared	0.424696	0.440106

NOTE: t-statistics in parenthesis. \* = Signif. 5%; \*\* = Signif. 1%.  
See Appendix A and B for the list of the sectors considered and the construction of the series.

Under Random Effects the coefficients obtained are consistent with the predictions of the model<sup>10</sup>. Differences in sizes, the vertical specialization index, productivity and

<sup>9</sup>The variables are renamed as follows

$$\text{EXPORT} = \ln \left( \frac{X_{it}^{jm}}{X_{it}^{km}} \right), \text{FACTOR} = \ln \left( \frac{PF_{it}^j}{PF_{it}^k} + \frac{I_{it}^j}{I_{it}^k} \right), \text{VS} = \ln \left( \frac{VS_{it}^j}{VS_{it}^k} \right), \text{TFP} = \ln \left( \frac{TFP_{it}^j}{TFP_{it}^k} \right),$$

$$\text{R\&D} = \ln \left( \frac{R\&D_{it}^j}{R\&D_{it}^k} \right), \text{COST} = \ln \left( \frac{C_{it}^j}{C_{it}^k} \right).$$

In the model with Vertical Specialization, the dependent variable EXPORT is regressed over all the other variables, while, in the model without Vertical Specialization the variables incorporating intermediates (VS and I) are not considered.

<sup>10</sup>The choice of the level of aggregation of factors and sectors and the interpolation of data for the VS variable could introduce an error in the measures of productivity and cost variables. If this is the case,

R&D expenditures have a positive effect on relative exports while difference in endowments affects them negatively. The coefficients are highly significant (all null hypotheses rejected at 1% level, with the exception of the TFP case) and the fit is acceptable. The country pair factor (specific-country effects and trade barriers) and the individual effects were found not be significant while the specific time effects have a considerable importance. The inclusion of the intermediate inputs role and the isolation of the VS component of trade does not improve the fit of the model in this case. On the other hand, the model with vertical specialization seems to provide further information with respect to the simpler one. In fact, the key-role is still played by the gap in the investment in Research & Development activities existing between the two economies, suggesting that the difference in the export toward the other OECD members could be credited to the difference in the grade of innovation incorporated, but when fragmentation of production is taken into account the absolute value of the R&D coefficient is reduced. Furthermore, the Ricardian component (differences in productivity) loses its importance and a decrease in the value of the coefficient related to the difference in sizes is observed as well. These findings suggest that fragmentation of production allows France to cope with the possible gap in productivity, innovation and market size. The Vertical Specialization variable shows, in fact, a positive impact on relative exports even if, in the case considered, it is not extremely high. This is probably due to the time period investigated: the unavailability of data did not allow us to consider the second half of the 1990s, which is the phase in which France established itself as one of the leading countries outsourcing activities to the Central and Eastern European Countries.

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the Fixed Effect methodology is less robust than the Random Effects one. This is a possible explanation for the different results obtained under the two methods (See Table 3 - Appendix D for further results).

For what concerns Japan, the estimation of the model in the same time period and for the same number of sectors led to the results presented in Table 2.

**Table 2.** Estimates JAPAN/US toward OECD 1980-1994

Dependent Variable: EXPORT		
10 manufacturing sectors out of 11 (missing Wood)		
	Model with VS	Model without VS
Estimation Technique:	Random Effects with Specific Time Effects	Random Effects with Specific Time Effects
INTERCEPT		-2.150835057** (-7.96890)
FACTOR	0.652736741** (18.30691)	0.774948648** (3.74497)
VS	-0.281122060** (-4.19751)	
TFP	0.581997196** (4.82106)	2.819298987** (6.66826)
R&D	0.634616594* (2.48015)	2.611273673** (5.21685)
COST	-0.527917437** (-4.24257)	-2.114352224** (-5.19358)
R-squared	0.759963	0.516719

NOTE: t-statistics in parenthesis. \* = Signif. 5%; \*\* = Signif. 1%.  
See Appendix A and B for the list of the sectors considered and the construction of the series.

Under Random Effects I have highly significant coefficients (5% for R&D, 1% for all the other variables). Considerations about country pair, individual and time specific effects are analogous to the French case, but now there is a strong improvement in the empirical performance of the model when intermediates are taken into account and there is a specific consideration of the VS impact. The fit of the model significantly increases ( $\Delta R$ -squared = 24%) and the amount of information contained in the intercept term in the model without VS is fully captured by the regressors of the model with VS. Here the differences in sizes, productivity and endowments seem to play an important role while the differences in expenditure in R&D activities have not a major impact on the relative export. This is very representative of the structural difference between the Japanese

and French economies when compared to the US. And, of course, this is not surprising as Japan is one of the leading countries for the innovation content of its exports and among the most disadvantaged regarding its endowments of raw materials. Krugman (1991) claims that «Japan must pay for its raw materials by running a trade surplus in manufactures, presumably by importing less. European countries do more than half their manufactures trade with each other; Japan has no neighboring advanced nation». This was especially true in the period considered in our analysis and should help us to understand why the negative sign for coefficient of the Vertical Specialization variable should not be seen as something unexpected.

For a long period Japan has been acting as an importer of raw materials more than intermediate goods. If we focus on the Eastern Asia region we can see that, during the 1980s, Japan has actually been exporting intermediate goods (mainly components for high-tech industries) and selling final products through domestic companies' affiliates. Furthermore, Park and Park (1991) argue that in the very same region U.S. has been playing an opposite role: «The East Asian NICs depend on the U.S. market for their exports of manufactured products and rely heavily on Japan as a major supply source of capital goods, intermediate inputs, technology, and management know-how. As a group, the four economies have also accumulated a growing trade surplus from their trade with the United States while running a large and persistent deficit with Japan since around the early 1970s». On the basis of these considerations the negative impact of Vertical Specialization on Japanese exports in the 15 years considered in my analysis is amply justified. It is noteworthy that the negativity of the sign is driven by the major impact in the Japanese export performance of the sectors in which Japan suffer a gap in Vertical Specialization with respect to US. In fact, if I drop the Transport Equipment sector the VS coefficient decreases dramatically and ceases to be significant<sup>11</sup>. However, I would hardly expect this negative sign to be persistent. In fact, as Ernst and Guerrieri (1998) point out, since the early 1990s Japanese firms have «begun gradually to open their International Production Networks» showing an increasing localization of component sourcing in Asia as well as a rapid growth of the imports of electronics products after the 1992. By consequence, considering that the high-tech industries account for the largest part of Japanese selling abroad, the imported intermediates content of exports is extensively growing. It is likely that if I could have relied on a larger database, this

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<sup>11</sup>Result about the regression mentioned can be found in the Table 5 - Appendix D. I also ran a regression that considered just the sectors in which Japan tends to fragment its production activities more than US and another one that took into account just the sectors in which the US propensity to vertically specialize was prevailing. As expected the sign for VS was positive in the first case and negative in the second. It should be noticed that among the sectors considered in the latter case there were Fabricated Metal Products, Machinery and Transport Equipment that are the most important Japanese exporting sectors. I think this finding support the robustness of the negative sign obtained for VS in the general estimation.

trend would be already highlighted.

## 5. Concluding Remarks

According to the theory there can be different reasons for a country to vertically specialize its production activities: for example, the existence of a comparative advantage in a phase of the production process or the exploitation of an absolute cost advantage. But when international fragmentation of production becomes possible new comparative advantages may arise and new patterns of trade can be shaped: the decomposition of the value added chain may give a country a comparative advantage in a good where it had no advantages before. Furthermore, having a comparative advantage in a single part of the production process may allow a country to branch into international markets with no need to be an efficient producer of an entire good. In addition, countries engage in the formation of international production networks in order to combine possible scale economies with the flexibility of decentralization.

Thus, vertical specialization can affect the direction of trade of each country in different ways depending on factors like differences in economic structures (size, competitiveness of markets, innovation content of production), differences in the endowments of factors and differences in productivity.

The comprehensive general equilibrium model of trade and fragmentation of production presented in this paper tries to explain the export performances of different countries considering simultaneously these elements. The econometric implementation and its application to a case study show that the framework is able to highlight the possible dissimilarity in the impact of vertical specialization on the exports of different countries. In particular, I compared the French and Japanese relative export with respect to the US toward OECD members for different manufacturing sectors. In the 15 years from 1980 to 1994 I found that, through its positive effect, fragmentation allowed France to reduce the gap in terms of productivity and innovation suffered with respect to United States. For what concerns Japan, I observed a significantly different picture: fragmentation of production played a very singular role with its impact being negative in the sectors in which the country enjoyed a better export performance. This is amply explained by the Japanese propensity to provide intermediate inputs, technology and capital in those sectors to its commercial partners (especially East Asian developing countries) in the period considered.

The bottom line is that the impact of fragmentation of production on trade patterns is not one-way and, as expected, depends strictly on the structural characteristics of the participants in the formation of international value chains.

These results are consistent with what had been found in the past through the statistical analysis of trade flows, but, coming from an all-inclusive theoretical and empirical framework, new information may be attached to them. The unavailability of

data prevented me from extending the analysis to the developing countries whose export performances might show very interesting features in the light of possible inclusions into international production networks.

An interesting development would be the inclusion in the model of an instrument that accounts for the role of geographic spillovers and their interaction with those arising because of international fragmentation of production.

## APPENDIXES

### A. The Model of Chaudhri and Hakura (2000)

Let  $I$  be the number of monopolistic-competitive industries in the  $J$  countries considered. It is possible to define the consumer demand for each variety produced in every single industry on the basis of a Dixit and Stiglitz (1977) utility function. Thus, assuming that the demand for final products and the demand for intermediates have the same form, country  $m$  demand for a variety produced in the sector  $i$  of a country  $j$  can be written as

$$d_i^{jm} = \frac{E_i^m \left( P_i^j B_i^{jm} \right)^{-\sigma}}{\sum_{k \in J} n_i^k \left( P_i^k B_i^{km} \right)^{1-\sigma}}, \quad (1)$$

where  $i = 1, \dots, I$  indexes sectors,  $E_i^m$  is the total expenditure in country  $m$  on domestic and foreign varieties produced in the considered sector,  $P_i^j B_i^{jm}$  is the price on country  $m$ 's market of the variety produced in country  $j$ 's industry ("home price for a foreign variety" multiplied by an "industry trade barriers index"),  $n_i^j$  is the number of firms (each producing one variety) in the sector  $i$  and  $\sigma$  is the elasticity of substitution that is assumed identical across industries.

The industry  $i$  export from country  $j$  to country  $m$  is defined as

$$X_i^{jm} \equiv n_i^j P_i^j d_i^{jm},$$

thus the relative export of a pair of countries ( $j, k$ ) to a third country's market ( $m$ ) can be defined as

$$\frac{X_i^{jm}}{X_i^{km}} \equiv \left( \frac{n_i^j}{n_i^k} \right) \left( \frac{B_i^{jm}}{B_i^{km}} \right)^{-\sigma} \left( \frac{P_i^j}{P_i^k} \right)^{1-\sigma}. \quad (2)$$

Assuming that each variety is produced in a plant with CRS and requires a certain fixed amount of headquarter services, it is possible to define the production function for every firm in the plant as

$$q_i^j = \alpha_i^j f_i^j, \quad (3)$$

where  $q_i^j$  is the output of the firm,  $\alpha_i^j$  is the technical coefficient (productivity) and  $f_i^j$  is the quantity of the composite factor employed in the firm.

$f_i^j$  is a function of the vectors of primary factors,  $\underline{v}_i^{pj}$ , and intermediate goods,  $\underline{z}_i^{pj}$ , employed in the plant; it follows that  $f_i^j \equiv \tilde{\phi}_i(\underline{v}_i^{pj}, \underline{z}_i^{pj})$ , where the function  $\tilde{\phi}_i(\cdot)$  is homogeneous of degree 1 and identical across countries. Then equation (3) allows for technology differences among countries only of the Hicks-neutral type.

A unit of the composite factor can be employed incurring in the cost

$$C_i^j = \tilde{\chi}_i(\underline{W}^j, \underline{P}_i^{zj}),$$

where  $\underline{W}^j$  is the price vector for primary factors and  $\underline{P}_i^{zj}$  is the price vector for

intermediate inputs. The unit variable cost can be easily obtained from (3),  $\frac{C_i^j}{\alpha_i^j}$ , and from the profit maximization process we have

$$\frac{C_i^j}{\alpha_i^j} = \left( \frac{\sigma - 1}{\sigma} \right) P_i^j. \quad (4)$$

The production of headquarter services requires a fixed amount of composite factor defined as a function of the primary factors ( $\underline{v}_i^{hj}$ ) and intermediate inputs ( $\underline{z}_i^{hj}$ ) employed  $\bar{h}_i \equiv \tilde{\phi}_i(\underline{v}_i^{hj}, \underline{z}_i^{hj})$ .

The initial assumption of monopolistic-competitive market implies the following definition of the zero-profit condition

$$\frac{\bar{h}_i C_i^j}{q_i^j} + \frac{C_i^j}{\alpha_i^j} = P_i^j,$$

where  $\bar{h}_i C_i^j / q_i^j$  is the unit fixed headquarter cost. Using the equations (3) and (4) we obtain<sup>12</sup>

$$f_i^j = (\sigma - 1) \bar{h}_i. \quad (5)$$

Let  $A_i^j$  represent the Total Factor Productivity of the industry  $i$  in the country  $j$ , defined as  $A_i^j = \frac{Q_i^j}{F_i^j}$ , where  $Q_i^j \equiv n_i^j q_i^j$  is the industry output and  $F_i^j \equiv n_i^j (f_i^j + \bar{h}_i)$  represents the total amount of composite factor employed in the industry. By (3) and (5) we can obtain the relation existing between the coefficient  $\alpha_i^j$  (technology) and the TFP<sup>13</sup>

$$\alpha_i^j = A_i^j \frac{\sigma}{\sigma - 1}. \quad (6)$$

From equation (5) we can derive the number of firms in the industry  $i$  of the country  $j$  as a function of the total amount of the composite factor employed in the industry. From the definition of  $F_i^j$  we have

$$n_i^j = \frac{F_i^j}{\sigma \bar{h}_i}. \quad (7)$$

Now it is possible to go back to equation (2) in order to enrich the export relation by incorporating the assumption and the results of the production side of the model. Using equations (4), (6) and (7) we can write

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<sup>12</sup>It is possible to write  $\frac{\bar{h}_i C_i^j}{\alpha_i^j f_i^j} + \frac{C_i^j}{\alpha_i^j} = P_i^j$  and by the equation (4)  $\frac{\bar{h}_i}{f_i^j} \left( \frac{\sigma - 1}{\sigma} \right) P_i^j + \left( \frac{\sigma - 1}{\sigma} \right) P_i^j = P_i^j$ .

After the computations we have  $\left[ \left( \frac{\bar{h}_i}{f_i^j} + 1 \right) \left( \frac{\sigma - 1}{\sigma} \right) - 1 \right] P_i^j = 0$ , from which we derive  $1 + \frac{\bar{h}_i}{f_i^j} = \frac{\sigma}{\sigma - 1}$ , then  $\frac{1}{\sigma} f_i^j = \frac{\sigma - 1}{\sigma} \bar{h}_i$  and finally the equation (5).

<sup>13</sup> $A_i^j = \frac{Q_i^j}{F_i^j} = \frac{n_i^j \alpha_i^j f_i^j}{n_i^j (f_i^j + \bar{h}_i)} = \frac{\alpha_i^j (\sigma - 1) \bar{h}_i}{(\sigma - 1) \bar{h}_i + \bar{h}_i} = \alpha_i^j \frac{(\sigma - 1)}{\sigma}$ .

$$\frac{X_i^{jm}}{X_i^{km}} \equiv \left( \frac{F_i^j}{F_i^k} \right) \left( \frac{B_i^{jm}}{B_i^{km}} \right)^{-\sigma} \left( \frac{C_i^j}{C_i^k} \right)^{1-\sigma} \left( \frac{A_i^j}{A_i^k} \right)^{-(1-\sigma)}. \quad (8)$$

The first component on the right-hand side (the relative employment of the composite factor) proxies for the ratio of number of firms in the industry, accounting for the relative size of the two countries. The second component on the right-hand side accounts for trade barriers and trade costs. The relative cost of the composite factor represents the Heckscher-Ohlin part of the model accounting for endowments. The relative productivity is the Ricardian part of the model accounting for possible Hick-neutral technical differences across industries and countries.

## **B. The Manufacturing Sectors Taken into Account**

In bold the sectors considered:

### **Total Manufacturing**

#### **Food Products, Beverages and Tobacco**

Food Products and Beverages

Tobacco Products

#### **Textiles, Textiles Products, Leather and Footwear**

Textiles and Textile Products

Textiles

Wearing Apparel, Dressing and Dying of Fur

Leather, Leather Products and Footwear

#### **Wood and Products of wood and cork**

#### **Pulp, Paper, Paper products, Printing and Publishing**

Pulp, Paper and Paper Products

Printing and Publishing

#### **Chemical, Rubber, Plastic and Fuel Products**

Coke, Refined Petroleum Products and Nuclear Fuel

Chemicals and Chemical Products

Rubber and Plastic Products

#### **Other Non-Metallic Mineral Products**

#### **Basic Metals**

Iron and Steel

Non-ferrous Metals

#### **Fabricated Metal Products**

#### **Machinery and Equipment**

Machinery and Equipment

Electrical and Optical Equipment

Office, Accounting and Computing Machinery

Electrical Machinery and Apparatus

#### **Transport Equipment**

Motor Vehicles, Trailers and Semi-Trailers

Other Transport Equipment

Building and Repairing of Ships and Boats

Aircraft and Spacecraft

Railroad Equipment and Transport Equipment

#### **Other Manufacturing**

### C. The Database

1.  $X_{it}^{jm}$  represents the value of country  $j$ 's export toward country  $m$  of goods produced in sector  $i$  in thousands of US dollars. We draw out the series from OECD's Bilateral Trade Database.
2.  $Y_{it}^j$  is the added value at 1990 prices and purchasing power parity [PPP 1990, US\$]. It can be draw out from ISDB where it is named GDPD.
3.  $K_{it}^j$  is the gross capital stock at 1990 prices and purchasing power parity [PPP 1990, US\$]. It can be taken from ISDB where it is named KTVD.

4.  $L_{it}^j$  is the total employment in the sector  $i$  of country  $j$  and it can be taken from ISDB where it is named ET.
5.  $\tilde{w}_i$  is the coefficient of the labor contribution to the formation of the added value in the sector  $i$ . It can be computed as the average value in the considered period:

$$\tilde{w}_{it} = \left( \frac{WSSS * ET}{EE} \right) / GDP$$

where WSSS is the compensation per worker at current prices in national currency, ET is the total employment, EE is the number of employees, GDP is added value at current prices in national currency. All series are available on the ISDB.

6.  $(1 - \tilde{w}_i)$  is the coefficient of the capital contribution to the formation of the added value in the sector  $i$  and can be computed as a difference with respect to the  $\tilde{w}_i$  series.
7.  $y_i$  is the coefficient of the added value contribution to the formation of the output at current prices in the sector  $i$ . Thus it is a mean of the values computed for the considered period as a ratio of the following type

$$y_{it} = \frac{VALU}{PROD},$$

both the series are available on the STAN.

8.  $k_i = y_i(1 - \tilde{w}_i)$ ,  $w_i = y_i\tilde{w}_i$  and  $\theta_i = 1 - k_i - w_i$ .
9.  $\widetilde{R\&D}_{it}^j$  is the Research & Development intensity (value added) for the sector  $i$  in country  $j$  as measured in the OECD's Main Industrial Indicators database. Thus  $\ln \widetilde{TFP}_{it}^j = \ln \tilde{A}_{it}^j - \ln \widetilde{R\&D}_{it}^j$ .
10.  $\widetilde{VS}_{it}^j$  is computed as in Hummels et al. (2001),

$VS_i^j = \left( \frac{\text{imported intermediates}_i^j}{\text{gross output}_i^j} \right) \text{exports}_i^j$ , drawing the series out from the OECD's Input-Output Tables.  $\tilde{I}_{it}^j$  is obtained as the difference between the total amount of intermediates (domestic and imported) employed in the sector  $i$  of country  $j$  and  $\widetilde{VS}_{it}^j$ .

11.  $W_{it}^j$  is the wage rate computed as

$$W_{it}^j = \frac{WSSS}{EE},$$

both the series can be taken from ISDB.

12.  $R_{it}^j$  is the return on capital in US\$. We can follow Chaudhri and Hakura (2000) computing it as

$$R_{it}^j = (r + \delta)P_I$$

where  $r$  is the real interest rate (difference between the nominal long-term interest rate on treasury bills and the consumer price index). Both the series are available on the IMF's IFS;  $\delta$  is the depreciation rate conventionally considered equal to 10%;  $P_I$  is the price of the investment good in US\$ that can be computed as

$$P_I = \frac{ITD}{ITV * ER},$$

where  $ITD$  is the gross fixed capital formation at 1990 prices and 1990 PPPs (US\$),  $ITV$  is the gross fixed capital formation at 1990 prices in the national currency, both the series are available in the ISDB.  $ER$  is the exchange rate (national currency per US\$) and it is taken from the IMF's IFS.

The lack of the  $ITD$ ,  $ITV$  series for Japan has been overcome computing the prices of the investment goods by the proxy

$$P_I = \frac{GDPD}{GDPV * ER},$$

where  $GDPD$  is the added value at 1990 prices and 1990 PPPs (US\$);  $GDPV$  is the added value at 1990 prices in national currency. These series are available in the ISDB, as well.

## D. Other results

**Table 3.** Estimates FRANCE/US toward OECD 1980-1994 (Fixed Effects)

Dependent Variable: EXPORT		
Panel of Annual Data from 1980 to 1994		
10 manufacturing sectors out of 11 (missing Other Manufacturing)		
Estimation Technique:	Model with VS	Model without VS
	Fixed Effects with Specific Time Effects	Fixed Effects with Specific Time Effects
FACTOR	-0.280581866 (-1.98268)	1.030392440** (7.31791)
VS	0.931006341** (10.48795)	
TFP	-0.321053884** (-3.20044)	1.727801691** (8.33241)
R&D	0.437408804 (1.62577)	2.793771435** (11.62669)
COST	-0.202869814* (-2.60393)	-0.120196598 (-1.41026)
R-squared	0.674363	0.570450

NOTE: t-statistics in parenthesis. \* = Signif. 5%; \*\* = Signif. 1%.  
See Appendix A and B for the list of the sectors considered and the construction of the series.

**Table 4.** Estimates JAPAN/US toward OECD 1980-1994 (Fixed Effects)

Dependent Variable: EXPORT		
Panel of Annual Data from 1980 to 1994		
10 manufacturing sectors out of 11 (missing Wood)		
Estimation Technique:	Model with VS	Model without VS
	Fixed Effects with Specific Time Effects	Fixed Effects with Specific Time Effects
FACTOR	0.719009396** (11.62216)	0.815639684** (3.68819)
VS	-0.333012382** (-4.69495)	
TFP	0.131688111 (0.30710)	2.797262609** (6.18809)
R&D	0.319593703 (0.67602)	2.624763958** (5.06142)
COST	-0.139431051 (-0.37514)	-2.089871172** (-4.78797)
R-squared	0.770954	0.574154

NOTE: t-statistics in parenthesis. \* = Signif. 5%; \*\* = Signif. 1%.  
See Appendix A and B for the list of the sectors considered and the construction of the series.

**Table 5.** Estimates JAPAN/US toward OECD 1980-1994  
(without Transport Equipment)

Dependent Variable: EXPORT		
Panel of Annual Data from 1980 to 1994		
9 manufacturing sectors out of 11 (missing Wood and Transport Equipment)		
Estimation Technique:	Model with VS	Model With VS
	Random Effects with Specific Time Effects	Fixed Effects with Specific Time Effects
FACTOR	0.660777232** (18.05278)	0.615236327** (7.73596)
VS	-0.123874446 (-1.40717)	-0.129755224 (-1.11204)
TFP	0.494221978** (4.17313)	0.975589165 (1.65715)
R&D	0.758121280** (2.85866)	1.41600090* (2.02907)
COST	-0.524876948** (-4.34236)	-0.941550816 (-1.77341)
R-squared	0.742153	0.763606

NOTE: t-statistics in parenthesis. \* = Signif. 5%; \*\* = Signif. 1%.  
See Appendix A and B for the list of the sectors considered and the construction of the series.

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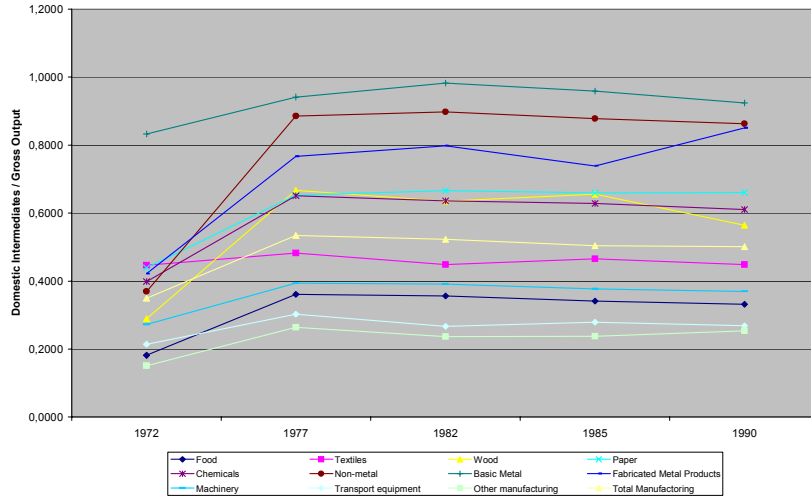


Figure 1: US employment of domestic intermediates

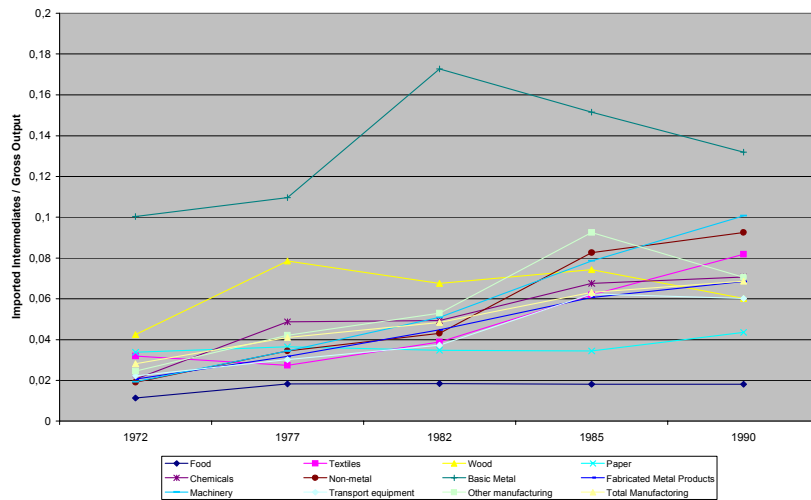


Figure 2: US employment of imported intermediates

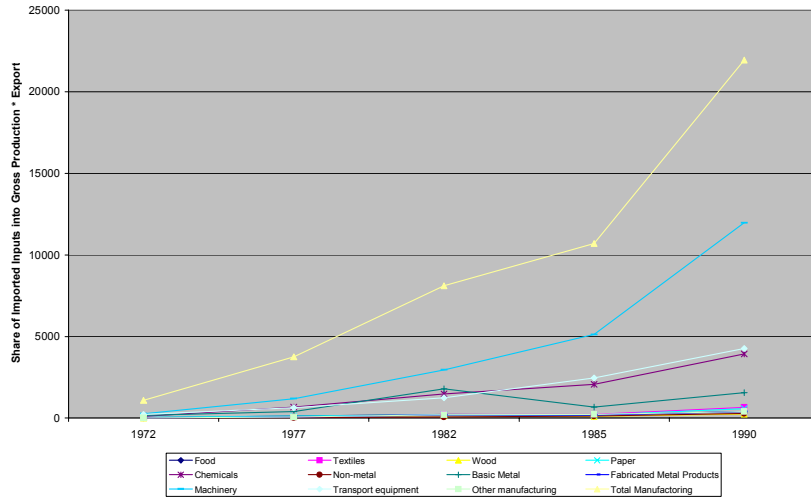


Figure 3: US Vertical Specialization

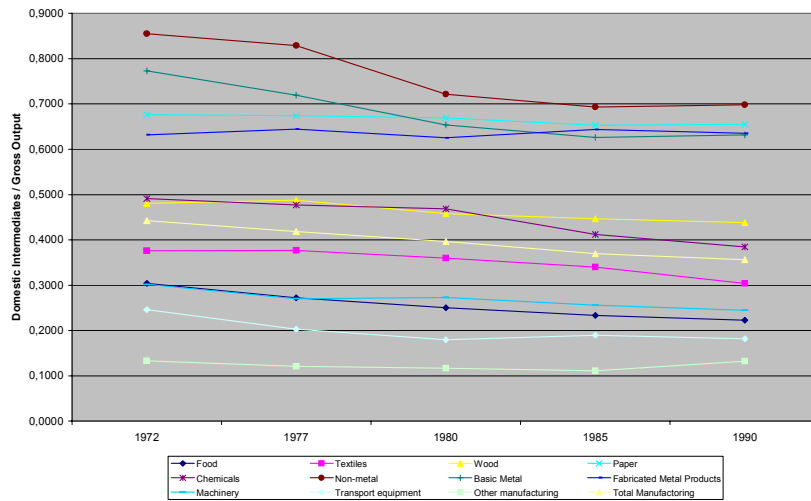


Figure 4: FRANCE employment of domestic intermediates

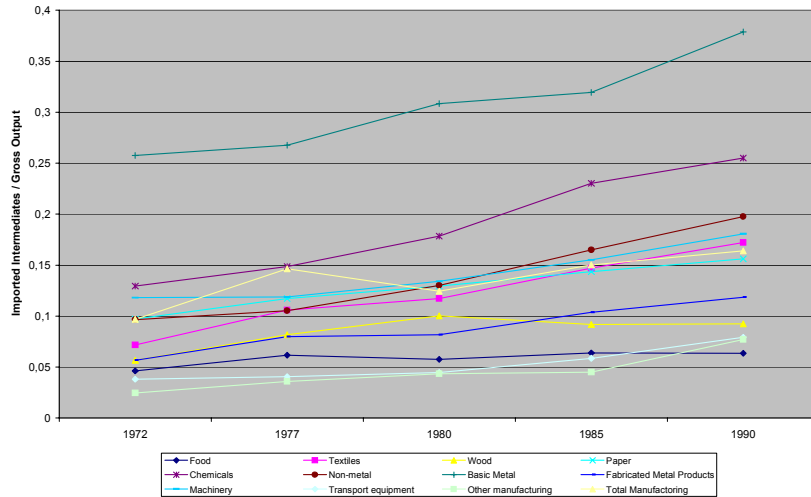


Figure 5: FRANCE employment of imported intermediates

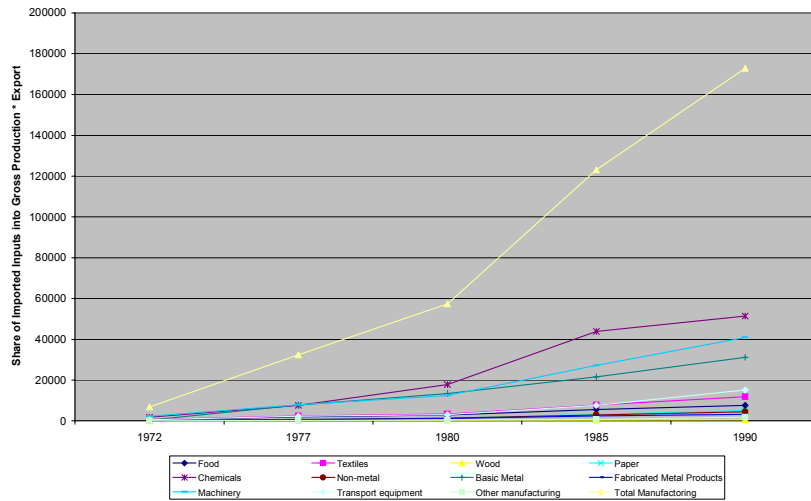


Figure 6: FRANCE Vertical Specialization

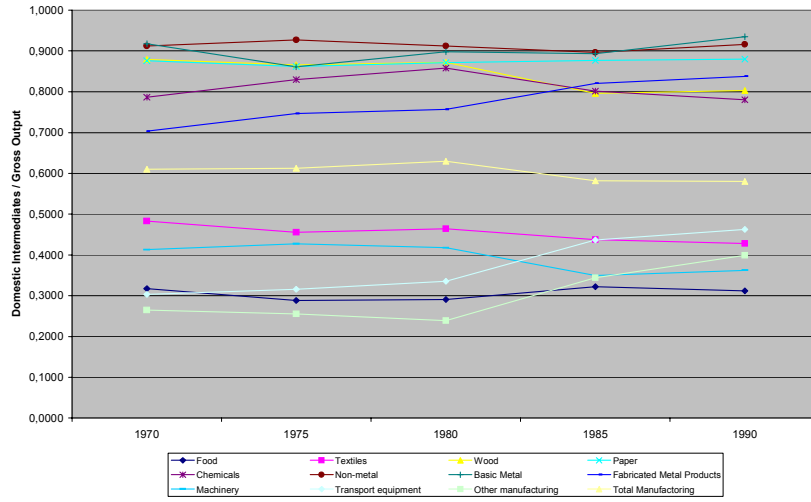


Figure 7: JAPAN employment of domestic intermediates

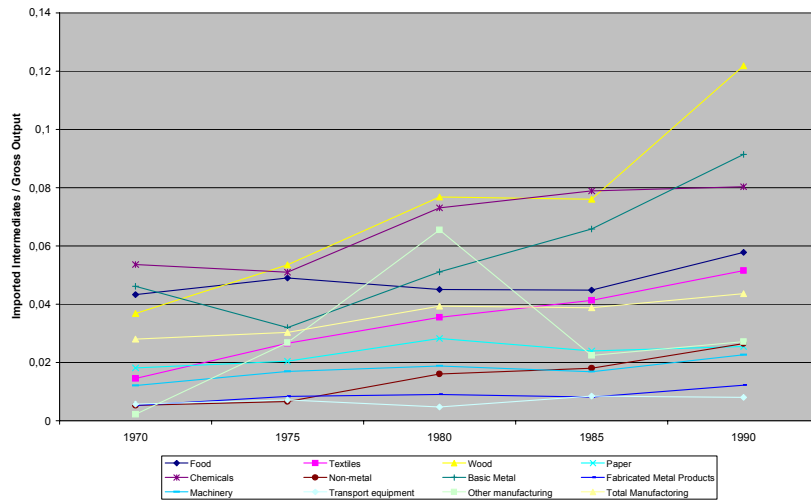


Figure 8: JAPAN employment of imported intermediates

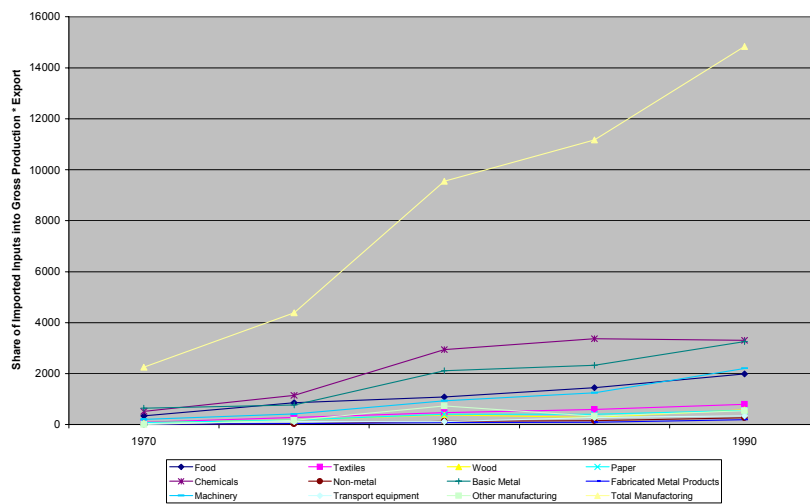


Figure 9: JAPAN Vertical Specialization