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Relative Export Structures and Vertical Specialization: A Simple Cross-Country Index*

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Abstract

Relative export structures have changed substantially over the last forty years. We map these changes using a new cross-country specialization index - the $B^{\star}$ -, defined as the export weight of a given product on total domestic exports, "normalized" by the average weight across all countries of the world. This indicator is close to the Revealed Comparative Advantage index suggested in Balassa (1965); it has been used as an intermediate calculation in some papers but it has never been highlighted or interpreted as an alternative index in its own right.

We provide empirical evidence on the shape of the distribution of the $B^{\star}$ for different technological sectors (high, medium-high, medium-low and low-technology sectors), how it has evolved through time and how its intra-distribution dynamics behave. The results indicate a relatively important degree of persistence, although the cross-country specialization distributions depict substantial differences as we move up the technology ladder. Special attention is given to the G5 countries and China. These economies are relatively more specialized in high-tech and medium high-tech products. China shows a striking increase in specialization in high-tech products and a substantial decrease in low-tech. Finally, by computing the $B^{\star}$ for both exports and imports, we have identified countries with significant vertical specialization activities. These activities are predominant in high-tech industries and seem to be geographically concentrated in East-Asia.

Keywords: International Trade, Export Specialization, Balassa Index, Distribution Dynamics, Vertical Specialization.
JEL Codes: C14, F14, O50

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1 Introduction

Over the last decade, international trade has grown, on average, by more than 8.5 per cent per annum in nominal terms. This paper addresses two types of issues raised by this striking feature of the world economy. Firstly, the entrance of new countries in the world trade system inevitably implied changes in relative export structures, which are interesting to map. Secondly, although the classical determinants of international trade are well-established in the literature, substantial effort has been made to understand the importance of international relocation of production and vertical specialization activities, defined as the use of imported inputs to produce goods that are afterwards exported either as final goods or as intermediate goods.

One strand of the empirical trade literature is based on the computation of indices that aim to capture revealed comparative advantages. The most commonly used is the index suggested by Balassa (1965), which uses the world export share in a given sector to "normalize" the export share of each country, being particularly suited to perform static analysis. In this paper we propose an alternative indicator - the $B^{\star}$ - with a highly intuitive nature: the share of exports of a given sector in total exports of each country relative to the world unweighted average share. This indicator has shown up as an intermediate calculation in some papers but it has never been highlighted or interpreted as an alternative index in its own right. The $B^{\star}$ has a clear link with the Balassa index and similarities with other indices already known in the literature, such as the Proudman and Redding (1997, 2000), showing suitable cardinal properties. For each product category, the behavior of the $B^{\star}$ bears information on how the overall degree of international trade specialization has evolved over time and identifies the countries that are relatively more specialized in that category. In addition, we argue that, for a country i, a simultaneous high share of a specific sector in total exports and imports, relative to the world average, provides indirect evidence of vertical specialization.

The paper is organized as follows. In the next section we present the product specialization index that is used in the analysis and discuss its properties. In section 3 we examine how international specialization has changed since the late 60s, using a product breakdown based on four aggregates with increasing technological intensities. These sectors have been designated as high-technology, medium-high-technology, medium-low-technology and low-technology sectors. In this context, the shape of the distribution of the $B^{\star}$ and its intra-distribution dynamics are analyzed for each sector. Some emphasis is put on the analysis of G5 countries and China's relative export structures. In section 4 we investigate the vertical specialization phenomenon. By computing the suggested index for both exports and imports and by imposing a restrictive selection criteria, we identify countries where vertical specialization seems to be relevant and map the evolution of both indices in the selected countries through time. Section 5 presents some concluding remarks.

2 Measuring international trade specialization

2.1 The Balassa index

Assume that the world economy comprises N countries and m products. Country i exports of product j are x_{ij} and total exports of country i are given by $X_i = \sum_{j=1}^{m} x_{ij}$. World exports of product j amount to $x_{Wj} = \sum_{i=1}^{N} x_{ij}$, while total world exports can be seen either as the sum of all products or as the sum of all countries, i.e. $X_W = \sum_{j=1}^{m} x_{Wj} = \sum_{i=1}^{N} X_i$.[1] To evaluate the revealed comparative advantage of country i in sector j, Balassa (1965) suggested the following index:

$$B_{ij} = \frac{\frac{x_{ij}}{x_{Wj}}}{\frac{X_i}{X_W}} \qquad \text{country } i = 1, 2 \ldots N; \text{ product } j = 1, 2 \ldots m \tag{1}$$

If the market share of country i in product j is higher than its total market share, i.e. if $(\frac{x_{ij}}{x_{Wj}}) > (\frac{X_i}{X_W})$, then the country is classified as having a *revealed* comparative advantage in sector j. The simplicity and highly intuitive nature of the Balassa index explains its wide utilization. The author is simply using $\frac{X_i}{X_W}$ to "normalize" $\frac{x_{ij}}{x_{Wj}}$ and proposing a threshold level of 1. Besides this dichotomous feature, dividing countries between those that have and those that do not have a *revealed* comparative advantage, the Balassa index has also been used as a cardinal and ordinal measure, allowing interpretations between countries in a given product or across products in a given country.[2] The index has a lower bound of $B_{ij} = 0$ in the extreme case where country i does not export product j ($x_{ij} = 0$). In the other extreme situation where country i is the only exporter in sector j (international monopoly), such that $(\frac{x_{ij}}{x_{Wj}}) = 1$, the relative nature of the Balassa index implies that $B_{ij} = \frac{X_W}{X_i}$, thus dependent on the relative dimension of country i.[3] Given that X_i and X_W are, in general, time varying, the upper bound does not only change across countries, but also through time.

[1] Note that the "world" included in this definition can be interpreted as any well defined reference area and the number of products as any relevant basket. Balassa (1965) did not use the world as a whole, but an aggregate comprising 6 areas (European Common Market, USA, Canada, UK, Sweden and Japan). Primary products were also excluded from his analysis to ensure that trade patterns reflected comparative advantages and not the impact of subsidies, quotas and other special arrangements.

[2] The comparisons between countries in Balassa (1977) are only based on the rankings of the sectors. The author does not report levels and simply investigates the ranks of the different j products for each country. Averages across selected groups of industries are also calculated. See also Ballance, Forstner and Murray (1987) and De Benedictis and Tamberi (2001).

[3] It is generally stated that the B_{ij} index ranges from 0 to $+\infty$. In fact, the effective upper bound is $\frac{X_W}{X_i}$, which tends to $+\infty$ when X_i tends to 0, i.e. when the share of country i in total world exports is negligible.

Equivalently, the Balassa index can also be written using relative export structures

$$B_{ij} = \frac{\frac{x_{ij}}{X_i}}{\frac{x_{Wj}}{X_W}} \qquad \text{country } i = 1, 2 \dots N; \text{ product } j = 1, 2 \dots m \tag{2}$$

According to (2), if the share of product j in total exports of country i is higher than the equivalent share of product j in world exports, i.e. $(\frac{x_{ij}}{X_i}) > (\frac{x_{Wj}}{X_W})$, then $B_{ij} > 1$ and country i is classified as having a *revealed* comparative advantage in sector j.

In summary, the B_{ij} follows an asymmetric distribution with a fixed lower bound of 0, a variable upper bound across countries and across time, and with a threshold value of 1.[4]

2.2 A new international product specialization index - the $B^\star$

The international product specialization index suggested here draws from formulation (2) and simply uses a different "normalization", i.e. a different denominator. To evaluate the relative export specialization of country i in sector j, we suggest the use of

$$B^\star_{ij} = \frac{\frac{x_{ij}}{X_i}}{(\overline{\mu_i})_j} \qquad \text{country } i = 1, 2 \dots N; \text{ product } j = 1, 2 \dots m \tag{3}$$

Where $(\overline{\mu_i})_j \equiv (\overline{\frac{x_{ij}}{X_i}})_j = \frac{1}{N}\sum_{i=1}^{N} (\frac{x_{ij}}{X_i})_j$ is the *average* export weight of sector j across the different i countries. Each country $i = 1, 2 \dots N$ has a particular share of product j in total exports, $\frac{x_{ij}}{X_i}$, and $(\overline{\mu_i})_j$ is just the *unweighted* average of this export weight in all countries. As in Balassa index, if country i does not export product j ($x_{ij} = 0$), then $B^\star_{ij} = 0$, otherwise $B^\star_{ij} > 0$. The suggested threshold is also 1. If the share of product j in total exports of country i is higher than the average share of product j in the N economies of the world, i.e. $(\frac{x_{ij}}{X_i}) > (\overline{\mu_i})_j$, then $B^\star_{ij} > 1$ and this country is classified as being relatively more specialized in product j. In the other extreme situation, where country i is an international monopolist in product j , $B^\star_{ij}$ is simply equal to N - the upper bound - thus neither dependent on the relative dimension of country i, nor variable across time. In every period t, the sum of all indices across countries within each product j yields, by construction, the upper bound. Thus, the value of each $B^\star_{ij}$ can be interpreted as the contribution of each country i, in product j , to N.[5] The level of $B^\star_{ij}$ is therefore clearly dependent on the number of countries

[4] It is also easily seen that its standard deviation and mean values are also not constant (again across countries and across time). Hinloopen and Marrewick (2001) report an outcome where, due to one single additional sector, the average Balassa index increases by more than 20 per cent.

[5] Note that if country i has an international monopoly in sector j, then its $B^\star_{ij} = N$, while the indices of the remaining countries will be nil in this sector.

or regions under consideration, requiring a wider set of information than the Balassa index.

This international product specialization index also has the appealing feature that its mean within each sector (cross-country analysis) is always equal to 1, i.e. $\frac{1}{N}\sum_{i=1}^{N} B^{\star}_{ij} = 1$ for each j product. If a given country i is relatively specialized in product j ($B^{\star}_{ij} > 1$), there must exist another country in the world that is not relatively specialized in the same sector ($B^{\star}_{j,c\neq i} < 1$). Unless the share of product j in total exports is identical across the world, some countries will have indices above average and some countries will have indices below average. Within a time dimension approach, if the level of $B^{\star}_{ij}$ increases, this will have a unique interpretation: country i has become relatively more specialized in product j than the average of the other countries. In particular, this had to be done at the expense of lower specialization in some other country.

In summary, the $B^{\star}_{ij}$ follows an asymmetric distribution with fixed lower and upper bounds across countries and across time, given by 0 and N, respectively, and with a threshold value of 1. By showing proper cardinal properties (across countries in a given sector), the $B^{\star}_{ij}$ index is particularly suitable for ranking the specialization of the different countries in a given sector across time, which is one of the questions to be addressed in Section 3. The indicator can also be computed for imports, bearing similar characteristics and similar interpretations. This will be useful in Section 4, where we analyze the phenomenon of vertical specialization.

2.3 The Balassa index and the $B^{\star}$

The Balassa index has been subject to several critiques, leading some authors to propose several modified versions. For instance, Laursen (1998) suggests a transformation that produces a symmetric outcome, ranging from -1 to 1 and with a threshold of 0; Proudman and Redding (1997, 2000) suggest a transformation that results in a constant mean across the different products for a given country. Nevertheless, the popularity of the original suggestion remains in place and the traditional Balassa index has been used extensively in the literature.[6]

As in the Proudman and Redding (1997, 2000) contribution, the product specialization index suggested here has a clear and well-defined link with the original Balassa index.

[6] See Hinloopen and Marrewick (2001) for a list of references, Widgrén (2005) for a recent application to selected Asian, American and European countries and Shafaeddin (2004) for a study on Chinese exports and imports. Richardson and Zhang (1999) map the US revealed comparative advantage by trading partner and Hinloopen and Marrewick (2004) analyse the dynamics of Chinese comparative advantage. De Benedictis and Tamberi (2001), who discuss in detail the characteristics of both the original B_{ij} index and the above-mentioned two alternative versions, end up using the original mean-variant formulation of the index. Vollrath (1991), who surveys alternative revealed comparative advantage measures, states that, among the measures using only exports, the traditional Balassa index is one of "the most satisfying".

After some simple algebra, it can be shown that

$$B^{\star}_{ij} = \frac{B_{ij}}{(\overline{B_i})_j}$$

where $(\overline{B_i})_j = \frac{1}{N}\sum_{i=1}^{N} B_{ij}$ is simply the cross-country unweighted average of B_{ij}. Thus, the original Balassa index of country i in product j is just being "re-normalized" by the average index of product j across countries. Therefore, if the outcome for a group of countries is clustered around similar levels, be it in the case of $B^{\star}_{ij}$ or in the case of B_{ij}, such a result only implies that the share of product j in total exports is similar in these countries. The ranking of the different i countries within a certain product j is exactly the same in both indicators and simply corresponds to the ranking of their respective share of product j in total exports. Thus, if the objective is just to rank the countries across a given sector, there is no need to implement any "normalization". The share of product j in total exports has sufficient information to provide an ordinal measure of the countries.[7] As in the case of the traditional B_{ij} index, the value of the $B^{\star}_{ij}$ will not be invariant with respect to the choice of sectoral aggregation, the geographical benchmark considered and the time length chosen. Nevertheless, there are also some important differences that should be highlighted.

One non-negligible difference in comparison with the Balassa index is that the country position relative to the threshold level may change in the two indicators. While the Balassa index in formulation (2) is "normalizing" $\frac{x_{ij}}{X_i}$ by $\frac{x_{Wj}}{X_W}$, which is a "weighted average" across countries where the larger countries have more weight, the $B^{\star}_{ij}$ is "normalizing" $\frac{x_{ij}}{X_i}$ by an "unweighted average", in which all countries have the same weight.[8]

More precisely,

$$\frac{\dfrac{x_{ij}}{X_i}}{\sum_{i=1}^{N} \alpha_i \frac{x_{ij}}{X_i}} = \begin{cases} B^{\star}_{ij} & \text{if } \alpha_i = \frac{1}{N} \quad \text{for each country } i, \\ \\ B_{ij} & \text{if } \alpha_i = \frac{X_i}{X_W} \quad \text{for each country } i. \end{cases}$$

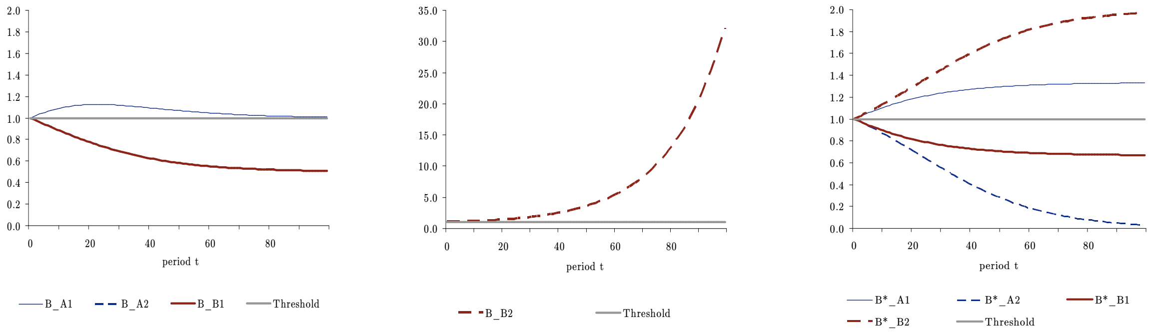
The information content of these different normalizations will be explored empirically in the next section.

Another relevant difference between the two indices is that they not bear the same cardinal properties. In particular, the levels of the Balassa indices may not be easily comparable through time. Whereas the mean of the Balassa index may be changing

[7] Using formulation (2): If $B_{ij} = B_{c\neq i,j} \Leftrightarrow \frac{x_{ij}}{X_i}\frac{X_W}{x_{Wj}} = \frac{x_{c\neq i,j}}{X_{c\neq i}}\frac{X_W}{x_{Wj}} \Leftrightarrow \frac{x_{ij}}{X_i} = \frac{x_{c\neq i,j}}{X_{c\neq i}}$; using formulation (3): If $B^{\star}_{ij} = B^{\star}_{c\neq i,j} \Leftrightarrow \frac{x_{ij}}{X_i}(\frac{1}{N}\sum_{i=1}^{N}(\frac{x_{ij}}{X_i})_j)^{-1} = \frac{x_{c\neq i,j}}{X_{c\neq i}}(\frac{1}{N}\sum_{i=1}^{N}(\frac{x_{ij}}{X_i})_j)^{-1} \Leftrightarrow \frac{x_{ij}}{X_i} = \frac{x_{c\neq i,j}}{X_{c\neq i}}$.

[8] It can be easily demonstrated that the denominator of the Balassa index in formulation (2) is a weighted average of the share of product j in total exports of each country i, where the weights are the proportion of each country i in total world exports. Likewise, it can also be shown that the denominator in formulation (1) is a weighted average of the shares of country i in world exports of each product j, where the weights are the proportion of each product j in total world exports.

Figure 1: The behaviour of B_{ij} in comparison with B^*_{ij} between $t = 0$ and $t = 100$.



(a) Balassa indices (b) Balassa index: B_{B2}. (c) B^* indices

in time, the mean of the $B^\star_{ij}$ across countries in a given sector is always constant and equal to 1. The existence of this constant average and a fixed upper bound are relevant characteristics of the $B^\star_{ij}$, as they facilitate direct comparisons of the magnitude of the different individual indices (cardinal measure). The different characteristics of the two indices may be further clarified by a simple theoretical example. Assume for simplicity that the world is made up of 2 countries (A and B) and 2 products (1 and 2). Country A exports x_{A1} and x_{A2}, country B exports x_{B1} and x_{B2}. At time $t = 0$, assume furthermore that both countries export a nominal value of 100 euros of each product. At $t = 0$, therefore, $B_{ij} = B^\star_{ij} = 1$, where $j = 1, 2$ and $i = A, B$. Finally, assume that x_{A1} grows 5% per period and that all other exports remain unchanged at 100 euros. In this case, world exports of product 1 (i.e. $x_{w1} = x_{A1} + x_{B1}$) are accelerating over time, reaching an export growth that is becoming closer to 5%, as x_{A1}/x_{w1} tends to 1. On the contrary, world exports of product 2 remain unchanged at 200 euros (i.e. $x_{w2} = x_{A2} + x_{B2} = 200$). Figure 1 reports the outcome for both indices between $t = 0$ and $t = 100$. In terms of the Balassa indices - see Figures 1(a) and 1(b) - the first conclusion is that the levels, as already mentioned, are not easily comparable. Second, the relative nature of the index implies that the higher levels in the case of country A in sector 1 (the only sector where exports are growing) will only be temporary, as depicted in Figure 1(a). As x_{A1} grows 5% per period, the weight $\frac{x_{A1}}{(x_{A1}+x_{A2})}$ reaches higher levels in the initial periods than the equivalent world aggregate (i.e. $\frac{x_{w1}}{(x_{w1}+x_{w2})}$), implying that B_{A1} will exhibit an initial upward movement. However, as $\frac{x_{w1}}{(x_{w1}+x_{w2})}$ accelerates, the accumulated differences fade away and B_{A1} tends towards the initial position. Third, country B in sector 2 will not only exhibit sharper increases, but also an explosive trajectory (Figure 1(b)). As x_{A1} grows 5% per period, the weight $\frac{x_{B2}}{(x_{B1}+x_{B2})}$ does not change, and this compares to an equivalent world aggregate (i.e. $\frac{x_{w2}}{(x_{w1}+x_{w2})}$) that goes on decreasing. Finally, B_{A2} and

B_{B1} show an identical downward movement. Given the explosive trajectory of the B_{B2}, the sum (and the average) of all B_{ij} also follows an explosive trajectory. As for the $B^{\star}_{ij}$, on the contrary, the "normalization" used implies that the results are not only comparable, but symmetric and bounded across countries (Figure 1(c)). Moreover, in the case of country A in sector 1, the index reaches a permanent higher level. Country B in sector 2 will also exhibit the highest increase, but this will be obtained at the expense of country A in sector 2. This symmetry also applies to sector 1. Finally, at each point in time, the sum of the $B^{\star}_{ij}$ is unchanged at $N = 2$ (and the average at 1).

As already mentioned, the Proudman and Redding (1997, 2000) index has also a constant mean. However, it does not have a constant upper bound and makes use of an unweighted average of export market shares in a given country, which may pose some interpretation issues.[9] The $B^{\star}_{ij}$ has a stable mean *and* a constant upper bound. Moreover, the emphasis shifts from a country analysis (across sectors) to a sector analysis (across countries).[10] Whereas the Proudman and Redding index makes use of the export market share, the $B^{\star}_{ij}$ uses the weight of a given product in national exports, which by itself is not a novelty in the empirical trade literature. Recently, Hausmann, Hwang and Rodrik (2005) calculate a weighted average of per-capita GDPs, where the weights correspond to the revealed comparative advantage of each country in a given product. It turns out that these weights are fully equivalent to a further transformation of the $B^{\star}_{ij}$. In particular, the weights for the per-capita GDP of each country i within each product j are simply given by $\beta_i = \frac{B^{\star}_{ij}}{N}$, where $\sum_{i=1}^{N} \beta_i = 1$.[11]

3 The changing relative export structures

Changes in relative export structures are analyzed by exploring the intrinsic characteristics of the proposed international product specialization index (as defined in (3)). The shape of its distribution is presented in section 3.1; the intra-distribution dynamics in section 3.2 and, finally, in section 3.3, a special focus will be placed on specific countries, namely the G5 countries and China.

There are numerous empirical studies of revealed comparative advantages, international product specialization and changing trade patterns. Nevertheless, these studies mostly

[9]See De Benedictis and Tamberi (2001). Due to its similarity to the index proposed here, the Proudman and Redding (1997, 2000) normalization is reviewed in Appendix A.

[10]Hinloopen and Marrewick (2001) also state that the (cross-industry) distribution of the Balassa index differs considerably between countries, making international comparisons problematic. However, we are focusing on each industry so as to analyze the evolution of the specialization pattern across countries (in that product).

[11]Hausmann et al. (2005) called this quantitative index $PRODY_j$. It represents the income level associated with that product. Their rationale for using such weights was to ensure that country size did not distort the ranking of goods. Furthermore, the final objective is not to calculate these indices for each good, but to construct an index measuring the income/productivity level that corresponds to a country´s export basket (which they call $EXPY_i$). This is done by calculating the export-weighted average of all $PRODY_j$ for that country, where the weights are simply the shares of each product in the country´s total exports. See Di Maio and Tamagni (2006) for a recent application of these indices to the Italian economy.

focus on the evolution of the export structure of a given country or group of countries, i.e. a cross-sector analysis.[12] Following the intrinsic characteristics of the $B^{\star}_{ij}$, this section focuses on a comparison of the different countries within a given sector, i.e. a cross-country analysis.

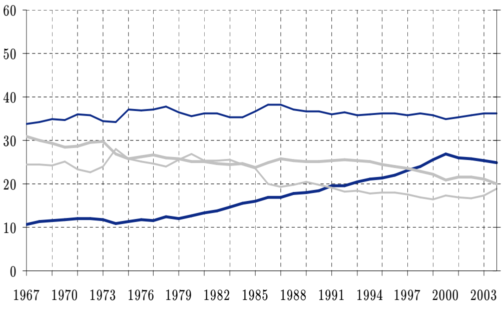
Our database comprises 79 countries or country groups (N=79) and four different sectors (m=4), in which $x_{Wj} = \sum_{i=1}^{79} x_{ij}$ and $X_W = \sum_{i=1}^{79} X_i$. The data source used for this exercise was the CEPII-Chelem database, which reports bilateral trade flows for goods in value terms (the unit being the US dollar). The sample period starts in 1967 and ends in 2004. The category breakdown was made in accordance with the technological intensity of each product and follows the OECD classification of R&D intensities. The sectors are: high-technology (HT), medium-high-technology (MHT), medium-low-technology (MLT) and low-technology (LT). Although this product classification may bring important insights on some of the general trends registered in world exports in the last forty years, one needs to bear in the mind the caveat that this analysis relies on a relatively broad sectoral breakdown and, therefore, not all intra-category relative changes are captured. This issue can be especially relevant for products with an extremely high degree of heterogeneity, like HT products.[13] Therefore, the database also includes a second level disaggregation for each sector, comprising between 4 and 5 sub-sectors. The technological breakdown is reported in Appendix B and the list of countries in Appendix C.

Over the last forty years, world trade has been characterized by substantial changes in terms of technological content. The left panel of Figure (2) depicts the ratio of each technological category in total world exports, i.e the weighted world manufacturing export share that would be used as a denominator in the Balassa index. The most striking features of this figure are that the ratio of LT goods in total world exports has dropped by around 10 percentage points in that period, to only 20 per cent in 2004, and that of HT products has increased by around 15 percentage points, standing at levels close to 25 per cent in 2004. However, the technological upgrade was not uniform across countries, since the increase in technological content was sharper in larger countries than in smaller ones. This can be easily illustrated by comparing this figure with an unweighted average of the export structures of the individual countries, i.e. by comparing the denominators of B_{ij} and $B^{\star}_{ij}$, respectively. Clearly, the outcome

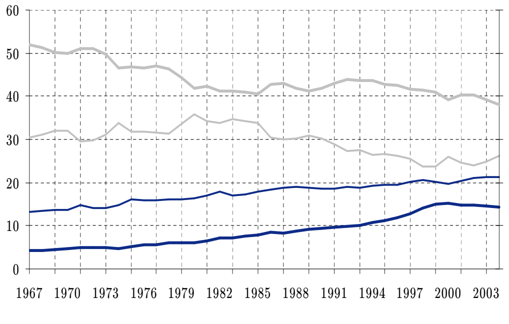
[12] As described by De Benedictis and Tamberi (2001), even the traditional B_{ij} index allows both cross-sector (different products within one geographical zone) and cross-country analysis (different countries in the same sector).

[13] See Peneder (2003) for an analysis of the major classifications used in applied economic studies. Lall, Weiss and Zhang (2005) discuss the problems associated with different product classifications, focusing on those dealing with technology intensities. The authors argue that the industry-based technical characteristics of products may not reflect the technologies used in their manufacture in a specific location. In particular, the sharp increase in vertical integration processes can disturb the analysis, as the normal assumption that products use the same technologies across countries no longer holds when the different stages of production can be separated and located in different countries.

Figure 2: World manufacturing trade by technological intensity
(Shares in total)



(a) Weighted average

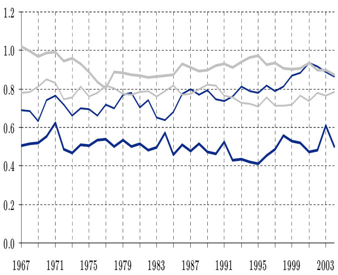


(b) Unweighted average

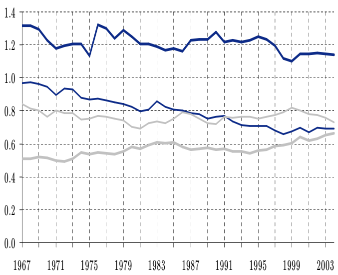
High-technology (HT) Medium-high-technology (MHT) Medium-low-technology (MLT) Low-technology (LT)

of using the unweighted average implies a lower share of HT to MHT products in total world exports, as most countries where these products represent a higher proportion of exports were given a smaller weight (which is the same for all of them and equal to 1/79) than its share in total world exports (defined as $\frac{X_i}{X_W}$). The opposite is true for LT and MLT goods, as larger countries in terms of international trade tend to export products with higher technological content.[14]

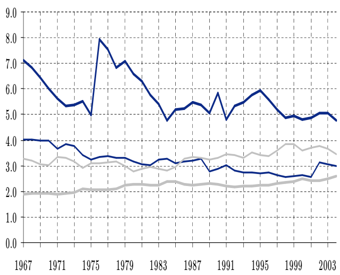
Figure 3: Some descriptive statistics of B^*_{ij} in four technological categories



(a) Median of B^*



(b) Standard deviation of B^*



(c) Maximum of B^*

High-technology (HT) Medium-high-technology (MHT) Medium-low-technology (MLT) Low-technology (LT)

[14]This result is consistent with Hausmann et al. (2005), who state that rich (poor) countries export products that tend to be exported by other rich (poor) countries, if you further consider that countries with higher (lower) per capita income also tend to participate more (less) in international trade.

Table 1 - B* index: descriptive statistics

High-technology products (HT)

	1967-69	1970-74	1975-79	1980-84	1985-89	1990-94	1995-99	2000-04
Min.	0.01	0.00	0.01	0.00	0.00	0.01	0.01	0.01
1st Qu.	0.12	0.12	0.17	0.21	0.16	0.19	0.18	0.21
Median	0.58	0.52	0.52	0.46	0.51	0.50	0.53	0.51
Mean	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*
3rd Qu.	1.52	1.60	1.47	1.45	1.40	1.33	1.46	1.56
Max.	6.76	5.54	6.90	5.71	5.16	5.38	5.01	4.91
St Dev.	1.30	1.20	1.26	1.19	1.21	1.23	1.17	1.15
Kurtosis	6.88	3.92	6.04	2.79	2.06	2.66	2.71	2.12
Skewness	2.40	1.87	2.22	1.71	1.63	1.74	1.73	1.60
Count B* > 1	24	28	27	28	27	25	25	25

Medium-high-technology products (MHT)

	1967-69	1970-74	1975-79	1980-84	1985-89	1990-94	1995-99	2000-04
Min.	0.00	0.02	0.01	0.02	0.00	0.01	0.03	0.02
1st Qu.	0.25	0.22	0.29	0.31	0.37	0.43	0.45	0.45
Median	0.71	0.75	0.71	0.70	0.77	0.79	0.83	0.86
Mean	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*
3rd Qu.	1.62	1.58	1.55	1.58	1.52	1.44	1.46	1.46
Max.	4.00	3.69	3.31	3.06	3.04	2.80	2.65	2.54
St Dev.	0.97	0.92	0.85	0.83	0.78	0.73	0.68	0.68
Kurtosis	0.60	0.21	-0.18	-0.45	-0.34	-0.39	-0.65	-0.75
Skewness	1.13	1.02	0.90	0.83	0.80	0.73	0.59	0.53
Count B* > 1	32	29	34	31	32	35	36	35

Medium-low-technology products (MLT)

	1967-69	1970-74	1975-79	1980-84	1985-89	1990-94	1995-99	2000-04
Min.	0.00	0.03	0.02	0.01	0.04	0.05	0.04	0.04
1st Qu.	0.38	0.41	0.48	0.45	0.43	0.45	0.49	0.51
Median	0.78	0.81	0.79	0.77	0.80	0.72	0.69	0.77
Mean	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*
3rd Qu.	1.34	1.29	1.37	1.44	1.45	1.33	1.29	1.33
Max.	3.16	3.05	3.07	2.85	3.20	3.46	3.62	3.61
St Dev.	0.82	0.77	0.74	0.71	0.75	0.76	0.78	0.76
Kurtosis	0.55	0.68	0.79	0.01	0.75	1.53	1.74	2.12
Skewness	1.14	1.14	1.18	0.95	1.15	1.36	1.43	1.53
Count B* > 1	29	33	27	28	29	29	29	26

Low-technology products (LT)

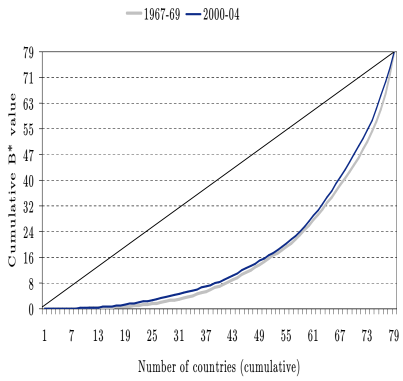
	1967-69	1970-74	1975-79	1980-84	1985-89	1990-94	1995-99	2000-04
Min.	0.01	0.02	0.01	0.01	0.00	0.03	0.03	0.02
1st Qu.	0.61	0.62	0.62	0.61	0.62	0.60	0.55	0.46
Median	0.97	1.00	0.85	0.89	0.91	0.90	0.94	0.93
Mean	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*
3rd Qu.	1.47	1.41	1.49	1.46	1.38	1.39	1.34	1.47
Max.	1.89	1.99	2.12	2.28	2.25	2.22	2.30	2.50
St Dev.	0.52	0.52	0.54	0.59	0.58	0.56	0.58	0.65
Kurtosis	-1.02	-0.96	-0.97	-0.69	-0.51	-0.57	-0.52	-0.61
Skewness	0.01	0.05	0.16	0.38	0.39	0.32	0.51	0.57
Count B* > 1	38	40	37	35	33	37	32	35

Source: Chelem database and own calculations.

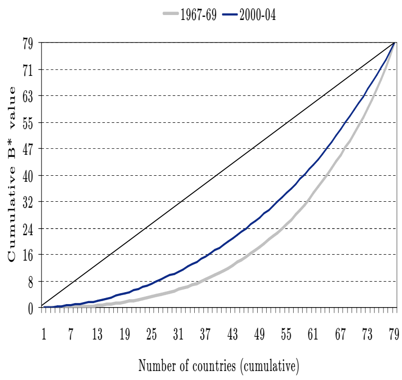
3.1 The shape of the $B^{\star}$ distribution

Table 1 and Figure 3 report some descriptive statistics of the cross-country $B^{\star}$ indexes in the four technological categories since 1967. An analysis of these common descriptive statistics reveals important differences among the specialization structures of the four categories. As shown in Figure 3(a), the medians of the four sectors have some clear differences: higher for LT products and lower for HT products. There is therefore a high proportion of countries that show a specialization in LT exports (around 45 per cent of the countries have a $B^{\star}$ value above one), while specialization in HT products is identified in a relatively smaller number of countries (around 30 per cent of the countries have a $B^{\star}$ value above one). The two other product categories show intermediate median values, but clearly growing in the case of MHT products, indicating an overall

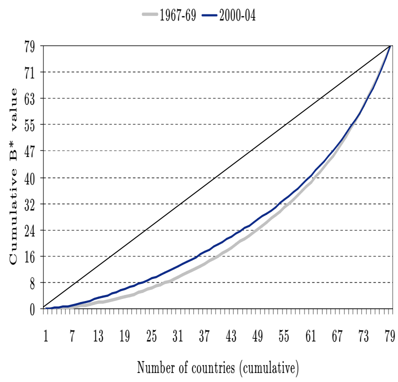
Figure 4: Lorenz curves in four technological categories - 1967-69 and 2000-2004



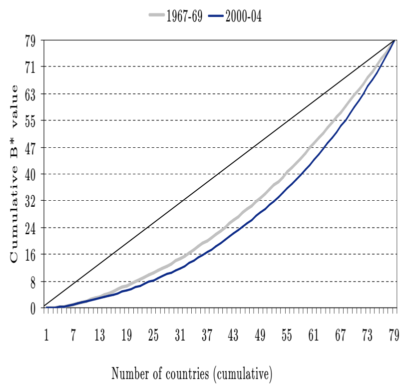
(a) HT industries



(b) MHT industries



(c) MLT industries



(d) LT industries

increase of these $B^{\star}$ values during the period.[15]

Regarding the dispersion of the $B^{\star}$, as measured by the sample standard deviation, Figure 3(b) shows that the dispersion is higher for HT products than for the other three categories, which suggests a higher inequality across countries within this category.[16] The existence of some countries with very high values of $B^{\star}$ in HT products is also illustrated by the magnitude of its local maximum (Figure 3(c)). The opposite is true for LT products. The values of the skewness and kurtosis indicators also differ between the different types of products, showing higher values for HT exports and, to a lesser extent, MLT exports.

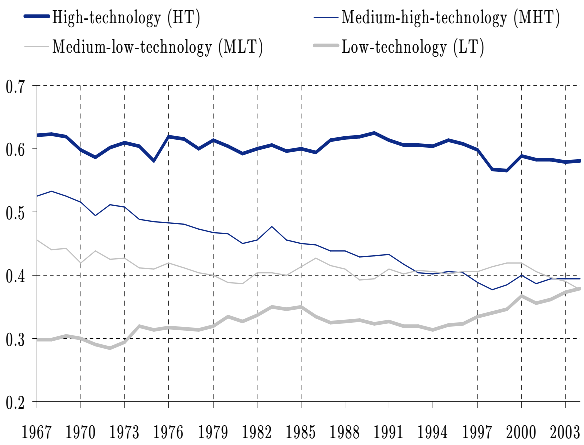
Another way to measure the relative export specialization is to compute Lorenz curves or Gini coefficients for each industry.[17] Figure 4 shows the Lorenz curves for the

[15] On the use of the median, see De Benedictis and Tamberi (2004). Note that a low median means that a product category has a large share of countries with low values of B*; a high median means that a sector has a large share of countries that are specialized in that product.

[16] The inequality index suggested by Yeats (1985) to flag the industries that have major differences in the cross-country distributions of revealed comparative advantage turns out to coincide with the variance of the $B^{\star}$ index.

[17] See for instance Brülhart (2001), Amiti (1999) or Mancusi (2001). It will be recalled that, as described in Section

Figure 5: Export specialization in four technological categories - Gini coefficient



Source: Chelem database and own calculations.

different sectors in the first and last periods of our sample. As expected, the results of the Lorenz curves confirm the analysis done previously: the HT sector curve is the most distant from the 45 degree line of perfect equality in both periods, signaling substantial differences in specialization between countries in these products. The opposite is true for LT exports, which appear much more geographically disperse. Comparing the results of the two periods, this information points to high stability in the cross-country export specialization: in fact, only in MHT industries is there visible some movement to the left, indicating a reduction in the inequality between countries in terms of export weights of these products. As shown in Figure 5, the Gini coefficient is also much higher in the HT sector and shows a downward trend in MHT industries, as previously estimated.

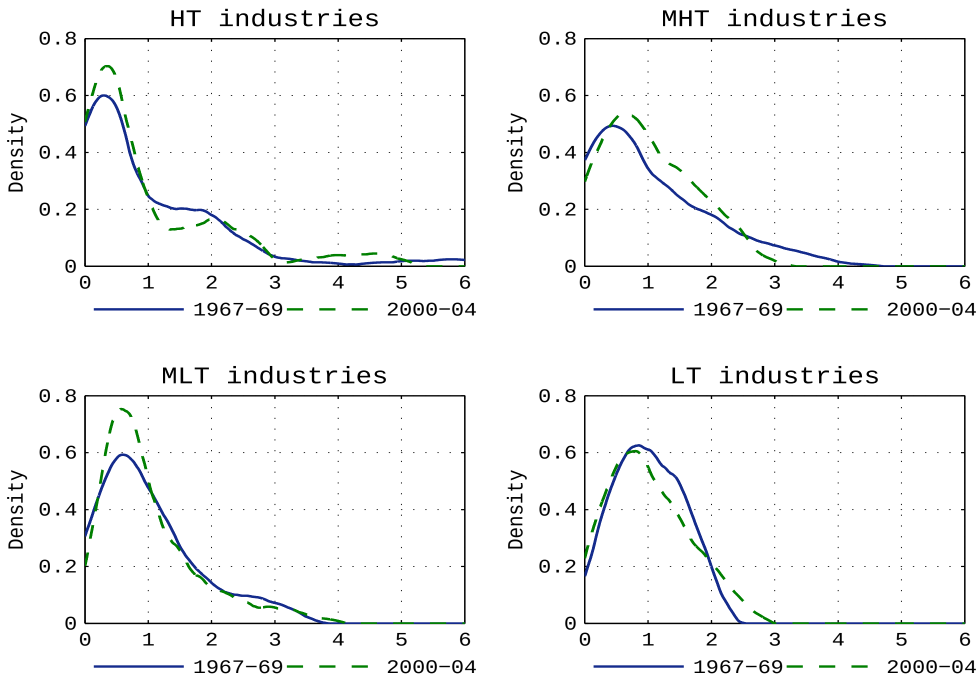
A more complete picture on the degree of international specialization can be obtained by an analysis of the country-distribution of the $B^{\star}$ indices for each product. Empirical research of the dynamics of trade patterns using the entire distribution was pioneered by Proudman and Redding (1997, 2000). Since then, several empirical have studies analyzed the product specialization of a given country (or group of countries) by estimating the entire (cross-sector) distribution of some relative specialization indicator over time.[18] Figure 6 depicts the estimated distribution of the (cross-country) specialization index for each product category, using an Epanechnikov kernel function in the first and last periods of the sample.[19] A visual inspection of the density estimates confirms the previous results of substantial differences in terms of specialization among

2, the result of the sum in both axis is the same (=79), so no rebasement is needed in the case of the $B^{\star}$.

[18]See Brasili, Epifani and Helg (2000), De Benedictis (2006) and Di Maio and Tamagni (2006).

[19]Density estimates depend crucially on the choice bandwidth or smoothing parameter. Several bandwidth variations were tested and the results were qualitatively similar. We used the optimal bandwidth for estimating densities for the normal distribution as the optimal smoothing parameter for the Epanechnikov kernel function, as suggested by Silverman (1986), tended to oversmooth the results. All kernel estimates were made assuming non-negativity.

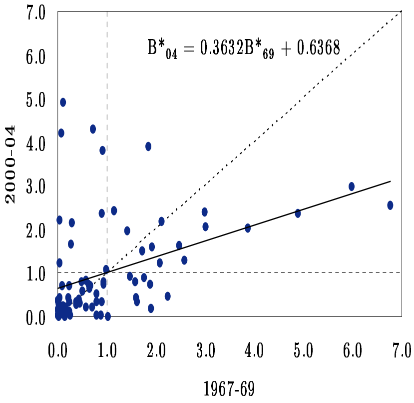
Figure 6: Estimated Kernel Densities - B^*_X



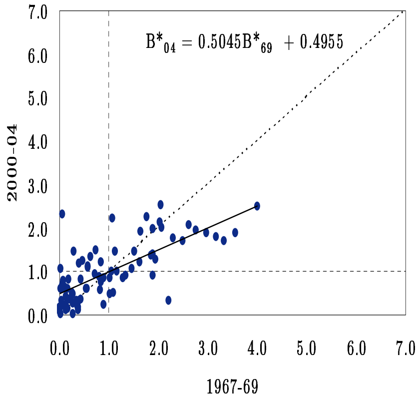
the four sectors. The density function of the HT sector is markedly more right skewed than that of the other sectors, indicating a high degree of specialization. The opposite is true for the density function of LT, which is much more symmetric and roughly centered around the threshold value, indicating more similar export weights among countries in these products. The density estimates of the four products appear quite stable over time. No substantial differences in the shape of the distribution between the two extreme periods are visible for HT and LT sectors. The density estimates for the MHT sector showed some movement to the right, while the MLT distribution seems to become slightly more concentrated below the threshold value in the most recent period.

To sum up, from a static point of view, the four sectors have very different $B^\star$ cross-country distributions. The HT specialization structure is more geographically concentrated and relies on fewer countries, with higher specialization indices. On the other hand, there are more countries revealing similar degrees of specialization in LT exports, with smaller differences among them. From a comparative statics perspective, the country specialization in each of the four types of industries considered shows some stability features over time.

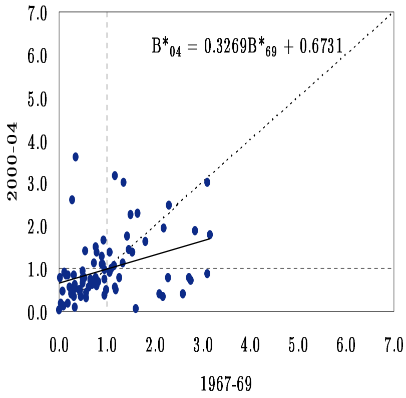
Figure 7: The B^{*}_{ij} in 1967-69 and in 2000-04



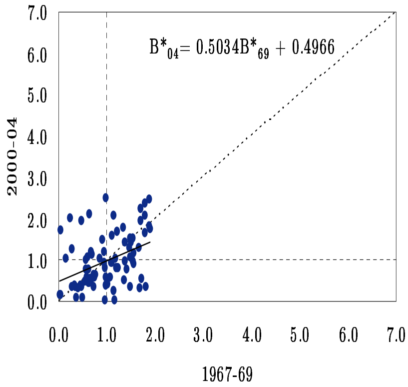
(a) HT industries



(b) MHT industries



(c) MLT industries



(d) LT industries

3.2 The intra-distribution dynamics of the $B^{\star}$

In order to compare the international trade intra-distribution structures in the periods 1967-69 and 2000-04, four scatter plots are depicted for each broad sector and an OLS regression line was superimposed (Figure 7).[20] The two lines drawn in the demarcation value $B^{\star} = 1$ (on both the x and y-axis) define four distinct quadrants. The upper left/right quadrants will be designated by Quadrants I/II, while the equivalent lower left/right by Quadrants III and IV. The 45 degree line identifies situations of pure persistence in which the *level* of relative specialization remains constant, i.e. the $B^{\star}$ index in these countries remains unchanged between 1967-69 and 2000-04. This line crosses quadrants II and III, which define areas in which the $B^{\star}$ index has changed, but the classification of countries in terms of relative specialization has not. Quadrants I and

[20]The data is reported in Appendix E. For the remaining periods, the data is available from the authors upon request. See De Benedictis (2006) and Brasili et al. (2000) for a similar analysis of mobility over time but within the cross-sector distribution of the specialization index.

IV contain countries that modified their relative specialization status, from specialized to unspecialized (quadrant IV) or vice-versa (quadrant I). The most populated area in all four sectors is quadrant III. Therefore, the most striking tendency in the world trade has been the persistence of a non-specialization status, i.e. countries that had a $B^\star < 1$ in 1967-69 had also a $B^\star < 1$ in 2000-04. The second most populated area in all product category is quadrant II, ie. countries with a $B^\star > 1$ in both periods. Thus, according to this product classification, the maintenance of the relative specialization *status quo* has been the rule in the last forty years (around 60 per cent of the total in LT industries, around 70 per cent in MLT industries and above 75 per cent in MHT and HT industries). The HT sector has the highest number of countries that are not specialized in these products either at the beginning or at the end of our sample. The opposite is true for LT products, where only 27 countries remain unspecialized in both periods.[21]

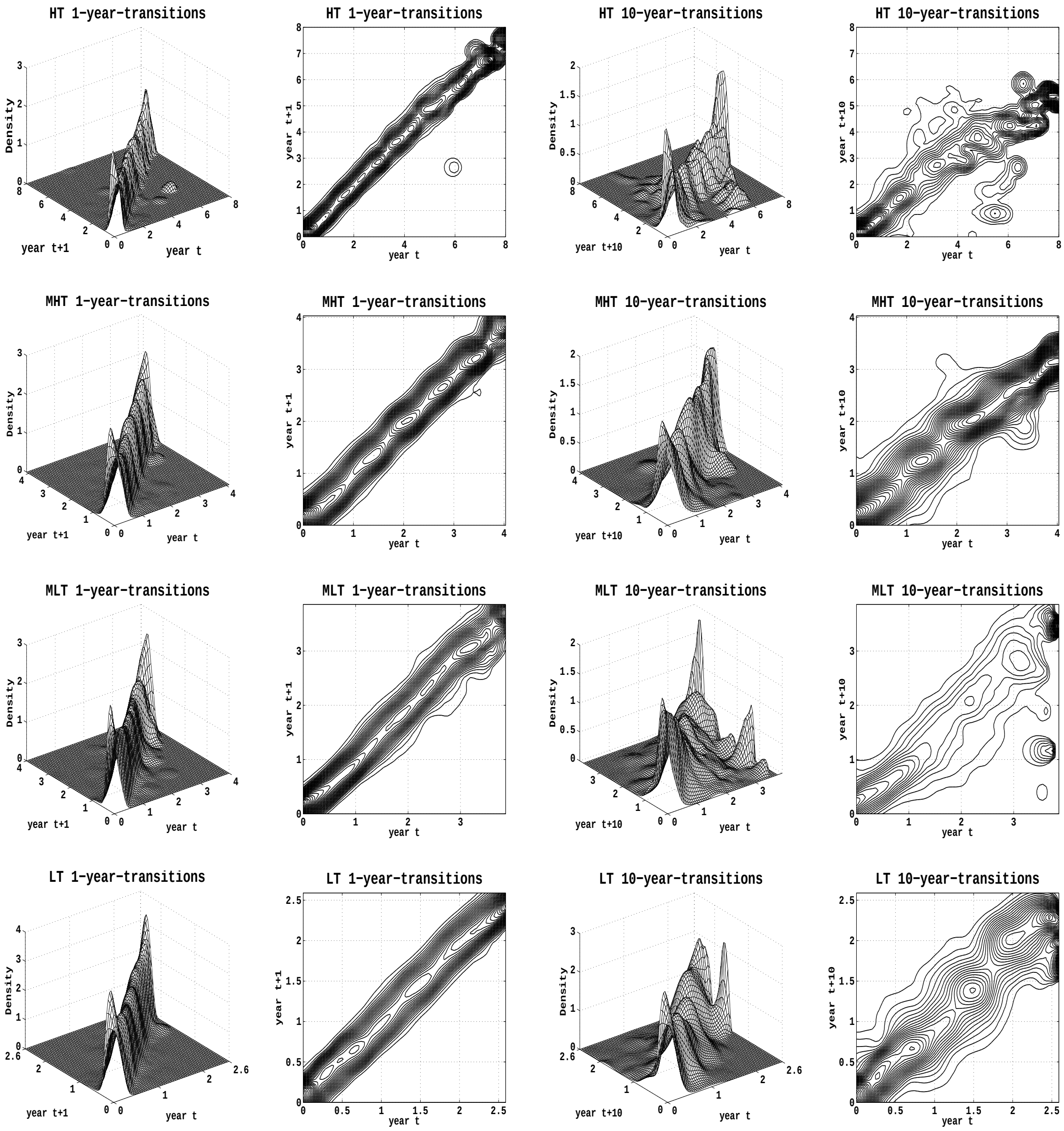
Although commonly used in the literature, the previous analysis gives only partial information on the dynamics of relative export structures. The methods of evaluating the intra-distribution dynamics were initiated by Quah (1993) in discrete time, applied on cross-country income convergence analysis, and extended afterwards towards a continuous time framework (See, in particular, Quah (1997)). The first application of intra-distribution dynamics to trade specialization patterns, using Markov transition matrices, was due to Proudman and Redding (1997, 2000). Brasili et al. (2000) extended this trade analysis to continuous time by estimating stochastic kernels and by drawing information from the conditional distributions at time $t+\tau$, given the value of the indices at time t.[22]

The kernel density estimates of the distribution of $B^\star$ at time $t+\tau$, conditional on its value at time t, were computed as follows. First, the joint density function of the distributions was estimated non-parametrically using Christian Beardah´s Kernel Density Estimation Matlab toolbox. An Epanechnikov kernel function was used, choosing the window width optimally as suggested by Silverman (1986). Second, the implied marginal probability distribution of the first period was calculated by numerical integration. Finally, the conditional distribution was computed as the ratio of the joint by the marginal densities. Figure 8 reports the estimated stochastic kernels for $\tau = 1$ and $\tau = 10$ and the respective contour plots. The interpretation of the 3-D figures is straightforward: from any point on the year t axis, we extend parallel to the axis marked year $t+\tau$, the resulting stochastic kernel is a probability density function that

[21] The information content of Figure 7 confirms also the existence of different export specialization patterns between the four different sectors, as described in the previous section. Again the higher specialization coefficients are found in the HT sector in both periods.

[22] Brasili et al. (2000) concentrated the analysis on $\tau = 15$. Mancusi (2001), from a different perspective, uses patents to measure a country's technological specialization profile.

Figure 8: Estimated Stochastic Kernels - 1-year and 10-year transitions



integrates to unity.[23] Such estimated probability density gives the transitions over $t+\tau$ from any $B^{\star}$ value in period t. The 2-D contour plots are just vertical projections of the stochastic kernel.

Again, there are some signs of persistence in the cross-country international trade pattern. This result could be expected in 1-year transitions because specialization structures are not easily mobile in the short-run. In all four technological categories,

[23]This projection is similar to a row of a Markov transition probability matrix, with all entries non-negative and summing to 1. See Quah (1997). Again, the projection assumed non-negativity.

most of the elements are concentrated along the 45 degree diagonal of the 2-D contour plots, implying that they tend to remain around the values where they started off. Nevertheless, the transitions calculated over a 10-year period still reveal some relatively important degree of persistence, although less strong than in the 1-year case.[24] In particular, all sectors show significant persistence of the low values of the index, pointing to relative stability of the non-specialization status over a 10-year horizon. There is also some evidence of a transfer of the probability mass to the area below the 45 degree line for high values of the $B^{\star}$ index. This is visible in all sectors, though in different degrees. In the LT sector, the dispersion of the index is more evenly distributed around the 45 degree diagonal. The sector that exhibits the highest degree of mobility, showing in particular a clearer tendency towards a reduction for very high specialization values seems to be the HT sector.

The dynamics of the relative export structures can be further developed by estimating the "long term" or "stationary distribution" implicit in the conditional distribution, i.e. the ergodic distribution. For its computation a two step method was adopted. Firstly, the conditional distribution is transformed into a very large Markov transition matrix, where all rows sum to unity. This matrix is then raised to a sufficiently large number so as to produce a matrix with virtually identical rows (i.e. of rank 1).[25] Figure (9) superimposes the ergodic distributions, obtained both from the 1-year and from the 10-years transitions, and the previously reported densities. Density functions are quite similar in all sectors, meaning that the actual relative export structures are not very different from the "long term distribution".

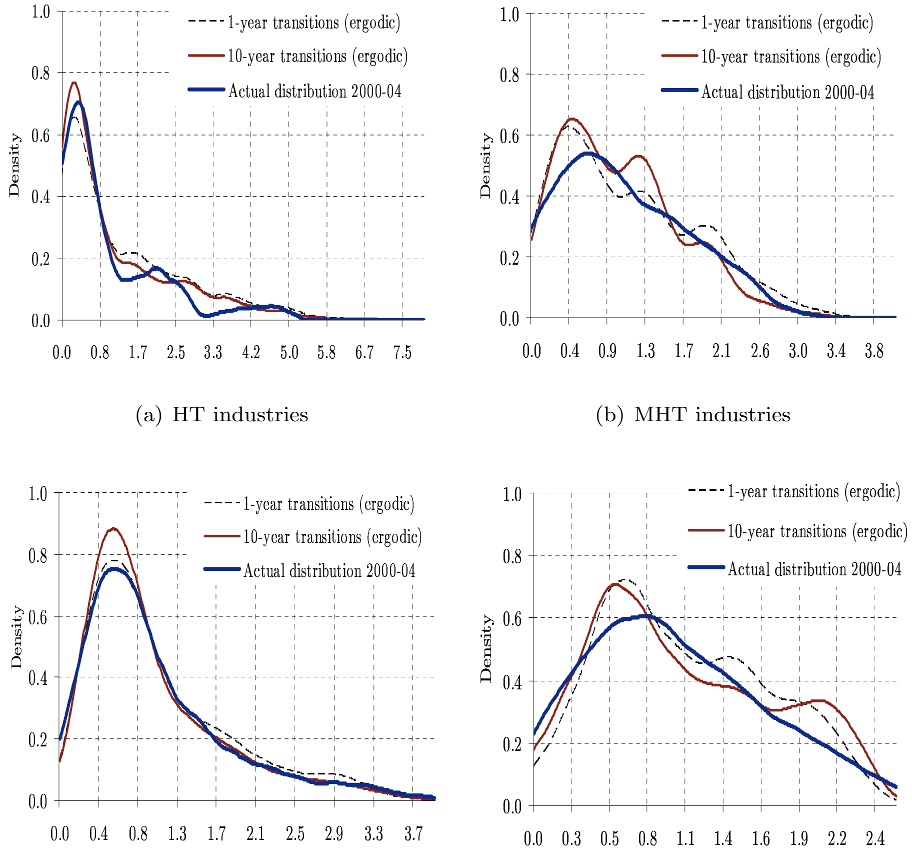
To gain further insights at the individual country level, Table 2 reports the values of the $B^{\star}$ index for the 10 top and bottom ranked countries in each of the four product categories in the eight reference periods. The countries that are ranked in two consecutive periods and both in the first and last periods of our sample are highlighted in the table. In most adjacent periods, the countries ranked are practically the same and even if we compare the two extreme reference periods, around 30 per cent of the countries appear in the top/bottom ranks in both periods.

Given the additive properties of the $B^{\star}$, the sum of all top/bottom countries is also reported, including the percentage of this result in the total (i.e. in $N = 79$). The contribution of the top 10 countries is the highest for HT products (covering more than 40 per cent of the total value in each period) and the lowest for LT goods (around half that percentage). This result is in line with the previous evidence that the HT sector

[24] We have carried out the analysis using 5-year and 15-year lags, as well as 5-years average periods, and the results do not change the overall assessment.

[25] In practical terms, the Markov transition matrix implicit in the estimated conditional density was iterated 1,000,000 times. On the computations of ergodic distributions in continuous time, see Juessen (2005) and Johnson (2004).

Figure 9: Actual and implicit ergodic distribution of B^{*}_{ij}



(a) HT industries

(b) MHT industries

(c) MLT industries

(d) LT industries

tends to have some countries with very high relative specialization indexes, while the relative specialization pattern in LT goods is much more similar across countries. The countries ranked as more specialized in HT products are mostly advanced economies, while the opposite happens in LT goods, where most of the countries that appear in the top 10 are least developed economies. The significant presence of East Asian countries in HT trade is evident from this data, as they appear in the top 3 places in the most recent period, with Ireland being the only euro area country in the top 10. The relative specialization of East Asian countries in these types of goods is not a new phenomenon as around half of the countries ranked in the top 10 since the 70s are from this geographical area. However, in the initial years of the sample, the Asian countries ranked are all advanced economies like Japan, Hong Kong, Singapore, South Korea and Taiwan. In the last periods, two East Asian emerging economies also appear as very specialized in HT products: Malaysia (since early 80s) and more recently Philippines (since the mid 90s). This fact may reflect the reorganization of production in Asia through increased international segmentation of production processes among Asian

Table 2 - B* index: Top10 and Bottom10 countries

High-technology products (HT)

1967-69		1970-74		1975-79		1980-84		1985-89		1990-94		1995-99		2000-04	
Country	B*	Country	B*	Country	B*	Country	B*	Country	B*	Country	B*	Country	B*	Country	B*
Switzerland	6.76	Switzerland	5.54	Hungary	6.90	Hungary	5.71	Hungary	5.16	Singapore	5.38	Singapore	5.01	Philippines	4.91
Taiwan	5.99	Taiwan	5.29	Taiwan	4.52	Taiwan	3.73	Singapore	4.71	Malaysia	4.92	Philippines	4.83	Singapore	4.29
United States	4.89	United States	4.74	Switzerland	4.30	United States	3.72	Malaysia	4.02	Others in South E	4.59	Malaysia	4.40	Malaysia	4.20
Japan	3.86	Japan	3.39	Singapore	3.79	Ireland	3.57	Ireland	3.93	Ireland	3.59	Others in South E	3.81	Ireland	3.91
Netherlands	3.01	United Kingdom	2.88	United States	3.78	Switzerland	3.54	United States	3.46	United States	3.24	Ireland	3.62	Others in South E	3.80
United Kingdom	2.99	Singapore	2.72	Hong Kong	3.29	Hong Kong	3.45	Japan	3.43	Japan	3.11	Taiwan	2.83	Taiwan	2.98
Germany	2.58	Hong Kong	2.60	Japan	3.13	Malaysia	3.38	Taiwan	2.96	United Kingdom	2.92	United States	2.56	Switzerland	2.54
France	2.46	Hungary	2.53	United Kingdom	2.67	Japan	3.32	Switzerland	2.95	Switzerland	2.85	United Kingdom	2.47	South Korea	2.43
Poland	2.24	South Korea	2.41	Ireland	2.59	Singapore	3.16	United Kingdom	2.94	Hong Kong	2.84	Japan	2.37	United Kingdom	2.38
Hungary	2.12	Netherlands	2.40	South Korea	2.35	United Kingdom	2.84	Hong Kong	2.94	Taiwan	2.77	Israel	2.37	Israel	2.38
TOP 10	36.9	TOP 10	34.5	TOP 10	37.3	TOP 10	36.4	TOP 10	36.5	TOP 10	36.2	TOP 10	34.3	TOP 10	33.8
% Total	46.7	% Total	43.7	% Total	47.2	% Total	46.1	% Total	46.2	% Total	45.8	% Total	43.4	% Total	42.8
Peru	0.03	Sri Lanka	0.03	Chile	0.05	Sri Lanka	0.05	Peru	0.03	Chile	0.08	Nigeria	0.07	Peru	0.04
Thailand	0.03	Paraguay	0.03	Peru	0.04	Morocco	0.04	Paraguay	0.02	Cambodia, Laos	0.08	Cote d'Ivoire	0.06	Cote d'Ivoire	0.04
Chile	0.02	Bolivia	0.02	Nigeria	0.04	Saudi Arabia	0.04	Bangladesh	0.02	Saudi Arabia	0.06	Venezuela	0.06	Bangladesh	0.03
Iceland	0.02	Chile	0.02	Paraguay	0.04	Libya	0.03	Venezuela	0.02	Peru	0.06	Chile	0.05	Nigeria	0.02
Cambodia, Laos	0.02	Libya	0.02	Bangladesh	0.03	Venezuela	0.03	Nigeria	0.02	Venezuela	0.05	Cameroon	0.04	Saudi Arabia	0.02
Saudi Arabia	0.02	Venezuela	0.02	Venezuela	0.02	Paraguay	0.02	Algeria	0.01	Nigeria	0.03	Cambodia, Laos	0.03	Brunei	0.02
Sri Lanka	0.01	Nigeria	0.02	Bolivia	0.02	Bangladesh	0.02	Saudi Arabia	0.01	Algeria	0.01	Algeria	0.03	Cameroon	0.02
Bolivia	0.01	Iceland	0.01	Iceland	0.01	Bolivia	0.01	Bolivia	0.00	Bangladesh	0.01	Bangladesh	0.02	Algeria	0.01
Nigeria	0.01	Bangladesh	0.00	Libya	0.01	Algeria	0.01	Libya	0.00	Brunei	0.01	Saudi Arabia	0.01	Libya	0.01
Paraguay	0.01	Brunei	0.00	Brunei	0.01	Brunei	0.00	Brunei	0.00	Libya	0.01	Libya	0.01	Cambodia, Laos	0.01
BOTOM 10	0.2	BOTOM 10	0.2	BOTOM 10	0.3	BOTOM 10	0.2	BOTOM 10	0.1	BOTOM 10	0.4	BOTOM 10	0.4	BOTOM 10	0.2
% Total	0.2	% Total	0.2	% Total	0.3	% Total	0.3	% Total	0.2	% Total	0.5	% Total	0.5	% Total	0.3

Medium-high-technology products (MHT)

1967-69		1970-74		1975-79		1980-84		1985-89		1990-94		1995-99		2000-04	
Country	B*	Country	B*	Country	B*	Country	B*	Country	B*	Country	B*	Country	B*	Country	B*
Germany	4.00	Germany	3.69	Germany	3.31	Germany	3.06	Former Czechoslo	3.04	Germany	2.80	Germany	2.65	Japan	2.54
United States	3.55	United States	3.19	United States	3.00	Former Czechoslo	2.92	Germany	2.86	Japan	2.71	Japan	2.54	Germany	2.50
United Kingdom	3.32	Switzerland	3.17	Switzerland	2.88	Japan	2.78	Japan	2.72	Mexico	2.69	Spain	2.36	Saudi Arabia	2.31
Switzerland	3.16	United Kingdom	2.97	Japan	2.66	Switzerland	2.65	Switzerland	2.46	Spain	2.44	Mexico	2.35	Spain	2.25
Italy	2.96	Italy	2.73	France	2.63	United States	2.61	Canada	2.45	Canada	2.30	Canada	2.18	Mexico	2.22
France	2.76	France	2.73	United Kingdom	2.63	Canada	2.52	Mexico	2.43	Switzerland	2.25	Switzerland	2.11	Former Czechoslo	2.15
Canada	2.61	Canada	2.52	Canada	2.53	United Kingdom	2.38	United States	2.29	France	2.14	BLEU	2.09	Canada	2.09
Poland	2.48	Japan	2.46	Italy	2.31	France	2.38	France	2.17	BLEU	2.10	Former Czechoslo	2.03	BLEU	2.03
Sweden	2.29	Poland	2.33	Sweden	2.27	Sweden	2.21	Spain	2.12	United States	2.08	Austria	2.03	Austria	1.98
Algeria	2.21	Sweden	2.30	BLEU	2.19	Italy	2.10	BLEU	2.03	Austria	2.04	France	1.99	France	1.97
TOP 10	29.3	TOP 10	28.1	TOP 10	26.4	TOP 10	25.6	TOP 10	24.6	TOP 10	23.6	TOP 10	22.3	TOP 10	22.0
% Total	37.1	% Total	35.6	% Total	33.4	% Total	32.4	% Total	31.1	% Total	29.8	% Total	28.2	% Total	27.9
Saudi Arabia	0.06	Pakistan	0.11	Bolivia	0.17	Others in Africa	0.17	Gabon	0.22	Peru	0.21	Paraguay	0.23	Cameroon	0.21
Indonesia	0.05	Thailand	0.09	Venezuela	0.15	Bangladesh	0.17	Bangladesh	0.18	Sri Lanka	0.21	Albania	0.21	Peru	0.20
Ecuador	0.05	Indonesia	0.09	African LDCs	0.15	Viet Nam	0.16	Others in Africa	0.17	Bangladesh	0.19	Peru	0.20	Iceland	0.18
East Asian LDCs	0.04	Saudi Arabia	0.08	Pakistan	0.11	Pakistan	0.13	African LDCs	0.15	Others in Africa	0.17	Bolivia	0.19	Albania	0.17
Peru	0.03	Bangladesh	0.07	Gabon	0.11	Nigeria	0.13	Ecuador	0.11	Bolivia	0.15	Sri Lanka	0.17	Sri Lanka	0.16
Cambodia, Laos	0.02	Libya	0.06	East Asian LDCs	0.11	Bolivia	0.11	Bolivia	0.09	Viet Nam	0.14	Bangladesh	0.16	Others in Africa	0.12
Thailand	0.02	Nigeria	0.06	Bangladesh	0.06	East Asian LDCs	0.11	Pakistan	0.08	Cambodia, Laos	0.10	Others in Africa	0.12	Pakistan	0.11
Nigeria	0.02	Cambodia, Laos	0.05	Libya	0.04	Algeria	0.11	Viet Nam	0.06	Iceland	0.05	Iceland	0.10	Bangladesh	0.09
Iceland	0.01	Brunei	0.02	Iceland	0.02	Iceland	0.03	Iceland	0.04	Pakistan	0.03	Cambodia, Laos	0.08	Cambodia, Laos	0.02
Bangladesh	0.00	Iceland	0.02	Brunei	0.01	Brunei	0.02	Brunei	0.00	Brunei	0.01	Pakistan	0.03	Brunei	0.02
BOTOM 10	0.3	BOTOM 10	0.6	BOTOM 10	0.9	BOTOM 10	1.1	BOTOM 10	1.1	BOTOM 10	1.2	BOTOM 10	1.5	BOTOM 10	1.3
% Total	0.4	% Total	0.8	% Total	1.2	% Total	1.4	% Total	1.4	% Total	1.6	% Total	1.9	% Total	1.6

Medium-low-technology products (MLT)

1967-69		1970-74		1975-79		1980-84		1985-89		1990-94		1995-99		2000-04	
Country	B*	Country	B*	Country	B*	Country	B*	Country	B*	Country	B*	Country	B*	Country	B*
Saudi Arabia	3.16	Saudi Arabia	3.05	Brunei	3.07	Brunei	2.85	Brunei	3.20	Brunei	3.46	Algeria	3.62	Algeria	3.61
Bolivia	3.11	Brunei	3.01	Libya	3.07	Algeria	2.74	Algeria	2.99	Algeria	3.27	Venezuela	3.15	Libya	3.17
Venezuela	3.10	Venezuela	2.97	Venezuela	2.96	Venezuela	2.71	Venezuela	2.95	Venezuela	2.93	Libya	3.14	Nigeria	3.02
Chile	2.85	Libya	2.89	Saudi Arabia	2.83	Saudi Arabia	2.51	Libya	2.68	Libya	2.84	Nigeria	2.86	Venezuela	3.01
Indonesia	2.75	Bolivia	2.74	Bolivia	2.55	Gulf	2.41	Gulf	2.55	Saudi Arabia	2.46	Saudi Arabia	2.66	Egypt	2.60
Brunei	2.72	Chile	2.71	Gulf	2.25	Libya	2.37	Saudi Arabia	2.52	Gulf	2.40	Gulf	2.57	Gulf	2.48
Malaysia	2.59	Indonesia	2.34	Chile	2.25	Bolivia	2.35	African LDCs	2.30	Gabon	2.33	Former USSR	2.21	Peru	2.29
Gulf	2.30	African LDCs	2.19	Algeria	2.08	African LDCs	2.10	Gabon	2.11	African LDCs	2.26	Peru	2.14	Former USSR	2.27
Singapore	2.28	Gulf	2.19	Indonesia	2.06	Former USSR	1.98	Chile	2.06	Former USSR	2.11	Egypt	1.98	African LDCs	1.94
African LDCs	2.19	Malaysia	1.99	African LDCs	2.04	Gabon	1.95	Bolivia	1.98	Chile	1.86	Chile	1.93	Chile	1.88
TOP 10	27.0	TOP 10	26.1	TOP 10	25.2	TOP 10	24.0	TOP 10	25.4	TOP 10	25.9	TOP 10	26.3	TOP 10	26.3
% Total	34.2	% Total	33.0	% Total	31.9	% Total	30.3	% Total	32.1	% Total	32.8	% Total	33.2	% Total	33.3
Hong Kong	0.22	East Asian LDCs	0.23	New Zealand	0.28	Tunisia	0.30	Morocco	0.28	Others in South E	0.33	Viet Nam	0.30	Israel	0.34
Philippines	0.19	Argentina	0.23	Philippines	0.27	New Zealand	0.29	Ireland	0.28	Morocco	0.32	Tunisia	0.30	Morocco	0.34
South Korea	0.18	Hong Kong	0.22	East Asian LDCs	0.27	East Asian LDCs	0.28	Hungary	0.25	Israel	0.30	Philippines	0.25	Viet Nam	0.34
Argentina	0.15	Morocco	0.22	Tunisia	0.26	Ireland	0.28	East Asian LDCs	0.25	Ireland	0.25	Hong Kong	0.23	Tunisia	0.32
Iceland	0.11	Philippines	0.20	Argentina	0.25	Hungary	0.25	Ecuador	0.22	Hong Kong	0.22	East Asian LDCs	0.19	Paraguay	0.19
Pakistan	0.09	New Zealand	0.14	Uruguay	0.24	Pakistan	0.20	Hong Kong	0.21	Uruguay	0.20	Ireland	0.16	Philippines	0.19
New Zealand	0.07	Pakistan	0.12	Hong Kong	0.18	Hong Kong	0.18	Uruguay	0.12	East Asian LDCs	0.14	Paraguay	0.16	Pakistan	0.13
Paraguay	0.03	Ecuador	0.07	Pakistan	0.13	Uruguay	0.14	Pakistan	0.09	Paraguay	0.12	Cambodia, Laos	0.16	Ireland	0.10
Ecuador	0.01	Bangladesh	0.05	Bangladesh	0.05	Bangladesh	0.08	Bangladesh	0.08	Bangladesh	0.06	Bangladesh	0.05	Cambodia, Laos	0.06
Bangladesh	0.00	Paraguay	0.03	Paraguay	0.02	Paraguay	0.01	Paraguay	0.04	Pakistan	0.05	Pakistan	0.04	Bangladesh	0.04
BOTOM 10	1.1	BOTOM 10	1.5	BOTOM 10	1.9	BOTOM 10	2.0	BOTOM 10	1.8	BOTOM 10	2.0	BOTOM 10	1.9	BOTOM 10	2.1
% Total	1.3	% Total	1.9	% Total	2.5	% Total	2.5	% Total	2.3	% Total	2.5	% Total	2.3	% Total	2.6

Low-technology products (LT)

1967-69		1970-74		1975-79		1980-84		1985-89		1990-94		1995-99		2000-04	
Country	B*	Country	B*	Country	B*	Country	B*	Country	B*	Country	B*	Country	B*	Country	B*
Iceland	1.89	Bangladesh	1.99	Bangladesh	2.12	Bangladesh	2.28	Bangladesh	2.25	Pakistan	2.22	Pakistan	2.30	Cambodia, Laos	2.50
Bangladesh	1.88	Pakistan	1.90	Pakistan	2.00	Pakistan	2.15	Pakistan	2.25	Bangladesh	2.19	Bangladesh	2.28	Bangladesh	2.47
New Zealand	1.88	New Zealand	1.89	East Asian LDCs	1.92	Paraguay	2.13	Ecuador	2.17	East Asian LDCs	2.03	Cambodia, Laos	2.26	Pakistan	2.36
Philippines	1.80	Philippines	1.88	Iceland	1.87	Uruguay	2.11	Uruguay	2.05	Paraguay	2.02	Paraguay	2.16	Paraguay	2.24
East Asian LDCs	1.79	Ecuador	1.86	New Zealand	1.87	East Asian LDCs	2.10	Paraguay	2.05	Cambodia, Laos	2.01	Sri Lanka	2.05	Sri Lanka	2.10
Pakistan	1.78	East Asian LDCs	1.83	Uruguay	1.85	Iceland	2.04	East Asian LDCs	2.05	Viet Nam	1.97	East Asian LDCs	2.01	East Asian LDCs	2.08
Ecuador	1.78	Paraguay	1.82	Philippines	1.85	Viet Nam	2.04	Viet Nam	2.01	Iceland	1.96	Albania	1.97	Albania	2.07
Egypt	1.71	Iceland	1.76	Paraguay	1.82	New Zealand	2.01	Iceland	1.97	Sri Lanka	1.96	Viet Nam	1.89	Brunei	2.02
Paraguay	1.70	Uruguay	1.69	Ecuador	1.73	Thailand	1.81	New Zealand	1.88	Ecuador	1.79	Iceland	1.89	Viet Nam	1.96
Uruguay	1.69	Egypt	1.67	Turkey	1.67	Philippines	1.80	Sri Lanka	1.79	Uruguay	1.75	Uruguay	1.84	Uruguay	1.95
TOP 10	17.9	TOP 10	18.3	TOP 10	18.7	TOP 10	20.5	TOP 10	20.5	TOP 10	19.9	TOP 10	20.6	TOP 10	21.8
% Total	22.7	% Total	23.2	% Total	23.7	% Total	25.9	% Total	25.9	% Total	25.2	% Total	26.1	% Total	27.5
Singapore	0.37	Switzerland	0.38	Switzerland	0.38	Bolivia	0.39	United States	0.38	Former USSR	0.39	Mexico	0.40	Ireland	0.34
United States	0.35	Singapore	0.31	Former USSR	0.35	Singapore	0.25	Former USSR	0.33	United States	0.39	United States	0.37	South Korea	0.32
Malaysia	0.33	Japan	0.31	Germany	0.33	Former USSR	0.25	Singapore	0.26	Mexico	0.35	Germany	0.37	Switzerland	0.32
Germany	0.27	Germany	0.29	Bolivia	0.32	Gulf	0.20	Gulf	0.23	Singapore	0.18	Switzerland	0.35	Nigeria	0.27
Indonesia	0.26	Chile	0.17	Singapore	0.29	Japan	0.19	Japan	0.14	Venezuela	0.15	Venezuela	0.16	Saudi Arabia	0.17
Brunei	0.23	Bolivia	0.17	Japan	0.20	Algeria	0.06	Venezuela	0.09	Japan	0.12	Singapore	0.12	Venezuela	0.15
Chile	0.15	Libya	0.14	Saudi Arabia	0.05	Saudi Arabia	0.04	Saudi Arabia	0.04	Saudi Arabia	0.07	Japan	0.11	Singapore	0.11
Venezuela	0.04	Brunei	0.07	Venezuela	0.04	Venezuela	0.03	Algeria	0.04	Brunei	0.06	Saudi Arabia	0.10	Japan	0.11
Bolivia	0.03	Venezuela	0.06	Brunei	0.01	Libya	0.01	Libya	0.00	Algeria	0.05	Algeria	0.04	Algeria	0.03
Saudi Arabia	0.01	Saudi Arabia	0.02	Libya	0.01	Brunei	0.01	Brunei	0.00	Libya	0.03	Libya	0.03	Libya	0.02
BOTOM 10	2.0	BOTOM 10	1.9	BOTOM 10	2.0	BOTOM 10	1.4	BOTOM 10	1.5	BOTOM 10	1.8	BOTOM 10	2.0	BOTOM 10	1.8
% Total	2.6	% Total	2.4	% Total	2.5	% Total	1.8	% Total	1.9	% Total	2.3	% Total	2.6	% Total	2.3

Source: Chelem database and own calculations.

Note:

Country also in the Top 10 / Bottom 10 in the previous period.

In **Bold**, country in the Top 10 / Bottom 10 in the 1967/69 and in the 2004/04 periods.

partners, a subject we will return to in Section 4.

3.3 Export specialization in the G5 and China

The technological content of exports of G5 countries and China will now be analysed in more detail. Table 3 reports the relative export specialization of these countries for the 2000-2004 period, not only for the main four product categories used previously, but also considering a second breakdown level that includes twenty more detailed sub-sectors.[26] All $B^{\star}$ indices higher than 2 are also highlighted in the table.

The six countries selected are more specialized than the world average in HT and MHT goods (the only exception being China in MHT) and show below 1 specialization coefficients in LT and MLT products in this period. However, sharp differences between countries exist at a more detailed level.

The UK, US, Japan and even China all have higher export weights of the HT category than the two biggest euro area countries. In particular, France and Germany have lower weights in "Office, accounting and computing machinery" and in "Radio, TV and communications equipment". On the contrary, the large proportion of the HT category in Chinese exports results mainly from these two products, in particular "Office, accounting and computing machinery", as Chinese exports of products like "Aircraft and spacecraft" and "Pharmaceuticals" are well below average. Besides China, the UK also has a high export weight in "Office, accounting and computing machinery", while in "Radio, TV and communications equipment" the highest specialization coefficient is Japan's. The US has the highest specialization coefficient in "Aircraft and spacecraft" products, followed by the UK and France. These two countries have also a relatively higher proportion of "Pharmaceuticals" in total exports. The share of "Medical, precision and optical instruments" in total exports is especially relevant in the US, Japan, and, to a lesser extent, in the UK and Germany. Within the euro area, French exports have a higher overall share of HT goods than German exports, mainly due to "Aircraft and spacecraft" products.

As regards the main category of MHT, its export weight is the highest in Japan and Germany and the lowest in China. Japan, Germany and France have especially high export weights of "Motor vehicles, trailers and semi-trailers". The share of "Railroad equipment and other transport equipment", which includes bicycles and motorcycles, is well above world average in Japanese and Chinese exports. Exports of "Other machinery and equipment" are especially relevant in Germany, Japan and the US.

[26] Note that the $B^{\star}$ of the broader sector can be decomposed as a weighted sum of $B^{\star}$ indices of the sub-sectors. These weights correspond to the ratio of the unweighted world average share of the sub-sector to the unweighted world average share of the broader sector. The analysis of these "contributions" will not be explored in the current paper.

Table 3 - Relative product specialization of G5 countries and China, B* average 2000-2004

	US	France	Germany	UK	Japan	China
High-technology products	**2.4**	**1.6**	**1.3**	**2.4**	**2.0**	**2.2**
Aircraft and spacecraft	8.2	6.6	1.8	6.6	0.5	0.2
Pharmaceuticals	1.6	2.5	1.8	3.0	0.5	0.4
Office, accounting and computing machinery	1.7	0.8	1.0	2.4	2.0	4.2
Radio, TV and communications equipment	1.6	0.9	0.8	1.4	2.5	2.2
Medical, precision and optical instruments	3.8	1.7	2.4	2.5	3.4	1.5
Medium-high-technology products	**1.9**	**2.0**	**2.5**	**1.7**	**2.5**	**1.0**
Other electrical machinery and apparatus	1.5	1.5	1.7	1.4	2.0	2.1
Motor vehicles, trailers and semi-trailers	2.0	3.0	3.9	2.0	4.1	0.3
Chemicals excl. pharmaceuticals	1.5	1.5	1.4	1.4	1.2	0.6
Railroad equipment and other transport equip.	1.5	1.5	1.8	0.7	5.5	3.4
Other machinery and equipment	2.5	1.9	3.1	2.1	2.9	1.4
Medium-low-technology products	**0.5**	**0.6**	**0.6**	**0.6**	**0.5**	**0.5**
Coke, refined petroleum prod. and nuclear fuel	0.2	0.2	0.2	0.4	0.0	0.1
Rubber and plastics products	1.3	1.4	1.5	1.1	1.1	1.2
Other non-metallic mineral products	0.7	1.2	1.1	0.8	0.8	1.3
Building and repairing of ships and boats	0.1	0.4	0.2	0.2	1.3	0.4
Basic metals	0.4	0.6	0.6	0.5	0.6	0.3
Fabricated metal products, excl. machinery	1.2	1.3	1.9	1.3	0.9	2.0
Low-technology products	**0.4**	**0.5**	**0.3**	**0.4**	**0.1**	**0.9**
Other manufacturing and recycling	0.7	0.6	0.6	0.7	0.5	2.3
Wood, pulp, paper and printed products	0.8	0.6	0.7	0.6	0.1	0.3
Food products, beverages and tobacco	0.4	0.7	0.3	0.4	0.0	0.2
Textiles, textile products, leather and footwear	0.2	0.3	0.2	0.2	0.1	1.3

Source: Chelem database and own calculations.

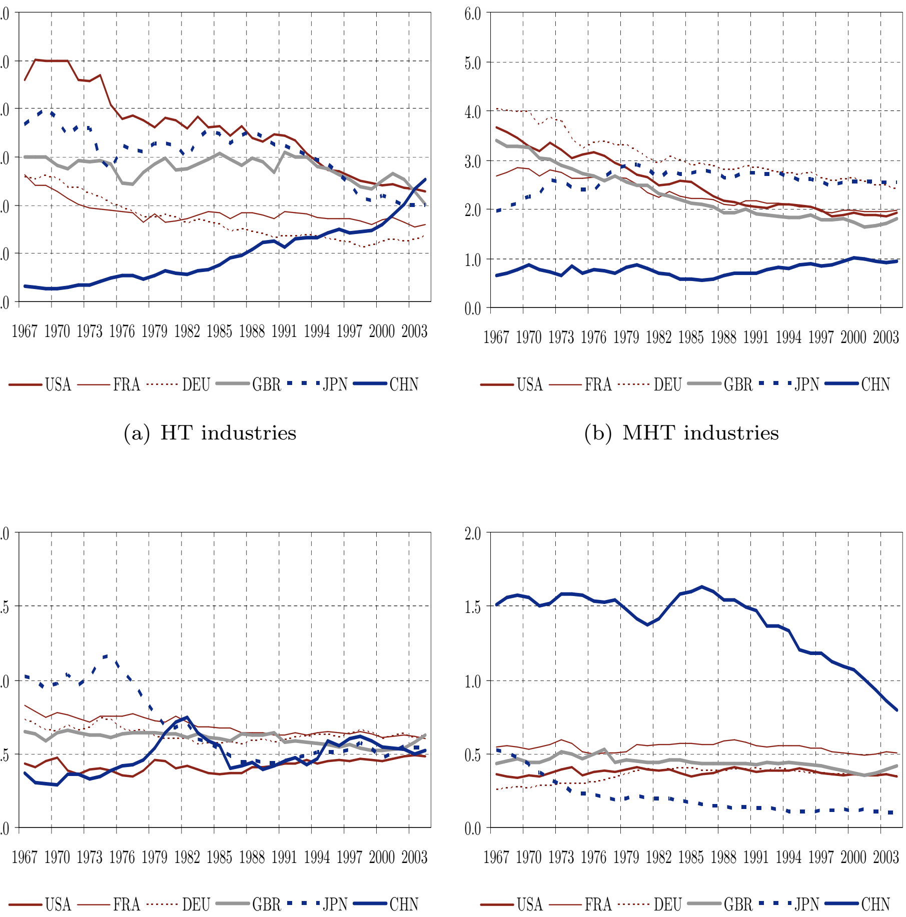
Notes: (a) Higher than 1 outcomes indicate a relative specialization in that product, i.e. a weight in total domestic exports that is higher than the equivalent unweighted average of 79 countries; (b) Each index embodies suitable cardinal properties, where the sum across countries is equal to 79 (thus $B^*_{ij}/79$ represents the percentage contribution of each country i in sector j).

In terms of MLT industries, the relative importance of this broad category is very similar in all six countries analysed, and below world average. Nevertheless, some differences emerge at the second breakdown level. The six countries have above average exports weights in "Rubber and plastics products", slightly higher in France and Germany than in the other four countries. Exports of "Fabricated metal products, excluding machinery" are also important for these six countries, specially in Germany and China where the weights are around twice the world unweighted average.

Finally, in the LT broad category, Japan has the lowest export proportion of these countries and China the highest, although both are below world average. However, while Japanese exports have the lowest specialization coefficient in all LT sub-sectors, China is the only country where a specialization status emerges, not in the broad category, but in "Textiles, textile products, leather and footwear" and in "Other manufacturing and recycling", which include goods like furniture, games and toys.

Figure 10 illustrates the relative export specialization of G5 countries and China by

Figure 10: The B^{*}_{ij} in G5 countries and China



(a) HT industries

(b) MHT industries

(c) MLT industries

(d) LT industries

displaying the value of $B^{\star}$ of each broad technological category over the period 1967-2004. The performance of the Chinese economy in HT products is specially striking: having started with a lower than average share in total exports, it shows the highest specialization coefficient of the six countries selected in the last years of our sample. This result is in line with Rodrik (2006), who concludes that China has an export basket that is significantly more sophisticated than what would be normally expected for a country at its income level and also that it has experienced a high rate of growth in the sophistication of its exports.[27] This pattern may be related with vertical specialization activities, based on inputs imported from other Asian countries. Such products, however, are mostly assembled in China with as yet little "Made in China" technol-

[27]Rodrik (2006) uses an indicator that measures the productivity level associated with a country's export basket constructed in Hausmann et al. (2005). The author also provides evidence suggesting that the rapid increase in the overall sophistication of Chinese exports has been an important contributor to China's recent growth and emphasizes the role of production- and technology-oriented policies of the Chinese government.

ogy.[28] Declining trends of $B^{\star}$ in the HT category are visible in the USA (since the 70s), in Japan and in the UK since the early 90s, bringing the HT export weight of these countries closer to, although still around twice, world average. Following a decrease in the initial years of the sample, France and Germany have maintain their relative specialization in HT exports fairly stable in the last 20 years, but always below the other three developed countries considered.

The high specialization of Japan and Germany in MHT exports has been a stable feature of these two countries in the last 20 years, with a share in total exports around 2.5 higher than the world average. After falling at the beginning of the sample, the US, the UK and France have a proportion of MHT exports that has stood at around twice the world average since the early 90s. The share of MHT products in total Chinese exports is slightly below world average throughout the entire sample.

The relative (non-)specialization of these six countries in MLT exports displays a very stable pattern in the last 20 years, more clustered around similar levels than in the other product categories.

Lastly, the most distinctive result in the LT category is the strong decrease in the specialization of Chinese exports relatively to the world unweighted average. After more than two decades of high specialization, a significant reduction was recorded from the mid 80s onwards. At present, China still shows a percentage of total exports in this category higher than in the other countries considered, but already below the world unweighted average. All other countries have always had a proportion of LT products in total exports clearly below the world average, with Japan showing the lowest value since the mid-70s.

4 Some evidence on vertical specialization

One of the major factors underlying the high growth rate of international trade is the division of the production chain, with the different stages of production being performed in different countries.[29] An investigation on the importance of the vertical specialization phenomena across all countries of the world since the late sixties would typically require a substantial amount of information. In this section, we simply use the $B^{\star}$ to provide some evidence on a specific aspect of these international vertical linkages that we will designate by *vertical specialization*: the use of imported inputs

[28] Gaulier, Lemoine and Ünal Kesenci (2005) conclude that China is used as an export base by some advanced Asian economies, which transfer to China the final production and assembly stages of some HT and MHT goods. The final products are then exported directly to the EU and the US markets, displacing to some extend other Asian countries' exports.

[29] This phenomenon has been labelled quite extensively in the literature: "slicing up the value chain", "outsourcing", "disintegration of production", "fragmentation", "multi-stage production", "intra-product specialization", "production relocation", "segmentation of production", etc. See Hummels, Ishii and Yi (2001) for a discussion.

to produce goods that are afterwards exported either as final goods or as intermediate goods. It is important to establish the link between vertical specialization and intra-industry trade. At a highly disaggregated level, different intermediate and final goods are classified in distinct product categories. As a result, international trade stemming from vertical specialization activities is considered inter-industry trade. However, at a more aggregate level, intermediate and final goods tend be classified in the same product category. In this case, the trade associated with vertical specialization becomes intra-industry trade, therefore adding to the trade of different varieties/qualities of the same good.[30]

The phenomenon of vertical specialization, as defined above, has always been part of international trade as countries import manufactured goods to be incorporated in their exports. 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 vertical specialization. This led to the surge of new countries in world trade depending heavily on vertical specialization activities in industries where potential specialization gains are higher (mostly HT goods and to a lesser extent textiles and footwear). In geographical terms this phenomenon has been largely reported in emerging economies in East Asia. In parallel, vertical specialization has been associated with vertical FDI operations, as multinational corporations became prominent players in international trade.[31]

The measurement and mapping of vertical specialization activities would be more accurate if a detailed trade product classification could be made. If available, this would assure that the characteristics of the production chain could be identified and tracked properly, i.e. that a given product is indeed an intermediate good to be used in the production of another product to be exported. However, such data is typically unavailable, making accurate cross-country and/or cross-time analysis more difficult to implement. Therefore, the identification of countries with important vertical specialization activities and the assessment of their main trends has usually been carried out at a relatively aggregated product level.[32]

[30]Intra-industry trade can be defined as the existence of simultaneous exports and imports within industries, either associated with a specialization along quality ranges (intra-industry trade in vertically differentiated products) or associated with a specialization in varieties (intra-industry trade in horizontally differentiated products). On the link between vertical specialization and intra-industry trade see Jones, Kierzkowski and Leonard (2002).

[31]Several papers examine the nature and growth of vertical specialization in world trade. A theoretical approach to trade in intermediate products was established by Sanyal and Jones (1983) and Feenstra (1998). Some earlier measurement of this trend was presented by Grunwald and Flamm (1985) and Yeats (1998). More recently Hummels et al. (2001) take a sample of 10 OECD and four emerging market countries and make use of input-output tables to compute an index of vertical specialization. The index measures the share of such activities in total exports and reveals that it accounts for 21 per cent of exports in the countries considered and grew almost 30 per cent between 1970 and 1990. Other papers focus on specific regions or countries and make use of detailed trade data to analyze the vertical integration phenomenon. Understandably, the focus is put on East Asia and China's recent experiences. This is the case of Gaulier, Lemoine and Ünal Kesenci (2006, 2005) and Lemoine and Ünal Kesenci (2002).

[32]Recent empirical analysis on vertical specialization has been made using bilateral trade databases with different

In this section we use the $B^{\star}$ on two product breakdown levels, as defined in Appendix B, to provide some evidence of relevant episodes of vertical specialization across countries since 1967. The argument goes as follows. As already mentioned, the $B^{\star}$ indicator can be easily computed for exports ($B^{\star}_{ijX}$) or imports ($B^{\star}_{ijM}$). If *both* $B^{\star}_{ijX}$ and $B^{\star}_{ijM}$ are greater than one, then country i is simultaneously exporting and importing above the world average in the j category. If these are exports and imports of different qualities/varieties of the same j product, the result points to the existence of (traditional) intra-industry trade. However, if the j category is sufficiently broad as to include goods involved in the different stages of its production chain, this can also be due to vertical specialization activities. Indeed, given the broad product breakdown used in the two levels of aggregation, the intermediate good and the good then exported are typically classified under the same product category.[33] Therefore, both types of trade situations may be present, without it being possible to disentangle their relative importance.

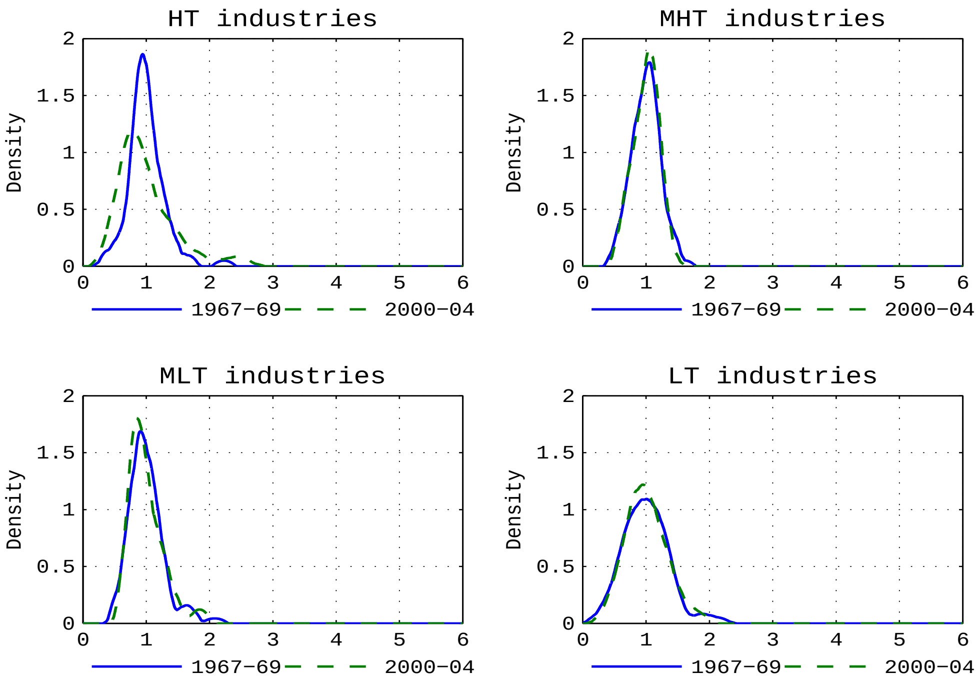
Assume now that the analysis is further restricted to situations in which *both* $B^{\star}_{ijX}$ and $B^{\star}_{ijM}$ are very high figures in one particular country i. In this case, we claim that the (traditional) intra-industry trade in sector j cannot be the sole explanation for such an outcome and that international vertical linkages must play a very important role. The estimated kernel densities of $B^{\star}_{M}$ for the four broad technological categories (Figure 11) reveal a degree of symmetry that is clearly in sharp contrast with the kernel densities for $B^{\star}_{X}$ (Figure 6), where specialization leads to major asymmetries between countries. Therefore, assuming a priori that relative consumption preferences are not very different across countries, there is apparently no other important reason for one country to simultaneously export and import much more than the world average, other than the existence of important vertical specialization activities. In short, if $B^{\star}_{ijX}$ and $B^{\star}_{ijM}$ are both very high in sector j, international vertical linkages must play a large role, being sufficiently important to influence the country's export and import weights.

Several important caveats are posed to this strategy of identification. Firstly, it is necessary to establish the threshold for $B^{\star}_{ijX}$ and $B^{\star}_{ijM}$ to give us some confidence in terms of tracing situations of vertical specialization (and not simply ordinary intra-industry trade). Secondly, caution must be put on possible abnormal values of the indexes or if the phenomenon has only become important in a particular period. Thirdly, it is possible that some vertical specialization exists at a detailed product disaggregation, though not showing up at the more aggregate level. This is the case if the detailed

product breakdown levels, mostly focusing on East Asia. Case studies of specific sectors have also been constructed to better examine this phenomenon (see Lemoine and Ünal Kesenci (2002) for references). Other type of studies, like the one proposed by Hummels et al. (2001), uses input-output matrices, which are available only for some countries on a comparable basis and are not updated regularly.

[33] The analysis of the input-output matrices at a 3 digit ISIC rev 3 disaggregation reveals that the major contributor to the unit value of production in each sector is the sector itself. See the World Bank's Trade and Production Database, which is available at www.worldbank.org/research/trade.

Figure 11: Estimated Kernel Densities - B^{*}_{M}



product is not sufficiently relevant as to affect the broad aggregate. Therefore, we are not identifying a necessary condition for the phenomenon to exist. The criteria is only to define situations where the phenomena is sufficiently important as to emerge in this simple indicator. Finally, if country i is a major trade warehouse, imports are, to a large extent, simply associated with subsequent export activities. Such activities will show up in the $B^{\star}_{ijX}$ and $B^{\star}_{ijM}$, but should not be considered as vertical specialization.

For all countries in the database and for the two product breakdown levels, the threshold set for $B^{\star}_{ijX}$ and $B^{\star}_{ijM}$ was 2. Therefore, for each j category, we start by restricting the analysis to countries where the structure of exports and imports is at least twice the average of world countries in any of the five-year periods selected. We excluded countries where large volatility is identified in the indicators due to specific observations (affecting the five-year average), which are typically associated with episodical operations that are very large relative to the size of the economy but have no structural interpretation. Residual categories of manufactured goods are also excluded from the analysis, given their typically irregular behaviour. On a purely illustrative basis, we will also carry out the analysis at a disaggregated level, taking two sub-sectors where vertical specialization activities have been identified as important for the case of China.

In general, the analysis of the $B^{\star}_{ijM}$ and $B^{\star}_{ijX}$ in the four broader product categories indicates that: (i) the incidence of vertical specialization varies considerably among the

Table 4: Top 5 ranking of B^*_M - average 2000-2004

High-tech	B^*_M	B^*_X	Medium High-tech	B^*_M	B^*_X
Malaysia	2.5	4.2	Argentina	1.5	1.1
Philippines	2.4	4.9	Canada	1.4	2.1
Singapore	2.4	4.3	Venezuela	1.3	0.8
Ireland	2.0	3.9	Colombia	1.3	1.1
Taiwan	1.9	3.0	South African Union	1.3	1.5

Medium Low-tech	B^*_M	B^*_X	Low-tech	B^*_M	B^*_X
Others in South Europe	2.0	0.5	Sri Lanka	1.8	2.1
Others in America	1.9	1.4	Bangladesh	1.8	2.5
African LDCs	1.7	1.9	Albania	1.7	2.1
Others in East Asia	1.6	0.9	Cambodia, Lao PDR	1.7	2.5
Cambodia, Lao PDR	1.5	0.1	Tunisia	1.6	1.6

Source: Chelem database and own calculations.
Note: For the composition of the geographical zones, see Appendix C.

different categories of products; (ii) there is a marked regional pattern; and (iii) the phenomenon has intensified substantially over the last decade. Note that these results are conditional on the definitions of the four broader categories, which include several sub-sectors that will be analyzed later.

Table 4 lists the $B^\star_M$ indices of the top 5 countries in each broad technological category in the period 2000-2004 and the corresponding $B^\star_X$ indices. It reveals that vertical specialization seems to be predominant in the HT category. The countries where these vertical specialization activities are more relevant are Malaysia, Philippines, Singapore, Ireland and Taiwan. The MHT sector has some countries with high values for $B^\star_{ijX}$ but with levels below the threshold value of 2 for $B^\star_{ijM}$. This is even more marked in the MLT category. In fact, this category is dominated by manufacturing products with low transformation like oil products, rubber, other non-metallic minerals, basic metals, not suited to vertical specialization activities but very important in the export structure of some countries. Regarding LT industries, although the threshold of 2 for both the import and export sides is not reached in any country, there are some high figures, for instance in Bangladesh and Cambodia, which are commented on below.

Using the simple indicator proposed in this paper, the empirical evidence of vertical specialization in the HT category can be further explored by looking at the behaviour of both the $B^\star_{ijX}$ and the $B^\star_{ijM}$ over time (in the selected countries) and by investigating the products included in the second breakdown level of the HT category.

On a time-series basis, it seems that the vertical specialization in the HT category is rather intense and has been developing since the seventies (Figures 12(a) and 12(b)). With the exception of Taiwan, we find evidence of increased vertical specialization throughout the sample period, with some evidence of stabilization in the last decade.

it is notable that Ireland is the only non-Asia country identified in this category. In Taiwan, there is a decrease since the late sixties, partly resulting from the emergence of other players.[34]

At the second breakdown level of the HT category, important vertical specialization activities were found in all five sub-sectors, but particularly relevant in "Radio, TV and communications equipment" and in "Office, accounting and computing machinery". The latter is specially relevant for some Asian and European countries (see Figures 12(c) and 12(d)). Taiwan is a traditionally important player in this sector but the importance of vertical specialization seems to be reducing compared with to other countries. On the other hand, Singapore shows a steady increase in vertical specialization activities since mid-eighties, with a small decline after the mid-nineties. Ireland recorded sharp increases until the mid-eighties but some decline in vertical specialization occurred afterwards, though high levels were maintained. The Netherlands shows a steady increase in the $B^{\star}_M$ and $B^{\star}_X$ indices during this period. Nevertheless, this country is a major European trade warehouse, so part of these transactions may not reflect vertical specialization activities. The other industrialized countries identified - the US, France, Germany, UK and Japan - show stable or slightly decreasing vertical specialization activities in this category.

As for "Radio, TV and communications equipment" (Figures 12(e) and 12(f)), all countries selected are located in East Asia. Taiwan shows again a decreasing path in the relevance of vertical specialization activities, Malaysia holds an important position, though stabilizing after the mid-eighties, and a sizeable increase is observable in the Philippines. Starting from very low levels of both $B^{\star}_M$ and $B^{\star}_X$, the Chinese economy shows a steady increase since the eighties, reaching values above two for both indices in the most recent years.

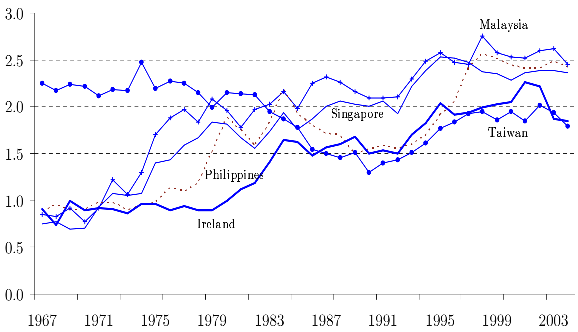
Products included in the MHT category, like most machinery items, are typically characterized by a high degree of heterogeneity. This fact might explain why vertical specialization activities are not identified with this indicator at the aggregate level. However, the application of the chosen threshold of 2 for both $B^{\star}_M$ and $B^{\star}_X$ to the sub-sectors of the MHT category allows us also to detect some well known vertical specialization phenomena, like the "Motor vehicles, trailers and semi-trailers" sector in Canada and US (see Figure 13) and the effects of *maquiladoras* (labor-intensive assembly operations) on "Other electrical machinery and apparatus" in Mexico.[35]

As an illustration of how the analysis can proceed at a very detailed level, taking

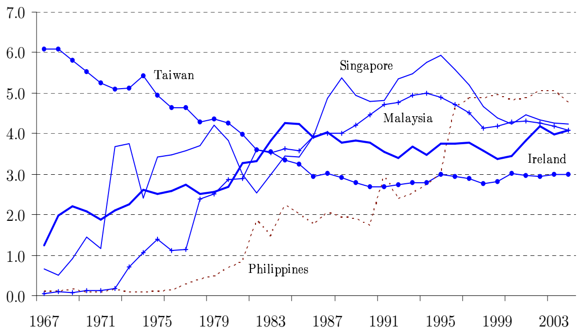
[34]It should be recalled that, given the characteristics of the indicator, there is a mechanical decrease in one country when others emerge as exporters of the good.

[35]See Jones et al. (2002).

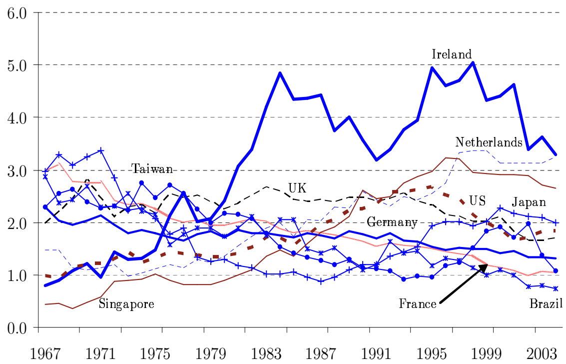
Figure 12: Vertical Specialization in High Tech Products



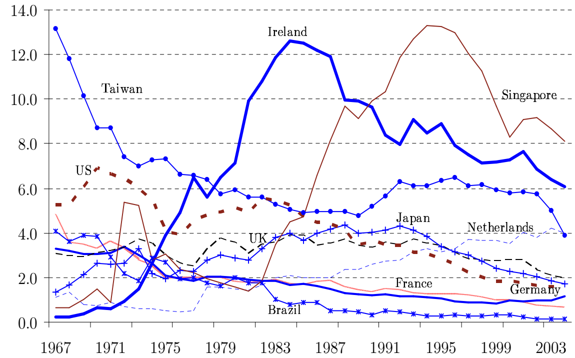
(a) High-technology industries B_M^*



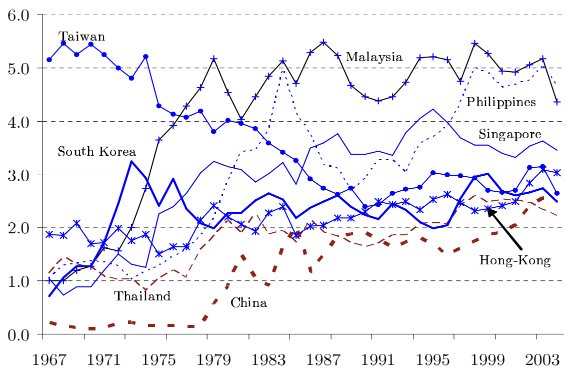
(b) High-technology industries B_X^*



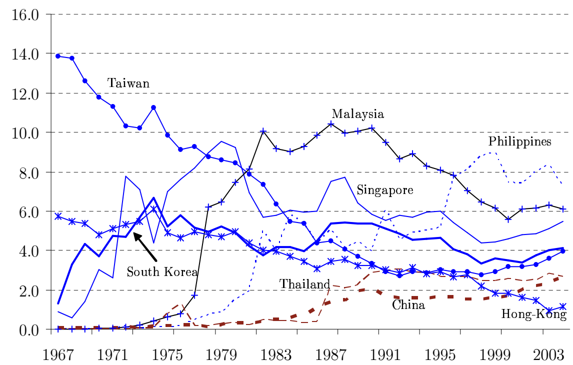
(c) Office, accounting and computing machinery B_M^*



(d) Office, accounting and computing machinery B_X^*

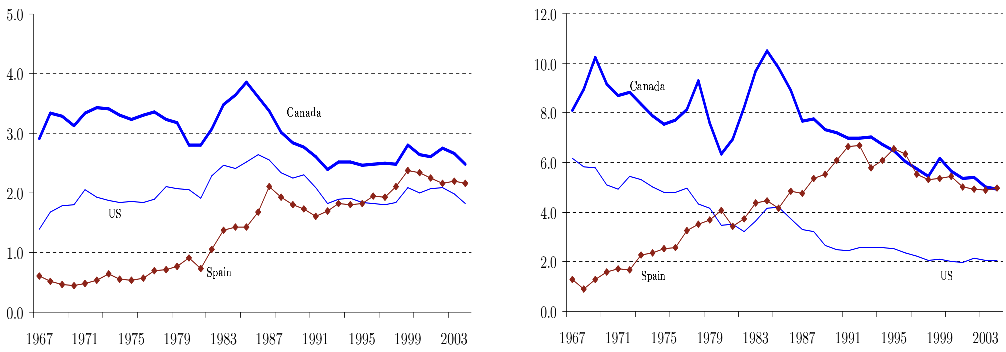


(e) Radio, TV and communications equipment B_M^*



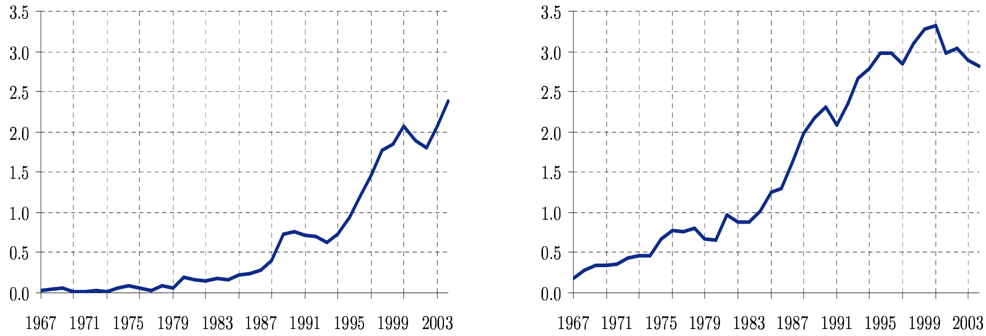
(f) Radio, TV and communications equipment B_X^*

Figure 13: Vertical Specialization in Medium-High-Tech Products - Motor vehicles, trailers and semi-trailers



(a) B_M^* index (b) B_X^* index

Figure 14: Vertical Specialization in Medium-High-Tech Subsectors in China - An illustration



(a) B_M^* - Accumulators and primary cells (b) B_X^* - Electric motors and generators

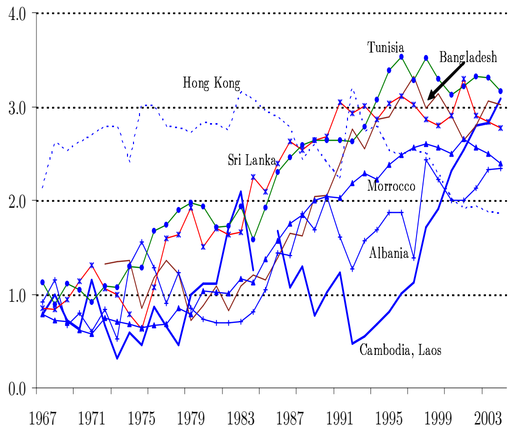
into consideration input-output information, Figure 14 depicts the subsectors of "Accumulators and primary cells" (imported - intermediate good), and "Electric motors and generators" (exported - intermediate or final good). These two products are not sufficiently important to affect the MHT category as a whole but, when taken autonomously, China emerges as having high and rising vertical specialization activities. This fact results from a high specialization coefficient on the import side for "Accumulators and primary cells" and an export weight of "Electric motors and generators" clearly above average.[36]

Within LT categories, there is only significant evidence of vertical specialization activities in the "Textiles, textile products, leather and footwear" sector (Figure 15). The countries where it is most important are Bangladesh together with Cambodia and Laos, the latter showing a sharp increase since the beginning of the nineties. It is interesting

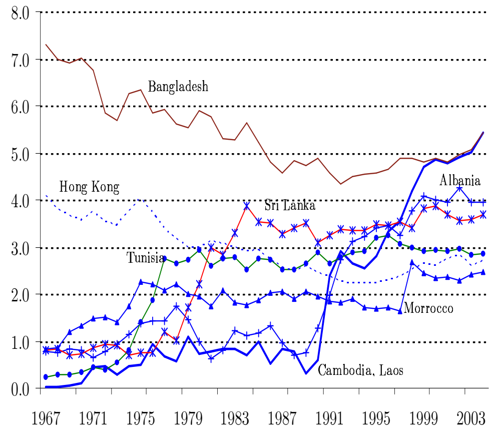
[36] This result confirms the findings of Gaulier, Lemoine and Ünal Kesenci (2006, 2005)) and Lemoine and Ünal Kesenci (2002) on the significant importance of imports of intermediate products in Chinese exports of electrical machinery.

to note that vertical specialization in this sector appears to be also relatively important in North Africa, with countries like Morocco and Tunisia displaying upward trends.

Figure 15: Vertical Specialization in Low-Tech Products - Textiles, textile products, leather and footwear



(a) B_M^* index



(b) B_X^* index

5 Conclusions

In this paper we introduced an international specialization index - the $B^{\star}$ -, which is suitable to characterize the relative world export structure and to identify the major changes observed since the late sixties.

The $B^{\star}$ is simply the share of exports of a given product in total domestic exports, normalized by the world unweighted average share. At each point in time, the index stands between 0 and N (the total number of countries), i.e. between a no-export situation and a monopolistic exporter situation. The sum of all $B^{\star}$ across countries is always equal to N and the average unchanged at 1. Therefore, each $B^{\star}$ can be interpreted as a cardinal measure that represents the contribution of each country, in a particular product, to N. Within a time dimension approach, if the level of $B^{\star}$ increases, this will have a unique interpretation: this country has become relatively more specialized than the average of the other countries in the world (necessarily at the expense of lower specialization in some other country).

Given the characteristics of the $B^{\star}$, the analysis was based on the comparison of different countries within a given sector, i.e. a cross-country analysis, whereas the more traditional approach on revealed comparative advantages, international product specialization and changing trade patterns focuses on the evolution of the export structure of a given country or group of countries, i.e. a cross-sector analysis.

The analysis focused on four technological sectors (high, medium-high, medium-low and low-technology sectors, following the OECD classification of R&D intensities). The world aggregate comprises 79 countries and special emphasis was put on the G5 economies and on China. In addition, we provide empirical evidence on vertical specialization activities which have become very important in some economies.

The four technological sectors have very different $B^{\star}$ cross-country distributions. The high-tech specialization structure is more geographically concentrated. Contrary to this, there are more countries revealing similar degrees of specialization in low-tech exports. From a dynamic point of view, there is evidence of relative persistence of the cross-country international trade pattern. This result is supported by intra-distribution dynamics analysis and by the comparison of the distributions in 1967-69 and in 2000-04. In addition, it was noted that the estimated ergodic distributions and the estimated densities of the period 2000-04 were rather similar in all sectors.

G5 countries and China are more specialized than the world average in high-tech and medium-high-tech goods (the only exception being China in medium-high-tech) and show a non-specialization *status* in low-tech and medium-low-tech products. However, sharp differences between countries exist at a more detailed level. The performance of the Chinese economy in high-tech products is specially striking: having started with a lower than average share in total exports, it has reached an export proportion that is more than twice the world average in the last years. On the contrary, in the low-tech sector, a significant reduction was recorded from the mid-80s onwards, after more than two decades of high specialization. Nevertheless, China continues to present specialization in some low-tech sub-sectors, namely "Other manufacturing and recycling" and "Textiles, textile products, leather and footwear".

The identification of relevant vertical specialization activities was accomplished by computing the $B^\star$ for both exports and imports in the different sectors, for the 79 countries, and by setting a threshold of 2. Although we acknowledge that intra-industry trade may explain relatively high values of both $B^\star$ indicators, it is hard to accept that such trade justifies import structures that are twice the world average. In such cases, vertical specialization activities must be the underlying explanation. Using these criteria, relevant vertical specialization activities at an aggregate level were found in high-tech industries and, to a lesser extent, in some medium-high-technology (motor vehicles and electrical machinery) and low-technology sectors (textiles, clothing and footwear). These activities appear to have intensified in the last decade. In geographical terms, significant vertical specialization activities are predominantly identified in East Asia, but also in some countries of Europe and North Africa.

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Appendices

A The Proudman and Redding normalization procedure

Proudman and Redding (1997, 2000) proposed the following index

$$B_{ij}^{PR} = \frac{\frac{x_{ij}}{x_{Wj}}}{(\overline{\mu_j})_i} \qquad \text{country } i = 1, 2 \ldots N; \text{ product } j = 1, 2 \ldots m \tag{4}$$

Where $(\overline{\mu_j})_i \equiv (\overline{\frac{x_j}{x_{Wj}}})_i = \frac{1}{m}\sum_{j=1}^{m}(\frac{x_{ij}}{x_{Wj}})_i$ is the average export market share of country i. Each sector $j = 1, 2 \ldots m$ has a particular $\frac{x_{ij}}{x_{Wj}}$, and therefore $(\overline{\mu_j})_i$ is just the *unweighted* average across sectors (in this country). Again, the index has a clear lower bound of $B_{ij}^{PR} = 0$ in the extreme case where country i does not export product j ($x_{ij} = 0$), otherwise $B_{ij}^{PR} > 0$. In the other extreme situation where country i is the only exporter in sector j (international monopoly), such that $(\frac{x_{ij}}{x_{Wj}}) = 1$, the upper bound is $\frac{m}{\sum_{j=1}^{m}\frac{x_{ij}}{x_{Wj}}}$, thus not constant over time and also dependent on the relative dimension of country i. If the export market share of country i in sector j is higher than the average market share of country i, i.e. $(\frac{x_{ij}}{x_W}) > (\overline{\mu_j})_i$, then $B_{ij}^{PR} > 1$ and country i is classified has being specialized in sector j. Equivalently, B_{ij}^{PR} can also be written down in terms of the original Balassa indices. After some simple algebra, expression (4) is equivalent to

$$B_{ij}^{PR} = \frac{B_{ij}}{(\overline{B_j})_i}$$

Where $(\overline{B_j})_i$ is simply the cross-industry average of B_{ij}, i.e. $(\overline{B_j})_i = \frac{1}{m}\sum_{j=1}^{m} B_{ij}$.

By construction, the Proudman-Redding index has the property that its average, within a given country, is equal to one, i.e $\frac{1}{m}\sum_{j=1}^{m} B_{ij}^{PR} = 1$. This implies that if sector j exhibits an advantage ($B_{ij}^{PR} > 1$), there must exist another sector in the economy that exhibits a disadvantage ($B_{i,h\neq j}^{PR} < 1$). Unless all sectors depict the same world market share, some will be above the average, while others below the average.

B Product classification by technological intensity

		ISIC rev.3
High-technology products	**HT**	
Aircraft and spacecraft	HT1	353
Pharmaceuticals	HT2	2423
Office, accounting and computing machinery	HT3	30
Radio, TV and communications equipment	HT4	32
Medical, precision and optical instruments	HT5	33
Medium-high-technology products	**MHT**	
Other electrical machinery and apparatus	MHT1	31
Motor vehicles, trailers and semi-trailers	MHT2	34
Chemicals excl. pharmaceuticals	MHT3	24 excl. 2423
Railroad equipment and other transport equip.	MHT4	352 + 359
Other machinery and equipment	MHT5	29
Medium-low-technology products	**MLT**	
Coke, refined petroleum prod. and nuclear fuel	MLT1	23
Rubber and plastics products	MLT2	25
Other non-metallic mineral products	MLT3	26
Building and repairing of ships and boats	MLT4	351
Basic metals	MLT5	27
Fabricated metal products, excl. machinery	MLT6	28
Low-technology products	**LT**	
Other manufacturing and recycling	LT1	36-37
Wood, pulp, paper and printed products	LT2	20-22
Food products, beverages and tobacco	LT3	15-16
Textiles, textile products, leather and footwear	LT4	17-19
Total manufacturing		15-37

Source: Chelem database.

The product breakdown used here and available in the CEPII - CHELEM database follows the OECD classification of manufacturing industries according to technology intensity using the ISIC Rev. 3 breakdown of activity. This classification was based on the analysis of R&D expenditure and output of 12 OECD countries in the period 1991-99. For more information, see OECD (2005).

C Geographical breakdown

The 79 countries or country groups included in our sample are the following:

United States; Canada; France; BLEU; Germany; Italy; Netherlands; United Kingdom; Ireland; Denmark; Finland; Norway; Sweden; Iceland; Austria; Switzerland; Spain; Greece; Portugal; Turkey; Israel; Former Yugoslavia; Others in South Europe; Japan; Australia; New Zealand; South African Union; Venezuela; Ecuador; Mexico; Brazil; Argentina; Chile; Colombia; Peru; Bolivia; Paraguay; Uruguay; Others in America; Algeria; Morocco; Tunisia; Egypt; Libya; Saudi Arabia; Gulf; Middle East (no OPEC); Nigeria; Gabon; Cameroon; Cote d'Ivoire; Kenya; Others in Africa; African LDCs; Indonesia; India; South Korea; Hong Kong; Singapore; Taiwan; Malaysia; Philippines; Thailand; Pakistan; Brunei; Bangladesh; Sri Lanka; Others in East Asia; East Asian LDCs; Former USSR; Bulgaria; Former Czechoslovakia; Hungary; Poland; Romania; Albania; China, People's Rep.; Vietnam; Cambodia, Laos.

The compositions of the different zones/country groups is the following:

a. BLEU includes Belgium, Luxembourg.

b. Germany includes the former German Democratic Republic until 1990.

c. Former Yugoslavia includes Serbia and Montenegro, Bosnia and Herzegovina, Croatia, Macedonia, Republic of Slovenia.

d. Others in South Europe includes Andorra, Cyprus, Gibraltar, Malta.

e. South African Union includes Botswana, Lesotho, Namibia, South Africa, Swaziland.

f. Others in America includes Anguilla, Antigua and Barbuda, Aruba, Bahamas, Barbados, Belize, Bermuda, Costa Rica, Cuba, Dominica, Dominican Republic, El Salvador, Grenada, Guatemala, Guyana, Haiti, Honduras, Jamaica, Montserrat, Netherland Antilles, Nicaragua, Panama, Saint Kitts and Nevis, Saint Lucia, Saint Vincent and the Grenadines, Suriname, Trinidad and Tobago, and all others in America nes.

g. Gulf includes Bahrain, Iran, Iraq, Kuwait, Oman, Qatar, United Arab Emirates.

h. Middle East, (no OPEC) includes Jordan, Lebanon, Syria, Yemen

i. African LDCs includes Angola, Benin, Burkina Faso, Burundi, Cape Verde, Central African Republic, Chad, Comoros, Democratic Republic of Congo (formerly Zaire), Djibouti, Equatorial Guinea, Eritrea, Ethiopia, Gambia, Guinea, Guinea-Bissau, Liberia, Madagascar, Malawi, Mali, Mauritania, Mozambique, Niger, Rwanda, Sao Tome and Principe, Senegal, Sierra Leone, Somalia, Sudan, Tanzania, Togo, Uganda, Zambia.

j. Others in Africa includes Congo, Ghana, Mauritius, Seychelles, Western Sahara, Zimbabwe, and all others in Africa nes.

k. East Asian LDCs includes Afghanistan, Bhutan, Kiribati, Maldives, Myanmar, Nepal, Solomon Islands, Vanuatu, Western Samoa.

l. Others in East Asia includes Fiji, French Polynesia, Guam, Macao, Mongolia, New Caledonia, North Korea, Pacific Islands, Papua New Guinea, Tonga, US Samoa, Vanuatu, Western Samoa, and all others in Asia and Oceania nes.

m. Former USSR includes the Commonwealth of Independent States (Armenia, Azerbaijan, Belarus, Georgia, Kazakhstan, Kyrgyzstan, Moldova, Russian Federation, Tajikistan, Turkmenistan, Ukraine, Uzbekistan), Baltic States (Estonia, Latvia Lithuania).
Former Czechoslovakia includes Czech Republic, Slovakia.

Source: Chelem database.

D Detailed $B^\star$ information

B* values for the 79 countries (countries sorted by 2000-04 values of B*)

High-technology (HT)

	1967-69		2000-04	
	Rank	**B***	**Rank**	**B***
Philippines	60	0.11	1	4.91
Singapore	35	0.71	2	4.29
Malaysia	64	0.08	3	4.20
Ireland	15	1.84	4	3.91
Others in South Europe	28	0.92	5	3.80
Taiwan	2	5.99	6	2.98
Switzerland	1	6.76	7	2.54
South Korea	23	1.15	8	2.43
United Kingdom	6	2.99	9	2.38
Israel	29	0.90	10	2.38
United States	3	4.89	11	2.36
Thailand	71	0.03	12	2.23
Hungary	10	2.12	13	2.19
China, People's Rep.	48	0.29	14	2.15
Netherlands	5	3.01	15	2.06
Japan	4	3.86	16	2.04
Mexico	22	1.42	17	1.97
Finland	49	0.27	18	1.65
France	8	2.46	19	1.63
Sweden	12	1.92	20	1.60
Denmark	17	1.71	21	1.51
Germany	7	2.58	22	1.28
Hong Kong	11	2.07	23	1.23
Indonesia	66	0.04	24	1.22
BLEU	25	0.99	25	1.06
Austria	21	1.47	26	0.93
Canada	16	1.76	27	0.90
Norway	40	0.58	28	0.84
Former Czechoslovakia	20	1.57	29	0.80
Brazil	26	0.93	30	0.80
Australia	43	0.49	31	0.79
Italy	14	1.88	32	0.75
Portugal	27	0.93	33	0.73
Spain	39	0.63	34	0.72
Greece	52	0.22	35	0.72
Others in America	37	0.67	36	0.70
Morocco	62	0.09	37	0.69
Former Yugoslavia	38	0.64	38	0.65
Gabon	42	0.51	39	0.58
Vietnam	34	0.78	40	0.51
Poland	9	2.24	41	0.45
India	54	0.22	42	0.44
Middle East, no OPEC	19	1.59	43	0.44
Turkey	67	0.03	44	0.42
Gulf	45	0.44	45	0.40
Bolivia	77	0.01	46	0.36
Romania	53	0.22	47	0.35
Former USSR	30	0.89	48	0.35
Colombia	33	0.79	49	0.34
Bulgaria	18	1.61	50	0.33
Others in East Asia	46	0.37	51	0.33
Kenya	44	0.44	52	0.31
Iceland	73	0.02	53	0.30
Sri Lanka	76	0.01	54	0.29
South African Union	47	0.37	55	0.27
New Zealand	65	0.06	56	0.25
African LDCs	61	0.10	57	0.24
Argentina	36	0.70	58	0.23
Uruguay	41	0.58	59	0.22
Tunisia	56	0.16	60	0.21
Others in Africa	59	0.12	61	0.21
Ecuador	13	1.89	62	0.17
Paraguay	79	0.01	63	0.14
Pakistan	51	0.23	64	0.13
Egypt	55	0.19	65	0.11
East Asian LDCs	63	0.09	66	0.10
Venezuela	68	0.03	67	0.10
Albania	57	0.15	68	0.07
Chile	72	0.02	69	0.06
Peru	70	0.03	70	0.04
Cote d'Ivoire	50	0.24	71	0.04
Bangladesh	31	0.87	72	0.03
Nigeria	78	0.01	73	0.02
Saudi Arabia	75	0.02	74	0.02
Brunei Darussalam	69	0.03	75	0.02
Cameroon	32	0.79	76	0.02
Algeria	58	0.14	77	0.01
Libyan Arab Jamahiriya	24	1.02	78	0.01
Cambodia, Laos	74	0.02	79	0.01

Medium-high-technology (MHT)

	1967-69		2000-04	
	Rank	**B***	**Rank**	**B***
Japan	12	2.05	1	2.54
Germany	1	4.00	2	2.50
Saudi Arabia	70	0.06	3	2.31
Spain	19	1.76	4	2.25
Mexico	29	1.07	5	2.22
Former Czechoslovakia	13	2.03	6	2.15
Canada	7	2.61	7	2.09
BLEU	11	2.06	8	2.03
Austria	16	1.88	9	1.98
France	6	2.76	10	1.97
Hungary	20	1.64	11	1.92
Italy	5	2.96	12	1.91
United States	2	3.55	13	1.89
Switzerland	4	3.16	14	1.82
Sweden	9	2.29	15	1.79
United Kingdom	3	3.32	16	1.72
Poland	8	2.48	17	1.71
Portugal	39	0.72	18	1.51
South African Union	27	1.12	19	1.47
South Korea	55	0.29	20	1.47
Former Yugoslavia	22	1.51	21	1.46
Netherlands	15	1.89	22	1.41
Denmark	18	1.84	23	1.37
Brazil	41	0.63	24	1.36
Tunisia	14	1.93	25	1.29
Ireland	46	0.46	26	1.27
Finland	36	0.83	27	1.23
Taiwan	21	1.61	28	1.22
Turkey	50	0.39	29	1.18
Argentina	43	0.56	30	1.13
Colombia	42	0.56	31	1.09
Thailand	76	0.02	32	1.07
Norway	23	1.45	33	1.06
Romania	26	1.15	34	1.02
Morocco	30	1.06	35	1.01
China, People's Rep.	40	0.71	36	0.95
Former USSR	24	1.34	37	0.93
Bulgaria	17	1.88	38	0.93
Libyan Arab Jamahiriya	38	0.80	39	0.90
Israel	34	0.89	40	0.86
Middle East, no OPEC	25	1.28	41	0.86
Australia	32	1.01	42	0.85
Gulf	62	0.18	43	0.84
India	47	0.42	44	0.82
Venezuela	69	0.06	45	0.79
Greece	35	0.84	46	0.77
Indonesia	71	0.05	47	0.71
New Zealand	68	0.11	48	0.64
Cote d'Ivoire	44	0.56	49	0.62
Singapore	45	0.53	50	0.62
Nigeria	77	0.02	51	0.62
Malaysia	64	0.16	52	0.61
Ecuador	72	0.05	53	0.61
Kenya	37	0.82	54	0.59
Egypt	59	0.26	55	0.53
Others in America	28	1.08	56	0.52
Others in South Europe	31	1.01	57	0.50
Chile	58	0.26	58	0.49
Uruguay	60	0.25	59	0.47
Philippines	66	0.12	60	0.42
African LDCs	61	0.19	61	0.38
Hong Kong	48	0.42	62	0.37
Algeria	10	2.21	63	0.35
Vietnam	49	0.40	64	0.35
East Asian LDCs	73	0.04	65	0.34
Gabon	54	0.34	66	0.33
Others in East Asia	57	0.27	67	0.28
Paraguay	33	0.90	68	0.25
Bolivia	65	0.12	69	0.24
Cameroon	53	0.35	70	0.21
Peru	74	0.03	71	0.20
Iceland	78	0.01	72	0.18
Albania	51	0.38	73	0.17
Sri Lanka	63	0.16	74	0.16
Others in Africa	67	0.12	75	0.12
Pakistan	52	0.38	76	0.11
Bangladesh	79	0.00	77	0.09
Cambodia, Laos	75	0.02	78	0.02
Brunei Darussalam	56	0.27	79	0.02

B* values for the 79 countries (countries sorted by 2000-04 values of B*)

Medium-low-technology (MLT)

	1967-69		2000-04	
	Rank	**B***	**Rank**	**B***
Algeria	60	0.35	1	3.61
Libyan Arab Jamahiriya	24	1.17	2	3.17
Nigeria	20	1.34	3	3.02
Venezuela	3	3.10	4	3.01
Egypt	66	0.26	5	2.60
Gulf	8	2.30	6	2.48
Peru	14	1.64	7	2.29
Former USSR	17	1.50	8	2.27
African LDCs	10	2.19	9	1.94
Chile	4	2.85	10	1.88
Saudi Arabia	1	3.16	11	1.78
Norway	19	1.42	12	1.74
South African Union	34	0.93	13	1.65
Kenya	13	1.81	14	1.64
Australia	42	0.77	15	1.52
Cameroon	18	1.46	16	1.44
Cote d'Ivoire	51	0.55	17	1.42
Bulgaria	40	0.78	18	1.39
Colombia	29	1.06	19	1.38
Others in America	16	1.54	20	1.37
Greece	37	0.89	21	1.28
Gabon	44	0.74	22	1.13
Middle East, no OPEC	21	1.33	23	1.12
Former Yugoslavia	36	0.90	24	1.10
Poland	35	0.91	25	1.09
Romania	26	1.15	26	1.06
Former Czechoslovakia	27	1.10	27	0.99
Others in Africa	33	0.94	28	0.98
Turkey	55	0.48	29	0.93
Iceland	74	0.11	30	0.91
Others in East Asia	28	1.06	31	0.90
Bolivia	2	3.11	32	0.88
Argentina	73	0.15	33	0.86
Brazil	65	0.30	34	0.85
South Korea	72	0.18	35	0.83
Brunei Darussalam	6	2.72	36	0.80
India	52	0.53	37	0.79
BLEU	22	1.25	38	0.78
Singapore	9	2.28	39	0.78
Ecuador	78	0.01	40	0.77
Spain	41	0.77	41	0.77
Finland	54	0.50	42	0.77
Austria	31	0.95	43	0.76
Italy	46	0.66	44	0.75
Indonesia	5	2.75	45	0.72
Canada	47	0.66	46	0.71
Sweden	38	0.82	47	0.70
Netherlands	43	0.76	48	0.68
Taiwan	53	0.50	49	0.65
Portugal	61	0.33	50	0.61
Germany	45	0.69	51	0.61
France	39	0.78	52	0.61
Albania	25	1.16	53	0.56
United Kingdom	48	0.62	54	0.56
Hong Kong	70	0.22	55	0.55
China, People's Rep.	62	0.32	56	0.52
Japan	30	0.98	57	0.52
Thailand	23	1.19	58	0.51
Others in South Europe	57	0.44	59	0.51
Denmark	59	0.41	60	0.51
Switzerland	67	0.26	61	0.49
New Zealand	76	0.07	62	0.47
United States	58	0.43	63	0.47
Hungary	50	0.56	64	0.45
Uruguay	68	0.25	65	0.42
Malaysia	7	2.59	66	0.42
Sri Lanka	12	2.09	67	0.40
East Asian LDCs	69	0.25	68	0.39
Mexico	32	0.95	69	0.38
Israel	56	0.46	70	0.34
Morocco	64	0.31	71	0.34
Vietnam	11	2.16	72	0.34
Tunisia	49	0.56	73	0.32
Paraguay	77	0.03	74	0.19
Philippines	71	0.19	75	0.19
Pakistan	75	0.09	76	0.13
Ireland	63	0.32	77	0.10
Cambodia, Laos	15	1.60	78	0.06
Bangladesh	79	0.00	79	0.04

Low-technology (LT)

	1967-69		2000-04	
	Rank	**B***	**Rank**	**B***
Cambodia, Laos	40	0.97	1	2.50
Bangladesh	2	1.88	2	2.47
Pakistan	6	1.78	3	2.36
Paraguay	9	1.70	4	2.24
Sri Lanka	56	0.64	5	2.10
East Asian LDCs	5	1.79	6	2.08
Albania	32	1.14	7	2.07
Brunei Darussalam	75	0.23	8	2.02
Vietnam	66	0.47	9	1.96
Uruguay	10	1.69	10	1.95
New Zealand	3	1.88	11	1.82
Others in Africa	26	1.34	12	1.78
Iceland	1	1.89	13	1.76
Bolivia	78	0.03	14	1.72
Others in East Asia	28	1.21	15	1.70
Ecuador	7	1.78	16	1.67
Tunisia	35	1.10	17	1.58
Morocco	20	1.48	18	1.54
Hong Kong	15	1.54	19	1.54
Cameroon	46	0.91	20	1.50
India	17	1.51	21	1.44
Gabon	23	1.38	22	1.43
Argentina	12	1.66	23	1.31
Cote d'Ivoire	21	1.45	24	1.29
Indonesia	74	0.26	25	1.26
Middle East, no OPEC	54	0.67	26	1.21
Romania	45	0.94	27	1.20
Turkey	13	1.56	28	1.16
Others in America	53	0.68	29	1.13
Portugal	18	1.49	30	1.08
Kenya	60	0.60	31	1.06
Chile	76	0.15	32	1.05
Greece	30	1.18	33	1.05
Bulgaria	47	0.85	34	1.04
African LDCs	62	0.57	35	1.00
Brazil	16	1.53	36	0.99
Israel	24	1.36	37	0.98
Colombia	34	1.10	38	0.95
Peru	44	0.95	39	0.95
Denmark	36	1.07	40	0.93
China, People's Rep.	14	1.55	41	0.90
Former Yugoslavia	42	0.96	42	0.82
Australia	29	1.18	43	0.82
Thailand	27	1.23	44	0.81
Finland	22	1.41	45	0.78
Poland	63	0.56	46	0.78
Italy	59	0.61	47	0.77
Austria	48	0.76	48	0.66
Canada	51	0.72	49	0.65
South African Union	37	1.06	50	0.60
Spain	41	0.97	51	0.59
Netherlands	49	0.74	52	0.59
BLEU	61	0.57	53	0.57
Sweden	52	0.69	54	0.55
Norway	55	0.66	55	0.55
Egypt	8	1.71	56	0.54
Others in South Europe	25	1.34	57	0.53
France	64	0.55	58	0.50
Former Czechoslovakia	57	0.62	59	0.47
Former USSR	58	0.62	60	0.46
Hungary	38	1.01	61	0.42
Mexico	39	0.98	62	0.39
United Kingdom	68	0.45	63	0.38
Malaysia	72	0.33	64	0.38
Taiwan	50	0.73	65	0.36
United States	71	0.35	66	0.36
Philippines	4	1.80	67	0.36
Gulf	67	0.47	68	0.35
Germany	73	0.27	69	0.35
Ireland	19	1.48	70	0.34
South Korea	11	1.68	71	0.32
Switzerland	69	0.39	72	0.32
Nigeria	33	1.13	73	0.27
Saudi Arabia	79	0.01	74	0.17
Venezuela	77	0.04	75	0.15
Singapore	70	0.37	76	0.11
Japan	65	0.49	77	0.11
Algeria	31	1.15	78	0.03
Libyan Arab Jamahiriya	43	0.95	79	0.02