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January 2011

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Is the World Spinning Faster?
Assessing the Dynamics of Export Specialization*

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January 2011

Abstract

The article suggests a methodology to measure the intra-distribution dynamics of export specialization and applies it to a large set of countries in the last four decades. The article contributes to the literature on the dynamics of international trade specialization, making use of the information contained in the distribution of specialization indices, as initially suggested in Proudman and Redding (1997, 2000). In addition, the article makes use of conditional kernel densities and highest density regions to measure persistency/mobility in way that is applicable to other studies. Finally, the article empirically tests the determinants of specialization dynamics. The results reveal that there is considerable export specialization dynamics and heterogeneity across countries. In addition, it seems that the export specialization dynamics decelerated in most countries from 1967-1994 to 1980-2008 and there is a significant positive correlation between the indicators in the two periods. The econometric formulations reveal that higher human capital, improvement in infrastructures and macroeconomic stability seem to increase specialization dynamics.

Keywords: International Trade, Export Specialization, Intra-distribution Dynamics

JEL Codes: C14, F14 F15

*The opinions expressed in the article are those of the author and do not necessarily coincide with those of Banco de Portugal or the Eurosystem. The author thanks Sónia Cabral for useful comments. The usual disclaimers apply. Address: Banco de Portugal, Research Department, R. Francisco Ribeiro 2, 1150-165 Lisboa - Portugal. E-mail: jamador@bportugal.pt

1 Introduction

The large increase in world trade in the last decades is one of the most important dimensions of globalization. The progressive fragmentation of the production chain, the entrance of new players in international trade, notably in Central and Eastern Europe and Asia, and the overall decrease in trade barriers have been pointed out as important determinants of this trend. In addition, strong technological progress and higher factor mobility have added volatility to international goods markets. All these factors led to an important and continuing reshuffling of the international patterns of comparative advantage.

The change in the patterns of comparative advantage poses a challenge for countries in international trade. When a country loses comparative advantage in a sector or a set of sectors that represent a large share of its total exports, it will loose market share in those sectors, with a reflex in its overall growth performance and external accounts. The reallocation of production factors to sectors with new comparative advantages is necessary but involves adjustment costs, affecting labor and capital. Unemployed workers may find it hard to acquire the new skills demanded by emerging export sectors and long-term unemployment may increase. In addition, part of the capital stock may also be difficult or impossible to reconvert to the production of new goods and services. These adjustment costs might pose a high burden on the economy and governments may feel tempted to increase trade barriers. Therefore, one important role for economic policies is to minimize adjustment costs associated with the reallocation of production factors in the economy by promoting higher flexibility. These pressures are reinforced by another feature of the globalization process, which is the need for continuous innovation. In fact, when a country creates value added with the export of new products, it is highly probable that other competitors will soon imitate, entering the market with lower production costs and prices. The innovation process and the production of differentiated products translates in changes in export patterns and also requires flexibility in the allocation of resources.

In this context, it is important to identify which countries have shown higher export specialization dynamics in the last decades, i.e., countries that are likely to have been affected by the worldwide reshuffling of comparative advantages and have responded with changes in the relative export pattern. In addition, it is important to compare the magnitude of the export specialization dynamics in different sub periods, i.e., to examine whether the dynamics of relative export patterns has accelerated or decelerated. The quantification and mapping of export specialization dynamics allows for the identification of its underlying determinants. Testing which variables explain cross-country changes in export specialization dynamics sheds some light on the factors that make some countries benefit from new trade opportunities, as opposed to others where there is high persistence of export patterns maybe because adjustment costs are perceived as too high or structural blockages exist.

The measurement of export specialization dynamics and the identification of its determinants are the two research questions that the article aims to address. The paper suggests a quantitative measure for the mobility/persistence of export specialization patterns in a large set of countries over the last four decades. It follows a nonparametric approach to characterize the dynamics of trade patterns, turning to the full distributional analysis of the symmetric transformation of the Balassa (1965) index of specialization suggested by Dalum et al. (1998) and building on a previous non-quantitative analysis carried out in Amador et al. (2010). The methodology for the quantification of persistency/mobility makes use of conditional kernel densities and highest density regions in way that is applicable to studies in other areas. Moreover, the article discusses the determinants of specialization dynamics using as regressors a set of structural variables for the countries in the sample. The trade database considers nominal export flows, including 121 sectors and 76 countries or groups of countries in the period 1967-2008.

The article is organized as follows. In the next section we discuss the distribution of the export specialization indices and their information content. Section 3 presents the methodology for the computation of a measure of specialization dynamics and it is organized along three steps. Subsection 3.1 presents the basic specialization index used, subsection 3.2 presents the robust conditional kernel density estimation procedure and subsection 3.3 presents the proposed metric for specialization dynamics. Section 4 presents the results of the specialization dynamics index in the period 1967-2008 and the discusses whether it has accelerated or decelerated between the sub-periods 1967-1994 and 1980-2008. Finally, section 5 performs a simple regression aiming at identifying the main determinants of specialization dynamics. Section 6 concludes.

2 From exports to intra-distribution dynamics

The simplest method of studying the export specialization of a country is to look at exports structures, i.e., the share of different sectors in total exports. Nevertheless, this calculation does not take into account the exports of other countries, thus it does not provide information on relative specialization, which is typically associated with the notion of revealed comparative advantage. Such adjustment is performed through the computation of specialization indices like the Balassa (1965) index of revealed comparative advantage. Nevertheless, although useful, the comparison of specialization indices across sectors does not capture the overall degree of specialization of a country or its intra-distribution dynamics over time. Therefore, the literature evolved and suggests that the analysis of trade specialization in an economy requires information on the entire distribution of specialization indices over the time, i.e., a full distributional analysis. This was initially suggested in Proudman and Redding (1997, 2000) and recent articles include Brasili et al. (2000), De Benedictis and Tamberi (2004), Maio and Tamagni (2008) and Amador et al. (2010).

The full distributional analysis of specialization indices comprises changes in the shape of the distribution and the analysis of the intra-distribution dynamics, i.e., the probability of a sector to move within the specialization distribution. The comparison of the shape of the distribution of specialization indices in different moments is not sufficient to fully assess export specialization dynamics. In fact, the external shape of the distribution of specialization indices may be similar in two periods, even though significant intra-distribution dynamics exists. This is true if specialization indices switch positions within the distribution. The proposed empirical framework for measuring the dynamics of export specialization builds on the intra-distribution dynamics of sectoral specialization indices. In particular, taking a given time horizon, a high probability of transition of an elementary specialization index to values significantly different from the initial ones reveals high specialization dynamics and may point towards a substantial degree of flexibility in the allocation of resources in the economy. In practical terms this involves the estimation of conditional kernel densities basing on the non-parametric methods suggested by Hyndman et al. (1996). However, the comparison of estimated conditional densities through visual inspection is frequently subjective and not feasible if a large set of countries or periods are being compared. Therefore, it is necessary to set a metric to define how distant is the density of the estimated conditional distribution from the initial conditioning value. This is the strategy followed in this article.

The discussion on the determinants of specialization dynamics is complex and it benefits from the existence of quantitative information such as a specialization dynamics index. The empirical trade literature has primarily focused on the magnitude of the adjustment costs after specific shocks affect sectors. Such short and medium term analysis of the effect of shocks in international trade typically centers on labor market variables.[1] Nevertheless, countries frequently do not fully explore the opportunities of international trade, maintaining export patterns that are not the most advantageous. This may occur because, either governments perceive the adjustment costs as too high,

[1] For an example of such approach see Molnar et al. (2007).

or structural blockages or market failures exist. As a consequence trade liberalization is postponed or the reallocation of resources to sectors where comparative advantages emerge is slow. Structural features like the adaptability of productive factors and the functioning of markets should play a role in facilitating this dynamics. This notion is linked with the literature on the effects of uncertainty and risk in international (for example, Eaton (1979) and Turnovsky (1974)). One objective in this article is to link long term export specialization dynamics with structural factors that may have lead (or allowed) countries to perform the adjustments required by changes in the pattern of comparative advantages. Given the impossibility of having a panel database (because the export specialization index is computed for a period of time and not on an yearly basis), country or time specific effects can not be included in the regressions. Although this reduces the overall robustness of the econometric exercises, some variables still emerge as important.

3 Methodology

3.1 Basic specialization indices

The empirical trade literature suggests several methods to evaluate the trade specialization of a given country, most of them aiming at identifying the comparative advantages revealed ex-post by international trade. The most widely used indicator is the Balassa index, as suggested by Balassa (1965).[2] 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 $x_{Wj} = \sum_{i=1}^{N} x_{ij}$ and total world exports can be seen either as the sum of all products or as the sum of all countries, i.e., $X_W = \sum_{j=1}^{m} x_{Wj} = \sum_{i=1}^{N} X_i$. The Balassa index can be written as:

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

If the share of sector j in total exports of country i is higher than the equivalent share of sector 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.

The use of the Balassa index, which follows an asymmetric distribution with a fixed

[2] For a discussion of alternative indicators of trade specialization, see Bowen (1983), Yeats (1985), Ballance et al. (1987), Vollrath (1991) and Iapadre (2001).

lower bound of 0, a variable upper bound and a variable mean, has been subject to several critiques, leading some authors to propose modified versions.[3] This article uses the transformation suggested by Dalum et al. (1998), because the high asymmetry of the traditional B_{ij} index complicates the analysis of its distribution. Dalum et al. (1998) labelled this new index as "Revealed Symmetric Comparative Advantage", which is defined as:

$$BS_{ij} = \frac{B_{ij} - 1}{B_{ij} + 1} \tag{2}$$

BS_{ij}^X ranges from -1 to 1 since B_{ij} equals zero when country i is not an exporter in sector j and tends to its upper bound when the country is the only exporter in that sector, respectively. If $B_{ij} = 1$, then $BS_{ij}^X = 0$, which is the new demarcation value. This new index leaves the ranking and the specialization status of the sectors within each country unchanged.

3.2 Kernel estimation of conditional densities

The analysis of international specialization patterns based on the cross-industry distribution of specialization indices raises the issue of persistence *vs* mobility of the initial patterns. The methods of evaluating intra-distribution dynamics were initiated by Quah (1993) in discrete time, applied to cross-country income convergence analysis, and extended afterwards to a continuous time framework (see 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 by drawing information from the distributions at time $t + \tau$, given its value at time t.

This article employs nonparametric kernel estimators for conditional densities, following the methodology described in Hyndman et al. (1996). The estimation of conditional densities is an important topic of research in statistics, and empirical economics articles are progressively making use of these more accurate nonparametric methods. Such methods allow researchers to explore several topics without making a priori assumptions about the underlying relationships.[4] The use of a consistent estimator for the conditional densities of export and import specialization indices at time $t + \tau$, given its value at time t is a distinctive feature of this article. Next, we follow closely Hyndman et al. (1996) and Huynh and Jacho-Chavez (2007) and briefly describe the estimation methodology.

[3] Modified versions of the original Balassa index may be found, for instance, in Proudman and Redding (2000) and in Amador et al. (2009).

[4] See, for instance, Huynh and Jacho-Chavez (2007) for an application of kernel conditional densities estimations to firm-level manufacturing data from Ecuador and Amador et al. (2010) for an application to international trade data.

Consider that the BS_{ij} index at time t is a scalar random variable on the space $\Re$ designated as X and, similarly, BS_{ij} index at time $t+\tau$ is designated as Y. Take a sample denoted by $(X_1, Y_1), (X_2, Y_2), \ldots, (X_N, Y_N)$. The density of Y conditional on $X = x$ can be written as:

$$f_{Y|X}(y \mid x) = \frac{f_{Y,X}(y, x)}{f_X(x)} \tag{3}$$

Consistent kernel-based estimations of (3) can be written as:

$$\widehat{f}_{Y|X}(y \mid x) = \sum_{i=1}^{N} w_i(x) K_{h_y}(y - Y_i) \tag{4}$$

where $w_i(x)$ is a weighting function and $K_h(u) = h^{-1}K(u/h)$. In addition, h is a bandwidth parameter and $K(.)$ designates a gaussian kernel function with the usual properties, i.e., a real, integrable, non-negative even function on $\Re$, concentrated at the origin, such that:

$$\int_{\Re} K(u)du = 1, \quad \int_{\Re} uK(u)du = 0, \quad \int_{\Re} u^2 K(u)du < +\infty \tag{5}$$

Furthermore, the weighting function is of the form:

$$w_i(x) = K_{h_x}(x - X_i) / \sum_{j=1}^{N} K_{h_x}(x - X_j) \tag{6}$$

which corresponds to local constant weights. The natural estimator of the conditional density (3), corresponding to the ratio of two kernel density estimators, is:

$$\widehat{f}_{Y|X}(y \mid x) = \frac{\widehat{f}_{Y,X}(y, x)}{\widehat{f}_X(x)} \tag{7}$$

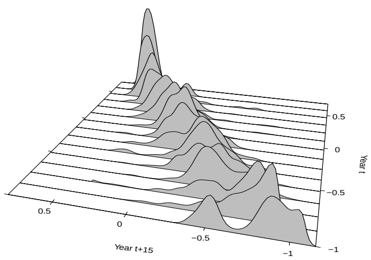
and, as shown by Hyndman et al. (1996), if $h_x \to 0$, $h_y \to 0$ and $Nh_x h_y \to +\infty$, as $N \to \infty$, then (7) is a consistent estimator of the conditional density (3).

Conditional density estimations and visual representations used in this article were performed with the hdrcde package by Hyndman and Einbeck (2009). The choice of the optimal bandwidths to be used in the estimation of the conditional density is very important, especially when the data does not come from normal or uniform distributions. Therefore, the np package by Hayfield and Racine (2008) was used to compute the optimal (data dependent) bandwidth for each conditional density estimation. The bandwidth selection method is the *maximum likelihood cross-validation* and bandwidth type is *fixed*, as discussed in Hall et al. (2004). The continuous kernel type chosen by the package in the different countries was a second-order Gaussian distribution. These parameters were plugged in the hdrcde package to estimate and plot the conditional densities and the corresponding highest density regions.

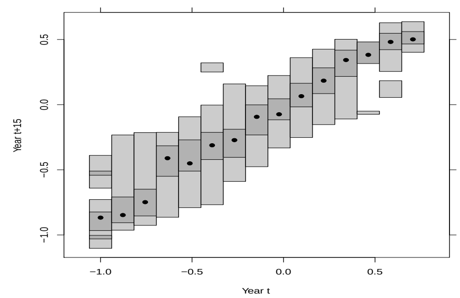
The analysis is based on the CEPII - CHELEM database, which reports bilateral trade flows for goods in value terms (the unit being the US dollar). The sample period starts in 1967 and ends in 2008, considering 76 countries or groups of countries and with a product breakdown at the four digits level of the ISIC classification (rev.3), which includes 121 manufacturing products.

As an illustration, Figure 1 presents the estimated conditional distributions for the four largest world economies - US, Japan, China and Germany over the period 1967-2008. The left-hand panels show the distribution of the export specialization index in period $t + 15$ over the range of the conditional variable, i.e., the BS^X in period t. The highest density regions (HDR) plotted in the right-hand panels are computed from the conditional density estimates and show the smallest region of the sample containing a given probability. The darker-shaded region corresponds to a 50% HDR and the lighter tone delimits the 95% HDR. The mode of each conditional density is shown as a bullet ($\bullet$). The shape of the conditional densities and the corresponding HDR are different across the countries, reflecting different dynamics of export patterns.

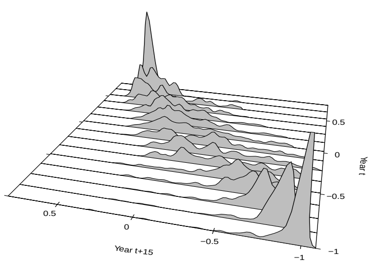
Figure 1: Exports - Estimated Conditional Densities - 15-year transitions



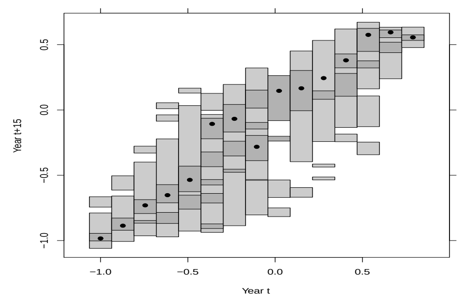
(a) USA



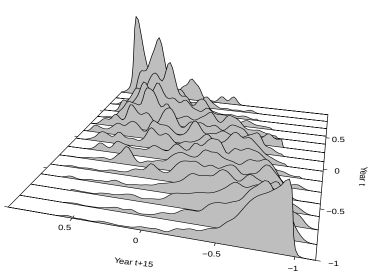
(b) USA



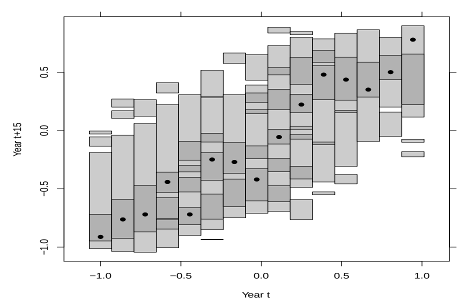
(c) Japan



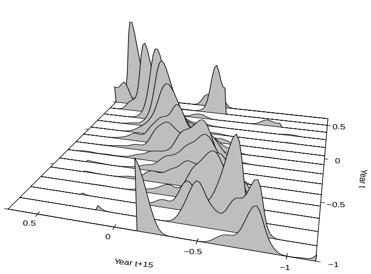
(d) Japan



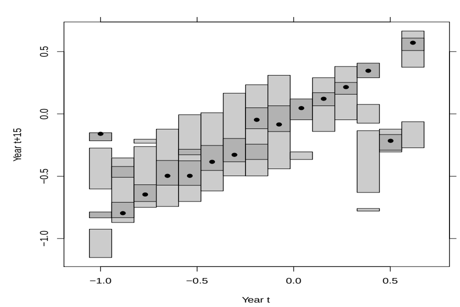
(e) China



(f) China



(g) Germany



(h) Germany

Sources: CEPII-Chelem database and authors' calculations.

3.3 Measuring specialization dynamics

As previously mentioned, export specialization dynamics in this article concerns the intra-distribution dynamics, i.e., the mobility/ persistence of export specialization indices, and it involves an assessment regarding the position of density within the estimated conditional distributions. The HDR plots are suited to perform this task because they identify the intervals where the density is the highest. Nevertheless, to take conclusions from a purely visual inspection of HDR plots is difficult because several dimensions need to be considered, especially if a large number of countries or periods is being studied. Therefore, the computation of a quantitative measure that summarizes this information is very useful. In addition, a quantitative measure can be used to perform econometric exercises. Two dimensions are important in the assessment of export specialization dynamics from the HDRs: i) how wide is the HDR interval and ii) how distant is the center of the HDR intervals from the 45 degree line. Dimension i) measures how wide is the interval of values for the specialization index after 15 periods, conditional on a given starting level. In this context, the wider the HDR interval, the higher the perceived mobility. Dimension ii) focuses on a complementary feature. If most of the density is close to (far from) the initial starting level, i.e., near (far from) the 45 degree line, this means that there is high persistence (high mobility). Therefore, the dimensions i) and ii) must be taken into account to infer on the mobility/ persistence of international trade patterns. These two dimensions can be quantified separately.

Take the conditional distribution k in the 95% HDR plot of country i and define its upper and lower limits as u_k^i and l_k^i, respectively. Considering that the maximum amplitude of the HDR is 2, i.e., the distance from -1 to 1, which are the bounds of the BS_{ij} specialization indices, the relative amplitude is simply defined as:

$$A_k^i = \frac{u_k^i - l_k^i}{2} \tag{8}$$

The maximum and minimum values for A_k^i are 1 (when the HDR covers the span of values for the specialization indicator [-1,1]) and 0 (when the HDR collapses in one point), respectively. In addition, as regards dimension ii), consider the absolute distance of the central point in the HDR interval to its conditioning value, the latter being defined as X_k. In order to obtain a relative deviation such distance is divided by the maximum possible deviation given the amplitude of the HDR under consideration. Therefore:

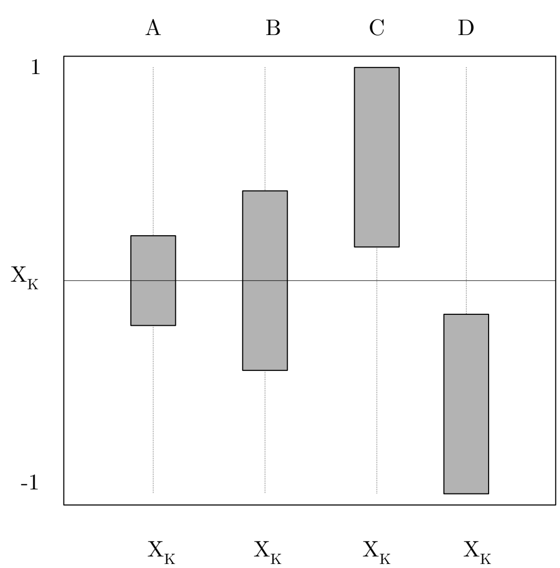
$$B_k^i = \frac{\left| \frac{u_k^i + l_k^i}{2} - X_k \right|}{\max\left(\left| \frac{u_k^i - l_k^i}{2} - 1 - X_k \right|, \left| 1 - \frac{u_k^i - l_k^i}{2} - X_k \right| \right)} \tag{9}$$

The maximum value for B_k^i is 1 (when $A_k^i = 1$) and the minimum is zero (when $X_k = u_k^i = l_k^i$). Figure 2 presents a visual example of the two dimensions taken into consideration in the computation of the specialization indicator. It takes a given conditional value X_k (which, as an example, is placed at zero) and presents four possible HDR's. When the HDRs A and B are compared, B translates a higher perceived mobility because its amplitude is wider (A_k^i is higher). When HDRs B and C are compared, C translates a higher mobility because, despite the similar amplitude, it is centered further away from the conditioning X_k (B_k^i is higher). HDRs C and D translate the same mobility because amplitudes are equal and their center is equally distant from X_k. Taking dimensions i) and ii) in equations 8 and 9 and dividing by the scalar $4b$, where b is the number of conditional distributions in the HDR, we obtain the specialization dynamics index (SDI) for country i:

$$SDI^i = \frac{1}{4b} \sum_{k=1}^{b} \left(1 + A_k^i\right) \left(1 + B_k^i\right) \tag{10}$$

Each term inside the summation attains a maximum of 2 (when $A_k^i = 1$ and thus $B_k^i = 1$). Therefore, the scalar $4b$ corresponds to the maximum possible value attained by the sum of the products $(1 + A_k^i)\,(1 + B_k^i)$, leading to a maximum SDI of 1.

Figure 2: Visual example



Summing up, the computation of the SDI proceeds in three stages. Firstly, the traditional export specialization indices are computed for the different sectors. Secondly, the intra-distribution dynamics of the specialization indices for each country are assessed, considering the evolution of the specialization index of each sector in each country over 15-year periods, which involves the estimation of robust conditional density distributions. Thirdly, the characteristics of the estimated conditional distributions, translated by the amplitude and location of the HDRs, are turned into a numerical indicator, taking a very simple metric.

The results of the *SDI* are dependent on the number of conditional distributions estimated for each country, though 15 is a standard number in the statistics literature. In addition, the metric proposed basically takes the upper and lower limits of the HDR, ignoring the small blanks that may exist in between. The consideration of these blanks would greatly increase the complexity of the metric, without bringing significant changes in the final results. The methodology proposed in the article requires considerable computational burden, especially in the robust estimation of the conditional distributions. Nevertheless, the procedure is straightforward and can be applied in other non-parametric contexts where the temporal dynamics of an economic indicator are to be measured. Possible examples are distributions on households' personal income over time (dynamics of income distribution) or the size of firms (firm demography).

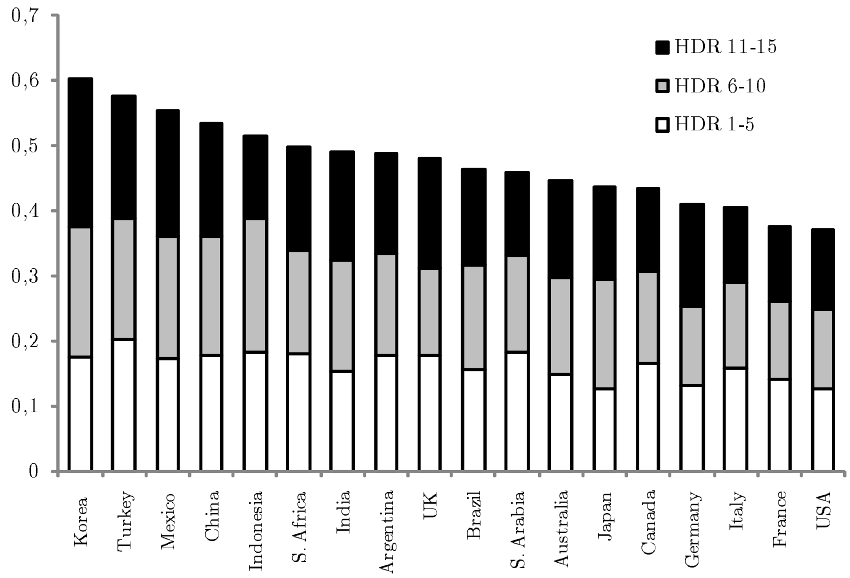
4 Dynamics of Export Specialization

4.1 Cross-country comparisons

The computation of the previously presented *SDI* for the set of countries or regions available in the CEPII - CHELEM database for the period 1967-2008 provides an overview of the dynamics of export specialization in the world. Figure 3 plots the results for the G20 countries (with the exception of Russia, for which there is no information for the whole period) and Appendix 1 includes the full list of countries and their ranking in terms of the indicator. Figure 3 also presents the contributions of the different blocks of conditioning values to the overall index, i.e., it provides information on whether the change in the specialization index of a given country is driven by dynamics on the sectors which start with low specialization, no specialization or high specialization. The blocks considered comprise the conditioning values associated with the 1 to 5, 6 to 10 and 11 to 15 HDR bins, counting from left to right.

The results reveal that the intra-distribution dynamics of export specialization are significant and there are important differences amongst countries. Within the G20, the country with the highest *SDI* is Korea (0.60) and the lowest value is observed for the US (0.36). The number for the US is the lowest in the full sample of countries but the

Figure 3: Specialization Dynamics Index (SDI) - countries of the G20, excluding Russia



Sources: CEPII-Chelem database and authors' calculations.

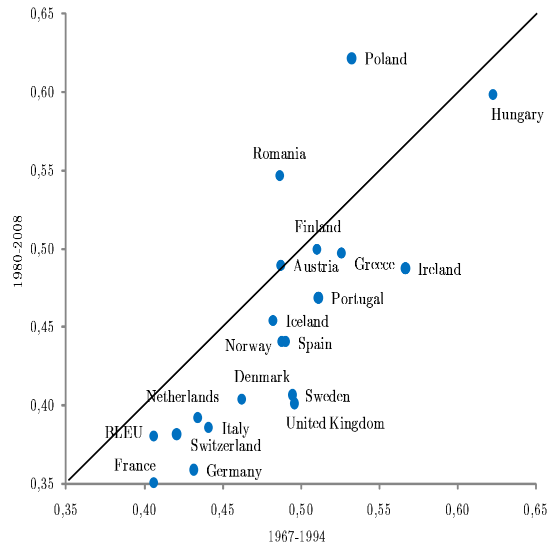
highest value is observed for Cambodia (0.75), while the countries unweighed average is 0.51. Going back to illustration presented in Figure 1, China is the country whose HDR intervals are larger and their center more deviated from the 45 degree line. Japan shows HDRs with a lower amplitude than those of China, and Germany and US present narrow HDRs whose center is broadly along the 45 degree line. This translates into a higher *SDI* for China than for Japan, with Germany and the US showing much smaller SDI values. As for the contribution of the different blocks of conditional values, they are relatively uniform, i.e., the changes in the value of the specialization indices are broadly uniformly driven by low specialized, non-specialized and specialized sectors. The same pattern is observed for the full set of countries.

4.2 Have export specialization dynamics increased?

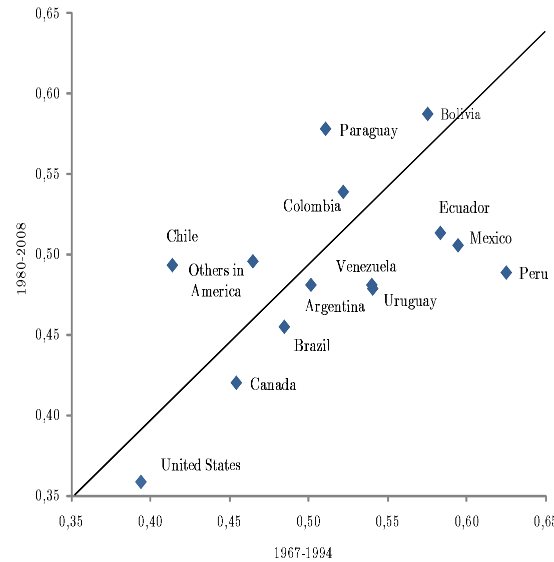
Another relevant question is to know whether export specialization dynamics have increased or decreased along the last decades. This can be analyzed by computing the *SDI* for different subperiods. The computation procedure is unaltered but the number of transitions that are used to estimate each conditional distribution is naturally smaller. Figure 4 presents the *SDI* for the different countries or sets of countries for the periods 1967-1994 and 1980-2008, organized in different world regions. Given that we are considering 15-year transitions, the overlap of periods does not mean that the same transitions are used twice, e.g., the observation for 1994 is the final point in the last transition of the block 1967-1994 but 1995 is the final point of the first transition of the block 1980-2008.

The panel a) of Figure 4 presents the *SDI* for the European countries in the sample. Three points are worth noting. Firstly, as expected, the Central and Eastern European countries that adopted market economies in the beginning of the nineties record

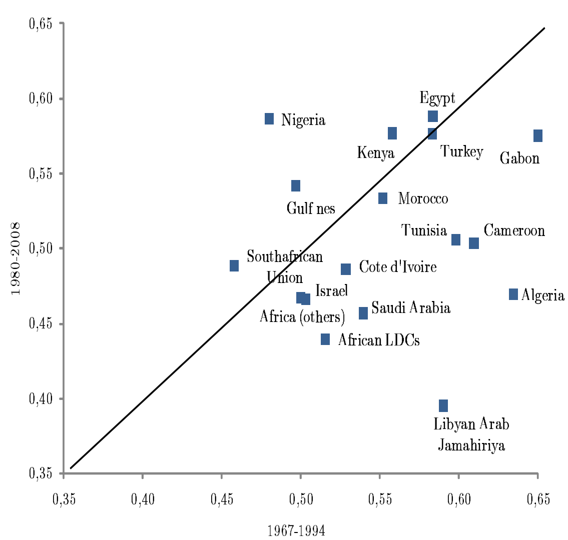
Figure 4: Specialization Dynamics Index (SDI)



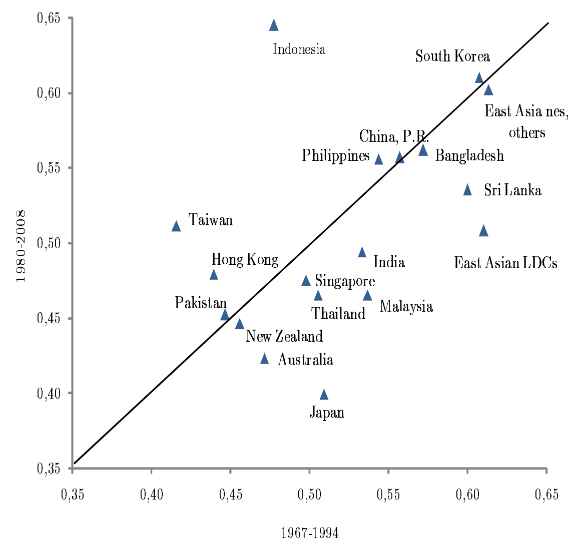
(a) Europe



(b) America



(c) Africa and Middle-East



(d) Asia and Oceania

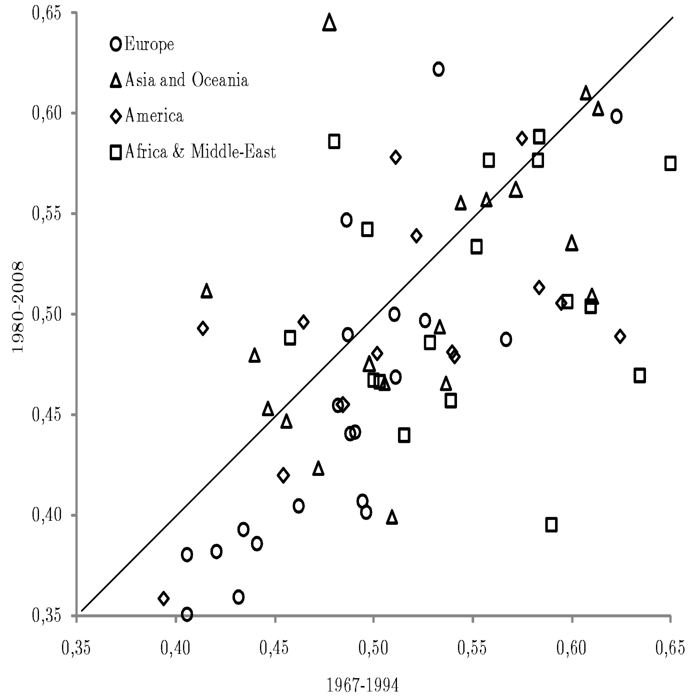
Sources: CEPII-Chelem database and authors' calculations.
Note: To facilitate representation, countries with SDI outside the bounds of figure are not represented (Albania, Brunei Darussalam, Bulgaria, Cambodia, Vietnam and Others in South Europe).

high and/or accelerating *SDI*. Those are the cases of Romania, Poland and Hungary.[5] Secondly, some European economies underwent significant export restructuring either due the fall of the iron curtain, EU accession, severe macroeconomic crisis or a combination of some of these aspects. These countries show high, though decreasing *SDI* (Finland, Ireland, Greece and Portugal). Thirdly, the largest and more developed European economies like, France, Germany and the UK show relatively lower *SDI*. As for the American continent (panel b) of Figure 4), large developed countries like the US and Canada show a relatively low *SDI* but the overall specialization dynamics in this continent looks larger than in Europe, with some countries increasing between the two periods considered. Nevertheless, it should be recalled that the *SDI* is computed in nominal terms, so for countries with a strong share of transformed agricultural products or raw materials, like some of those in America, fluctuations in international prices of these products may change the corresponding relative export specialization indices, without a real change in the type of products being exported. The panel c) of Figure 4 presents the *SDI* for African and Middle-East countries in the sample. The values of the *SDI* in this group are more dispersed than those of America and Europe, but the quality of the trade statistics in some countries is poor and the dependence on exports of raw-materials is very important. Finally, as regards Asia and Oceania, panel d) of Figure 4 reveals that developed countries like Japan, Australia and New Zealand show a relatively low *SDI*, while China presents significant dynamics in both periods. In addition, although having modernized early, Korea, Hong-Kong and Taiwan present an acceleration of export specialization dynamics between the two periods.

Overall, there is considerable heterogeneity in export specialization dynamics across the world. Figure 5 pools the values of the *SDI* for the countries included in the sample. In this figure, most countries lie below the 45 degree line, meaning that export specialization dynamics decelerated between the two periods. In addition, there is no clear regional pattern since there are examples of countries above the 45 degree line in all continents. Furthermore, there is also a positive correlation between the *SDI* in each country in the two periods. Africa and Middle-East and Asia and Oceania seem to be the regions where specialization dynamics changed the most, i.e., where more countries show substantial changes in specialization dynamics between the two periods.

[5] For other central and eastern European countries the database does not contain sufficiently long information to perform the computation.

Figure 5: Specialization Dynamics Index (SDI) - All countries



Sources: CEPII-Chelem database and authors' calculations.

5 Determinants of export specialization dynamics

This section examines the determinants of export specialization dynamics. The question to pose is why do some countries show more dynamics in the export specialization indices of the different sectors than others. The candidate explanatory variables could be arranged in three groups. Firstly, the size, level of development and degree of openness of the economy. It can be argued that larger and more developed economies tend to be more stable in terms of the structure of international trade. It can also be argued that more open economies have a more established trade pattern when compared with those that face a trade liberalization process. Nevertheless, more open economies may also face changes in export specialization precisely because they may be more exposed to international shocks. Secondly, the quality of human capital, physical infrastructure, development of the financial system or macroeconomic stability may influence countries' ability to reallocate resources across sectors, thus changing export specialization in response to changes in the pattern of comparative advantages. Thirdly, there might be specific aspects like the large share of agricultural products or raw-materials in total exports, whose relative price movements induce changes in the export specialization indices. In addition, the occurrence of major economic disruptions based on political instability or natural catastrophes may affect some particular countries, showing up as outliers.

The econometric approach adopted in the article consists in the estimation of simple cross-country OLS regressions for the *SDI* in the period 1967-2008, using a set of explanatory variables that covers the main arguments previously mentioned. One very strong limitation of this approach is the lack of good statistical information for such a wide set of countries for a long period of time. Most of the information was obtained from the World Development Indicators database maintained by the World Bank. A detailed explanation of the variables used is presented in Appendix 2.

Table 1 shows the results of the econometric analysis. Equation 1 bases on indicators of the quality of inputs and their role in facilitating the reallocation of resources in the economy. The coefficients indicate that the change in the quality of the physical infrastructure, proxied by the change in the number of telephone lines per 100 habitants, the level of education, proxied by the enrolment rate in primary school, and macroeconomic stability, proxied by the change in inflation rate, have a positive impact in the *SDI*. On the contrary, the percentage of domestic credit in GDP, which should proxy the development of the domestic financial system, shows a negative impact. Nevertheless, this indicator may also reflect the degree of liberalization of capital flows. In this case, the higher the domestic credit to GDP ratio, the lower the liberalization of capital flows, with a negative impact on the *SDI*. All coefficients are significant and this formulation resists to the usual range of statistical tests.[6]

Equation 2 adds the UN Human Development Index to the set of explanatory variables in order to capture the overall degree of development of the economy. The coefficient is significant and negative and the signs of the other variables remain unaltered. Equation 3 in table 1 includes a proxy for the importance of vertical specialization activities in the economy and dummies for recent EU accession and important energy exporters. These dummies are significant and the results reveal that the deeper the participation of the economy in international production chains, the EU accession of central and eastern European countries or being an important energy producer increases the *SDI*.

Finally, equation 4 tested the inclusion of dummy variables for a set of individual countries and was used mainly as robustness check. The choice of these countries based on the dummy saturation procedure suggested by Hendry et al. (2008). The signs of the coefficients for the variables tested in previous formulations do not change. Variables like the "degree of openness", "FDI as a percentage of GDP" and "GDP per capital" did not come as significant in the different formulations tested.

[6]The econometric tests performed on the different specifications include the normality of the residuals, the heteroescedasticity test (White (1980)) and the regression specification test (Ramsey (1969)). The general-to-specific modelling strategy was performed using the statistical software PcGive for cross-section data models and the Autometrics option for automatic model selection.

Table 1: Determinants of specialization dynamics (*SDI* 1967-2008)

	Eq. 1	Eq. 2	Eq. 3	Eq. 4
Constant	0.3937^{***}	0.4408^{***}	0.4162^{***}	0.4131^{***}
	(0.0518)	(0.0485)	(0.0443)	(0.0353)
Telephone	0.0048^{**}	0.0071^{***}	0.0040^{**}	0.0082^{***}
	(0.0019)	(0.0018)	(0.0019)	(0.0004)
Inflation	0.0003^{***}	0.0004^{***}	0.0004^{***}	0.0018^{***}
	(0.0001)	(0.0001)	(0.0001)	(0.0001)
Domestic credit	-0.0012^{***}	-0.0008^{***}	-0.0007^{***}	-0.0010^{***}
	(0.0002)	(0.0002)	(0.0002)	(0.0013)
Primary education	0.0015^{***}	0.0023^{***}	0.0025^{***}	0.0021^{***}
	(0.0005)	(0.0005)	(0.0005)	(0.0003)
UN Human Development Index		-0.1999^{***}	-0.1961^{***}	-0.1160^{***}
		(0.0538)	(0.0501)	(0.0409)
Vertical specialization index			0.0039^{**}	
			(0.0018)	
Dummy EU-Eastern accession			0.0768^{***}	
			(0.0255)	
Dummy oil producer			0.0439^{**}	
			(0.0181)	
Dummy France				-0.1045^{***}
				(0.0304)
Dummy BLEU				-0.1029^{***}
				(0.0308)
Dummy Australia				-0.0848^{***}
				(0.0309)
Dummy Venezuela				-0.0727^{**}
				(0.0311)
Dummy Brazil				0.5687^{***}
				(0.1402)
Dummy Bolivia				0.1133^{***}
				(0.0311)
Dummy Algeria				0.0678^{**}
				(0.0303)
Obs.	62	62	62	62
R^2 adjusted	0.49	0.59	0.66	0.78
F	15.9	18.3	16.1	19.4

Note: Robust standard errors in parenthesis. * significant at 10%, ** significant at 5%, *** significant at 1%.

A different exercise would be to perform a cross-country estimation to test the determinants of the *evolution* of the *SDI* between two sub-periods (1967-1994 and 1980-2008). Nevertheless, the informational content of the explanatory variables for such a wide set of countries and a long period of time is insufficient to obtain a significant relation with changes in the *SDI*.

6 Conclusions

The article proposes a methodology to measure the intra distribution dynamics of export specialization across countries. The measure builds on three of steps. Firstly, the traditional export specialization indices are computed for all sectors in a large set of countries and, on an yearly basis, for the last four decades. Secondly, the intra-distribution dynamics of the specialization indices for each country are analyzed, considering the evolution of the specialization index of each sector over 15-year periods. This analysis involves the estimation of robust conditional kernel density distributions, i.e., the distribution of the specialization indices after 15 years, conditional on its starting value. Thirdly, the shape of the estimated conditional kernel distributions, translated by the amplitude and location of the highest density regions, is summarized into a numerical indicator.

The results reveal that there are considerable export specialization dynamics and heterogeneity across countries. In addition, it seems that the export specialization dynamics decelerated in most countries from the 1967-1994 to the 1980-2008 period and there is a significant positive correlation between the indicators in the two periods.

The article also tests a set of dependent variables as determinants of the export specialization dynamics across countries for the period 1967-2008. Higher human capital, improvements in infrastructure and macroeconomic stability seem to contribute to stronger specialization dynamics. Inversely, domestic credit to the private sector as a percentage of GDP shows a negative impact. Variables such as GDP per capita, degree of openness and FDI inflows do not seem significant determinants of export specialization dynamics.

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Appendices

A Detailed country results - Specialization Dynamics Index

Country	SDI	Rank	Country	SDI	Rank
United States	0.370	76	Uruguay	0.512	38
France	0.376	75	Finland	0.513	37
BLEU	0.393	74	Others in America	0.513	36
Switzerland	0.401	73	Indonesia	0.515	35
Italy	0.404	72	Greece	0.516	34
Netherlands	0.407	71	Peru	0.518	33
Germany	0.411	70	Colombia	0.520	32
Sweden	0.423	69	Cote d'Ivoire	0.520	31
Denmark	0.433	68	Nigeria	0.521	30
Pakistan	0.434	67	Ireland	0.526	29
Canada	0.435	66	Morocco	0.527	28
Japan	0.436	65	Kenya	0.528	27
Australia	0.446	64	Cameroon	0.530	26
Spain	0.449	63	China. People's Rep	0.535	25
Hong Kong	0.449	62	Philippines	0.536	24
Chile	0.449	61	Sri Lanka	0.536	23
New Zealand	0.451	60	East Asian LDCs	0.539	22
Saudi Arabia	0.459	59	Egypt	0.554	21
Brazil	0.465	58	Mexico	0.554	20
Africa (others)	0.465	57	Ecuador	0.554	19
African LDCs	0.471	56	Tunisia	0.557	18
Iceland	0.471	55	Poland	0.562	17
Norway	0.474	54	Paraguay	0.572	16
Israel	0.477	53	Turkey	0.577	15
Portugal	0.480	52	Brunei Darussalam	0.580	14
United Kingdom	0.480	51	Libyan Arab Jamahiriya	0.586	13
Austria	0.480	50	Algeria	0.593	12
Venezuela	0.485	49	Hungary	0.599	11
Romania	0.487	48	Others in south Europe	0.600	10
Argentina	0.488	47	South Korea	0.604	9
Gulf nes	0.490	46	East Asia nes, others	0.605	8
India	0.490	45	Bulgaria	0.608	7
Thailand	0.495	44	Vietnam	0.618	6
Malaysia	0.496	43	Bolivia	0.623	5
Taiwan	0.497	42	Middle East, no OPEC	0.624	4
Southafrican Union	0.498	41	Gabon	0.651	3
Bangladesh	0.498	40	Albania	0.699	2
Singapore	0.500	39	Cambodia, Lao PDR	0.748	1

Note: Results based on 15-year transitions over the period 1967-2008. Sources: CEPII-Chelem database and authors' calculations.

B Description of variables used in regression

Telephone: Change in the number of telephone lines per 100 people, averages of the periods 1967-1994 and 1980-2008. Source: World Development Indicators (World Bank).

Inflation: Change in inflation rate, averages of the periods 1967-1994 and 1980-2008. Source: World Development Indicators (World Bank).

Domestic credit: Domestic credit as a percentage of GDP, average of the period 1967-2008. Source: World Development Indicators (World Bank).

Primary education: Gross enrolment ratio in primary education, average of the period 1967-2008. Source: World Development Indicators (World Bank).

Human Development Index: Human Development Index, average of the period 1980-2007. Source: United Nations.

Vertical specialization index: Change in the relative importance of vertical specialization activities in total domestic trade, as described in Amador and Cabral (2009) (threshold percentile 80 and 118 inputs), averages of the periods 1967-1994 and 1980-2005.

Dummy EU-Eastern accession: Eastern European countries (in the sample) that acceded the European Union in 2004 and 2007: Bulgaria, Hungary, Poland and Romania.

Dummy oil producer: Countries where oil or gas production is important: Algeria, Brunei Darussalam, Libyan Arab Jamahiriya, Nigeria and Saudi Arabia.

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