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## **Economic Integration and Similarity in Trade Structures**

Lucia Tajoli and Luca De Benedictis

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Lucia Tajoli, *Dipartimento di Ingegneria Gestionale Politecnico di Milano*  
Luca De Benedictis, *Università di Macerata*

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# Economic Integration and Similarity in Trade Structures

## Summary

In this paper we look at the similarity of trade structures in an integrating area. In particular, we analyse the export flows toward the EU market of four of the so-called “accession countries” of Central and Eastern Europe by comparing them to those of the pre-2004 members of the European Union (EU15). From a methodological point of view, we evaluate the appropriateness of different classes of similarity indices - correlation indices and distance metrics - opting for the use of the Bray-Curtis semi-metric to assess changes in the trade similarity. We examine its evolution over time - from 1989 to 2001 - considering both self-similarity (how the export composition of a CEEC has changed with respect to the beginning of the transition process) and EU-similarity (if and how the export composition of a CEEC has changed with respect to the EU15 export composition). Finally, we use EU-similarity matrices to test if the dynamics of sectoral distribution of total exports of Poland, Hungary, Romania, and Bulgaria to the EU is related to the role acquired by processed trade in the 1990s. Using a nonparametric Mantel test we give evidence that: (1) processed trade is crucial in explaining changes in the overall structure of exports of transition countries, and (2) that greater economic integration in terms of trade flows and processing trade does not always lead to greater export similarity between the CEECs and the EU15 member States.

**Keywords:** EU, CEECs, Transition, Similarity, Nonparametrics

**JEL Classification:** F3, F42

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*Address for correspondence:*

Lucia Tajoli  
Dipartimento di Ingegneria Gestionale  
Politecnico di Milano  
via Giuseppe Colombo 40  
20133 Milano  
Italia  
Phone: +39 02 2399 2752 / 2750  
Fax: +39 02 2399 2710  
E-mail: lucia.tajoli@polimi.it

# 1 Introduction

The trade effects of economic integration between a group of countries have been studied extensively since the path-breaking analysis of Jacob Viner in 1950 and the signing of the Treaty of Rome in 1957. Much emphasis has been placed on the welfare effects of the change in trade volumes and trade partners related to regional integration agreements, but the issue of how economic integration might change the specialization and the export composition of a country has received less attention. In this paper we address this issue, examining the case of trade integration between the pre-2004 European Union members (EU15) and four Central-Eastern European Countries (CEECs): Poland, Hungary, Romania and Bulgaria. The integration of the CEECs with the EU15 is an extremely relevant experiment of how the elimination of trade barriers might shape a country trade structure. In fact the CEECs, opening their economies to the international markets in the 1990s, to a large extent had to restructure their specialization pattern, following a long period of economic isolation from the rest of the world.

Our research objective is twofold: (1) finding if this restructuring brought the CEECs to become more similar to the EU15 in terms of trade structure; (2) test if the changes in similarity have anything to do with the increased relevance of processing trade in this countries. Finding if countries are becoming more or less similar in trade structure<sup>1</sup> (and what variables are influ-

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<sup>1</sup> It is far from obvious whether countries increasing their mutual trade exchanges should become more similar in their export structures. A priori, theoretical models allow both possibilities of increased similarity and dissimilarity. Countries can be pushed by trade toward a polarization of their export structures following their comparative advantage (to the extreme case of full specialization in a few sectors for small countries). But not all trade is driven by comparative advantages, and similar export patterns can be observed

encing this process) is an important issue, specially in the context of regional integration.<sup>2</sup> We pursue our objectives examining the export flows toward the EU market of four of the so-called “accession countries” of Central and Eastern Europe by comparing them to those of the EU15.

Measuring and describing a country’s overall export pattern and its changes over time is not an obvious task. From a methodological point of view we tackle the issue of similarity, evaluating the general and specific appropriateness of different classes of similarity indices - correlation indices and distance metrics - opting for the use of the Bray-Curtis semi-metric to assess changes in the trade similarity. We examine its evolution over time - from 1989 to 2001 - considering both self-similarity (how the export composition of a CEEC has changed with respect to the beginning of the transition process) and EU-similarity (if and how the export composition of a CEEC has changed with respect to the EU15 export composition).

Finally, we use EU-similarity matrices to test if the dynamics of sectoral distribution of total exports of Poland, Hungary, Romania, and Bulgaria to the EU is related to the role acquired by processed trade in the 1990s. Using a nonparametric Mantel test we give evidence that: (1) processed trade is crucial in explaining changes in the overall structure of exports of transition countries, and (2) that greater economic integration in terms of trade flows

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for highly integrated countries such as the European ones. If the removal of barriers to trade is accompanied by the removal of obstacles to movement of factors of production, the number of possible outcomes is further increased, as re-localisation and restructuring of industries at the regional level can occur both through domestic resource reallocation and through delocalisation of industries between countries (Forslid *et al.*, 2002).

<sup>2</sup> In the trade literature it is often assumed that similarity in production and trade structures among countries will ease the integration process, allowing to improve resource exploitation while requiring relatively small industry reallocations (see Krugman (1981) and Menon and Dixon (1997)).

and processing trade does not always lead to greater export similarity between the CEECs and the EU15 member States. Poland, Hungary, Romania and Bulgaria changed indeed their patterns of sectoral exports towards the EU. The change is remarkable, different for every country, and lasting the early phases of their transition. Such differences appear to be linked to the involvement of these countries in international production networks, through the recourse to processing trade.

## **2 Exports, export composition and outward processing trade**

Our analysis focuses on the changes that occurred in the exports of Poland, Hungary, Romania and Bulgaria towards EU 15 member States, between 1989 and 2001. We chose these countries because they account for 70% of the total trade of the CEECs with the EU, and here we want to consider exclusively their transition process in terms of changes in trade patterns. Our implicit assumption is that the CEECs' exports embody many of the underlying changes in their economic structures as they occurred through the transition and the economic integration with the EU.<sup>3</sup> Poland and Hungary are both countries normally considered well advanced in the process of transition, they both signed agreements aimed at liberalizing trade with the EU at very early stages of the opening-up process, but they are however remarkably

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<sup>3</sup>The central role of trade in transition is addressed in many of the early works on the CEECs as well as in more recent assessments of their economies. See for example Halpern (1995), Kaminski *et al.* (1996), Hoekman and Djankov (1997), Landesmann (2002), Landesmann and Stehrer (2002).

different.<sup>4</sup> Romania and Bulgaria are much behind in their transition path, they have much lower levels of income per capita, and they are expected to join the EU only in 2007. We expect therefore that differences in the starting points and in the transition process would show up in the evolution of trade structures.

In the analysis, we extracted from the *Comext Eurostat Database* - containing custom trade data collected by EU national statistical institutes - the flows in value terms (thousands of euro) of both *total exports* towards the EU15, which include conventional trade flows as well as temporary EU exports of goods to be processed, and *final exports* towards the EU15 at a 2-digit sectoral level of the Combined Nomenclature organized in the 97 sectors listed in Appendix 1. Subtracting final exports from total exports we obtain the value of temporary exports recorded as Outward Processing Trade (OPT).<sup>5</sup>

In figure 1 we summarize - from top-left to bottom-right panel - the dynamics of Poland, Romania, Bulgaria, and Hungary total and final exports towards the EU15, taken as an aggregate. We also plot an estimate of total

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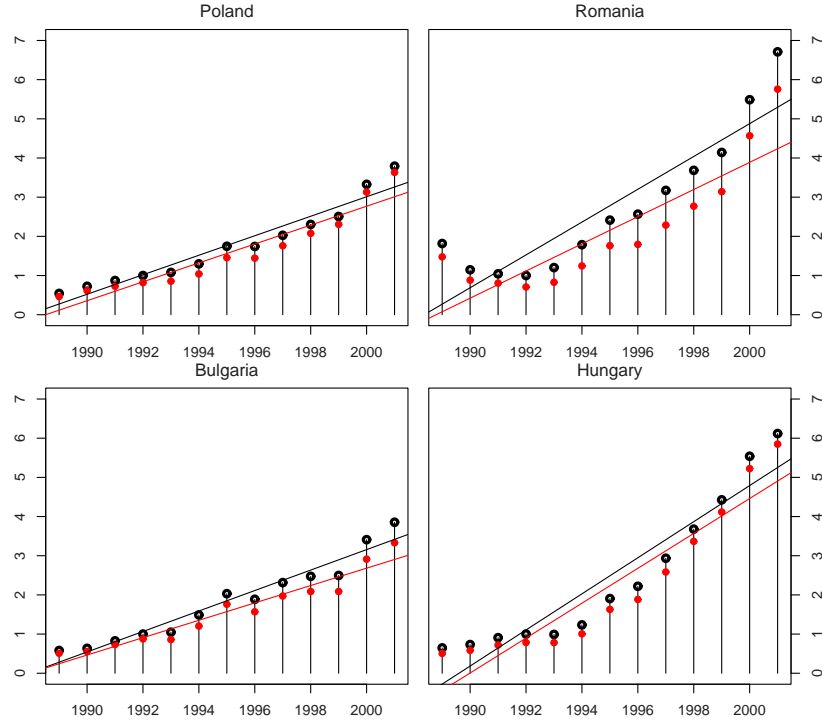
<sup>4</sup>For instance, Poland is much larger than Hungary in terms of population and land, and it has a much larger agricultural sector. In transition, Poland followed the so-called “shock therapy” approach, while the Hungarian government chose a much more gradual approach (Facchini and Segnana, 2003). For a comprehensive review of the transition process in the CEECs see Svejnar (2002).

<sup>5</sup>It is important to underline the difference between total and final or normal exports because total flows include goods temporarily exported to be processed and re-imports of processed goods. This kind of trade constitutes a large part of the CEECs’ trade in some sectors, but these flows are to a large extent activated and controlled by EU firms rather than by local firms and local production capacities.

The *Comext Eurostat Database* records separately normal or final trade flow (mainly goods exported definitely and released into free circulation, either directly or via a customs warehouse) from the trade flow which has undergone outward processing. Outward processing makes it possible to export goods temporarily for processing and to import the compensating products with a full or partial exemption from duties and levies.

Figure 1: CEECs Exports towards EU: Total and Final Exports

**Note:** Total exports are represented by the vertical lines surmounted by darker dots, while the lighter (red) dots correspond to final exports. In all cases the exports flows are measured relative to 1992 value of national exports towards the EU (Total Exports in 1992=1).



and final exports towards EU15 obtained through a simple linear regression of exports on a time trend [See Appendix 2 for details].<sup>6</sup> Figure 1 shows eloquently that each of the four export pattern is a case on its own. In the case of Poland, from 1989 to 2001, the value of total exports flows jumped from 6,975 million euro to 26,447 million euro. The case of Hungary is even more remarkable, the value of total exports almost sextupled from 1992 to 2001 from 3,973 to 24,311 million euro. The results of the linear regression

<sup>6</sup>The choice of the base year is irrelevant for the shape of the four series in figure 1. The choice is therefore only suggestive: 1992 is a significant year in terms of trade reorientation as the former USSR no longer exists.



of total exports on a linear time trend indicate a highly significant average yearly increase in Hungarian exports to the EU of 46%, (almost twice as high as Poland) but the fit of the regression line indicates that the linear functional form is probably not the most appropriate choice. In fact, until 1993 the series is almost flat, growing rapidly afterwards.

The value of total Romanian exports to the EU followed a J-shaped path, decreasing from 1989 to 1992 and increasing in the following years from 1,393 to 9,349 million euro. The linear time trend is again partially misrepresenting the true dynamics of Romanian exports. In the Bulgarian case total exports almost quadrupled from 1992 to 2001 from 901 to 3,472 million euro.

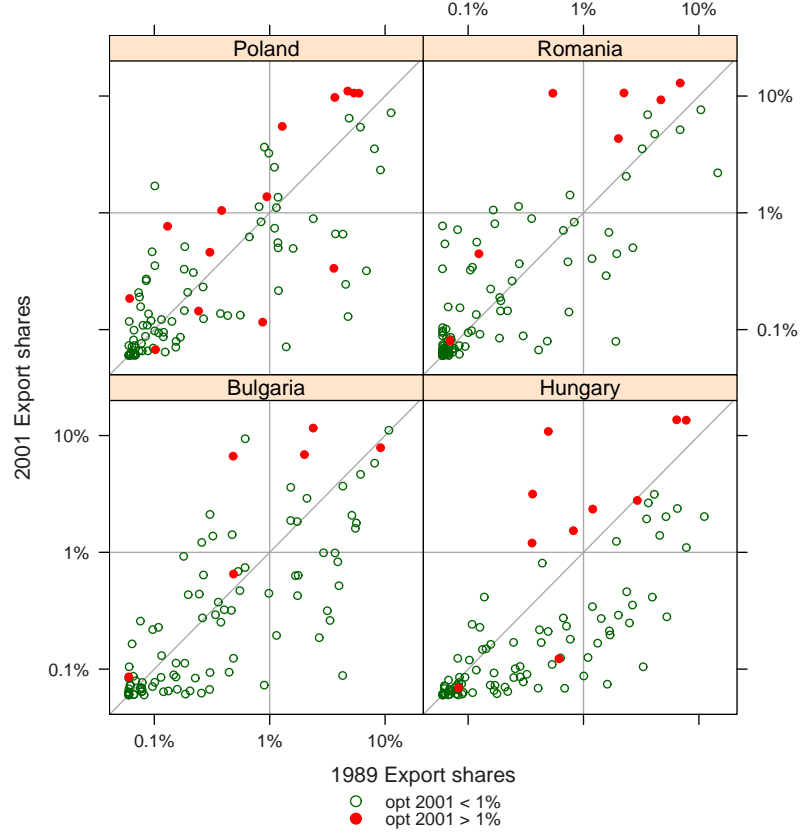
Considering separately exports of final goods and re-exports after processing, more differences emerge among countries. Polish final exports follow a path that is very similar to the one of total exports, and the same is true for Hungary. Re-export flows were almost irrelevant in 1989 and reached a maximum relevance in 1996, slowly decreasing until 2001.<sup>7</sup> In contrast, the role of processed trade in Romania is and remains substantial during the second half of the 1990s, as shown in figure 1. In Bulgaria processed trade becomes gradually substantial along the second half of the 1990s, as shown in the bottom-right panel of the same figure. For all four countries, the coefficients of the time trend estimated over final exports only are smaller than the coefficients for total trade, indicating that final trade alone grew at a

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<sup>7</sup>A part of the decrease observed in the Eurostat database in the flows of processed re-exports in Poland and Hungary can be due to statistical reasons. Brenton and Manchin (2003) convincingly argue that registration of temporary flows continues where it guarantees the costless way of accessing the EU market in presence of stringent regulation of Rules of Origin. Scattered evidence from the CEECs' statistical sources (rather than from Eurostat) shows no negative trend in processing trade even in very recent years. For an analysis with Romanian data see De Arcangelis *et al.* (2005).

Figure 2: Changes in export structure and fragmentation of production between 1989 and 2001.

**Note:** Darker (red) bullets identify sectors in which OPT is  $> 1\%$  of total OPT in 2001.



slower pace than trade inclusive of processing traffic. The difference in the two coefficients for each country is statistically significant in all cases, and it is quite large for Romania and Bulgaria.

The changes that occurred during the 1990s to CEECs' total exports to the EU are the result of complex sectoral dynamics with common elements and peculiarities that deserve some inspection.

The scatter plots in figure 2 show the pattern of exports toward the

EU market of Poland, Hungary, Romania and Bulgaria, comparing export shares in 97 industries in the year 1989 (horizontal axis) and in the year 2001 (vertical axis). We present sectoral exports in percentage points indicating for each country the share of each industry on its overall exports toward the EU in order to allow an easier comparison among the countries considered. We chose to normalize the original data and to move from sectoral exports in thousands of euro to sectoral share in percentage points in order to allow comparisons among the countries considered and to emphasize proportions instead of absolute values. We also plotted the data on a asymmetric scale around 1%, in order to give more visual emphasis to sectors with a share greater than 1%. For all four countries the large majority of sectors contribute to total exports with a small share, below 0.5%, very few industries have a share of 10% or higher, so that the distributions of export shares are always right skewed.<sup>8</sup> In 1989, only a handful of sectors were comparatively more important for all the countries examined: these are fuels, iron, and apparel. Poland, Hungary, and to some extent Bulgaria displayed a specialization in machinery and electrical machinery as well, and Poland and Romania in the furniture sector. Autovehicles' export in Poland were moderately relevant already back in 1989. All countries exported agricultural products to the EU.

While the overall volume of export toward the EU increased sharply in the 1990s, the share of most sectors remained stable during the transition. But a few sectors - especially those exporting agricultural goods - experi-

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<sup>8</sup> The right skewness of the distributions can be deduced from figure 2, noticing the scale of both horizontal and vertical axes. The same result is evident from the shape of box-plots (that can be requested from the authors).

Table 1: OPT shares and export shares growth.

**Note:** The table shows sectors with OPT share > 1% in 2001 and reports the share of each of these sectors on OPT export (in percentage). Numbers in square brackets are the growth rate of total export in the same sector between 1989 and 2001.

	Poland	Hungary	Romania	Bulgaria
Fish	2.07 [-506%]			
Meat preparations	4.23 [-582%]			
Cotton		1.71 [-382%]		
Textile fibres	1.00 [-391%]			
Leather goods				1.22 [19%]
Knitted apparel	9.69 [23%]	10.24 [36%]	9.71 [60%]	37.80 [69%]
Apparel	40.23 [70%]	16.60 [38%]	56.19 [74%]	44.65 [86%]
Other textiles	3.85 [52%]			
Footwear		6.63 [59%]	18.52 [94%]	4.69 [88%]
Aluminium			1.04 [47%]	
Cutlery and tools	3.18 [-78%]			
Machinery	6.06 [72%]	17.19 [74%]		1.16 [-28%]
Electrical machin.	8.90 [65%]	31.04 [81%]	3.98 [47%]	
Railway	1.36 [80%]			
Autovehicles	2.85 [60%]	1.23 [95%]		
Aircraft	1.19 [98%]	1.88 [-133%]	2.09 [51%]	5.51 [100%]
Precision tools	1.42 [28%]	2.53 [80%]		
Furniture	4.16 [71%]	1.69 [-4%]		
Toys			2.34 [73%]	

enced a dramatic fall in their share on total exports, and a few others had a remarkable increase. As shown in figure 2, visible changes appear in a limited number of sectors (the dots further away from the diagonal) that seem to drive most of the modification in the export structure. In 2001 it is difficult to describe a common pattern of exports for the CEECs, even if most

of them had moved away from agriculture toward traditional manufacturing industries.

The concentration of change in a few industries is a common feature to all these countries, but the affected industries and also the direction of change are different between countries. Many of the sectors whose share has visibly changed in the observation period are affected by OPT, as indicated in figure 2. Table 1 shows that generally the sectors where OPT is concentrated display an increase in their share on total exports between 1989 and 2001, even if the relevance of OPT and its effect on the countries' export shares is quite differentiated. For instance, a relevant part of OPT takes place in the machinery sector for Poland, Hungary and Bulgaria, but while in Hungarian and Polish total exports the share of machinery increased sharply, the same share actually declined for Bulgaria. Apparel and knitted apparel absorb much of the processing trade for all the countries considered, but the effect on the relevance of this sector on total exports is strong for Bulgaria and small for Hungary. Overall, OPT is concentrated in a few sectors within the mechanical and traditional industries, but its presence is associated to significant changes in export shares.

### **3 Comparing the export composition of countries**

In this section we will quantify more precisely mobility and persistence in export composition with the help of appropriate indices.

The traditional measure of the degree of association between two variables is Pearson's coefficient of correlation, which captures the strength of the

*linear* association between the two variables taking the mean as the positional index and the standard deviation,  $\sigma$ , as the spread of the two distributions. In the present case, at any given point in time  $t \in [1989, 2001]$ , the two variables are vectors of sectoral export's shares  $x \equiv [x_1, \dots, x_n]$  and  $y \equiv [y_1, \dots, y_n]$ , with  $0 \leq x_i \leq 1$  and  $0 \leq y_i \leq 1$ , so that the coefficient of correlation is

$$r_{xy} = \frac{\sigma_{xy}}{\sigma_x \sigma_y} = \frac{\sum_i (x_i - \frac{\sum_i x_i}{n})(y_i - \frac{\sum_i y_i}{n})}{\sigma_x \sigma_y}. \quad (1)$$

The distribution of CEECs exports to the EU is markedly skewed (even after the log transformation of the data). In presence of pronounced asymmetry the mean overestimates the location of the distribution and the standard deviation gives a distorted account of the spread of the distribution. Under these circumstances there is a strong presumption that the coefficient of correlation could not be the most appropriate index to use in measuring the similarity of CEECs sectoral exports structure along time or with respect to that of the EU, and that a more robust method should be used. The confirmation of such a presumption is an empirical matter, the level of distortion being related to the degree of asymmetry in the distribution.

In order to bypass the problem posed by the comparison of asymmetric distributions, the traditional choice is to use a correlation coefficient based on ranks.<sup>9</sup> However the use of rank correlation induce a trade-off. It under emphasizes by construction the role of the mean, which is precisely fine given

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<sup>9</sup> We calculated the Spearman's rank correlation coefficient,  $\rho_{xy}$ , between each country in our sample and the EU along time and we also use  $\rho$  to calculate autocorrelation matrices for each country, measuring the rank correlation between sectoral export's shares of the same country given a time lag. In this case the  $t \times t$  autocorrelation matrix contains the  $t^2$  couples of rank correlations (but only  $t \times (t - 1)/2$  pieces of information) between two specific years. All correlation and autocorrelation matrices are available on request.

the skewness of the data, but at the cost of giving no relevance at all to sectors relative weights, which is in our case an excessive information loss.

A different and preferable alternative is to measure similarity in terms of distance<sup>10</sup> selecting the best candidate among the many distance metrics used in geostatistics and in biostatistics (Legendre and Legendre, 1998).<sup>11</sup>

Among the many candidates for which the above properties are respected, the most common metric measure is the *Euclidean distance*.<sup>12</sup>

The use of the Euclidean distance as a measure of EU-similarity or as a measure of self-similarity on the basis of sectoral relative weight, may lead to a well reported phenomenon (Legendre and Legendre, 1998) called the *double-zeros paradox* of two countries without any sectoral share in common that because of a number of zero observations in the sample appear as being

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<sup>10</sup>It is worthwhile noticing that since distance (dissimilarity) is equivalent to the additive inverse of similarity ( $d = 1 - s$ ) when  $d \in [0, 1]$ , using similarity (or closeness) instead of dissimilarity has no qualitative effect on the analysis: it merely changes the sign of the coefficients. We will make use of this property in section 4.

<sup>11</sup> All metrics used as a measure of distance must share the same properties, so that we can say that an index  $d$  is a metric if:

1.  $x = y$ , then  $d_{xy} = 0$
2.  $x \neq y$ , then  $d_{xy} > 0$
3.  $d_{xy} = d_{yx}$
4.  $d_{xk} + d_{ky} \geq d_{xy}$

where property (1) states that the minimum distance should be 0; property (2) says that distance should be a positive real number; property (3) assumes that symmetry is respected; and property (4) states triangular inequality (not respected in cases of semi-metrics). As a remark, the Pearson's correlation coefficient is a semimetric, respecting properties 1-3 and violating property 4.

<sup>12</sup> The Euclidean distance between two countries  $x$  and  $y$  identified by  $n$  sectoral export shares is computed applying Pythagora's formula to country-points in a  $n$ -dimensional space. The Euclidean distance is bounded to the left but it does not have an upper limit, its value increasing in  $n$ , and it depends on the scale of  $x$  and  $y$ , changing the scale may result in measures that are not monotonic to each other (Legendre and Legendre, 1998). To avoid this inconvenience, variables should be standardized or should be dimensionally homogeneous.

at a smaller distance than another pair of countries characterized by the same structure of sectoral export shares. In general, double-zeros lead to reduction in distances. In our case the number of sectoral shares with zero value is limited but not irrelevant, therefore, we chose to use the *Bray-Curtis* formula,<sup>13</sup> obtained by normalizing the Manhattan distance:<sup>14</sup>

$$d_{xy}^{bc} = \frac{\sum_i |x_i - y_i|}{\sum_i (x_i + y_i)}. \quad (2)$$

The Bray-Curtis semimetric is a bounded measure,  $0 \leq d_{xy}^{bc} \leq 1$ , it has the advantage of not increasing in  $n$ , of being invariant to proportional sub-classifications of the  $n$  sectors considered,<sup>15</sup> it is not subject to the *double-zeros paradox*, it lessens the effect of the largest differences since difference in high sectoral export shares contribute the same as difference between small sectoral export shares, and is appropriate in presence of skewed distributions. The  $d_{xy}^{bc}$  semimetric has also the suggestive characteristic of being equivalent to the Finger and Kreinin (1979) Index,<sup>16</sup> when  $x_i$  and  $y_i$  are proportions, as they are in our case.

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<sup>13</sup> The Bray-Curtis semimetric - largely used in the natural sciences - takes its name from the two botanists that in 1957 used it in the analysis of forest species in southern Wisconsin. The index has been attributed to the zoologist Odum by Legendre and Legendre (1998) and has been derived by Sun and Ng (2000) taking an axiomatic approach.

<sup>14</sup>In spite of its use in trade empirics (Krugman, 1991; Clark and van Wincoop, 2000; Imbs, 2001), the Manhattan metric presents however the same problems of right unboundeness and of double zeros as the Euclidean distance does.

<sup>15</sup> The index is invariant to *proportional* sub-classification, not to sub-classification *tout court*. If one moves from 2-digit level to 4-digit level of the Combined Nomenclature some sector will become heavily disaggregated while others will remain virtually untouched. In this case the index could vary its numerical value but still remains less sensitive than other possible alternatives to the level of aggregation of the data considered.

<sup>16</sup> The Finger-Kreinin index,  $d_{xy}^{fk} = \sum_i \min(x_i, y_i)$  is the only case of distance (semi)metric that has been explicitly selected for the measurement of export similarity.



## 4 Similarity and convergence in trade structures

To facilitate the interpretation of the data we use a similarity index defined as  $s_{xy}^{bc} = 1 - d_{xy}^{bc}$ . We will calculate *self-similarity* in order to measure the distance of each one of the members-to-be to the beginning of the transition process. Moreover, we will calculate *EU-similarity* measuring the distance between each member-to-be export structure and that of the EU as a whole. The EU is an appropriate benchmark not only because of the ongoing integration process and the absolute relevance of the EU market for the CEECs exports (over 60% of the CEECs exports is directed to this market), but also because, since the EU export composition has been very stable during our observation period, convergence or divergence in trade structures is due to changes occurring in the CEECs export composition. Computing and plotting the correlation coefficient  $r_{xy}$  and the similarity index  $s_{xy}^{bc}$  the changes in the CEECs export structure relative to their initial situation and to the EU are more readily evident. For both indices, a value of 1 represents identity with the initial situation or with the EU, respectively, and a lower value indicates the extent of the difference. The use of these indices confirms that many important changes occurred in the pattern of sectoral export shares of the CEECs toward the EU market in the past decade. It is worth noticing that a large number of changes took place toward the end of the 1990s, much after the initial phase of transition.

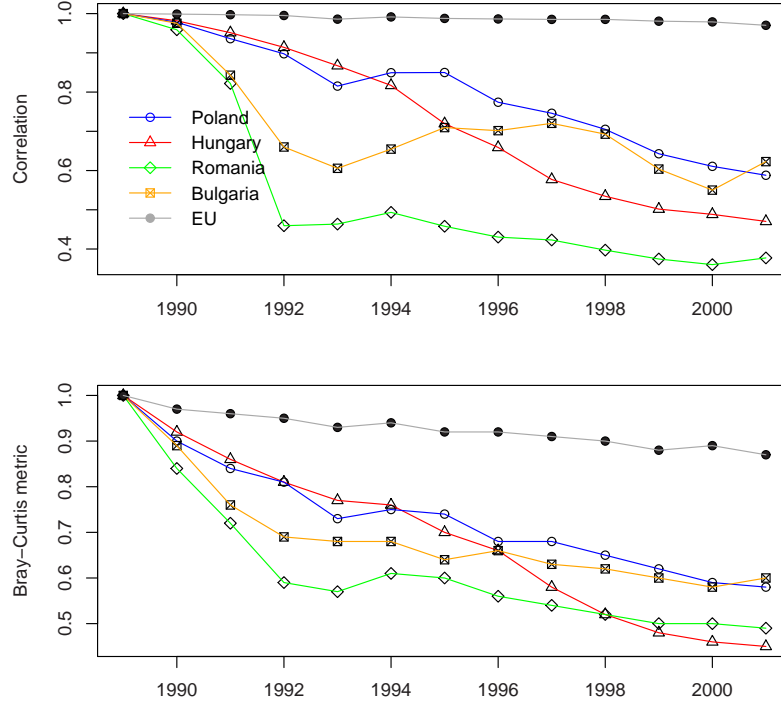
#### 4.1 Self-similarity: Moving away from 1989's exports structure?

The observation of figure 3 suggests that the CEECs export structures indeed display a strong dynamics: in the past decade CEECs' exports changed much more extensively than the EU export and remarkable differences appear in the path followed by the four countries examined. In Poland, the fall of  $r_{xy}$  after 1995 shows that export shares kept moving also in the most recent years. In terms of this index, the Polish trade structure of 2001 is less similar to the one of 1995 than the latter was to the one of 1990. The similarity indices present a similar pattern, indicating that Poland kept moving away from its initial specialization, and there is a remarkable distance also between the current trade pattern and the one of 1995.

The change in the Hungarian pattern of trade is even sharper: by comparison with the dynamics of the EU trade pattern, one can appreciate the extent of the changes that affected the Hungarian export shares. While the self-correlation for the EU is never lower than 0.96, and the distance metrics reach at most 0.13, for Hungary the Pearson's correlation between exports in the year 1989 and 2001 is only about 0.5 and the distance measures arrive to 0.55, much higher than in the Polish case.

The dynamics is quite different in the case of Romania and Bulgaria. Over the entire time span, Romania changes more than Hungary and Poland in terms of correlation, but most of the change is concentrated in the early years and takes place before 1992. After this initial big jump, Romanian export shares show a modest dynamic. The country appears locked in the specialization reached in the early 1990s. Something similar occurs to Bul-

Figure 3: Self-similarity dynamics



garia, which has changed especially at the beginning of transition and shows a period of stability in the mid-1990s, while some movement starts to appear again in the last few years. Note that the extent of change for Romania seems stronger than for Hungary using  $r_{xy}$ , but not when the similarity index  $s_{xy}^{bc}$  is used.

Summing up, at the beginning of the 2000s, the overall picture of the CEECs specialization looks remarkably different from just five years earlier, and it seems difficult to relate these changes to the initial transition shock only. These changes are far from being uniform across countries. As the transition process went on, substantial diversity emerged among the CEECs, who display different dynamics of overall changes, and different sectoral move-

ments.<sup>17</sup>

Possibly, given that much of the change is concentrated in a few industries, the dynamics of specialization depends on which are the sectors driving the change.<sup>18</sup> While Romanian and Bulgarian exports are concentrated first of all in traditional, labour-intensive industries (such as textiles, apparel and footwear), Poland's and Hungary's exports grew in industries such as autovehicles and machinery, in spite of the very large initial gap with the EU members in these sectors. In this catching-up process, it is likely that foreign capital and technological cooperation with EU firms played an important role.

## **4.2 EU-similarity: Converging toward the EU trade structure?**

In this section we examine whether the observed change in the CEECs export structures brought these countries closer to the EU structure. Here again we use  $r_{xy}$  and  $s_{xy}^{bc}$ , comparing them in figure 4.

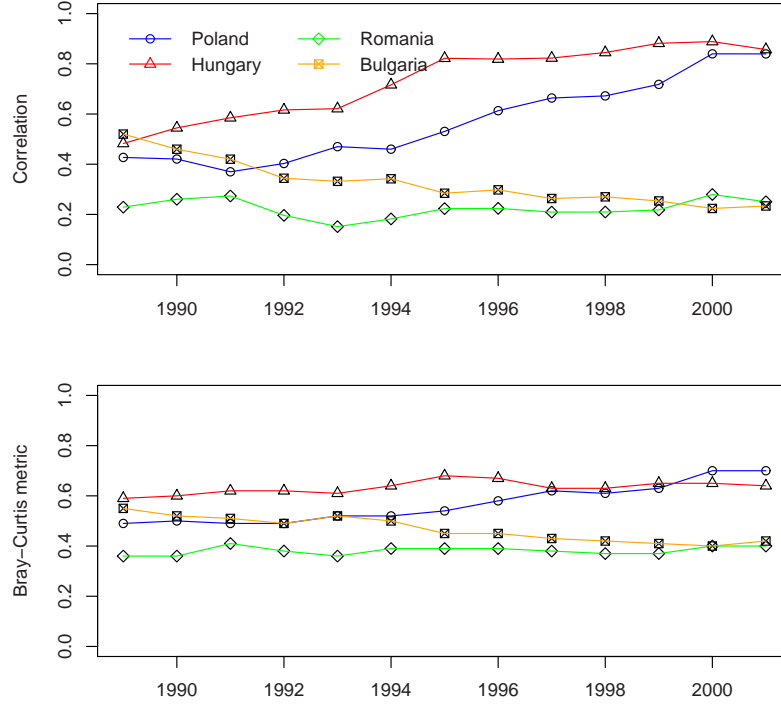
In the case of Romania the indices are concordant in giving evidence of a fluctuating path until 1995, while only after 1997 the country shows some convergence toward the EU export structure. The tendency for Bulgaria is even more unexpected. This country's export structure has been diverging from the one of the EU, and this tendency appears quite clearly from all indices. Even in the last period there are no signs of a reversal in this trend.

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<sup>17</sup>The tendency toward diverging specializations among the CEECs is pointed out also in other studies (Chiarlone, 2002; Landesmann and Stehrer, 2002).

<sup>18</sup>Our evidence is in line with Redding (2002) that suggests that over medium time horizons (five years), changes that are specific to individual industries explain most of the observed mobility in the patterns of specialization of the OECD countries he examines.

Figure 4: EU-similarity dynamics



In the case of Poland, all indices show convergence toward the EU, especially after 1994, and possibly speeding up in the last few years.

Finally, the Hungarian case is paradigmatic and gives the possibility of solving the methodological issue regarding the choice of the appropriate metric to use in the analysis of similarity. Contrary to the other three cases, in the one of Hungary the correlation index and the Bray-Curtis metric are *not* monotonically related. In terms of correlation, Hungary approaches the EU and gets even closer than Poland. But if we look at the distance indices, after a period of fast reduction in the distance from the EU, from 1995 onward Hungary reversed its trajectory and start diverging from the benchmark.

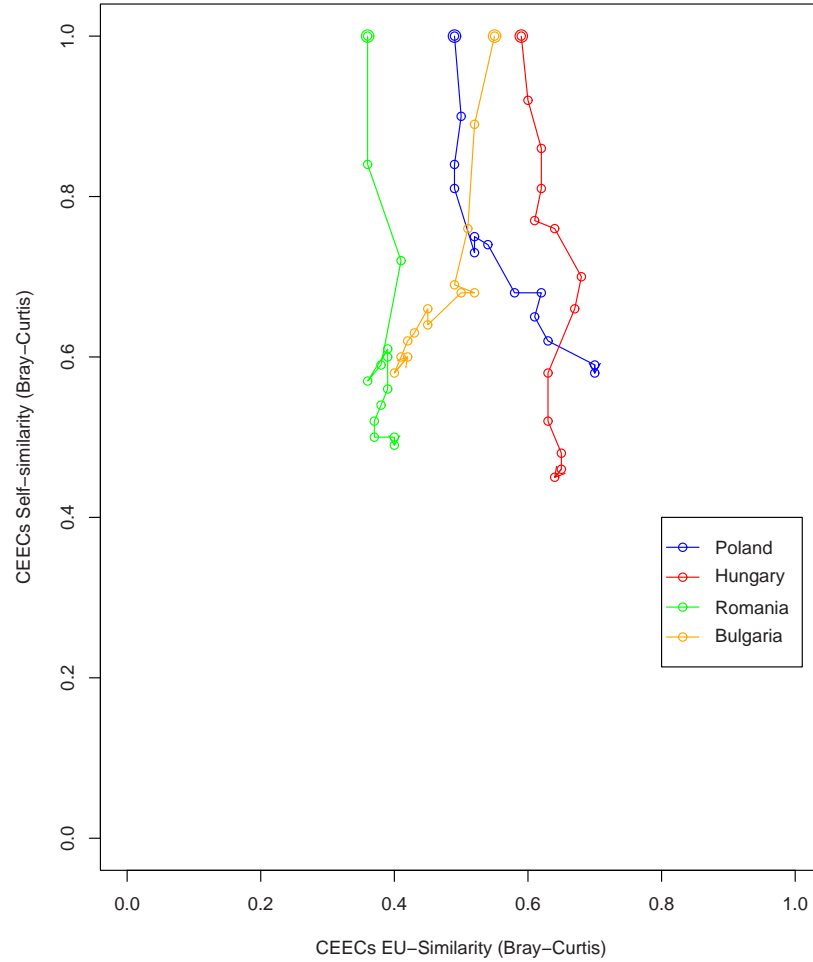
Why this inconsistency among metrics? Which index should we trust?

Leaving the more proper analytical treatment of both questions to the Appendix, the careful examination of the data is sufficient to give hints to what drives both answers. Broadly speaking, one can say that the explanation is in the dynamic of Hungarian sectoral export shares “overshoot” EU sectoral export shares. In fact, on the one hand, sectors relevant in 1989 - such as Meat and Apparel - decrease their relevance along time, on the other hand, sectors as automobiles, machinery and electrical machinery become more and more relevant. Both changes contribute to the increase in the Hungarian EU-similarity, regardless of the metric used. After 1995, the share of the fast growing sectors, increasing but till then smaller than for the EU, becomes progressively higher than that for the EU. This leaves unchanged the trajectory of the correlation index, while inverting the one of the Bray-Curtis semimetric. After 1995 only  $s_{xy}^{bc}$  is catching the peculiarity of the Hungarian path, and in this respect  $s_{xy}^{bc}$  is a superior metric because the use of  $r_{xy}$  hides the evidence of an “overshooting” paths.

A summary of the information content of figures 3 and 4 on the dynamics of the CEECs’ self-similarity and on the eventual convergence toward the EU export structure is presented in figure 5, measuring on the horizontal axis the yearly EU-similarity of each country’s export structure, and on the vertical axis each country self-similarity. Vertical movements show the extent of the changes in a country export structure, and rightward horizontal movements indicate convergence toward the EU.

Figure 5 once more shows that the evolution of the candidates is remarkable and quite differentiated. The country that changed the most its initial trade structure appears to be Hungary, followed by Romania, and Bul-

Figure 5: Self and EU similarities



garia. Poland has undergone fewer changes from the initial structure than the other countries. Interestingly, Poland is considered to be the country that was fastest in stabilizing its macroeconomic fundamentals, but most observers agree on the fact that in microeconomic terms Poland still has a long way to go. Anyway, in the year 2001, Poland seems to have the most similar structure to the EU. Hungary is instead characterized by a reversal

in its EU-similarity due to an “overshooting” path after 1995, driven by the increasing role of the Machinery and Electrical Machinery sectors.

## **5 Integration, processed trade, and similarity in export composition**

Our next step is to test if the dynamics of sectoral distribution of total exports of Poland, Hungary, Romania, and Bulgaria to the EU is related to the role acquired by processed trade in the 1990s. But this task is confounded by two fundamental issues. First, total trade and processed trade are intercorrelated among themselves,<sup>19</sup> and so it may be difficult to ascribe causal mechanism even if it can be shown that the convergence/divergence with respect to the European benchmark is correlated with countries’ sectoral export distribution. Secondly, trade variables are highly persistent, and so their influence is likely to be expressed only at particular scales of reference. Furthermore, the likelihood that the sectors itself may exhibit high autocorrelation in its distribution is not a extreme event, due vertical and horizontal linkages.

In conventional statistical analyses, the former problem is addressed via multivariate methods that allow one to attend the correlations among predictor variables; partial regression is a familiar solution to this problem. But conventional parametric approaches are confounded by the second issue, namely that autocorrelation in the variables violates the assumptions of parametric analysis.

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<sup>19</sup> See footnote 3.



## 5.1 Mantel's test

Mantel's test (Legendre and Legendre, 1998) is a nonparametric approach that overcomes some of the problems inherent in explaining the relationships between total exports and processed trade. Mantel's test is a regression in which the variables are themselves distance or dissimilarity matrices summarizing pairwise similarities among time periods.

One advantage of Mantel's test is that, because it proceeds from a distance or a similarity matrix, it can be applied to different kinds of variables (categorical, rank, or interval-scale data) and all that matters is that an appropriate distance metric be employed, such as one we used previously. The Mantel statistic can be described as the evaluation of the significance of a matrix correlation between two dissimilarity matrices. Since the significance cannot be directly assessed, because there are  $N(N - 1)/2$  entries for just  $N$  observations, the test uses permutations of  $N$  rows and columns of *one* dissimilarity matrix. The statistic can be evaluated either as a moment correlation or as a rank correlation.

Because the elements of a distance matrix are not independent, Mantel's test of significance is evaluated via permutation procedures. In this, the rows and columns of one of the two distance matrices are randomly rearranged. Mantel statistics are recomputed for these permuted matrices, and the distribution of values for the statistic is generated via an iterative procedure.<sup>20</sup>

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<sup>20</sup>The number of iterations varies in accordance to the significance of the test: 1000 for  $\alpha = 0.05$ , 5000 for  $\alpha = 0.01$ , 10,000 for greater precision (Legendre and Legendre, 1998). Moreover, the Mantel's test is based on linear correlation and nonlinear relationships between variables may be degraded or lost. Moreover, the test of time dependence is averaged over all time periods and so the test cannot discover changes in the pattern of correlation at different point in time.

## 5.2 Results

We applied a Mantel’s test to each one of the four countries considered in the analysis, using distance matrices for total exports shares and for processed export shares. The operative question is, “Do changes in self-similarity in processed trade tend to match changes in total export self-similarity?”

We applied the Mantel’s test to the Bray-Curtis distance matrices using either as a Pearson’s correlation or as a Spearman’s rank correlation, iterating the procedure of column-row permutation 1000 times.

Table 2: Mantel’s test results.

	Spearman’s correlation	Pearson’s correlation
	Bray-Curtis	Bray-Curtis
Poland	0.908 (0.383)	0.8971 (0.375)
Hungary	0.9374 (0.382)	0.9405 (0.383)
Romania	0.9303 (0.542 )	0.9407 (0.581)
Bulgaria	0.8556 (0.502)	0.8815 (0.470)

Note: Empirical 99% upper confidence limits of  $m$  in parenthesis.

In all cases, with notable differences, the operative question passed the nonparametric test, meaning that changes in total exports occurred along with the changes in processed trade. This suggest that processed trade is crucial in explaining changes in the overall structure of exports of transition countries. This is true not only for Poland and Hungary, whose trade structures are getting more similar to the EU, but also in the case of Romania (no convergence toward the EU export structure) and even in the case of Bulgaria

(divergence from the EU export structure). Apparently, the phenomenon of delocalisation of production witnessed by the extent of processed trade, can enhance complementarities among countries within the same industry (like in the case of similar export structures) as well as complementing different export structures through a market division of labour.

## 6 Conclusions

The dynamics of the CEECs' specialization and their convergence toward the EU export structure show that the process of re-shaping their pattern of trade has been long and profound, and it is still continuing. Along with this general result, the analysis undertaken in this work reveals different indications on the speed and the degree of similarity in trade patterns using different indices, rising a methodological issue on how to measure similarity. If similarity in trade structure should be a criterion for the formation of an integrated area, or an indicator of the adjustments expected, how to measure similarity and convergence is a point that needs to be tackled. Our contribution shows that when specialization changes are driven by sectors characterized by large export shares the use of a single aggregate index can be problematic. In particular, in this case the traditional correlation analysis can lead to misleading conclusions, and the Bray-Curtis metric is a better indicator.

Another result of the empirical analysis is that the evolution of different candidates is dissimilar, confirming that it is impossible to generalize the effects of trade integration on trade patterns. While we have a converging behaviour for Poland and Hungary (until 1995), moving away from the initial

specialization toward the EU, Romania started to converge toward the EU only in the last few years and to a very small extent, and Bulgaria displays a diverging trend. It seems therefore that two different tendencies emerge, creating a “convergence club” and a group of countries that so far are not showing a clear and definitive sign of convergence towards the EU trade structure.

The evidence reported in the paper shows that CEECs total exports toward the EU are linked to other forms of integration, such as fragmentation of production. Processing trade can foster both convergence or divergence in trade structures, according to the characteristics of the sectors involved, and whether these are shrinking in the EU and being moved to other locations or expanding.

Finally, even if the heterogeneity among the CEECs has been already emphasized in many contributions, it is interesting that our comparison, without making any assumption on the countries’ structural characteristics, indicates the countries displaying less convergence are also the countries that were found not ready for accession, using quite different criteria. This result gives support to the view of the evolution of trade patterns being in line with the evolution of other economic indicators.

## **7 Appendix**

The Appendix contains three different sections. The first one contains the description of the sectors included in the analysis. The second one contains a detailed report of the time-trend regressions described in figure 1. The third one analytically replicates the dynamics of the EU-similarity for the Hungarian case, in order to identify the cause of different prediction rising from the use of the correlation index or the Bray-Curtis distance metric.

### **7.1 Appendix 1. Data sources and sectors**

The source of all the data presented in the tables and in the analysis of this paper is the Eurostat database Comext "Intra-EU and extra-EU trade", reporting annual trade data classified according to the Combined Nomenclature of the European Communities. The abbreviated definition of the 97 two-digit sectors of the Combined Nomenclature is reported in the table below.

Table 3: Sectors

Products			
Animals	Raw minerals	Silk	Nickel
Meat	Ores	Wool	Aluminium
Fish	Fuels	Cotton	Lead
Dairies	Inorganic chem.	Textile fibres	Zinc
Other animal prods.	Organic chem.	Filaments	Tin
Plants	Pharmaceuticals	Staple fibres	Other metals
Vegetables	Fertilizers	Special yarns	Cutlery and tools
Fruit	Dyes	Carpets	Other metal articles
Coffee and spices	Cosmetics	Tapestries	Machinery
Cereals	Soaps	Coated fabrics	Electrical machin.
Flours	Glues	Knitted fabrics	Railway
Seeds	Explosives	Knitted apparel	Autovehicles
Resins	Photog. Products	Apparel	Aircraft
Other vegetal prods.	Other chem.	Other textiles	Ships
Fats and oils	Plastics	Footwear	Precision tools
Meat preparations	Rubber	Hats	Clocks
Sugar	Leather	Umbrellas	Musical articles
Cocoa	Leather goods	Feather articles	Arms
Cereal preparations	Furs	Cement	Furniture
Veget. preparations	Wood	Ceramics	Toys
Other edibles	Cork	Glass	Other manuf.
Beverages	Wickerwork	Jewellery	Art pieces
Resid. food ind.	Cellulose	Iron	Others
Tobacco	Paper	Iron articles	
	Printing	Copper	

## 7.2 Time trend regressions

Table 4: Total Exports regressions on a time trend.

	Estimate	Std. Error	t value	Pr(> t )	Adjusted- $R^2$
(Poland)					0.925
time trend	0.2489	0.0204	12.21	0.0000	
(Hungary)					0.883
time trend	0.4607	0.0482	9.57	0.0000	
(Romania)					0.801
time trend	0.4189	0.0596	7.03	0.0000	
(Bulgaria)					0.940
time trend	0.2612	0.0189	13.81	0.0000	

Table 5: Final Exports regressions on a time trend.

	Estimate	Std. Error	t value	Pr(> t )	Adjusted- $R^2$
(Poland)					0.891
time.trend	0.2412	0.0241	9.99	0.0000	
(Hungary)					0.866
time.trend	0.4454	0.0502	8.87	0.0000	
(Romania)					0.731
time.trend	0.3468	0.0598	5.80	0.0001	
(Bulgaria)					0.924
time.trend	0.2218	0.0182	12.18	0.0000	

### 7.3 Appendix 3. $r_{xy}$ vs $d_{xy}$

Let's assume that the sectoral distribution both in Hungary and in the EU is characterized by  $n$  different sectors,  $i \in [1, n]$ . One of these sectors - machinery - becomes progressively relevant in the case of Hungary and remains stable in the case of the EU. We call  $x_j$  the Hungarian export share of that sector, and  $y_j$  the export share of the same sector in the European case, so that  $x \equiv [x_1, \dots, x_j, \dots, x_n]$  and  $y \equiv [y_1, \dots, y_j, \dots, y_n]$ .

Since the data under scrutiny are export shares, then

$$\sum_i x_i \equiv \sum_i y_i \equiv 1 \quad (3)$$

and

$$\frac{\sum_i x_i}{n} \equiv \frac{\sum_i y_i}{n} \equiv \frac{1}{n}$$

The distribution is therefore characterized by a *constant* mean, regardless the changes in sectoral shares.

Let's focus the analysis on the changing sector  $x_j$  alone, shadowing the dynamic of the other  $n - 1$  sectors, so that the changes in the sectoral distribution of the  $x_i$  only depend on the variations of  $x_j$ . In the case of the EU the sectoral distribution remains unchanged.

The linear correlation index expressed in equation 1 can be written as follow

$$r_{xy} = \frac{\sigma_{xy}}{\sigma_x \sigma_y} = \frac{\left(x_j - \frac{1}{n}\right) \left(y_j - \frac{1}{n}\right) + (n-1) \left(\frac{1-x_j}{n-1} - \frac{1}{n}\right) \left(\frac{1-y_j}{n-1} - \frac{1}{n}\right)}{\sigma_x \sigma_y} \quad (4)$$

where

$$\sigma_x = \sqrt{\left(x_j - \frac{1}{n}\right)^2 + (n-1) \left(\frac{1-x_j}{n-1} - \frac{1}{n}\right)^2}$$

and

$$\sigma_y = \sqrt{\left(y_j - \frac{1}{n}\right)^2 + (n-1) \left(\frac{1-y_j}{n-1} - \frac{1}{n}\right)^2}.$$

The sign of  $r_{xy}$  depends on  $x_j$  according to the following rule:

$$r_{xy} \quad \begin{cases} < 0 & \text{if } x_j < \frac{1}{n} \\ = 0 & \text{if } x_j = \frac{1}{n} \\ > 0 & \text{if } x_j > \frac{1}{n} \end{cases}$$

and the sign of the partial derivative of  $r_{xy}$  w.r.t.  $x_j$  is

$$\frac{\partial r_{xy}}{\partial x_j} = \frac{\left(y_j - \frac{1-y_j}{n-1}\right)}{\sigma_x \sigma_y} - \frac{r_{xy}}{\sigma_x} \sigma'_x \quad \begin{cases} < 0 & \text{if } y_j < \frac{1+(1-n)(r_{xy}\sigma_y\sigma'_x)}{1+(1-n)\frac{n}{r_{xy}\sigma_y\sigma'_x}} \\ > 0 & \text{if } y_j > \frac{1+(1-n)(r_{xy}\sigma_y\sigma'_x)}{1+(1-n)\frac{n}{r_{xy}\sigma_y\sigma'_x}} \end{cases}$$

where  $\sigma'_x$  is the partial derivative of  $\sigma_x$  w.r.t.  $x_j$ .



In the present case, since the dynamic of the  $n - 1$  residual sectors is perfectly collinear,  $r_{xy}$  will always take the values -1 or +1. In general, when  $n$  is sufficiently large and  $x_j$  is relevant as well,  $r_{xy}$  is positive and increases (decreases) as  $x_j$  becomes larger depending on  $y_j$  being sufficiently large (small).

In fact, the values in the Hungarian EU-similarity were  $n = 97$ ,  $y_j = 0.15$  and  $x_j$  was growing from a 10% to a 30% value between 1989 and 2001. It is now clear why  $r_{xy}$  was steadily growing during the period.

On the other hand, the Bray-Curtis metric expressed in equation 2 can be rewritten as

$$d_{xy}^{bc} = \frac{1}{2} (|y_j - x_j| + |x_j - y_j|). \quad (5)$$

given our assumptions on  $x_j$  and  $y_j$  and taking into account equation 3.

The sign of  $d_{xy}^{bc}$  is always positive while the sign of the partial derivative of  $d_{xy}^{bc}$  w.r.t.  $x_j$  is

$$\frac{\partial d_{xy}^{bc}}{\partial x_j} = -\frac{1}{2} \frac{|y_j - x_j|}{y_j - x_j} + \frac{1}{2} \frac{|x_j - y_j|}{x_j - y_j} \quad \left\{ \begin{array}{ll} < 0 & \text{if } x_j < y_j \\ \text{undefined} & \text{if } x_j = y_j \\ > 0 & \text{if } x_j > y_j \end{array} \right.$$

The shape of  $d_{xy}^{bc}$  only depends on the value of  $y_j$  and it decreases as  $x_j$  tends to  $y_j$  from the left, it has a kink when  $x_j = y_j$ , and increases for values of  $x_j > y_j$ .

This explains why in the Hungarian EU-similarity the distance metric was decreasing until when  $x_j$  reached the same value of  $y_j$  and suddenly it

changed its slope.  $r_{xy}$  and  $d_{xy}^{bc}$  go in the same direction only for values of  $x_j < y_j$ , the concordance is broken when  $x_j$  becomes greater than  $y_j$ .

In the choice between the correlation index and the Bray-Curtis metric, two general aspects run against the former. On the one hand,  $r_{xy}$  is heavily dependent on the mean and the standard deviation of the distribution of  $x_i$  and  $y_i$  that in case of pronounced skewness are distorted estimates of the location and the spread of the distribution. On the other hand, the mean value is fixed regardless of changes in the sectoral composition of export shares and it is sensitive to the number of sectors considered in the data aggregation.

The  $d_{xy}^{bc}$  semimetric has instead the advantage of not increasing in  $n$ , of being invariant to proportional sub-classifications of the  $n$  sectors considered (Sun and Ng, 2000), it is not subject to the *double-zeros paradox* (Legendre and Legendre, 1998), it lessens the effect of the largest differences since difference in high sectoral export shares contribute the same as difference between small sectoral export shares, and is appropriate in presence of skewed distributions.

Finally, since  $d_{xy}^{bc}$  catches changes in the sign of  $x_j - y_j$  while  $r_{xy}$  reacts minimally to those changes, the former has to be preferred to the latter, when the sign of  $x_j - y_j$  is of interest. In other cases the two are monotone.  $d_{xy}^{bc}$  should be therefore preferred to  $r_{xy}$  in general.

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