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Comparative advantage of the EU in global value chains: How important and efficient are new EU members in transition?[1]

1. Introduction

In economic analysis, the measures of competitiveness are expressed in terms of shares of gross output in world export markets. In recent years, these types of measures have become questioned, as one could observe the increasing fragmentation of production across borders. Due to easier communication, increasing information flow, and changes in coordination costs, the various stages of the production process are no longer conducted at geographically close locations. The rising fragmentation of production implies that more and more stages of the production process are faced with international competition. In the past decades, the competitiveness of countries was mainly determined by domestic firms. In most cases, these companies competed 'sector to sector' with similar firms from other countries. The competition was usually taking place in the sphere of the price and quality of traded products.

Fragmentation of production, the process by which different production stages of final goods are conducted in different countries, has been increasing over the last several decades. It is clear that this tendency reflects the globalization process in the world economy. An illustrative example of this phenomenon, often discussed in economic literature, is the case of the German automobile industry, which is a leader in the car world market, at least in terms of traditional competition indexes (Dudenhoeffer, 2005). Since a big share of the intermediate production stages

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of German cars is conducted in some other countries (mostly in Europe) and, therefore, a considerable part of the value of German cars is produced abroad, one can ask the following question: To what extent are German cars really German? As Marin (2010) stresses, the 'super-competitiveness' of the German economy is in large part derived from the increasing use of imported intermediates. Therefore, the high share of German car exports in the world may not result from the high competitiveness of the German economy. This example clearly shows that, in the time of increasing globalization, new measures of competitiveness are needed. Such measures should be based on the value added in production by a country and on the jobs and capital involved in global production chains. In this paper, we derive such measures empirically from world input-output (IO) tables.

Fragmentation of production is one of the most important sources of structural changes in the CEE economies in transition. This process is likely responsible for the rise (after a dramatic drop in the first half of the 90s) of the share of industrial production in gross domestic product that has been observed in CEE transition economies since the last five years of the Twentieth Century[2].

The EU membership of Poland and other CEE countries, globalization and fragmentation process speeded up the rate of growth of the ratio of investment loans to consumption loans and supported growth rate of manufacturing and construction, which has been reflected in the rise of shares of these sectors in the GDP of Poland and other CEE countries.

The fragmentation of production processes can be principally classified into two main forms. The first one is usually called a "snake" and the second – a 'spider' (Baldwin and Venables, 2013). Under this notion, the 'snake' is understood as a sequence in which intermediate goods are exported from country X to Y. Next, these goods are incorporated into intermediate goods and sent from country Y to country W. This export pattern goes on until the goods reach their final stage of production. In contrary, the 'spiders' comprehend multiple parts coming together from a number of countries. The goal is a single location for assembly of a new component or final product. In the world economy, we usually observe production processes that are complex mixtures of these two types. In this paper, we label the fragmented production processes as 'chains' irrespective of their type. This notion is widely used in the economic literature despite the fact that it rather appeals to the snake-like description of this term.

[2] For example, in Poland during the years 1996–2015, the gross domestic product increased by 105%, industrial production increased by 156%, and output of the processing industry expanded by 260%. In addition, the growth rate of exports in Poland has recently outperformed the rate of growth of GDP, and net exports became positive. At the beginning of transition, the share of employees in agriculture amounted to more than 33%; but in recent years, this index has dropped to under 13%. Moreover, the share of manufacture in the GDP exhibits more than a third, which is higher than the average share in the EU-28.

The most influential framework used in the study of globalization is the so-called **global value chain** (GVC) concept. The calculation of GVC incomes is a very interesting methodology to deal with increasing fragmentation of production, and it surely adds more useful information about competitiveness than the raw export data. However, interpretation of trends in GVC income as trends in competitiveness should be conducted carefully and with a dose of criticism. The reason is that there are very interesting patterns of specialization within different manufacturing of final goods. Results of GVC analysis may be relevant for policy makers and have important policy implications. The application of this methodology with respect to value added, labor productivity, and capital efficiency in the ten new EU members in transition from the CEE region is the main topic of our contribution. We focus on a relative context and try to answer the question of how important and efficient are the CEE transition economies when it comes to building a comparative advantage of the European Union in global value chains. To the best of our knowledge, this paper is the first study dedicated to the issue of answering the latter question by using some original modifications and extensions of methodological developments on an ex-post accounting framework in global value chains presented in the recent IO literature.

The rest of the paper is organized as follows. In Section 2, we conduct a literature review. In the third section, we formulate main research hypotheses. The methodology of studying GVC, the data sources used to measure GVC incomes, as well as indexes of jobs and capital efficiency and discussion on topics that are important for assessing the validity of the empirical results are presented in Section 4. Section 5 is the most important one, as it presents the empirical results along with the respective discussion. The last section provides concluding remarks and some suggestions for future research.

2. Literature review

Early studies on fragmentation were conducted by Fukao et al. (2003) and Ando and Kimura (2005) for Japanese firms, Hanson et al. (2005) for US firms, and Marin (2006) and (2011) for German and Austrian international companies. Macroeconomic evidence has been presented by Hummels et al. (2001) and Johnson and Noguera (2012). They found increasing vertical specialization in trade for most countries. Below, we provide a brief review of the literature that provides direct evidence of fragmentation focusing on the value chains of final products.

In the light of the literature, there are growing discrepancies between growth in gross exports and the generation of incomes and jobs for workers involved in GVC. Sinn (2006) showed that the increasing imports of intermediate goods

mainly from Eastern Europe were a source of decline in the German value added per unit of exports. However, export-earned value added as a share of GDP was preserved in Germany. This was possible due to increased specialization and more than proportional growth of exports. In opinion of Sinn (2006), high and rigid wages for unskilled workers were a source of over-specialization on the skill- and capital-intensive segments of the production chain. In the framework of revealed comparative advantage analysis based on gross exports, Di Mauro and Forster (2008) claim that the specialization pattern of the countries from the euro zone was nearly the same between the 1990s and 2000s. In their opinion, the reason for that is the inability of gross export statistics to include the value added in internationally fragmented production. Koopman et al. (2012) analyzed the structure of the export sector of China and found that the latter is mainly based on imported intermediates. The contributors demonstrated that value added in this sector was much lower than suggested by the gross export values. However, the rate of growth of this sector was indeed very high.

It has been found (see e.g., Koopman et al., 2012; Ottaviano et al., 2009) that structures provided by respective columns for particular industries in the Use IO table may only provide average production structures across all firms and all products in those industries and, thus, might be quite different for exporters and non-exporters. However, according to the authors, further evidence on this issue is needed to better understand the nature of the discussed problems.

In order to take into account some issues that are typical in the time of globalization (like the increasing trade in intermediate goods), the World Trade Organization and the Institute of Developing Economies/Japan External Trade Organization have suggested a new methodology of the so-called Trade in Value-Added (TiVA) instead of the common trade in gross terms (Escaith and Inomata, 2011). The WTO and OECD have provided the first empirical results based on international input-output tables. In the economic literature, the global trade network in the framework of TiVA is called a global value chain (GVC). According to GVC, value-added exports from an origin country to a destination country is understood as the origin country's value-added induced by the destination country's final demand (excluding intermediate goods exports) to the rest of the world. The GVC methodology is an extension of the methodology presented in Trefler and Zhu (2010), Bems et al. (2011), and Johnson and Noguera (2012). These papers refer to old contributions on input-output accounting with multiple regions initiated by Isard (1951) and developed in a particular work by Miller (1966). One of the main advantages of the discussed approach is the fact that the data calculated in the framework of the GVC methodology can be used for explaining the causes of structural change. Herrendorf et al. (2013) demonstrated that structural change may be interpreted as caused by non-homothetic demands

or by asymmetric productivity growth. A crucial role is played by the type of data analyzed; i.e., data on production or consumption expenditure. In order to conduct GVC analysis, reliable time series data on global input-output tables is required. Such data allows us to map value added sectoral shares (which are the ones that should enter the production functions) into consumption sectoral shares (which are the ones that should enter the utility functions). The key role here is played by the import–export relation in the data, since there are quite different implications of productivity changes in open and closed economies.

The fragmentation of the global production process does not necessarily lead to an increase of unemployment in advanced countries. Grossman and Rossi-Hansberg (2008) found that offshoring may lead to lower output prices and increased demand for the final output. Therefore, the net impact on domestic jobs might be even positive.

In the study by Kuboniwa (2015), which presents an analysis of the role of Russia in GVC, a modified version of the original World Input Output Data (WIOD) was used. The study also uses an alternative definition of value-added trade based on the contribution of Trefler and Zhu (2010). The author proves that this alternative definition is bilaterally equivalent to the traditional definition of TiVA. In the paper, one may also find (rather straightforward) proof of a theorem on the identity between the sum total of a country's value-added trade balances and gross trade balances (net "gross exports" or net exports). In other words, the author claims that the sum total of the differentials between balances in value-added and those in gross terms equals zero. In addition, it is also proven in the paper that a country's total factor content of trade is simply its net exports in conventional terminology. Using several versions of aggregated data taken from WIOD, the contributor supplies evidence supporting the theorems. A modification of the approach, with respect to Russia's trade flows and value-added for sectors related to oil (both crude and refined) and natural gas, are next examined in the empirical part of the paper[3].

Our paper is widely based on the innovative paper by Timmer et al. (2013), which concerns with the World fragmentation process. The authors introduce new indicators of competitiveness that take fragmentation into account. Their method measures the value added in each activity in the process, irrespective of its position in the production network. The contributors stress that concepts like 'global supply chains' or 'international production chains' typically refer to only the physical production stages, whereas the value chain concept used by them refers to a broader set of activities, both in the pre- and post-production phases, including research and development, software, design, branding, finance,

[3] These sectors are among the key ones of both the Russian and EU economies.

logistics, after-sales services, and system integration activities. In other words, the GVC income measures of Timmer et al. (2013) will take into account the value added in all of these stages of production. This methodology seems especially important in an IT branch where (in the case of many products) a major part of value is added (Ali-Yrkko et al., 2011; Dedrick et al., 2010).

Timmer et al. (2013) use recently compiled time series of input-output data of the world (41 countries and regions, 35 industries, time span 1995–2008). The contributors analyze global value chains (GVC) based on the methodology of Trefler and Zhu (2010), Bems et al. (2011), and Johnson and Noguera (2012). In particular, for every pair of a **final good** and a **country of use**, the authors obtain a vector with the value added generated in every possible **sector** in **the countries of origin** and a vector with the corresponding number of workers involved in every possible **sector** in the **countries of origin**. Next, using a traditional static IO approach, they invert and aggregate the respective matrices of data to obtain the total value added and number of workers in each country used to produce the world **final manufactured goods**. They call these indicators **manufactures global value chains** (denoted GVCm) income and jobs. Moreover, the authors keep track of the sectors in each country (including non-manufactures, like services and agriculture) that originate the GVCm income and jobs.

Timmer et al. (2013) focus in particular on the European region as a whole, since it has undergone a strong process of integration in the past two decades (both inside and outside the European Union). Their main findings can be summarized as follows. First of all, they proved that in recent years a strong process of international fragmentation of manufacturing production across Europe has been taking place. This process was the reason for rising differences between changes in gross exports and GVC incomes. In particular, they found that growth in manufactures GVC income during 1995–2008 is essentially lower than the growth in gross manufacturing exports for all European countries (in particular for Austria, Greece, Spain, and Eastern European countries). Moreover, the authors established strong differences in the estimated indexes of comparative advantages of the EU calculated on the basis of the new measures and gross exports. They found that European GVC income is increasing fastest in activities carried out in the production of nonelectrical machinery and transport equipment, and it is declining in activities related to the production of non-durables. In the opinion of the contributors, these findings reflect observed changes in measures of comparative advantage more precisely than the suggestion based on gross export data that implies rather stable patterns of comparative advantage.

The contributors were also surprised that this pattern for both the old and new EU members is somewhat similar to the pattern for Mexico-US integration in the 1990s (Feenstra, 1998; 2010). The authors stress that the manufactures

GVC income of a country estimates the income resulted from activities on the domestic territory related to the production of final manufacturing goods by multinational corporations.

We aim to study the production fragmentation of final products. A final product is consumed while intermediate products continue on in the production process. Total consumption includes both private and public consumption as well as investment. A global value chain of a final product is defined as the value added of all activities that are directly and indirectly required to produce it. This global value chain is identified by the country-industry where the last stage of production is performed before delivery to the final user. The final stage of production in a particular country is not equivalent to the governance of the value chain by a domestic country. For example, large IT corporations from the USA govern the production networks of CEE or India.

In general, the originality of our paper is twofold. First, we focus on a relative context and try to answer the question of how important and efficient the CEE transition economies are when it comes to building a comparative advantage of the European Union in global value chains. To the best of our knowledge, this paper is the first study dedicated to the issue of answering this type of question regarding the new EU members in transition. Second, we propose original modifications and extensions of recently presented methodological developments in ex-post accounting framework in global value chains (e.g., those presented in Timmer et al., 2013), which seems to provide a background for interesting empirical deliberations on both country-specific level as well as for the whole group of CEE economies analyzed.

3. Main research conjectures

In general, each research hypothesis examined in this paper consists of three major components. First, in each hypothesis, we refer to one of the three relative measures discussed in this study. These are the relative value added in the group of CEE economies in transition and the measures of relative productivity and capital efficiency. Second, we try to express (and verify) our suppositions on the dynamics of these indexes over the period under study. Finally, we try to extend the general statements on the whole group of examined CEE transition economies by focusing on country- and sector-specific results.

In the economic literature, it is often stressed that one of the major features of the economies of CEE in the 90s was the process of **de-industrialization**, which lead to heavy losses in the secondary sector of the economy (Kalvet and Kattel, 2006). As a consequence, the economic activity in these countries was partly redi-

rected to other sectors (especially services). The latter was accompanied with the ongoing process of globalization, especially in the sphere of economic openness and information flows; this had a significant positive causal impact on economic growth in new EU member countries from the CEE region (Gurgul and Lach, 2014). Since we are interested in the analysis of value added in CEE transition economies in the relative context with respect to the EU in total, we should also underline that, in recent years, the level of technological progress in new EU members has not reached the average EU level as of yet[4]. This implies that these economies are still not playing a key role in high-technology sectors but rather focus on usage of their natural resources/conditions and aim at specializing in rather low-technology production; e.g., in the sector of agriculture, food production, products of wood, etc. Moreover, the energy sectors of the largest EU members from the CEE (e.g. Poland) are still heavily dependent on coal and lignite, while the richest EU counties have already implemented many programs aimed at moving toward alternative sources of energy; e.g., renewable sources or nuclear energy.

On the other hand, during the period of transition, some sectors of CEE economies have grown dramatically (especially after EU accession). A good example here would be the sector of tourism. After the collapse of the Iron Curtain, the societies of CEE transition economies gained the possibility of traveling freely abroad. At the same time, the tourist offerings of the region have been continuously expanding.

All of the above-mentioned observations may have a significant impact on the levels of sector-specific value added in new EU member countries measured as a share of total value added by all EU countries in the framework of GVC. Taking into account these remarks (along with some basic characteristics of the new EU member countries from CEE), one may expect the following hypothesis to hold true:

> **Hypothesis 1:** *The role of selected CEE economies in transition in the creation of value added with respect to the total value added in the European Union in the GVC framework was biggest in the case of the following sectors: Agriculture, Hunting, Forestry and Fishing, Mining and Quarrying, Wood and Products of Wood and Cork, Other Non-Metallic Mineral, and Other Supporting and Auxiliary Transport Activities; Activities of Travel Agencies. When it comes to the country-specific results, one may expect that, among new EU members in transition, the highest shares in the EU total GVC value added were obtained in the largest countries, e.g. Poland and Romania*[5].

[4] For example, the share of R&D expenditure in GDP in new EU members in transition is still much lower as compared to old EU countries.

[5] In all of the research hypotheses listed in Section 3, we use the WIOD names of the respective sectors.

Beside analyzing the relative sector-specific shares in the value added in the group of the ten CEE economies in this paper, we propose new GVC-embedded measures of productivity and capital efficiency and focus on an analysis of their levels and growth rates in two sub-periods: before and after EU expansion[6]. At this place one should underline that, contrary to the values of shares in the EU total GVC value added, the growth rates of productivity are expected to be higher in smaller CEE transition economies. The latter follows from the fact that the smaller the size of the country, the larger the gain from trade. A small country can successfully export the surplus production to a large country (with large market capacity), and it can take advantage of foreign trade (comp. the theory of comparative costs). Thus, small countries are usually encouraged to specialize (or even forced to, due to a scarcity of primary products). In contrary, large countries typically do not suffer from a scarcity of primary products. However, they could have problems with respect to export of (large) excess output to smaller markets (with small market capacity). Therefore, they are not forced (or even encouraged) to specialize. Taking into account these observations (along with the history of structural change in CEE transition economies in the past 25 years), the compositions of key sectors in CEE transition economies and West European countries as well as the differences between labor markets in both groups of EU countries, one may formulate the following conjecture:

> **Hypothesis 2:** *After the two decades of transition, productivity in the ten CEE economies was still much lower as compared to the EU average for most of the sectors. However, during this period, the growth rates of the measures of productivity were, in general, positive. Moreover, they increased at a higher rate after EU accession. The highest levels and growth rates of productivity were found for smaller CEE countries*.

Before the beginning of the transition, the group of CEE countries strongly relied on fixed capital, which was an important input in manufacturing. One of the consequences of economic transition was de-industrialization in CEE along with the following shift towards new types of economic activities (especially services). The latter was also accompanied with the process of privatization. Taken altogether, one may expect that the levels of capital efficiency in CEE transition economies with respect to the EU average will be much higher that the corresponding indexes of relative productivity. Moreover, one could expect that, after EU accession, the role of capital input in the process of production and creation

[6] We focus on EU expansion which took place in 2004.

of value added in the new EU members in transition could be even smaller, due to the shift towards less capital-intensive activities. These general remarks suggest the formulation of our final hypothesis:

> **Hypothesis 3:** *After the two decades of transition, capital efficiency in the ten CEE economies in 2009 was comparable to the EU average for most of the sectors. Moreover, during this period, the growth rates of the measures of the capital efficiency were, in general, positive. However, the growth rates of these indexes dropped after EU accession. The highest levels and growth rates of indexes of capital efficiency were found for smaller CEE countries.*

The hypotheses listed above will be verified using the methodology and dataset presented in Section 4. In the next section, we will briefly present the main empirical findings of the paper.

4. Dataset and research methodology

In order to analyze the dynamics of value added shares as well as the indexes of productivity and capital efficiency in the ten CEE transition economies, we will use the global value chain (GVC) approach introduced in Timmer et al. (2013). In order to provide an ex-post accounting of the value of final demand, we will trace the value added at the various stages of production in an international input-output model. First, we will briefly introduce the accounting framework drawing on the exposition in Johnson and Noguera (2012) and Timmer et al. (2013); then, we will generalize and extend their approach to analyze the value added by specific production factors in the case of the group of new EU members in transition.

Let us now shed some light on the GVC approach. Henceforth, we assume that there are C countries, S sectors, and F production factors. Under the term **country-sector**, we shall understand one specific sector operating in one selected economy. Each of these country-sectors produces one good; thus, there are SC products. It is clear that the output in each country-sector is produced by using both domestic production factors as well as intermediate inputs (which, in turn, may be provided by domestic or foreign suppliers. As usual in an input-output framework, we assume that output in each sector is either used to satisfy final demand (either at home or abroad) or serves the role of intermediate input in production processes in other sectors. Final demand consists of consumption expenditure by households, non-profit organisations serving households, and

government as well as gross fixed capital formation (investment) and changes in inventories and valuables. Following Timmer et al. (2013), we use the simplifying notation for each product, with *i* denoting the source country, *j* denoting the destination country, *s* standing for the source sector, and *r* denoting the destination sector. We assume that product market clearing takes place; thus, the quantity of a good produced in a particular country-sector must equal the quantities of this product used domestically and abroad. For every year *t*, the product market clearing condition takes the following form:

$$y_i^t(s) = \sum\nolimits_j f_{ij}^t(s) + \sum\nolimits_j \sum\nolimits_r m_{ij}^t(s,r) \tag{1}$$

Where $y_i^t(s)$ stands for the value of output in sector *s* of country *i* in year *t*, $f_{ij}^t(s)$ denotes the value of goods shipped from this sector for final use in country *j* in year *t*, and $m_{ij}^t(s, r)$ stands for the value of goods shipped from this sector for intermediate use by sector *r* in country *j* in year *t*[7].

Using simple matrix algebra, the market clearing conditions (1) for each of the *SC* goods can be combined into a compact global input-output system. In order to obtain this compact form, let Y_t denote the $SC \times 1$ vector of production in year *t*, which is obtained by row-wise concatenation of output levels (each in the form of a $S \times 1$ vector) in each country-sector:

$$Y_t = \begin{bmatrix} Y_1^t \\ Y_2^t \\ \vdots \\ Y_C^t \end{bmatrix}, \quad Y_i^t = [y_i^t(s)]_{s=1,\ldots,S}, \quad i = 1,\ldots,C \tag{2}$$

Analogously, we may define the $SC \times 1$ vector of global final demand (denoted as F_t) by stacking world final demand for output from each country-sector $f_i^t(s)$. The latter takes the form of a summation of demand for a product of the sector *s* from any country, i.e.,

$$f_i^t(s) = \sum\nolimits_j f_{ij}^t(s), \quad i = 1,\ldots,C, \quad s = 1,\ldots,S \tag{3}$$

Using this notation, we may write:

$$F_t = \begin{bmatrix} F_1^t \\ F_2^t \\ \vdots \\ F_C^t \end{bmatrix}, \quad F_i^t = [f_i^t(s)]_{s=1,\ldots,S}, \quad i = 1,\ldots,C \tag{4}$$

[7] Note that the use of goods can be at home (in the case of $i = j$) or abroad ($i \neq j$).

For each year t, we define a $SC \times SC$ global intermediate input coefficient matrix $A_t = [a^t_{wz}]_{w,z=1,\ldots,SC}$ using the following formula:

$$a^t_{wz} = \frac{m^t_{ij}(s,r)}{y^t_i(r)}, \text{ for } w = s + (i-1)S,\ z = r + (j-1)S \tag{5}$$

where $i, j = 1, \ldots, C$, $s, r = 1, \ldots, S$. The elements a^t_{wz} represent the output from sector s in country i used as intermediate input by sector r in country j as a share of output in the latter sector in year t (Timmer et al., 2013). Using matrix A_t, we may now answer the question of which combination of various intermediate products (both domestic and foreign) are required to produce one unit of each country-sector product. Using this definition, we can now re-write the global market clearing conditions (1) in a compact IO-based form:

$$Y_t = A_t Y_t + F_t \tag{6}$$

or equivalently:

$$Y_t = (I - A_t)^{-1} F_t \tag{7}$$

where I is an $SC \times SC$ identity matrix.

Using the approach of Timmer et al. (2013), one may attribute the value of final demand for a specific product to value added in all country-sectors that directly and indirectly participate in the production process of the final good. Throughout this paper, we define value added in a traditional way; namely, as the difference between gross output value (at basic prices) and the cost of intermediate goods and services (at purchaser's prices). For each sector s and country c, we define $p^t_c(s)$ as the value added per unit of gross output produced in year t, and create the stacked $SC \times 1$-vector p^t_{VA} containing these (direct) value added coefficients:

$$p^t_{VA} = \begin{bmatrix} p^t_{VA}(1) \\ p^t_{VA}(2) \\ \vdots \\ p^t_{VA}(C) \end{bmatrix}, \quad \text{where} \quad p^t_{VA}(c) = \begin{bmatrix} p^t_c(1) \\ p^t_c(2) \\ \vdots \\ p^t_c(S) \end{bmatrix} \tag{8}$$

In order to take 'indirect' contributions into account, we derive the $SC \times 1$-vector of value added levels v^t_{VA} as generated to produce a final demand vector F_t. To get this vector, the gross outputs needed for production of this final demand should be multiplied by the elements of the direct value added coefficient vector p^t_{VA}. After multiplying (7) by $diag(p^t_{VA})$, one gets[8]:

[8] Henceforth, for a given vector $[x_j]_{j=1,\ldots,n}$ the symbol diag(x_j) denotes the $n \times n$ diagonal matrix with elements x_j on the diagonal.

$$v_{VA}^{t} = diag(p_{VA}^{t})(I - A_t)^{-1}F_t \tag{9}$$

where:

$$v_{VA}^{t} = \begin{bmatrix} v_{VA,1}^{t} \\ v_{VA,2}^{t} \\ \vdots \\ v_{VA,C}^{t} \end{bmatrix} \tag{10}$$

Using model (9), one can now multiply matrix $diag(p_{VA}^{t})(I - A_t)^{-1}$ with any vector of final demand levels F_0^t to find out which value added levels v_{VA}^{t} should be attributed to this particular set of final demand levels in all C countries[9].

The GVC-embedded methodology outlined so far are based on suggestions of traditional IO literature and has already been applied in empirical research (see e.g., Timmer et al., 2013). Below, we will briefly present a modification of this approach aimed at analyzing dynamics of value added, productivity, and capital efficiency in ten new EU members in transition. Our goal is to establish a GVC-embedded research framework to examine the dynamics of the discussed variables in ten CEE economies in a relative context with respect to the EU total.

For each sector s^* and year t, let us define the $SC \times 1$ global final demand vector using the following formula:

$$F_t(s^*) = \begin{bmatrix} F_1^t(s^*) \\ F_2^t(s^*) \\ \vdots \\ F_C^t(s^*) \end{bmatrix}, \quad F_i^t(s^*) = f_i^t(s^*)e(s^*) \tag{11}$$

where $e(s^*) = [e_q]_{q=1,\ldots,S}$ is an $S \times 1$ vector defined as:

$$e_q = \begin{cases} 1, & q = s^* \\ 0, & otherwise \end{cases} \tag{12}$$

[9] Although the ex-post accounting framework described above does not allow us to explicitly deal with the interaction of prices and quantities as in a full-fledged Computable General Equilibrium model, it is also free of bias resulting from the need of econometric estimation of various key parameters of production and demand functions. The latter, along with characteristics of the annual IO data, makes the approach particularly well-suited for a wide range of ex-post analysis (Timmer et al., 2013).

In other words, the vector $F_t(s^*)$ contains the C values of final demand for sector s^* across all the countries. For remaining sectors j ($j \neq s^*$), the corresponding entries in vector $F_t(s^*)$ are all equal to zero. Using formulas (8)–(10), we may now establish the distribution of value added to be attributed to the set of final demand levels contained in vector $F_t(s^*)$:

$$v_{VA}^t(s^*) = diag\left(p_{VA}^t\right)(I - A_t)^{-1} F_t(s^*) \tag{13}$$

We will now focus on the construction of GVC-embedded indexes measuring the role of selected CEE economies in transition in the creation of value added with respect to the total production in the European Union. We are also interested in analyzing the dynamics of the indexes of productivity and capital efficiency in the new EU member countries in transition. Let J_{EU27} and J_{CEE} denote the sets of indexes for EU27[10] and the ten new EU members from the CEE region[11]. For each sector s^* and year t, we may calculate the value added in GVC in the whole EU27 and in the group of ten CEE economies using equation (13). Next, we may define the **Value Added Share (VAS)** attributed in the new EU members with respect to the EU27 total using the following formula:

$$VAS_{CEE|EU27}(s^*, t) = \frac{\sum_{j \in J_{CEE}} v_{VA,j}^t(s^*)}{\sum_{j \in J_{EU27}} v_{VA,j}^t(s^*)} \times 100\% \tag{14}$$

For example, we may use formula (14) to assess the size of value added attributed to the global final demand in agriculture in the ten CEE economies in transition, with respect to the value added in this sector in the whole European Union[12].

One can generalize the decomposition of the value of final demand outlined above to analyze the value and quantities used of specific production factors. In this paper, we focus on two basic types of inputs: labor and capital. We define $p_{L,c}^t(s)$ as the direct labor input per unit of gross output produced in sector s in

[10] Due to a lack of required data on Croatia throughout this paper, we do not focus on the EU28.

[11] The ten new EU members are as follows (respective abbreviations are given in brackets): Bulgaria (BGR), Czech Republic (CZE), Estonia (EST), Hungary (HUN), Latvia (LVA), Lithuania (LTU), Poland (POL), Romania (ROM), Slovakia (SVK), and Slovenia (SVN). It should be mentioned that, during the period of 2004–2010, 12 countries joined the EU. However, Malta and Cyprus have not been taken into consideration in this study because they have never been in transition.

[12] It is clear that $VAS_{CEE|EU27}(s^*,t) \in [0,100\%]$ for all sector and all years. For example, if $VAS_{CEE|EU27}(s^*,t) = 10\%$, this implies that 10% of GVC value added in the sector s^* in year t in the whole European Union was due to the economic activity carried out in the ten new member countries from the CEE region.

country c in year t. Using an analogous formula to equation (8), we can now obtain a stacked $SC \times 1$ vector p_L^t containing these (direct) coefficients. Analogously to the case of analysis of value added, the elements of vector p_L^t do not account for labor embodied in the intermediate inputs used. However, analogous to formula (13), for each sector s^* and each year t, we may derive all direct and indirect labor inputs needed for the production of a specific final product:

$$v_L^t(s^*) = diag\left(p_L^t\right)(I - A_t)^{-1} F_t(s^*) \tag{15}$$

Using this formula, we may now simply calculate the **ratio of labor** (**labor share, denoted *LS***) used in the global production processes in sector s^* in the group of ten CEE economies, with respect to the labor used in the whole EU27:

$$LS_{CEE|EU27}(s^*,t) = \frac{\sum_{j \in J_{CEE}} v_{L,j}^t(s^*)}{\sum_{j \in J_{EU27}} v_{L,j}^t(s^*)} \times 100\% \tag{16}$$

Using analogous formulas to (15)–(16), we may define respective indicators for the second input considered – capital:

$$v_C^t(s^*) = diag\left(p_C^t\right)(I - A_t)^{-1} F_t(s^*) \tag{17}$$

Using this formula, we may now simply calculate the **ratio of capital** (**capital share, denoted *CS***) used in the global production processes in sector s^* in the group of ten CEE economies with respect to the labor used in the whole EU27:

$$CS_{CEE|EU27}(s^*,t) = \frac{\sum_{j \in J_{CEE}} v_{C,j}^t(s^*)}{\sum_{j \in J_{EU27}} v_{C,j}^t(s^*)} \times 100\% \tag{18}$$

The labor ($LS_{CEE|EU27}(s^*,t)$) and capital ($CS_{CEE|EU27}(s^*,t)$) ratios defined above may serve as a basis to define the following GVC-embedded index of workforce productivity:

$$PRODUCTIVITY_{CEE|EU27}(s^*,t) = \frac{VAS_{CEE|EU27}(s^*,t)}{LS_{CEE|EU27}(s^*,t)} \times 100\% \tag{19}$$

and the GVC-embedded index of capital efficiency:

$$CAP\_EFF_{CEE|EU27}(s^*,t) = \frac{VAS_{CEE|EU27}(s^*,t)}{CS_{CEE|EU27}(s^*,t)} \times 100\% \tag{20}$$

The interpretation of both indexes defined above is rather straightforward. If, for example, $PRODUCTIVITY_{CEE|EU27}(s^*,t) = 50\%$, this implies that, in the GVC framework, the labor used to create one unit of value added in sector s^* in year t in the ten CEE economies in transition was twice as high as the labor used in all of the EU27 countries.

To measure share in value added and calculate the indexes of productivity and capital efficiency for each of the EU27 countries, we need to track country gross output and value added by industry, the global input-output matrix, final goods shipments over time, as well as labor and capital inputs. This type of data is available from the recently released World Input-Output Database (WIOD). In this paper, we use the most-recent world IO tables published by the WIOD, which cover the period 1995–2009 and provide data on 41 regions of the world (40 major countries and the aggregate data on the rest of the world). Thus, the respective IO matrices (vectors) are 1435 × 1435 (1435 × 1) in size[13]. For each sector $s^* \in \{1,35\}$ and year $t \in \{1995,2009\}$, the vector of final output Y_t, input coefficient matrix A_t, sector-specific final demand $F_i^t(s^*)$, and vector of direct value added coefficient $\hat{p}_{VA}^t$ are derived directly from the WIOD database[14]. We used the WIOD data on hours worked to proxy the direct labor input per unit of gross output (i.e., vector $\hat{p}_L^t$) and the WIOD data on gross fixed capital formation as approximation of direct capital input per unit of gross output (vector $\hat{p}_C^t$)[15].

5. Empirical results

In order to analyze the role of the new EU members in transition in the creation of value added in the European Union within the global value chain (GVC)

[13] WIOD consists of a series of detailed and reliable databases and covers 27 EU countries and 13 other major countries in the world. For more details on the WIOD database, see Timmer (2012).

[14] If e stands for a $SC \times 1$ summation vector containing ones, one may write $(\hat{p}_{VA}^t)' = (e)'(I - A)$. This implies that, in (9), the elements of the vector of distribution of the value of final output as attributed to sectors in the value chain of any product (v_{VA}^t) add up to the elements of the vector of final demand $F_i^t(s^*)$ (for a short proof, see Timmer et al., 2013).

[15] We used exchange rates published by the World Bank to transform the original WIOD data on gross fixed capital formation expressed in national currencies into comparable values expressed in US dollars.

framework, one should first take a look at data on the size and dynamics of global final demand for all of the products examined. For this purpose, we used the WIOD input-output tables expressed in the previous years' prices (covering the period 1996–2010). Next, we used the chain rule to obtain the final demand levels in 2009 expressed in 1995 US dollars. Finally, we calculated real growth rates for all 35 sectors. Table 1 presents the respective results[16].

There are some similarities when it comes to the list of the sectors with the biggest and lowest values of final demand in EU27, EU15[17], the group of ten CEE economies in transition, and the world total. The sectors of **Construction**, **Real Estate Activities**, **Public Admin and Defense**, **Compulsory Social Security**, and **Health and Social Work** were listed among the sectors with the largest levels of final demand, while the sectors of **Wood and Products of Wood and Cork** and **Water Transport** were characterized with the smallest levels of final demand (no matter the group of economies examined). Except for the **Water Transport** sector, all remaining sectors experienced more than 60% of real growth of final demand in the group of ten CEE economies under study. Moreover, in the case of some sectors, the final demand levels in the ten CEE economies have risen by more than six times during the period of 1995–2009. More attention should be given to the sector of **Mining and Quarrying** in the case of which one could see a significant rise in global final demand (in particular, a 60% rise in the case of the ten CEE economies). At the same time, the final demand for the products of this sector has fallen in the remaining group of EU countries, especially the old EU members (EU15).

In the next stage, we used equation (14) to analyze the role of new EU members in transition (as a group of ten countries and individually for each country) in the creation of value added in the European Union within the global value chain (GVC) framework. The results of this analysis are presented in Table 2[18].

[16] In addition to the EU-related data in Table 1, we also provide data on the discussed trade statistics for all countries in the world (see the column named World). The latter illustrates the evolution of GVC value added from a global perspective.

[17] EU15 consist of the 15 so-called **old members** of the EU.

[18] The goal of this paper is to analyze the GVC value added in the ten CEE economies expressed as a share of GVC value added in the EU27. However, one may be interested in understanding the process of catching-up of the CEE towards the EU15 as well as the absolute and relative convergence of the CEE towards the EU15. In such a case, one would be interested in taking the EU15 as a benchmark (rather than the EU27, as the CEE economies belong to the EU27). Fortunately, the transformation of the shares of relative GVC value added in CEE economies into the shares of GVC value added in CEE economies with respect to GVC EU15 is quite simple. If, for a particular sector, one denotes the GVC value added in the respective groups of countries as CEE_VA, EU27_VA, and EU15_VA, and if one defines VAS1 = CEE_VA/EU27_VA then after a simple algebraic reformulation, one may get CEE_VA/EU15_VA = VAS1/(1 – VAS1), since EU27_VA = EU15_VA + CEE_VA.

One can list several sectors in the case of which the GVC value added in 2009 in CEE transition economies (measured as a share of the EU27 GVC total value added) was largest. These were **Agriculture**, **Hunting**, **Forestry and Fishing**, **Mining and Quarrying**, **Wood and Products of Wood and Cork**, **Other Non-Metallic Mineral**, and **Other Supporting and Auxiliary Transport Activities**, **Activities of Travel Agencies**. In other words, in the case of these sectors, the group of ten new EU members in transition had the greatest effect on the value added in the whole EU in global production processes. With just a few exceptions, the highest share of value added among the ten CEE countries was usually reported for Poland[19].

When it comes to the analysis of the dynamics of the measures of value added in the examined CEE economies, one should underline that, during the period of 1995–2009, the sectors of **Mining and Quarrying**, **Wood and Products of Wood and Cork**, and **Other Non-Metallic Mineral** experienced the highest rise in the share of the EU27 GVC value added[20]. In general, the share of the GVC value added in the sector of **Mining and Quarrying** in ten CEE economies in the EU27 GVC value added rose during the transition period. Moreover, the highest growth rate was observed especially after EU accession. This result, however, should be interpreted together with the outcomes presented in Table 1; namely, the shrinking demand for coal observed in the EU15 countries accompanied with a shift towards low-carbon energy sources evident in the richest European economies. Taken altogether, these results provide solid support for the Hypothesis 1.

In the next stage, for each sector $s^* \in \{1,35\}$ and each year $t \in \{1995,2009\}$, we calculated the indexes of productivity and capital efficiency for the group of ten CEE countries examined (using formulas (19) and (20)). The results are presented in Tables 3 and 4.

In the case of most of the sectors, the index of productivity in the ten CEE economies in 2009 was still below 50%. This implies that, in general, the CEE economies in transition were still using approximately twice as much labor to create one unit of value added as compared to the EU27 average. The highest levels of the index of productivity (around 70–80%) were obtained for the sectors of **Other Supporting and Auxiliary Transport Activities**; **Activities of Travel Agencies** and **Sale**, and **Maintenance and Repair of Motor Vehicles and Motorcycles**; **Retail Sale of Fuel**.

[19] Using the formula that allows changing the benchmark from EU27 to EU15 (see footnote 18), one may easily see that the ordering of sectors according to the relative GVC value added in the ten CEE economies in transition is exactly identical (no matter if the EU27 or EU15 was taken as a benchmark).

[20] In the case of the sectors of **Wood and Products of Wood and Cork** and **Other Non-Metallic Mineral**, the share in the EU27 GVC value added in 2009 was more than twice as high as in 1995.

Beside the two mentioned sectors, the largest positive changes of the index of productivity during the period of 1995–2009 were obtained for the sector of **Mining and Quarrying**. Moreover, the growth rates of these indexes increased after EU accession. When it comes to the data on individual counties, it is worth underling that the index of productivity was highest most frequently for Slovenia. In other words, these results provide support for Hypothesis 2.

Quite different results were obtained for the index of capital efficiency. In the case of most of the sectors, this index in 2009 was close to (or higher than) 100% in the case of the group of ten CEE economies in transition. In general, this implies that, in order to create one unit of value added, the CEE economies were using similar amounts of capital input as the average values of this input in the whole EU27. The highest levels of the index of capital efficiency (around 110–120%) were obtained for the sectors of **Real Estate Activities, Mining and Quarrying, Renting of M&Eq and Other Business Activities**, and **Water Transport**.

The largest positive changes of the index of capital efficiency during the period of 1995–2009 were obtained for the sectors of **Electricity, Gas and Water Supply**, **Post and Telecommunications**, **Financial Intermediation**, and **Renting of M&Eq and Other Business Activities**. In contrary to the results presented in Table 4, the growth rates of these indexes dropped after EU accession[21]. These results, in turn, provide support for Hypothesis 1.

In addition to the results presented in Tables 1–4 (which were dedicated to the whole group of ten CEE economies), we conducted a detailed country- and sector-specific individual analysis of the shares in value added and indexes of productivity and capital efficiency for all ten CEE economies. Since this analysis was carried out for individual countries, the results significantly extend the group-overall information presented in Tables 1–4. We focused on the top five sectors with respect to the shares in the GVC EU27 value added. The list of the top value-added sectors is as follows: **Agriculture**, **Hunting, Forestry and Fishing**, **Mining and Quarrying, Wood and Products of Wood and Cork, Other Non-Metallic Mineral, and Other Supporting and Auxiliary Transport Activities**, **Activities of Travel Agencies**. The respective results are presented in the Figures 1–5.

It is worth mentioning that, in the case of the sector of **Mining and Quarrying**, one could notice extremely small or even negative values of VAS in the case of some CEE transition economies. The latter implies that, in the global-market framework, some CEE countries have experienced a situation when the final demand for products of the sector **Mining and Quarrying** was equal to or even smaller than the intermediate consumption. The latter is evidence of inefficiency of this sector in the ten new EU members in transition in the global framework, as it did not make enough profit to cover the cost of doing business. In general, the detailed results presented in Figures 1–5 support Hypotheses 1–3.

[21] Except for the sector of **Electricity, Gas, and Water Supply**.

Table 1

Levels and real growth rates of final demand in the 35 sectors[a]

Sector Name	Final output in 2009 (1995 USD)				Real growth in final output in 1995–2009 (1995 prices) (in %)			
	WORLD	EU27	EU15	CEE	WORLD	EU27	EU15	CEE
Agriculture, Hunting, Forestry and Fishing	1089.0	266.4	220.8	44.9	91	62	56	107
Mining and Quarrying	188.4	11.0	8.4	2.7	209	–24	–34	60
Food, Beverages and Tobacco	2554.5	820.3	721.4	97.5	76	58	50	169
Textiles and Textile Products	581.3	158.1	138.3	19.8	35	4	–2	90
Leather, Leather and Footwear	139.1	43.8	38.8	5.0	56	11	6	89
Wood and Products of Wood and Cork	43.8	23.9	20.7	3.2	–20	32	21	226
Pulp, Paper, Paper, Printing and Publishing	348.5	155.3	143.8	11.2	46	36	31	209
Coke, Refined Petroleum and Nuclear Fuel	728.6	250.6	228.5	22.1	288	242	234	359
Chemicals and Chemical Products	754.6	335.0	312.9	21.8	107	105	98	301
Rubber and Plastics	150.5	57.3	50.5	6.6	54	41	29	411
Other Non-Metallic Mineral	66.1	37.1	31.4	5.5	15	37	23	246
Basic Metals and Fabricated Metal	334.6	133.2	118.6	14.4	43	37	27	308
Machinery, Nec	1185.5	450.3	417.1	33.2	63	67	59	365
Electrical and Optical Equipment	1381.1	337.5	292.1	45.1	76	47	31	568
Transport Equipment	1711.8	615.7	553.2	62.3	69	70	57	553
Manufacturing, Nec; Recycling	461.9	178.0	155.2	22.4	62	39	27	314
Electricity, Gas and Water Supply	788.5	350.6	310.5	39.5	85	79	67	335
Construction	5823.7	1614.4	1450.7	160.0	98	89	77	345

Table 1 cont.

Sale, Maintenance and Repair of Motor Vehicles and Motorcycles; Retail Sale of Fuel	558.8	296.9	276.4	20.1	69	97	90	282
Wholesale Trade and Commission Trade, Except of Motor Vehicles and Motorcycles	2048.2	677.2	618.5	57.4	85	89	80	308
Retail Trade, Except of Motor Vehicles and Motorcycles; Repair of Household Goods	2378.3	632.0	575.1	55.3	62	89	82	208
Hotels and Restaurants	1936.3	773.0	740.4	29.7	89	112	107	330
Inland Transport	842.8	267.3	232.2	34.9	83	69	54	355
Water Transport	113.6	42.6	41.8	0.8	173	183	193	–6
Air Transport	233.4	72.9	69.8	2.7	77	98	94	281
Other Supporting and Auxiliary Transport Activities; Activities of Travel Agencies	260.8	140.8	123.4	16.9	102	106	95	241
Post and Telecommunications	829.8	259.2	234.7	23.9	168	144	128	645
Financial Intermediation	2097.6	648.9	610.0	37.7	137	183	173	659
Real Estate Activities	4757.6	1649.1	1534.6	110.6	101	109	100	408
Renting of M&Eq and Other Business Activities	1608.1	534.6	502.6	31.6	157	134	127	359
Public Admin and Defence; Compulsory Social Security	6110.2	1454.1	1348.8	101.5	112	100	93	281
Education	2051.6	908.5	840.8	65.8	102	90	83	310
Health and Social Work	4436.7	1698.5	1623.7	72.8	125	134	129	357
Other Community, Social and Personal Services	1970.7	744.5	683.8	58.2	93	100	91	368
Private Households with Employed Persons	96.5	70.8	67.7	2.9	114	126	122	240

Source: own elaborations based on WIOD world IO tables in previous years' prices.
[a] Dark (grey) shading indicates 5 largest (smallest) values.

Table 2

Share in value added attributed in the new EU members with respect to the EU27 total[a]

Sector Name	Value added in CEE countries (share in EU27) (in %)				CEE country with highest value added (share in EU27)			
	2009	1995–2009 Change	Average annual change 2000–2004	Average annual change 2004–2009	1995	2000	2005	2009
Agriculture, Hunting, Forestry and Fishing	13.97	2.13	0.19	0.06	POL	POL	POL	POL
Mining and Quarrying	17.65	7.81	0.22	1.41	POL	POL	POL	POL
Food, Beverages and Tobacco	10.96	4.31	0.26	0.44	POL	POL	POL	POL
Textiles and Textile Products	9.57	3.65	0.24	0.31	POL	POL	POL	POL
Leather, Leather and Footwear	8.30	2.62	0.11	0.38	POL	POL	ROU	POL
Wood and Products of Wood and Cork	13.31	7.27	0.33	0.99	POL	POL	POL	POL
Pulp, Paper, Paper, Printing and Publishing	6.69	3.60	0.17	0.47	POL	POL	POL	POL
Coke, Refined Petroleum and Nuclear Fuel	10.40	4.88	0.30	0.47	POL	POL	POL	POL
Chemicals and Chemical Products	5.69	2.41	0.14	0.26	POL	POL	POL	POL
Rubber and Plastics	9.25	6.18	0.29	0.81	POL	POL	POL	POL
Other Non-Metallic Mineral	12.67	7.24	0.54	0.45	POL	POL	POL	POL
Basic Metals and Fabricated Metal	10.01	5.90	0.31	0.70	POL	POL	POL	POL
Machinery, Nec	7.35	4.30	0.25	0.44	POL	POL	POL	POL
Electrical and Optical Equipment	9.30	6.31	0.41	0.56	POL	POL	HUN	POL

Table 2 cont.

Transport Equipment	9.35	6.41	0.36	0.70	POL	POL	POL	POL
Manufacturing, Nec; Recycling	10.61	6.06	0.40	0.52	POL	POL	POL	POL
Electricity, Gas and Water Supply	11.17	6.92	0.43	0.66	POL	POL	POL	POL
Construction	8.44	4.34	0.20	0.58	POL	POL	POL	POL
Sale, Maintenance and Repair of Motor Vehicles and Motorcycles; Retail Sale of Fuel	6.34	2.94	0.17	0.31	POL	POL	POL	POL
Wholesale Trade and Commission Trade, Except of Motor Vehicles and Motorcycles	7.93	4.12	0.29	0.31	POL	POL	POL	POL
Retail Trade, Except of Motor Vehicles and Motorcycles; Repair of Household Goods	7.97	2.84	0.14	0.37	POL	POL	POL	POL
Hotels and Restaurants	3.85	1.79	0.11	0.18	POL	POL	POL	POL
Inland Transport	11.19	6.62	0.52	0.35	POL	POL	POL	POL
Water Transport	3.26	–1.81	–0.24	0.14	POL	POL	POL	POL
Air Transport	4.36	2.19	0.14	0.19	POL	POL	POL	POL
Other Supporting and Auxiliary Transport Activities; Activities of Travel Agencies	11.21	4.27	0.15	0.69	CZE	CZE	CZE	CZE
Post and Telecommunications	8.68	5.76	0.40	0.45	POL	POL	POL	POL
Financial Intermediation	5.13	2.86	0.19	0.24	POL	POL	POL	POL
Real Estate Activities	5.77	3.04	0.20	0.25	POL	POL	POL	POL
Renting of M&Eq and Other Business Activities	5.15	2.31	0.12	0.27	POL	POL	POL	POL

Table 2 cont.

Sector Name	Value added in CEE countries (share in EU27) (in %)				CEE country with highest value added (share in EU27)			
	2009	1995–2009 Change	Average annual change 2000–2004	Average annual change 2004–2009	1995	2000	2005	2009
Public Admin and Defence; Compulsory Social Security	6.54	2.87	0.19	0.24	POL	POL	POL	POL
Education	6.56	3.24	0.24	0.21	POL	POL	POL	POL
Health and Social Work	3.98	1.76	0.10	0.19	POL	POL	POL	POL
Other Community, Social and Personal Services	7.00	3.72	0.22	0.39	POL	POL	POL	POL
Private Households with Employed Persons	7.24	4.34	0.23	0.51	POL	POL	POL	ROU

Source: own elaborations based on WIOD world IO tables.
[a] Dark (grey) shading indicates 5 largest (smallest) values.

Table 3

Indexes of productivity in the new EU members with respect to the EU27 total[a]

Sector Name	Productivity in CEE countries (in %)				CEE country with highest productivity			
	2009	1995–2009 Change	Average annual change 2000–2004	Average annual change 2004–2009	1995	2000	2005	2009
Agriculture, Hunting, Forestry and Fishing	27.43	6.62	0.37	0.72	CZE	SVK	EST	SVK
Mining and Quarrying	62.36	46.97	2.69	5.02	SVN	SVN	SVN	SVK
Food, Beverages and Tobacco	30.44	11.52	0.74	1.02	SVN	SVN	SVN	SVK

Table 3 cont.

Textiles and Textile Products	23.69	5.06	0.18	0.82	SVN	SVN	SVN	SVN
Leather, Leather and Footwear	21.29	0.42	–0.18	0.55	SVN	SVN	SVN	SVN
Wood and Products of Wood and Cork	39.98	23.59	1.12	3.09	SVN	SVN	SVN	LVA
Pulp, Paper, Paper, Printing and Publishing	49.00	25.82	1.51	2.69	SVN	SVN	SVN	SVN
Coke, Refined Petroleum and Nuclear Fuel	24.83	11.47	0.64	1.28	SVN	SVN	HUN	SVK
Chemicals and Chemical Products	39.44	18.14	1.58	0.58	SVN	SVN	SVN	SVN
Rubber and Plastics	53.33	30.30	1.94	2.72	SVN	SVN	SVN	SVN
Other Non–Metallic Mineral	37.47	19.74	1.81	0.42	SVN	SVN	SVN	SVN
Basic Metals and Fabricated Metal	41.22	13.94	0.86	1.33	SVN	SVN	SVN	SVN
Machinery, Nec	35.62	22.33	1.55	1.71	SVN	SVN	SVN	SVN
Electrical and Optical Equipment	40.15	20.52	1.72	0.82	SVN	SVN	SVN	SVN
Transport Equipment	41.36	22.72	1.68	1.48	SVN	SVN	SVN	SVN
Manufacturing, Nec; Recycling	34.27	11.34	0.55	1.45	SVN	SVN	SVN	SVN
Electricity, Gas and Water Supply	32.32	18.10	1.02	1.98	SVN	SVN	SVN	SVK
Construction	39.42	15.53	1.48	0.19	SVN	SVN	SVN	SVN
Sale, Maintenance and Repair of Motor Vehicles and Motorcycles; Retail Sale of Fuel	72.58	42.89	1.56	6.83	SVN	SVN	SVN	SVN
Wholesale Trade and Commission Trade, Except of Motor Vehicles and Motorcycles	36.97	13.91	1.30	0.22	SVN	SVN	SVN	SVN
Retail Trade, Except of Motor Vehicles and Motorcycles; Repair of Household Goods	46.73	6.72	0.05	1.57	SVN	SVN	SVN	SVN

Table 3 cont.

Sector Name	Productivity in CEE countries (in %)				CEE country with highest productivity			
	2009	1995–2009 Change	Average annual change 2000–2004	Average annual change 2004–2009	1995	2000	2005	2009
Hotels and Restaurants	35.03	10.92	0.70	0.97	SVN	SVN	SVN	SVN
Inland Transport	45.01	24.81	1.84	1.60	SVN	SVN	SVN	SVK
Water Transport	31.15	10.63	0.63	1.08	SVN	SVN	SVN	SVN
Air Transport	40.54	25.00	1.65	2.13	SVN	SVN	SVN	SVN
Other Supporting and Auxiliary Transport Activities; Activities of Travel Agencies	88.22	55.61	4.21	3.37	SVN	SVN	SVN	SVN
Post and Telecommunications	54.79	33.75	2.38	2.49	SVN	SVN	SVN	SVN
Financial Intermediation	60.46	31.12	2.87	0.61	SVN	SVN	SVN	SVN
Real Estate Activities	22.56	9.25	0.94	–0.03	SVN	SVN	SVN	SVN
Renting of M&Eq and Other Business Activities	58.33	31.08	2.12	2.47	SVN	SVN	POL	SVN
Public Admin and Defence; Compulsory Social Security	37.18	10.52	0.47	1.45	SVN	SVN	SVN	SVN
Education	28.22	11.90	0.84	0.87	SVN	SVN	SVN	SVN
Health and Social Work	29.32	13.33	0.81	1.30	SVN	SVN	SVN	SVN
Other Community, Social and Personal Services	47.32	19.64	0.86	2.77	SVN	SVN	SVN	SVN
Private Households with Employed Persons	28.23	14.52	1.66	–0.51	SVN	SVN	SVN	SVN

Source: own elaborations based on WIOD world IO tables.
[a] Dark (grey) shading indicates 5 largest (smallest) values.

Table 4

Indexes of capital efficiency in the new EU members with respect to the EU27 total[a]

Sector Name	Capital efficiency in CEE countries (in %)				CEE country with highest capital efficiency			
	2009	1995–2009 Change	Average annual change 2000–2004	Average annual change 2004–2009	1995	2000	2005	2009
Agriculture, Hunting, Forestry and Fishing	98.55	–6.21	–0.39	–0.58	LVA	BGR	HUN	LTU
Mining and Quarrying	125.55	9.11	–1.21	5.29	BGR	POL	POL	POL
Food, Beverages and Tobacco	88.30	–3.18	–0.37	0.12	BGR	BGR	POL	LTU
Textiles and Textile Products	88.85	–0.73	–0.50	1.07	POL	LTU	POL	LTU
Leather, Leather and Footwear	94.01	0.28	–0.13	0.40	LVA	LTU	POL	SVK
Wood and Products of Wood and Cork	94.78	14.74	–0.24	4.29	BGR	BGR	POL	LTU
Pulp, Paper, Paper, Printing and Publishing	90.35	1.17	–1.16	3.20	BGR	BGR	POL	LTU
Coke, Refined Petroleum and Nuclear Fuel	100.98	16.99	0.41	3.22	LVA	BGR	LTU	LTU
Chemicals and Chemical Products	78.32	1.79	–0.26	1.10	BGR	BGR	POL	LTU
Rubber and Plastics	63.32	–11.43	–0.52	–1.57	BGR	BGR	LTU	LTU
Other Non–Metallic Mineral	79.89	2.58	–0.26	1.30	BGR	BGR	POL	SVK
Basic Metals and Fabricated Metal	86.08	8.03	0.01	1.97	BGR	BGR	POL	LTU
Machinery, Nec	78.43	–0.10	–0.83	2.06	BGR	BGR	POL	LTU
Electrical and Optical Equipment	84.71	2.12	0.15	0.16	BGR	BGR	POL	LTU
Transport Equipment	79.66	–5.76	–2.06	3.72	BGR	BGR	LTU	LTU
Manufacturing, Nec; Recycling	80.35	–6.60	–1.01	0.89	BGR	LTU	POL	SVK
Electricity, Gas and Water Supply	107.20	39.13	1.12	6.98	BGR	BGR	POL	HUN
Construction	72.34	–0.22	0.03	–0.14	BGR	LTU	POL	SVK

Table 4 cont.

Sector Name	Capital efficiency in CEE countries (in %)				CEE country with highest capital efficiency			
	2009	1995–2009 Change	Average annual change 2000–2004	Average annual change 2004–2009	1995	2000	2005	2009
Sale, Maintenance and Repair of Motor Vehicles and Motorcycles; Retail Sale of Fuel	91.96	2.96	–0.44	1.84	POL	LTU	POL	LTU
Wholesale Trade and Commission Trade, Except of Motor Vehicles and Motorcycles	85.14	9.43	1.16	–0.53	BGR	LTU	POL	SVK
Retail Trade, Except of Motor Vehicles and Motorcycles; Repair of Household Goods	103.51	–12.29	–1.75	1.29	POL	LTU	POL	LTU
Hotels and Restaurants	75.17	–6.77	–0.53	–0.37	LVA	LTU	POL	LTU
Inland Transport	94.54	–8.99	–0.51	–0.97	BGR	BGR	POL	LTU
Water Transport	119.38	–12.34	–2.64	3.51	SVN	BGR	POL	LTU
Air Transport	89.52	–17.89	–2.33	1.36	BGR	BGR	ROU	LTU
Other Supporting and Auxiliary Transport Activities; Activities of Travel Agencies	80.43	–28.06	–3.82	2.54	BGR	BGR	POL	LTU
Post and Telecommunications	94.99	38.63	4.01	–0.36	BGR	BGR	POL	LTU
Financial Intermediation	85.68	24.25	2.46	–0.08	LVA	EST	LTU	SVK
Real Estate Activities	128.38	–21.78	–1.56	–1.55	LVA	LVA	ROU	EST
Renting of M&Eq and Other Business Activities	118.94	30.58	2.92	0.34	LVA	HUN	POL	SVK
Public Admin and Defence; Compulsory Social Security	95.45	–14.72	–1.95	1.20	POL	BGR	CZE	HUN
Education	71.79	–10.23	–0.77	–0.63	LVA	LTU	LTU	LTU
Health and Social Work	77.46	1.77	–0.05	0.57	LVA	LTU	HUN	LTU
Other Community, Social and Personal Services	88.86	–1.09	0.45	–1.40	LVA	BGR	LTU	LTU
Private Households with Employed Persons	79.93	–1.39	0.74	–2.19	BGR	BGR	POL	LTU

Source: own elaborations based on WIOD world IO tables.
[a] Dark (grey) shading indicates 5 largest (smallest) values.

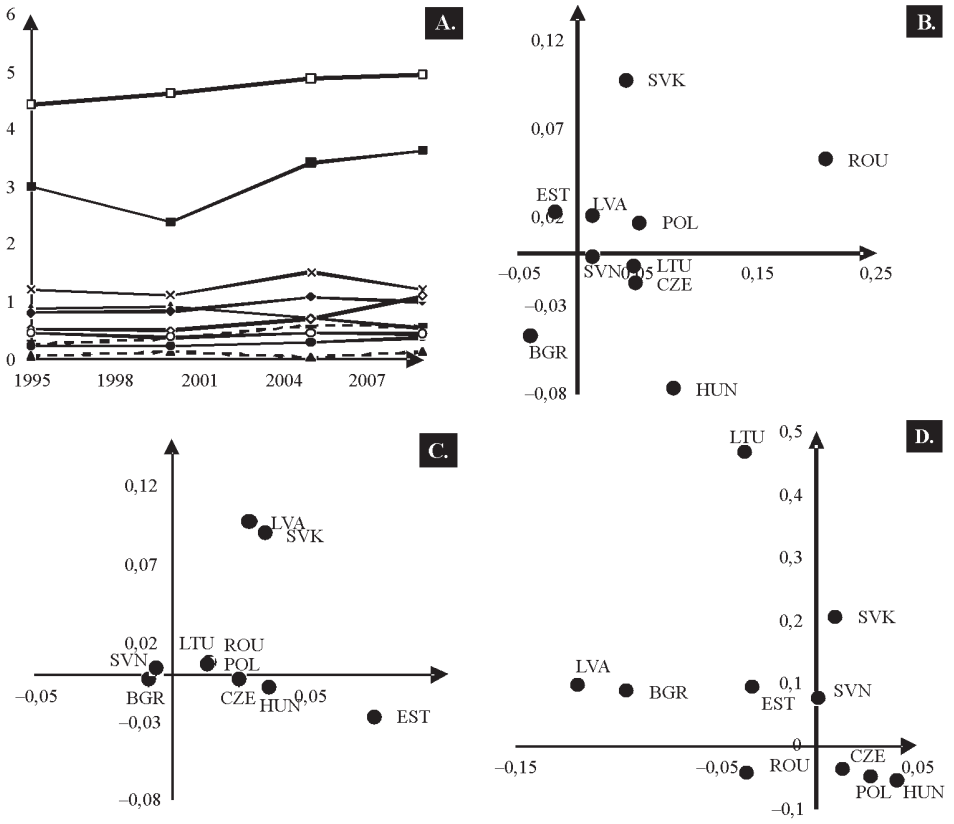

Figure 1. Share in value added and indexes of productivity and capital efficiency attributed in the sector of **Agriculture, Hunting, Forestry and Fishing** in the new EU members with respect to the EU27 total

Figure notes:

Panel **A:** Share in value added (in%) in the new EU members with respect to the EU27 total.

Legend: BGR, CZE, EST, HUN, LTU, LVA, POL, ROU, SVK, SVN

Panel **B:** Change of share in value added (in %) in the new EU members with respect to the EU27 total (horizontal axis: change in 2000–2004 period, 2004–2009: change in 2004–2009 period).

Panel **C:** Annual change of index of productivity (in %) in the new EU members with respect to the EU27 total (horizontal axis – before EU accession, vertical axis – after EU accession).

Panel **D:** Annual change of index of capital efficiency (in %) in the new EU members with respect to the EU27 total (horizontal axis – before EU accession, vertical axis – after EU accession).

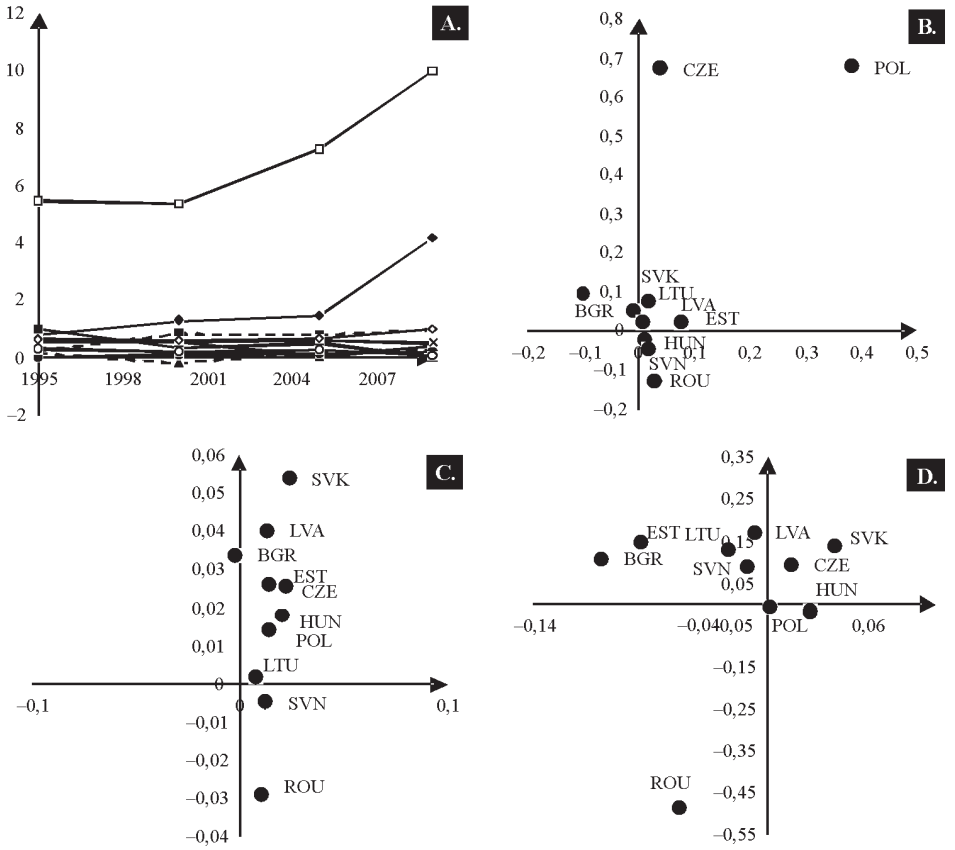

Figure 2. Share in value added and indexes of productivity and capital efficiency attributed in the sector of **Mining and Quarrying** in the new EU members with respect to the EU27 total

Figure notes:

Panel **A:** Share in value added (in%) in the new EU members with respect to the EU27 total.

Legend: BGR, CZE, EST, HUN, LTU, LVA, POL, ROU, SVK, SVN

Panel **B:** Change of share in value added (in %) in the new EU members with respect to the EU27 total (horizontal axis: change in 2000–2004 period, 2004–2009: change in 2004–2009 period).

Panel **C:** Annual change of index of productivity (in %) in the new EU members with respect to the EU27 total (horizontal axis – before EU accession, vertical axis – after EU accession).

Panel **D:** Annual change of index of capital efficiency (in %) in the new EU members with respect to the EU27 total (horizontal axis – before EU accession, vertical axis – after EU accession).

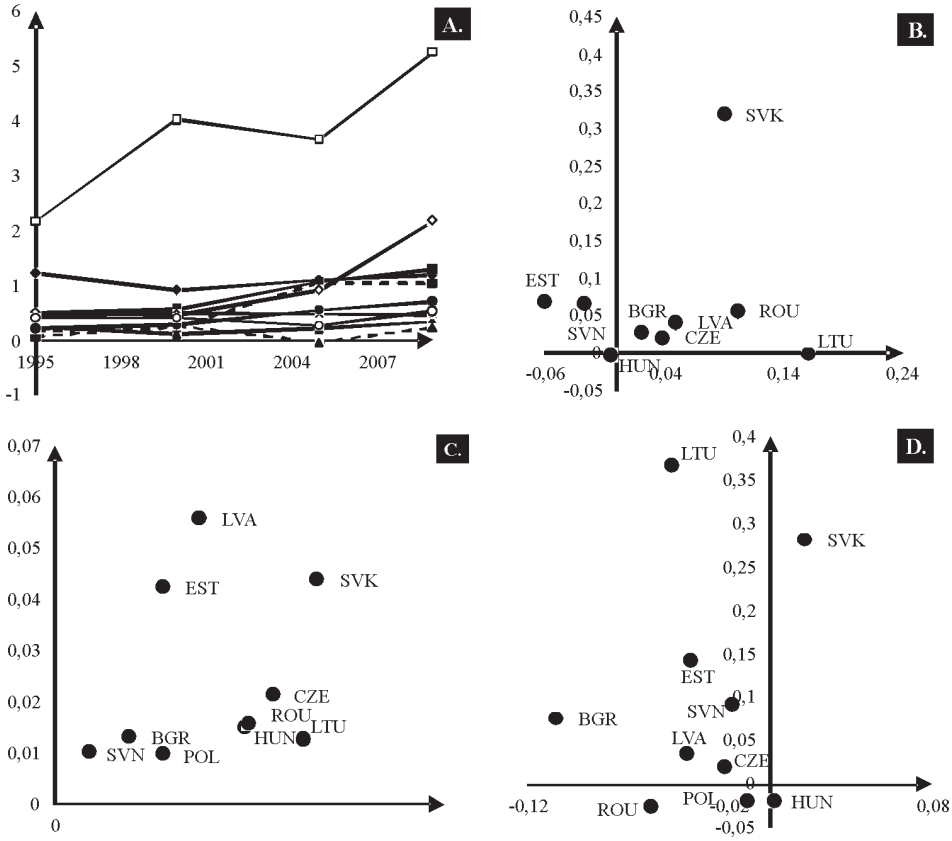

Figure 3. Share in value added and indexes of productivity and capital efficiency attributed in the sector of **Wood and Products of Wood and Cork** in the new EU members with respect to the EU27 total

Figure notes:

Panel **A:** Share in value added (in%) in the new EU members with respect to the EU27 total.

Legend: BGR, CZE, EST, HUN, LTU, LVA, POL, ROU, SVK, SVN

Panel **B:** Change of share in value added (in %) in the new EU members with respect to the EU27 total (horizontal axis: change in 2000–2004 period, 2004–2009: change in 2004–2009 period).

Panel **C:** Annual change of index of productivity (in %) in the new EU members with respect to the EU27 total (horizontal axis – before EU accession, vertical axis – after EU accession).

Panel **D:** Annual change of index of capital efficiency (in %) in the new EU members with respect to the EU27 total (horizontal axis – before EU accession, vertical axis – after EU accession).

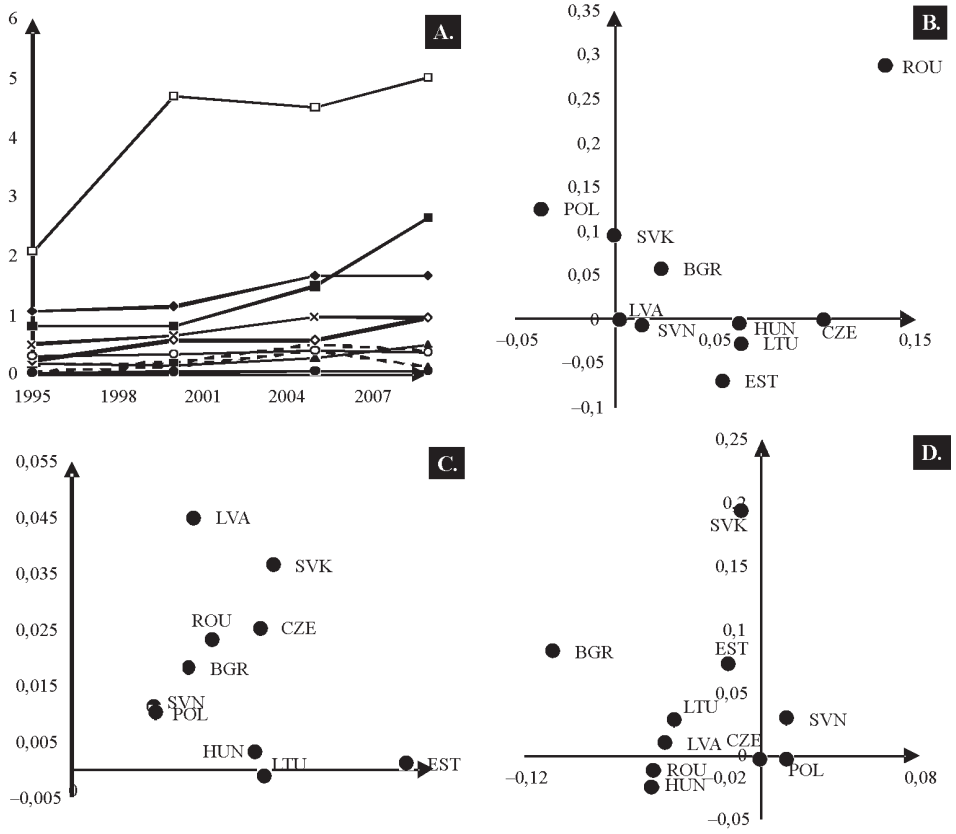

Figure 4. Share in value added and indexes of productivity and capital efficiency attributed in the sector of **Other Non-Metallic Mineral** in the new EU members with respect to the EU27 total

Figure notes:

Panel **A:** Share in value added (in%) in the new EU members with respect to the EU27 total.

Legend: BGR, CZE, EST, HUN, LTU, LVA, POL, ROU, SVK, SVN

Panel **B:** Change of share in value added (in %) in the new EU members with respect to the EU27 total (horizontal axis: change in 2000–2004 period, 2004–2009: change in 2004–2009 period).

Panel **C:** Annual change of index of productivity (in %) in the new EU members with respect to the EU27 total (horizontal axis – before EU accession, vertical axis – after EU accession).

Panel **D:** Annual change of index of capital efficiency (in %) in the new EU members with respect to the EU27 total (horizontal axis – before EU accession, vertical axis – after EU accession).

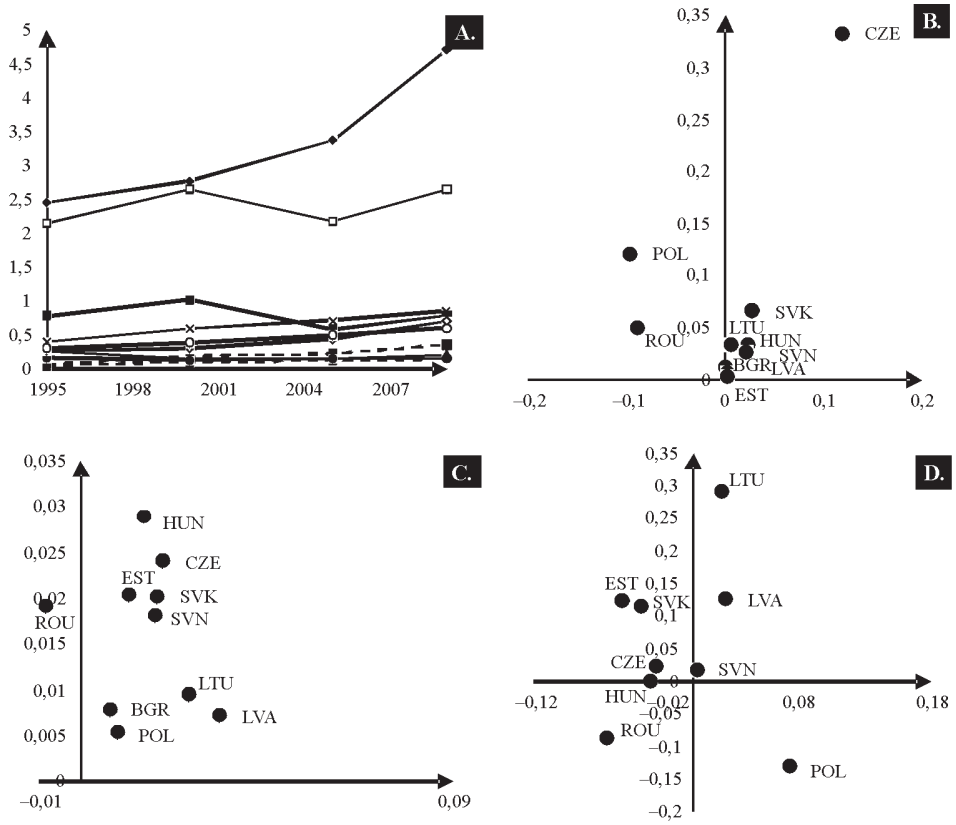

Figure 5. Share in value added and indexes of productivity and capital efficiency attributed in the sector of **Other Supporting and Auxiliary Transport Activities**, **Activities of Travel Agencies** in the new EU members with respect to the EU27 total

Figure notes:

Panel **A:** Share in value added (in%) in the new EU members with respect to the EU27 total.

Legend: BGR CZE EST HUN LTU LVA POL ROU SVK SVN

Panel **B:** Change of share in value added (in %) in the new EU members with respect to the EU27 total (horizontal axis: change in 2000–2004 period, 2004–2009: change in 2004–2009 period).

Panel **C:** Annual change of index of productivity (in %) in the new EU members with respect to the EU27 total (horizontal axis – before EU accession, vertical axis – after EU accession).

Panel **D:** Annual change of index of capital efficiency (in %) in the new EU members with respect to the EU27 total (horizontal axis – before EU accession, vertical axis – after EU accession).

6. Concluding remarks

Due to decreasing costs of communication and coordination, it has become more profitable to apply fragmentation of the production process. The stages of production are conducted at its lowest-cost locations. Knowledge about the size and future development of splitting of international production is still not extensively and sufficiently investigated in the economic literature. Some empirical papers have been concerned with cross-border fragmentation based on foreign investment flow data of firms and their affiliates. Using a decomposition technique that has recently become feasible due to the development of the World Input-Output Database, one can trace the value added by all labor and capital that is directly and indirectly used for the production of final manufacturing goods. The production systems of manufacturing goods are susceptible to a large extent to international fragmentation. The reason is that many stages of the production process can be conducted in different countries with little differences in quality yet with an essential difference in price.

Most of the previous empirical studies were dedicated to high-end electronic products and focused at one point in time. Therefore, one may ask very important questions concerning the extent to which these findings also represent more-general patterns. Another question is this: How pervasive is the process of international production fragmentation for a large number of other products? Finally, a very important research objective is the determination of specialization patterns between high-income and emerging economies that participate in these production chains.

This paper refers mostly to the abovementioned research questions. It is one of the first studies dedicated to the importance and efficiency of the CEE transition economies in the process of building a comparative advantage of the European Union in global value chains. We proposed original modifications and extensions of the recently presented methodological developments in ex-post accounting framework in global value chains in order to obtain detailed empirical results, both for the whole analyzed group of CEE economies as well as at a country-and-sector-specific level.

The empirical results show that the role of the selected CEE economies in transition in creating value added with respect to the total value added in the European Union in the GVC framework was biggest in case of the sectors related to agriculture, mining, wood products, metal production, and travel and tourism. The highest shares in the EU total GVC value added were obtained in the largest countries (e.g., Poland). We also found that, after two decades of transition, the GVC-embedded measures of workforce productivity in the ten CEE economies in 2009 were still much lower as compared to the EU average for most of the sectors. However, we found that, during this period, the growth rates of these indexes were, in general, positive. Moreover, these indexes were increasing, especially after

EU accession. The highest levels and growth rates of GVC-embedded workforce productivity were found for the smaller CEE countries.

Different conclusions arise from the analysis of the GVC-embedded indexes of capital efficiency. After two decades of transition, the measures of capital efficiency in the ten CEE economies in 2009 were comparable to the EU average for most of the sectors. Moreover, during this period, the growth rates of these indexes were, in general, positive. However, the growth rates of these indexes were dropping after EU accession. The highest levels and growth rates of indexes of capital efficiency were, once again, found for smaller CEE countries.

Despite our efforts, it is likely that some aspects of tracing the dynamics of relative GVC-embodied value added in new EU members in transition were not captured in our study. In further research on fragmentation in CEE countries, one should test whether international fragmentation is mostly regional (i.e., it is observed only within certain groups of neighboring countries and regional trade blocs) or whether it is more global (i.e., the production process also involves countries outside the region). The results of such an analysis would have significant implications for the shape of trade policies. In the case of fragmentation within regions, regional trade agreements are sufficient to create a rise in welfare from supply chain trade. In contrary to the fragmentation within the region, the global value chains would need multiregional trade agreements.

One may also claim that, for all industries, Poland seems to be the driver of the relative GVC value added due to the size effect of this economy in the group of ten CEE economies under study. At the same time, the development of Poland has been rather different from the other CEE countries examined. However, since the absolute size matters, the role of the other countries in value added creation in CEE could be partly hidden in the presentation chosen in this paper. Therefore, an interesting direction for future research would be to analyze the data for individual countries and group the industries according to characteristics such as low/medium/high-tech, etc., in order to shed some light on the differences between the CEE countries under study. It the transition period, one could list rather liberal countries like Poland, Slovenia, and Hungary, which – from a perspective of their institutions – were much closer to the Western economies than the Baltic States. Thus, it is quite likely that differences among these countries may still exist. Moreover, Bulgaria and Romania became members of the EU in 2007; therefore, there could also be some delay in the development of fragmentation process in the case of these two countries.

Special attention should be given to the mining industry. In general, the relative GVC value added in this sector in the ten CEE economies with respect to the EU27 was rising in the transition period, mostly because of the shrinking coal production and use observed in the EU15 countries caused by the shift towards

low-carbon energy sources in the richest European economies. In other words, the significant role of CEE economies in the creation of the relative GVC value added in the mining sector seems to be spurious. Thus, it seems reasonable to put more attention in future research to industries such as food, electrical and optical equipment, transport equipment and trade, or education and health & social work, which recently seem to be more important than mining for the relative GVC value added in the CEE economies in transition. This type of sector-oriented analysis could help us better understand the structural change and the importance of these industries in CEE economies and, thus, deserves considerable attention in the context of future research.

Among general directions for future research, one could also list an attempt to conduct an analogous study in a framework of dynamic input-output modeling.

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