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Vertical Specialization in Manufacturing Industry: Evidence from Central and Eastern European Countries (CEECS)

İmalat Sanayinde Dikey Uzmanlaşma: Orta ve Doğu Avrupa Ülkelerine Yönelik Bulgular

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Abstract

Since 1980 with the accelerating trends of globalization, the international fragmentation of production was one of the drastic transformations that occurred in the world economy. It is defined as the process whereby more than one country participates in previously integrated production activities (vertical specialization) involved in producing a final good. After the dissolution of the Soviet Union, the post-socialist Central and Eastern European countries (CEECs) boost their participation in global production networks. The main motivation of this paper is analyzing the extent to which the CEECs that joined the EU in 2004 (Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Slovakia, Slovenia) are involved in the global production process. Based on the World Input-Output Database (WIOD); HIY method proposed by Hummels, Ishii & Yi (2001) is applied to the national input-output tables (NIOTs) of CEECs to estimate the manufacturing industries' vertical specialization rate during 2000-2014. The results revealed that the CEECs' vertical specialization rate increased during 2000-2014 but decreased during the 2008-2009 global financial crisis. The highest rate was respectively accounted for Hungary, Slovakia, Estonia, Slovenia, Lithuania, Poland and Latvia. The countries with the highest manufacturing industry's vertical specialization were Hungary, Estonia, Slovakia, Latvia, Czech Republic, Slovenia, Poland and Lithuania, respectively. The manufacturing industries' vertical specialization rate in Estonia, Hungary, Latvia and Poland was higher than that of the entire economy. Finally, in the Czech Republic, Latvia, Lithuania and Poland; higher rates were accounted for the medium-low technology sectors, but for medium-high and high-tech sectors in Estonia, Hungary, Slovakia and Slovenia.

Jel Codes: *C67, D57, F14, F15, O14.*
Keywords: *Vertical Specialization, Manufacturing Industry, Input-Output Analysis.*

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Öz

Küreselleşme eğilimlerinin hız kazanmasıyla 1980 sonrası dönemde dünya ekonomisinde meydana gelen önemli dönüşümlerden biri de üretimin uluslararası parçalanmasıdır. Üretimin uluslararası parçalanması, bir nihai malın üretiminde birden fazla ülkenin üretim sürecinde farklı aşamalarında (dikey uzmanlaşma) farklı aşamaların yer alması ve bu süreçten katma değer sağlaması anlamına gelmektedir. Post-sosyalist ülkeler olarak tanımlanan Orta ve Doğu Avrupa (ODA) ülkeleri de özellikle Sovyetler Birliği'nin dağılmasıyla küresel üretim sürecine katılım eğilimleri artmıştır. Bu bağlamda çalışmanın teme amacı 2004 yılında AB'ye üye olana ODA ülkelerinin uluslararası üretimin parçalanma sürecine ne ölçüde katılım sağladığını analiz etmektir. Çalışmanın amacı doğrultusunda Hummels, Ishii & Yi (2001) tarafından önerilen HIY yöntemi kullanılarak analiz yapılmıştır. HIY yöntemini uygulamak için ülkelerin 2000-2014 dönemine ait ulusal girdi-çıktı tablolarından (NIOT) yararlanılmıştır. Elde edilen bulgulara göre ODA ülkelerinde dikey uzmanlaşma oranı 2008-2009 küresel finans kriz döneminde azalmakla birlikte çalışma dönemi boyunca artış gösterdiği görülmüştür. Dikey uzmanlaşma oranının en yüksek olduğu ülkeler sırasıyla Macaristan, Slovakya, Estonya, Slovenya, Litvanya, Polonya ve Letonya'dır. İmalat sanayisine yönelik yapılan analiz sonucunda elde edilen bulgulara göre dikey uzmanlaşmanın en yüksek olduğu ülkeler sırasıyla Macaristan, Estonya, Slovakya, Letonya, Çek Cumhuriyeti, Slovenya, Polonya ve Litvanya'dır. Ayrıca Estonya, Macaristan, Letonya ve Polonya'da imalat sanayisindeki dikey uzmanlaşma oranı toplam ekonomideki dikey uzmanlaşma oranından daha yüksektir. Son olarak dikey uzmanlaşma Çek Cumhuriyeti, Letonya, Litvanya ve Polonya'da orta-düşük teknolojili sektörlerde daha yüksek iken, Estonya, Macaristan, Slovakya ve Slovenya'da ise orta-yüksek ve yüksek teknolojili sektörlerde daha yüksektir.

Jel Kodları: *C67, D57, F14, F15, O14*.
Anahtar Kelimeler: *Dikey Uzmanlaşma, İmalat Sanayi, Girdi-Çıktı Analizi.*

1. Introduction

Since the 1980s, the increasing participation in the fragmentation of the production process inevitably strengthens the international integration which links the processes of production in a cross-border vertical chain. One aspect of the vertical connections is the vertical specialization in which each country specializes in a particular stage of production rather than producing a certain good (Ambroziak, 2018: 2) to deal with the dramatic changes in the nature of international trade (Kaplan, Kohl & Martínez-Zarzoso, 2017: 481). The development of the processes aimed to facilitate production improves countries' and companies' access to the global markets (Vrh, 2017: 406). By the 2000s, the internationally integrated response to the changing trade structure was imperative. Accordingly, the structure of the global trade evolved and affected the competitive structure of the countries by promoting the trade of not only final goods but also the intermediate ones (Soyyiğit, 2019: 377). The technological developments that provide low-cost and especially developments in information and communication technologies (ICT) have been considered as the main engine stimulating the fragmentation of the production process. The technological developments open up new ways of industrialization and enable complex production activities to be remotely accessed and

controlled (Vrh, 2017: 407-409; Olczyk & Kordalska, 2017: 91). Thus, today's international trade is increasingly determined by an internationally organized production process (Cieślik, Biegańska & Środa-Murawska, 2021: 3587). The evolution of international trade is accompanied by transforming the production from the advanced economics to some developing countries such as ones of Central and Eastern Europe (CEE) which produced an intense industrialization structure to adapt to the experienced change (Gerőcs & Pinkasz, 2019: 172). The CEE countries, known as post-socialist countries, maintained the centralized command economy during the period between World War I and the late 1980s (Cieślik, Biegańska & Środa-Murawska, 2021: 3589). However, in the aftermath of the dissolution of the Soviet Union, those countries began to replace the centralized command economy with a market-oriented system (Soyyigit, 2019: 378). The experienced economic and political transformation besides their immunity to globalization's effect enabled the CEE countries to join the EU in the middle of the 21st century (Cieślik, Biegańska & Środa-Murawska, 2021: 3589). Moreover, they play more active role in the global production chains since the early 1990s (Cieślik, Biegańska & Środa-Murawska, 2016: 467; Ambroziak, 2018: 2; Szymczak, Parteka & Wolszczak-Derlacz, 2022: 2). Based on their comparative advantages especially in the manufacturing industries, the CEE countries became more specialized in labor-intensive and resource-intensive sectors (Kaplan, Kohl & Martínez-Zarzoso, 2017: 483; Cieślik, Biegańska & Środa-Murawska,2021: 3589). To adapt to the market conditions, the CEE countries offered companies with low wages, flexible working, tax incentives and production sites (Gerőcs & Pinkasz, 2019: 172). Olczyk & Kordalska (2017: 92) state that one of the important gains of the supplied strategies was the greater participation in the global production process accounted for CEE countries compared with the European ones. Stojčić and Aralica (2018: 2) and Cieślik, Biegańska & Środa-Murawska (2021: 3589) attribute the CEE countries' adaption to the global markets for more than 25 years to the implications of the policies which depend upon building market institutions, macroeconomic stabilization, structural reforms policy packages and privatization. In this context, the main motivation question of this study is to analyze the extent to which the CEE countries (Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Slovakia, Slovenia) that joined the EU in 2004 participate in the global production process. Based on the World Input-Output Database (WIOD); the national input-output tables (NIOTs) of these countries are utilized to estimate the vertical specialization rate in manufacturing industries during the period from 2000 to 2014. HIY method proposed by Hummels, Ishii & Yi (2001) is employed for the reason that input-output models are more suitable for estimating the vertical specialization ratio (Hummels, Ishii & Yi, 2001: 78-81). With this respect, this paper derives its value methodologically and empirically due to the limited number of up-to-date studies investigated in CEE countries and especially in manufacturing industries. This work is made up of four sections. The first section includes the introductory part in which the general features of the global production process and the developments linked to the participation of CEE countries in it are summarized. In the second section literature review and theoretical framework are structured. The third section includes data, methodology and findings. The fourth section is about evaluating the results and conclusion.

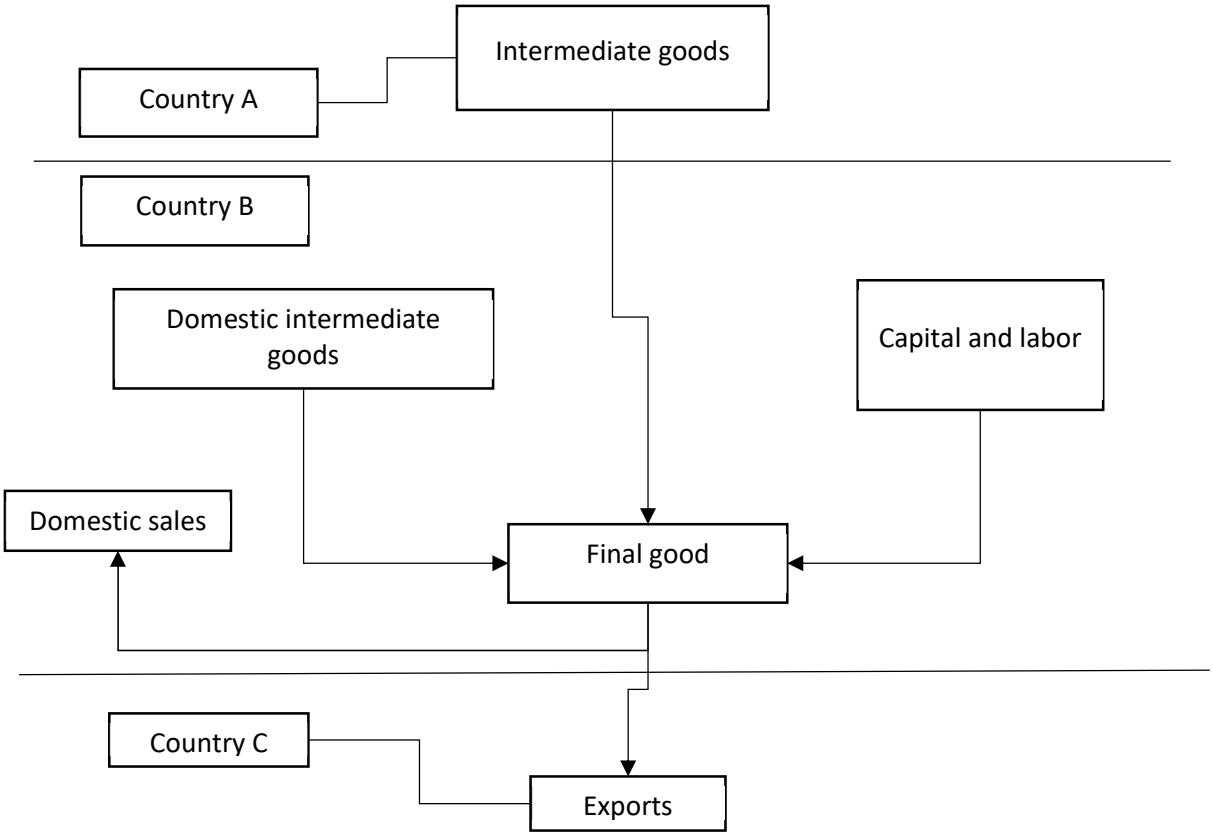
2. Literature Review and Theoretical Framework

One of the significant features of globalization is increasing the share of imports and exports in gross domestic product. The post-1980 period marked acceleration of globalization trends mirrored the effectiveness of export promotion policies which integrated the economics into the global economy (Hummels, Rapoport & Yi, 1998: 79-80). Many countries are related in a vertical trading chain by which each country specializes in particular stages of production. This process is known as a vertical specialization which is based on importing intermediate products and services to be produced for export. The production process will be completed once the final good reaches the destination country. Vertical specialization has also been labelled employing a set of different terms such as outsourcing, the disintegration of production, multi-stage production, intra-product specialization (Hummels, Ishii & Yi, 2001: 75-76).

The basic rationale behind vertical specialization is fragmenting the production processes via outsourcing the production stages until a good takes its final shape. To phrase it differently, it relies on importing the intermediate goods to produce them for export. Three basic conditions should be met for vertical specialization. The first one is that certain good passes through two or more sequential stages. Secondly, two or more countries must add value to the production process of this good. Finally, at least one country should use imported intermediate inputs in its production process and export some of the output (Hummels, Rapoport & Yi, 1998: 80; Hummels, Ishii & Yi, 2001: 78). Consequently, vertical specialization emerges once imported intermediate inputs are employed in any country's production process for export purposes. If the output obtained from utilizing imported intermediate supplies is not exported, then these imported intermediate inputs cannot be involved in the vertical specialization-based trade (Dağıstan, 2019: 5). The vertical specialization has an import aspect as well as an export one. While the import side represents the intermediate goods trade, the export side includes both intermediate and final goods. Moreover, while all intermediate goods' trade is compatible with the first and second conditions of vertical specialization, only the imported intermediate goods which are then exported are compatible with the third condition of it. (Hummels, Ishii & Yi, 2001: 77).

Figure 1 depicts the vertical specialization process formulated by Hummels, Rapoport & Yi (1998) and Hummels, Ishii & Yi (2001). It shows three different countries. The key country is country B. It combines the intermediate inputs imported from country A with labor, capital and domestically produced intermediate goods to produce either a final product or another intermediate input in the production chain. Afterwards, it exports some of its production to country C. No vertical specialization if either the imported intermediate inputs or exports are non-existent.

Figure 1: Vertical Specialization



Source: Hummels, Rapoport & Yi, 1998: 82; Hummels, Ishii & Yi, 2001: 78.

In the literature, I-O tables are generally utilized to estimate the rate of vertical specialization. I-O tables provide important data about domestic and foreign inputs, value-added, gross output and sectoral level exports (Hummels, Ishii & Yi, 2001: 80). One major advantage of I-O tables is that they offer information on the usage of products instead of rather arbitrary categorization schemes. This ensures the correct estimation of the imported intermediate inputs in sectoral production. Moreover, I-O tables are appropriate for calculating the vertical specialization on a sectoral base. Furthermore, I-O tables better reflect the complex relationships between sectors. Therefore, it is a good method for calculating vertical specialization (Duan et al., 2018: 180-181; Dağıstan, 2019: 9). The works of Hummels, Ishii & Yi (1998; 2001) became the pioneering researches on vertical specialization exposure literature. Hummels, Ishii & Yi (1998) state that the economics around the world are becoming increasingly globalized and integrated through increasing their exports and imports as share of GDP. They emphasized the doubling of the commodities' exports and the quadrupling of those of manufactured goods all around the world to mirror the process of the production internationalization. They captured the extent to which the G7 countries besides Australia, Denmark and the Netherlands participated in the change of international trade. The results revealed that during the period from 1968 to 1990, the vertical specialization had significantly grown in all the studied countries except for Japan. Furthermore, the authors attributed the international fragmentation of the production process and the growing integration to the

worldwide increasing production the matter that leads in this case to increase the international trade. The second significant pioneering work is that by Hummels, Ishii & Yi (2001) which is a theoretically extension of the previous study in 1998. Unlike to the previous study, Hummels, Ishii & Yi (2001) estimated the vertical specialization for 10 OECD and four emerging economics. The findings were similar to those of the previous study. It is observed that during the period from 1970 to 1990, the participation of the analyzed countries in the fragmentation of the production process had increased significantly. The vertical specialization rate in 14 countries increased from 0,165 in 1970 to 0,211 in 1990. The results revealed also that the vertical specialization has increased by about 28% over 20 years. Following the studies of Hummels, Ishii & Yi (1998; 2001), various studies in the empirical literature have been concerned about the vertical specialization for different countries or country groups. Similar findings for USA were found in Chen, Kondratowicz & Yi (2005) study. However, the results revealed that the vertical specialization rate in Japan and Denmark decreased during the period from 1968 to 1990. The results revealed that the vertical specialization rate was higher in small countries such as Denmark and the Netherlands compared with the large ones such as the USA, Japan and Australia. Another study for a different and wider group of countries conducted by Amador & Cabral (2009). The difference between this study and the previous ones is the product-based calculations of vertical specialization for sub-sectors. Furthermore, unlike to Hummels, Ishii & Yi (1998, 2001), Chen, Kondratowicz & Yi (2005) include some developing countries in their analyses such as: Malaysia, Philippines, Singapore, Taiwan, China, South Korea, Hong Kong, Ireland, Thailand and Hungary. The results showed a similar trend with literature, that is the vertical specialization increased during the period from 1967 to 2005. Furthermore, the results revealed that since the 1980s, the vertical specialization in high-tech products, especially in radio, TV and communication equipment, has increased significantly and continuously. Moreover, the results revealed that the vertical specialization increased in East Asia, especially in industrializing economies. The results supported the arguments that the ICTs has gained importance since the 1980s and that the industrial production shifted to Asian countries. The growth in the Chinese economy played a prominent role in the global economy. With this respect, Dean, Fung & Wang (2011) demonstrated that the vertical specialization has increased significantly in China from 18% in 1997 to 25% in 2002. Furthermore, the results revealed that the technology-intensive sectors recorded higher vertical specialization rate comparing with the rest sectors in the Chinese economy. Yang et al. (2015) continued to report similar results. The results revealed that the vertical specialization rate increased from 16% in 1995 to 25% in 2005. Amador, Cappariello & Stehrer (2015) postulated that the participation of euro area countries in global production process grew significantly especially after the creation of the Monetary Union. The results are similar to those mentioned above. The rate of the vertical specialization in 2011 was 21% for the Eurozone and 22% for China. However, the vertical specialization decreased in the major economies such as the USA, Japan and China during the period from 2007 to 2009. Similarly, Yu & Luo (2018) estimated the vertical specialization for a large group of countries. Furthermore, they shed light on the manufacturing sector. The obtained results are similar to those of the previous studies. However, the results of the manufacturing industries were different. The rate of the vertical specialization was higher in the manufacturing industries. In 2011, the country with the lowest

manufacturing industry's vertical specialization is Japan and that with the highest one is India. In general, the country with the lowest vertical specialization is Brazil but that with the highest one is South Korea.

Constantinescu, Mattoo & Ruta (2019) reported that the tendency to participate in the global production networks has increased during the period from 1995 to 2014. The results revealed that the rate of the vertical specialization decreased after 2000 but recovered after the 2009 financial crisis. These results, especially that of the decline of vertical specialization rate in 2009, had been supported by Amador, Cappariello & Stehrer (2015). However, Constantinescu, Mattoo & Ruta (2019) reported that the vertical specialization of the manufacturing industry was approximately equal to that of the entire economy in 2014. Padilla et al. (2019) emphasized that on regional basis the vertical specialization had grown worldwide during the period from 1997 to 2012. The results revealed that its rate was 31% in East Asia, 28% in NAFTA and 45% in the EU. Unlike previous studies, Lamonica, Salvati & Carlucci (2020) emphasize that the vertical specialization does not show a similar trend in a sample of 40 countries. The results revealed that the rate of the vertical specialization remained stable in Bulgaria, Cyprus, Indonesia. Moreover, it decreased in Canada, Estonia, Malta, Portugal and Russia. Furthermore, it increased in the remaining countries. Similar to the other studies, Lamonica, Salvati & Carlucci (2020) reported that the rate of the vertical specialization was affected by the 2009 financial crisis. Purwono et al. (2020) supported the result obtained by Lamonica, Salvati & Carlucci (2020) that the vertical specialization in Indonesia followed an almost constant trend during the period from 1995 to 2015. The results revealed that it was equivalent to 12% in 1995, 12.8% in 2011 and 12.9% in 2015. They stated that vertical specialization in the Indonesian manufacturing industry declined from 19.3% in 1995 to 17.6% in 2015. Purwono et al. (2020) supported the result obtained by the previous studies that the manufacturing industries' sub-sectors achieved higher rates of vertical specialization compared with the entire economy. Neumann & Tabrizy (2021) reported that the vertical specialization of the five Asian countries (China, Indonesia, Japan, South Korea, and Malaysia) that played an important role in global exports, grew during the period from 2001 to 2015. Moreover, they stated that the rate of the vertical specialization was higher in the high-tech products.

Small number of studies had been carried out for CEE countries. Recently, Cieślik (2014) presents the transformations of economy and the foreign trade of post-socialist countries. With this respect, those countries have become deeply integrated with the global markets especially with the EU market. Cieślik (2014) supported this argument by proving that the vertical specialization in Czech Republic, Latvia, Lithuania and Poland had increased during the period from 2000 to 2009. For CEE10[3] countries, Similar results to Cieślik (2014) were found by Cieślik, Biegańska & Środa-Murawska (2016). However, the results revealed that the participation rate in the global production networks differs between CEE10 countries. Whereas the rate of vertical specialization decreased in Estonia, Hungary, Slovakia, Bulgaria and Romania during the period from 2000 to 2009, it increased in Poland, Latvia and Lithuania at the same period. Unlike to other studies, Cieślik, Biegańska & Środa-Murawska (2016)

[3] Czech Republic, Estonia, Hungry, Poland, Slovakia, Slovakia, Bulgaria, Latvia, Lithuania, Romania

reported that vertical specialization in transportation and electronic equipment is higher in CEE countries. Vrh (2017) postulated that all CEE10 countries increased their participation in the global production process, being more evident in the manufacturing industry. Olczyk & Kordalska (2017) emphasized that during the period from 1995 to 2011 the vertical specialization rate increased in all the CEE countries except for Estonia. Poland and Hungary have shown more intense participation in the global production process than the other countries. Moreover, the results revealed that the medium-high and high-tech sectors' foreign value-added share had increased in Poland, Hungary, the Czech Republic and Slovakia. Ambroziak (2018) reported that among the CEE countries the participation rate of the Czech Republic, Hungary and Slovakia in the global production process exceeded 65% while it was around 55% in Poland and Slovenia. Likewise, Ambroziak (2011) emphasized that the participation of CEE countries in the global production process had grown during the period from 1995 to 2011. Unlike previous studies, Cieślik, Biegańska & Środa-Murawska (2021) and Kordalska & Olczyk (2021) conducted an empirical analysis for the period 2000-2014. Cieślik, Biegańska & Środa-Murawska (2021) reported that the highest rate of vertical specialization during the studied period accounted for Czech Republic and Poland. Furthermore, a strong decrease in the vertical specialization had been observed in Estonia and Lithuania. In general, the participation of the CEE countries in the global production network is still low and has a slow rate of growth. Kordalska & Olczyk (2021) reported that the CEE countries' participation in the global production network had grown especially in the transportation sectors and scientific and technical activities. During the period of 2000-2014, the Czech Republic increased its participation in the global production network by strengthening the link between the financial sector and the manufacturing industry. However, Poland, Hungary and Slovakia increased its participation in the global production network by strengthening the link between the manufacturing and competitive transportation services. As a result of the literature review, it had been thought that this paper would constitute a contribution to the literature since that there are limited studies on vertical specialization in CEE countries from one side and from another side the period that covered by most of those studies is not up-to-date.

3. Data, Methodology and Results

Based on the World Input-Output Database (WIOD); the national Input-Output Tables (NIOTs) of the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Slovakia and Slovenia countries are utilized. The database offers two different versions of I-O tables: the version for the year 2013 which classified the economic sectors according to ISIC Rev.3 and that for 2016 which classified them according to ISIC Rev.4. The first version is disaggregated into 35 sub-sectors during the period from 1995 to 2011. The second one is disaggregated into 56 sub-sectors during the period from 2000 to 2014. In this paper, the version for the year 2016 which classified the economic sectors according to ISIC Rev.4 had been utilized. The HIY method proposed by Hummels, Ishii and Yi (2001) was employed to estimate the vertical specialization rate in manufacturing industries for the Eastern European countries. Vertical specialization occurs once the country uses the imported intermediate inputs to produce other goods for

export. Therefore, the extent to which a country is involved as a part of the vertical specialization chain can be captured by calculating how much imported intermediate inputs are used in the production process of exporting products (Hummels, Rapoport & Yi, 1998: 81-82; Hummels, Ishii & Yi, 2001: 78; Dagistan, 2019: 8). The input-output model presented in equation (1) assumes that an economy consists of ***n*** sectors (Yang et al., 2015: 52-63; Liu et al., 2018: 692-693; Yin & Liu, 2019: 453).

$$\begin{bmatrix} x_1 \\ \vdots \\ x_n \end{bmatrix} \text{x} \begin{bmatrix} a_{11} & \cdots & a_{1n} \\ \vdots & \ddots & \vdots \\ a_{n1} & \cdots & a_{nn} \end{bmatrix} + \begin{bmatrix} f_1 \\ \vdots \\ f_n \end{bmatrix} = \begin{bmatrix} x_1 \\ \vdots \\ x_n \end{bmatrix} \qquad \textbf{(1)}$$

A summary notation for equation (1) is:

$$\boldsymbol{X} . \boldsymbol{A^d} + \boldsymbol{F} = \boldsymbol{X} \qquad \textbf{(2)}$$

To obtain equation (3), we need to isolate the ***X*** variable

$$\boldsymbol{X} = \left(\boldsymbol{I} - \boldsymbol{A^d}\right) + \boldsymbol{F}; \boldsymbol{X} - \boldsymbol{X}.\boldsymbol{A^d} = \boldsymbol{F}; \boldsymbol{X}.\left(\boldsymbol{I} - \boldsymbol{A^d}\right) = \boldsymbol{F} \qquad \textbf{(3)}$$

Equation (3) symbolizes the equilibrium level of output in an economy consisting of ***n*** sectors (Miller & Blair, 2009: 11-15; Aydoğuş, 2010: 49-52).

Where **X** ***nx1*** denotes the output vector, **A** ***nxn*** represents the matrix of technical coefficients, **I** ***nxn*** represents the identity matrix, **F** ***nx1*** denotes the final demand vector and (**I-A^d*) nxn*** represents the Leontief inverse matrix. The technical coefficients matrix **(A)** is made up of the sum of the domestic technical coefficients matrix **(A^d)** and the imported coefficient matrix **(A^m)**. It can be written as follows (Dean, Fung & Wang, 2011: 611; Yin & Liu, 2019: 453-454):

$$\boldsymbol{A} = \boldsymbol{A^d} + \boldsymbol{A^m} \qquad \textbf{(4)}$$

Using the equations derived above, the sectoral vertical specialization rates in an economy can be estimated utilizing the HIY method proposed by Hummels, Ishii & Yi (2001) (Hummels, Ishii & Yi, 2001: 78-82; Dean, Fung & Wang, 2008: 5; Duan et al., 2018: 181-182 Lamonica, Salvati & Carlucci, 2020: 18-20):

$$\boldsymbol{VS_d} = [\mathbf{1} \; . \; . \; . \; \mathbf{1}] . \begin{bmatrix} a_{11}^m & \cdots & a_{1n}^m \\ \vdots & \ddots & \vdots \\ a_{n1}^m & \cdots & a_{nn}^m \end{bmatrix} . \begin{bmatrix} x_1 \\ \vdots \\ x_n \end{bmatrix} / X_k \qquad \textbf{(5)}$$

If we condense equation (5) to matrix notation, then equation (6) will be obtained:

$$\boldsymbol{VS_d} = \mathbf{u}.\boldsymbol{A^m}.\boldsymbol{X}/\boldsymbol{X_k} \qquad \textbf{(6)}$$

Where, **u** ***1xn***, **A^m** ***nxn*** represents the imported coefficient matrix, **X** ***nx1*** is the vector of exports and **X$_k$** is the country's total exports.

Equation (6) expresses the rate of direct imported intermediate input used in the production process of exporting goods. However, in any economy, the indirect imported intermediate inputs are also employed in the production process of exporting products. The output obtained from using imported intermediate input can be used as an intermediate input to any sector of the economy. Put otherwise, the exporting outputs are those produced by any sector using imported intermediate input and could be used as an intermediate input to a second or

even a third sector. Therefore, the exporting products are used indirectly as an imported intermediate input in the production process. Meanwhile, imported intermediate inputs can be used in different stages of the production process of exporting goods. The I-O tables enable estimating the imported inputs used for export purposes indirectly and directly. By measuring direct and indirect imported intermediate inputs, any sector's vertical specialization rate could be obtained. Leontief inverse matrix ***(I-A^d)*** is utilized to calculate the total vertical specialization rate. The total vertical specialization rate of an economy or any sector could be obtained as follows (Hummels, Rapoport & Yi, 1998: 96; Hummels, Ishii, & Yi, 2001: 78-82; Sharma & Wei, 2014: 290; Duan et al., 2018: 181-182; Dağıstan, 2019: 8-10)

$$VS_t = [1 \; . \; . \; . \; 1] \cdot \begin{bmatrix} a_{11}^m & \cdots & a_{1n}^m \\ \vdots & \ddots & \vdots \\ a_{n1}^m & \cdots & a_{nn}^m \end{bmatrix} \cdot \begin{bmatrix} l_{11} & \cdots & l_{1n} \\ \vdots & \ddots & \vdots \\ l_{n1} & \cdots & l_n \end{bmatrix} \cdot \begin{bmatrix} x_1 \\ \vdots \\ x_n \end{bmatrix} / X_k \qquad (7)$$

If we condense equation (7) to matrix notation, then equation (8) will be obtained:

$$VS_t = u.\ A^m.\left(I - A^d\right).X\ /X_k \qquad (8)$$

Where u ***1xn*** denotes the summation vector, A^m ***nxn*** is the import coefficients matrix, $\left(I - A^d\right)$ **nxn** is Leontief inverse matrix, X ***nx1*** denotes the vector of exports and X_k is the country's total exports. Equation (8) shows not only the vertical specialization rate but also the rate of the import intermediate inputs produced for exporting (Egger & Egger, 2005, 148).

3.1. Results

Table 1, Table 1 and Table 3 show the results of vertical specialization using the national input-output tables (NIOTs) of CEE countries. The vertical specialization rate had been calculated for the total economy, manufacturing industry and its sub-sectors. Table 1 depicts vertical specialization rate in the manufacturing industry and total economy in the countries that joined the EU in 2004. During the period from 2000 to 2014, the entire economy's average vertical specialization rate was equivalent to 39.59% in the Czech Republic, 38.88% in Estonia, 49.20% in Hungary, 27.49% in Latvia, 30.82% in Lithuania, 28.88% in Poland, 45.44% in Slovakia, 35.78% in Slovenia. In 2000, the vertical specialization rate was 31.51% in the Czech Republic, 35.54% in Estonia, 47.78% in Hungary, 23.92% in Latvia, 23.06% in Lithuania, 24.70% in Poland, 38.31% in Slovakia and 33.04% in Slovenia. In 2014, the vertical specialization rate in CEE countries was 45.98% in Czech Republic, 38.88% in Estonia, 49.20% in Hungary, 27.49% in Latvia, 30.82% in Lithuania, 28.88% in Poland, 45.44% in Slovakia and 35.78% in Slovenia. During the studied period, the country with the highest vertical specialization rate was Hungary; but Latvia was the country with the lowest one. Table 1 shows that the vertical specialization rate had decreased in all countries during the 2008-2009 financial crisis. However, a rapid increase in CEE countries' vertical specialization had been observed after the period of 2003-2004.

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Doi: 10.25295/fsecon.1069470

Table 1: Vertical Specialization Rates, 2000-2014 (%)[4]

		2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	Av.
Czech Republic	VSt	31.51	32.29	32.52	33.84	37.94	39.47	40.74	41.56	40.70	39.19	42.86	44.53	45.41	45.28	45.98	***39.59***
	VSm.	33.33	33.88	31.78	34.76	37.86	38.34	38.79	40.74	39.07	38.41	40.89	41.92	42.20	42.29	43.14	***38.49***
Estonia	VSt	35.54	35.53	35.61	34.56	36.20	37.96	38.87	37.87	38.81	34.75	40.46	43.95	45.16	44.50	43.45	***38.88***
	VSm.	43.89	42.42	40.60	40.93	44.16	46.47	47.30	46.58	48.91	44.65	48.54	52.58	55.09	53.97	53.20	***47.29***
Hungary	VSt	47.78	45.83	44.47	45.64	46.83	47.55	51.01	50.89	51.01	47.72	51.46	52.63	52.10	51.20	51.87	***49.20***
	VSm.	53.87	51.76	48.17	49.07	48.57	47.40	52.39	51.88	51.79	49.09	51.23	51.54	50.34	49.79	50.82	***50.51***
Latvia	VSt	23.92	24.55	23.39	24.19	26.18	26.57	28.87	28.15	27.39	24.48	28.49	30.90	32.79	31.43	31.02	***27.49***
	VSm.	35.15	37.20	33.75	34.07	35.04	37.22	42.34	42.35	43.46	39.36	41.40	43.44	45.64	43.72	44.24	***39.89***
Lithuania	VSt	23.06	25.24	23.07	24.31	28.06	31.54	32.82	29.17	36.12	29.42	33.63	37.02	36.33	36.77	35.71	***30.82***
	VSm.	18.62	19.31	19.18	20.74	19.41	20.09	24.24	29.08	25.84	24.05	23.90	24.31	24.93	26.36	26.37	***23.10***
Poland	VSt	24.70	23.75	24.93	27.38	27.82	27.43	30.14	31.04	31.30	27.65	31.00	32.61	31.53	30.91	30.96	***28.88***
	VSm.	24.98	23.72	25.36	26.96	27.50	26.32	29.29	31.05	30.21	30.06	35.36	35.68	34.18	34.02	34.90	***29.97***
Slovak Republic	VSt	38.31	39.13	39.83	41.76	43.52	44.66	47.77	47.97	46.67	46.67	47.82	51.42	49.42	48.52	48.14	***45.44***
	VSm.	35.24	37.19	38.22	40.28	42.17	43.68	47.26	48.64	47.63	48.97	47.28	48.07	51.52	52.39	53.19	***45.45***
Slovenia	VSt	33.04	32.49	31.62	31.66	34.10	36.35	37.51	38.22	37.17	34.13	37.57	39.02	38.72	37.68	37.37	***35.78***
	VSm.	29.40	28.93	28.78	29.04	32.04	34.82	36.19	37.97	38.03	35.41	37.85	39.20	38.46	37.68	38.14	***34.80***

Source: Authors' calculations based on I-O tables.

At the same time, Table 1 depicts the vertical specialization rate in the manufacturing industry sector of CEE countries. During the period from 2000 to 2014, the manufacturing industry's average vertical specialization rate was equivalent to 38.49% in the Czech Republic, 47.29% in Estonia, 50.51% in Hungary, 39.89% in Latvia, 23.10% in Lithuania, 29.97% in Poland, 45.45% in Slovakia and 34.80% in Slovenia. The results revealed that the country with the highest vertical specialization in the manufacturing industry is Hungary, but the country with the lowest one is Lithuania. In 2000, the vertical specialization rate in the manufacturing industry sector was equivalent to 33.33% in the Czech Republic, 43.89% in Estonia, 53.87% in Hungary, 35.15% in Latvia, 18.62% in Lithuania, 24.98% in Poland, 35.24% in Slovakia and 29.40% in Slovenia. In 2014, the vertical specialization rate was equivalent to 43.14% in Czech Republic, 53.20% in Estonia, 50.82% in Hungary, 44.24% in Latvia, 26.37% in Lithuania, 34.90% in Poland, 53.19% in Slovakia and 38.14% in Slovenia.

When comparing the vertical specialization rate between manufacturing industry and the entire economy during the 2000-2014 period, we found that the manufacturing industry's vertical specialization rate in Estonia, Hungary, Latvia, Poland and Slovakia was higher than the vertical specialization rate in the entire economy, while the opposite was observed in the Czech Republic, Lithuania and Slovenia. Furthermore, it is observed that the vertical specialization rate in the manufacturing industry sector of all CEE countries (except for Hungary) increased during the period of 2000-2014 as shown in Table 1.

Table 2 shows the vertical specialization rates in the sub-sectors of the manufacturing industry in the Czech Republic, Estonia, Hungary, and Latvia. In the Czech Republic, the manufacture of

[4] VS_t: Total vertical specialization rate, VS_m: Manufacturing industry's vertical specialization rate.

coke and refined petroleum products (C19) has a high vertical specialization rate increased from 56.29% in 2000 to 70.44% in 2014. The sub-sector of computer, electronic and optical products manufacturing (C26) has also a high vertical specialization rate equivalent in average to 60.80% during the period from 2000 to 2014. The manufacture of food, beverages and tobacco products (C10-C12) had the lowest average vertical specialization rate which increased from 20.81% in 2000 to 29.72% in 2014. The repair and installation of machinery and equipment (C33), classified as medium-high and high technology manufacturing, had a low vertical specialization rate increased from 22.90% in 2000 to 30.262% in 2014. The medium-low technology manufacturing in the Czech Republic had generally a higher vertical specialization rate compared with low-tech ones.

In Estonia, computer, electronic and optical products manufacturing (C26) had the highest average vertical specialization rate equivalent to 63.96% during the period of 2000-2014. The rate of vertical specialization in computer, electronic and optical products manufacturing increased from 50.94% in 2000 to 78.59% in 2014. The manufacture of basic metals (C24) had also a high average vertical specialization rate which increased from 64.71% in 2000 to 66.63% in 2014. Manufacture of coke and refined petroleum products (C19) had the lowest average vertical specialization rate which decreased from 42.36% in 2000 to 28.26% in 2014. Manufacture of wood and products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials (C16), had also a low average vertical specialization rate which increased from 30.92% in 2000 to 35.39% in 2014. The vertical specialization rate in the Estonian manufacturing industry has decreased significantly in coke and refined petroleum products manufacturing. The vertical specialization rate of the Estonian manufacturing industry is in general higher in the medium-high and high-tech manufacturing industry.

In Hungary, during the period of 2000-2014, the manufacture of computer, electronic and optical products (C26) had a high average vertical specialization rate equivalent to 71.65%. The rate of vertical specialization in computer, electronic and optical products was 72.20% in 2000 and 72.54% in 2014. Manufacture of motor vehicles, trailers and semi-trailers (C29) had also a high average vertical specialization rate. The vertical specialization rate in this sub-sector increased from 61.40% in 2000 to 69.96% in 2014. Manufacture of chemicals and chemical products (C20) and the manufacture of food products, beverages and tobacco products (C10-C12) had the lowest average vertical specialization rate. The vertical specialization rate in the former increased from 47.54% in 2000 to 59% in 2014. It also increased in the latter from 30.93% in 2000 to 37.57% in 2014. Except for the repair and installation of machinery and equipment (C33), the vertical specialization rate tended to increase in all the Hungarian manufacturing industries.

Between the Latvian manufacturing industries, the manufacture of basic metals (C24) and the manufacture of rubber and plastic products (C22) respectively had the highest average vertical specialization rate which increased in the former from 44.21% in 2000 to 63.82% in 2014; and increased in the latter from 47.56% in 2000 to 52.28% in 2014. The average vertical specialization rate was 53.35% during the period from 2000 to 2014. In the rubber and plastic products' manufacturing sub-sector (C22), the vertical specialization rate increased from 47.56% in 2000 to 52.28% in 2014. The average vertical specialization rate in this sub-sector

during the period of 2000-2014 was 50.93%. Manufacture of basic pharmaceutical products and pharmaceutical preparations (C21) and manufacture of coke and refined petroleum products (C19) respectively had the lowest average vertical specialization rate which decreased in the former from 21.55% in 2000 to 15.77% in 2014 and from 29.40% in 2000 to 28.41% in 2014 in the latter. During the period from 2000 to 2014, the average vertical specialization rate in the former was 19.97% and 23.15% in the latter. The vertical specialization only in the manufacturing of basic pharmaceutical products and pharmaceutical preparations (C21) decreased significantly compared with other sectors.

Table 2: Vertical Specialization Rates in Sub-Sectors of Manufacturing Industry, 2000-2014 (%)[5]

Country	Sector	2000	2004	2005	2008	2009	2010	2014	Country	Sector	2000	2004	2005	2008	2009	2010	2014
Czech Republic	C10-C12	20.81	21.44	22.38	24.33	23.24	26.48	29.72	Estonia	C10-C12	33.80	35.36	35.18	36.88	32.70	36.44	38.21
	C13-C15	30.09	36.01	37.50	35.86	35.70	41.99	44.84		C13-C15	43.15	40.81	42.50	45.45	43.93	46.37	49.53
	C16	19.48	20.29	21.19	25.04	25.67	28.66	32.17		C16	30.92	32.10	33.99	34.67	30.42	34.54	35.39
	C17	32.84	33.66	35.10	36.22	36.40	39.02	43.20		C17	35.06	35.67	37.60	42.41	39.31	37.04	40.27
	C18	25.96	27.94	29.64	30.34	28.14	29.84	34.30		C18	42.06	40.22	41.86	42.93	41.60	44.89	46.06
	C19	56.29	57.31	61.81	63.73	65.26	69.36	70.44		C19	42.36	34.52	33.83	27.22	29.97	29.74	28.26
	C20	39.84	41.72	43.03	44.43	43.95	46.50	50.94		C20	53.65	54.68	55.78	57.34	58.48	56.20	66.69
	C21	20.91	24.51	28.80	28.39	26.80	26.64	34.01		C21	47.52	52.52	56.01	47.97	48.39	50.60	51.96
	C22	40.33	46.79	48.85	45.46	41.25	46.22	50.12		C22	47.91	49.58	51.23	54.21	50.14	52.34	53.04
	C23	26.07	30.50	31.13	31.55	29.77	33.10	35.34		C23	33.77	33.23	34.14	36.50	36.33	39.01	39.81
	C24	41.43	43.04	43.79	50.71	49.06	56.06	54.30		C24	64.71	64.89	67.81	52.54	51.91	59.91	66.63
	C25	31.82	36.31	36.67	37.49	34.59	38.06	41.54		C25	51.29	52.09	53.74	54.38	46.66	53.28	54.35
	C26	50.10	61.59	59.87	62.09	63.44	66.05	65.16		C26	50.94	56.10	60.83	60.33	63.54	73.42	78.59
	C27	41.24	45.57	46.13	47.48	45.74	49.48	51.61		C27	46.22	52.70	53.47	58.34	53.79	56.34	57.10
	C28	31.34	34.65	35.79	39.27	36.46	40.19	44.25		C28	46.02	46.02	46.77	47.43	43.02	47.62	51.26
	C29	45.47	46.30	49.81	48.80	49.88	52.60	57.34		C29	36.66	51.01	52.22	48.30	47.03	52.42	56.12
	C30	34.47	34.73	39.12	44.95	44.45	46.49	48.20		C30	40.72	41.15	37.82	37.79	31.83	39.57	42.30
	C31_C32	29.46	32.31	33.29	33.78	32.99	36.11	40.80		C31_C32	36.44	38.51	39.75	41.89	38.37	41.61	44.12
	C33	22.90	26.75	26.51	27.10	24.07	27.33	30.26		C33	38.52	39.30	40.36	35.81	32.77	35.91	37.90
Hungary	C10-C12	30.93	27.65	28.49	35.19	32.50	34.42	37.54	Latvia	C10-C12	23.95	29.12	30.22	32.54	29.32	32.25	37.40
	C13-C15	49.88	47.68	49.64	52.09	49.39	47.04	53.02		C13-C15	38.38	33.74	32.21	36.34	31.91	37.75	39.68
	C16	37.78	36.50	37.09	41.21	40.05	41.17	44.93		C16	19.21	24.60	26.32	25.67	20.95	23.05	28.65
	C17	52.33	47.96	48.50	51.12	50.53	53.77	51.86		C17	39.69	44.32	46.93	45.83	44.24	47.51	50.78
	C18	37.65	33.56	33.71	35.20	37.54	37.00	39.34		C18	28.36	33.88	34.82	35.59	33.53	40.14	46.20
	C19	51.23	43.52	51.96	57.06	55.10	64.72	70.03		C19	29.40	23.26	31.40	17.98	18.70	17.15	28.41
	C20	47.54	45.32	50.30	54.08	54.41	59.06	59.40		C20	24.86	25.46	23.92	37.29	36.14	36.41	42.24
	C21	24.53	21.67	22.38	32.99	33.82	31.34	37.14		C21	21.55	22.12	21.16	18.34	17.56	18.84	15.77
	C22	49.68	46.18	47.34	52.87	49.80	51.34	52.76		C22	47.56	51.93	51.26	51.26	46.53	50.82	52.28
	C23	34.57	35.71	37.46	39.87	39.00	40.52	45.10		C23	30.20	36.75	39.56	36.75	27.46	32.05	34.64
	C24	56.17	52.51	53.91	57.68	57.62	60.24	61.50		C24	44.21	47.48	53.06	55.06	53.42	53.58	63.82
	C25	42.36	42.21	42.23	45.02	42.74	44.94	46.73		C25	43.38	47.88	49.61	45.25	40.29	47.87	47.49
	C26	72.20	67.84	66.41	72.68	73.43	77.28	72.54		C26	40.65	36.40	34.01	31.20	35.89	42.40	39.46
	C27	55.77	44.21	43.03	49.86	56.05	61.86	59.23		C27	35.79	48.49	49.26	38.74	37.96	43.21	42.90
	C28	45.19	46.63	46.76	49.96	37.72	39.42	49.30		C28	35.61	36.96	35.07	36.32	27.88	38.00	40.96
	C29	61.40	59.64	60.68	65.28	60.58	63.60	69.96		C29	40.59	48.78	46.57	47.17	43.69	42.31	42.16
	C30	47.25	44.78	45.35	44.13	45.48	47.60	51.87		C30	36.38	42.05	45.11	40.07	39.17	44.81	47.18
	C31_C32	43.59	41.12	41.92	46.73	42.46	43.58	46.61		C31_C32	26.80	28.37	30.44	31.58	25.92	29.11	33.97
	C33	41.44	42.49	41.65	37.73	36.46	36.98	38.81		C33	28.49	33.92	34.79	27.05	27.18	28.06	29.14

Source: Authors' calculations based on I-O tables.

[5] Sectors' codes and description are given in the Annex Table 1

Table 3 shows the vertical specialization rates in the sub-sectors of the manufacturing industry in Lithuania, Poland, Slovakia, and Slovenia. In the Lithuanian manufacturing industry, the manufacturing of coke and refined petroleum products (C19) had a higher average vertical specialization rate (equivalent to 66.53%) compared with other industries during the period from 2000 to 2014. The vertical specialization rate of (C19) increased from 59.55% in 2000 to 75.17% in 2014. Manufacturing of chemicals and chemical products (C20) had also a high average vertical specialization rate (equivalent to 51.51%). The vertical specialization rate of (C20) increased from 39.91% in 2000 to 59.41% in 2014. Manufacturing of basic pharmaceutical products and pharmaceutical preparations (C21) and the repair and installation of machinery and equipment (C33) respectively had the lowest average vertical specialization rate during the studied interval. While the vertical specialization rate of (C21) decreased from 10.69% in 2000 to 7.86% in 2014, that of (C33) increased from 16% to 20.37% during the same period. The average vertical specialization rate of the former was 10.82% and that of the latter was 19.17%.

Between the manufacturing industries in Poland, the manufacturing of coke and refined petroleum products (C19) and the manufacturing of computer, electronic and optical products (C26) had the highest average vertical specialization equivalent to 49.16% and 48.19% respectively during the period from 2000 to 2014. The vertical specialization rate of (C19) increased from 47.72% in 2000 to 53.68% in 2014. Moreover, that of (C26) increased from 37.97% in 2000 to 59.22% in 2014. Manufacturing of basic pharmaceutical products and pharmaceutical preparations (C21) and manufacturing of food products, beverages and tobacco products (C10-C12) had the lowest average vertical specialization rate equivalent to 18.71% in the former and 21.33% in the latter during the studied interval. The vertical specialization rate of (C21) and (C10-C12) increased from 16.02% in 2000 to 22.24% in 2014 and from 18.24% in 2000 to 26.11% in 2014.

In Slovakia, the manufacturing of coke and refined petroleum products (C19) and manufacturing of motor vehicles, trailers and semi-trailers (C29) had the highest average vertical specialization equivalent to 68.25% and 63.81% respectively during the studied interval. The vertical specialization rate of (C19) increased from 53.73% in 2000 to 79.82% in 2014. Furthermore, that of (C29) increased from 57.41% in 2000 to 67.34% in 2014. Manufacturing of wood and products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials (C16) and manufacturing of basic pharmaceutical products and pharmaceutical preparations (C21) had the lowest average vertical specialization equivalent to 19.29% and 29.03% respectively during the studied interval. While the vertical specialization rate of (C16) decreased from 18.22% in 2000 to 17.99% in 2014, that of (C21), increased from 19.06% in 2000 to 33.13% in 2014.

In Slovenia, manufacturing of motor vehicles, trailers and semi-trailers (C29) and manufacturing of basic metals (C24) had the highest average vertical specialization equivalent to 59.31% and 49.60%, respectively during the studied interval. The vertical specialization rate of (C29) increased from 56.61% in 2000 to 60.75% in 2014. Moreover, that of (C24) increased from 43.50% in 2000 to 53.72% in 2014. Manufacturing of basic pharmaceutical products and pharmaceutical preparations (C21) and printing and reproduction of recorded media (C18)

had the lowest average vertical specialization equivalent to 13.94% and 23.23% respectively during the studied interval. The vertical specialization rate of (C21) increased from 11.23% in 2000 to 17.85% in 2014. Furthermore, that of (C18) increased from 16.83% in 2000 to 29.48% in 2014.

Table 3: Vertical Specialization Rates in Sub-Sectors of Manufacturing Industry, 2000-2014 (%)

Country	Sector	2000	2004	2005	2008	2009	2010	2014	Country	Sector	2000	2004	2005	2008	2009	2010	2014
Lithuania	C10-C12	26.20	31.42	32.39	34.98	29.22	30.68	33.67	Poland	C10-C12	18.24	19.28	18.34	21.39	20.18	23.41	26.11
	C13-C15	26.42	18.25	19.70	24.74	20.95	23.24	24.26		C13-C15	24.15	27.31	25.68	26.73	27.85	35.23	36.70
	C16	27.31	32.12	32.64	35.43	31.48	34.32	37.25		C16	18.98	21.10	21.92	23.36	20.61	24.39	25.45
	C17	25.39	32.40	31.51	37.98	33.40	35.76	38.72		C17	27.92	28.23	28.53	30.16	30.06	35.83	35.50
	C18	24.00	31.71	30.23	26.10	30.13	30.69	30.47		C18	23.77	26.20	24.85	24.51	24.39	28.31	28.43
	C19	59.55	64.52	65.35	67.64	68.52	67.72	75.17		C19	47.72	33.94	45.42	49.93	51.55	55.27	53.68
	C20	39.91	47.21	48.27	55.89	52.27	55.40	59.41		C20	31.74	33.34	33.51	37.22	36.12	41.34	42.42
	C21	10.69	14.54	16.97	5.01	6.62	4.03	7.86		C21	16.02	19.50	17.98	16.83	17.71	20.17	22.24
	C22	35.38	40.83	42.19	49.92	45.89	46.38	43.13		C22	28.79	31.01	30.83	33.05	31.84	37.61	39.34
	C23	19.57	22.79	24.40	30.61	23.49	27.27	29.09		C23	22.04	22.13	23.23	25.10	22.96	27.72	28.00
	C24	24.72	30.81	32.54	38.17	34.87	38.29	41.15		C24	33.38	36.03	37.43	43.97	38.77	48.13	46.12
	C25	20.17	24.66	27.91	30.90	27.61	29.96	32.04		C25	25.58	29.55	30.17	33.28	29.14	34.04	34.21
	C26	26.55	30.80	38.49	35.97	31.91	37.10	30.49		C26	37.97	42.30	42.05	47.62	46.09	59.33	59.22
	C27	26.83	33.72	36.37	46.35	43.04	41.91	45.22		C27	28.62	31.98	32.02	35.86	36.36	42.45	43.49
	C28	21.02	25.45	29.73	27.26	23.80	31.38	32.97		C28	26.79	33.26	32.72	35.34	30.64	34.72	37.11
	C29	16.62	21.40	21.82	25.69	23.90	26.64	32.04		C29	39.90	39.58	36.83	43.90	41.22	47.71	47.50
	C30	19.56	21.65	23.75	17.36	18.11	20.70	21.97		C30	33.25	38.40	35.42	38.25	32.57	32.65	33.73
	C31_C32	19.77	21.82	22.95	25.02	20.27	24.49	26.69		C31_C32	23.03	25.34	24.97	26.46	23.93	28.61	29.53
	C33	16.00	14.44	17.28	19.83	20.01	23.03	20.37		C33	25.84	30.22	29.11	28.45	33.00	35.63	29.96
Slovak Republic	C10-C12	25.77	28.38	28.70	28.83	26.03	30.13	33.46	Slovenia	C10-C12	25.57	26.06	26.76	30.97	26.21	29.86	31.32
	C13-C15	27.78	36.37	35.28	42.08	36.47	28.34	40.72		C13-C15	29.70	34.91	39.09	37.75	33.47	37.88	40.47
	C16	18.22	19.14	21.88	18.12	17.40	18.34	17.99		C16	28.73	30.56	32.07	35.37	33.26	37.11	37.91
	C17	25.65	33.24	36.06	35.55	31.38	34.54	38.62		C17	40.71	41.76	44.54	49.33	42.24	50.21	49.95
	C18	29.21	34.94	35.60	36.28	36.36	37.06	35.56		C18	16.83	18.74	21.07	26.05	24.70	27.03	29.48
	C19	53.73	56.42	62.63	65.89	70.09	72.74	79.22		C19	34.64	31.67	30.70	31.12	27.63	31.05	28.43
	C20	39.45	42.94	44.76	48.34	49.42	52.78	54.54		C20	40.23	43.35	46.88	51.32	46.71	50.24	50.91
	C21	19.06	31.91	32.89	29.12	21.96	23.61	33.13		C21	11.23	11.28	12.71	15.71	13.28	15.45	17.85
	C22	40.26	44.37	46.16	49.24	44.05	48.82	48.01		C22	36.55	37.89	41.90	45.91	41.37	45.27	43.75
	C23	27.25	29.51	31.17	31.36	28.97	30.01	35.50		C23	27.08	28.56	30.11	34.43	31.69	35.23	36.05
	C24	44.91	43.69	45.17	48.40	50.89	51.15	58.82		C24	43.50	47.48	47.48	51.14	48.97	52.96	53.72
	C25	33.52	34.36	35.25	35.14	34.02	35.00	39.65		C25	30.31	32.79	34.55	38.37	35.42	38.80	39.21
	C26	51.41	69.48	72.39	72.18	74.78	74.23	77.41		C26	33.59	32.78	36.66	37.45	34.13	37.17	39.58
	C27	52.84	60.27	60.13	56.15	60.88	57.94	61.50		C27	37.40	40.00	41.46	44.92	42.59	45.37	45.79
	C28	37.09	42.68	44.81	46.06	45.31	45.43	49.22		C28	36.40	38.96	40.98	43.78	39.97	42.72	43.20
	C29	57.41	62.27	64.24	63.77	64.89	63.13	67.34		C29	56.61	59.80	60.27	59.95	58.52	60.77	60.75
	C30	23.19	42.05	47.66	47.96	45.78	36.29	55.03		C30	34.55	38.46	39.06	39.61	37.60	40.71	38.39
	C31_C32	28.39	32.49	33.01	36.28	32.97	29.14	36.41		C31_C32	27.35	29.91	31.29	33.37	30.73	33.42	34.56
	C33	29.40	32.04	33.84	34.89	31.40	32.94	36.71		C33	29.56	27.80	29.07	28.86	27.05	29.14	30.62

Source: Authors' calculations based on I-O tables.

4. Conclusion

Aftermath the dissolution of the Soviet Union, CEE countries replaced the command economy with a market-oriented system. The economic and political transformation had been experienced to cope with the challenges of globalization. The CEE countries have achieved developments that ensured intensive participation in the cross-border production chains especially since the EU's membership in 2004. The results revealed that the CEE countries' vertical specialization rate increased during the period from 2000 to 2014 but decreased during the period of the 2008-2009 global financial crisis. After 2004, the vertical specialization rate continued to increase rapidly. During the studied interval, the highest average vertical specialization rate was respectively accounted for in Hungary, Slovakia, Czech Republic, Estonia, Slovenia, Lithuania, Poland and Latvia.

The vertical specialization rate of the manufacturing industries in Estonia, Hungary, Latvia and Poland was higher than that in the entire economy. During the period of 2000-2014, the vertical specialization rate of Hungarian manufacturing decreased but increased continuously in the rest countries (excluding the period of 2008-2009 global financial crisis). The highest vertical specialization rate of the manufacturing industries was respectively accounted for Hungary, Estonia, Slovakia, Latvia, the Czech Republic, Slovenia, Poland, and Lithuania during the studied interval.

Finally, when the manufacturing industry sub-sectors are evaluated according to the technological classification, we found a higher vertical specialization rate in medium-low technology sectors accounted for the Czech Republic, Latvia, Lithuania and Poland. Furthermore, the results revealed a higher vertical specialization rate in medium-high and high technology sectors accounted for Estonia, Hungary, Slovakia and Slovenia. The CEE countries' vertical specialization rate of both entire economy and manufacturing industries has increased since 2000 but this increase continued more rapidly after 2004.

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Annex Table 1: Sectors' Codes and Descriptions

Code	Description
Manufacturing Industry	
C10-C12	Manufacture of food products, beverages and tobacco products
C13-C15	Manufacture of textiles, wearing apparel and leather products
C16	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials
C17	Manufacture of paper and paper products
C18	Printing and reproduction of recorded media
C19	Manufacture of coke and refined petroleum products
C20	Manufacture of chemicals and chemical products
C21	Manufacture of basic pharmaceutical products and pharmaceutical preparations
C22	Manufacture of rubber and plastic products
C23	Manufacture of other non-metallic mineral products
C24	Manufacture of basic metals
C25	Manufacture of fabricated metal products, except machinery and equipment
C26	Manufacture of computer, electronic and optical products
C27	Manufacture of electrical equipment
C28	Manufacture of machinery and equipment n.e.c.
C29	Manufacture of motor vehicles, trailers and semi-trailers
C30	Manufacture of other transport equipment
C31_C32	Manufacture of furniture; other manufacturing
C33	Repair and installation of machinery and equipment

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