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The Vertical Specialisation in the Information and Communication Technologies Sectors of Central and Eastern European Countries

Şahin NAS[1], Maya MOALLA[2]

Abstract

With globalisation, the international fragmentation of production in world trade has come to the fore, and now different production stages occur in different countries. Countries specialise at a certain stage of the production process rather than producing a final good or service. In the 2000s, the international fragmentation process of production gained more importance concomitant with the technological developments that provide low cost and the developments in Information and Communication Technologies (ICT). In this context, the study's main purpose is to analyse the position of the ICT sub-sectors in the Central and Eastern European Countries (CEE) countries, that joined the European Union (EU) in 2004, in the global production networks. The Hummels, Ishii & Yi (HIY) method proposed by Hummels, Ishii & Yi (1998) and Hummels, Ishii & Yi (2001) was applied to appraise the vertical specialisation rate. We utilized the input-output tables for the period from 2000 to 2014 obtained from the World Input-Output Database (WIOD). The results revealed that during the period from 2000 to 2014, there was an increase in vertical specialization in the total economy of all countries, however, this trend wasn't invariably seen in the ICT sectors of every country. The outcomes revealed that the ICT sectors' vertical specialisation rate increased in the Czech Republic, Lithuania, and Poland. However, it decreased in Estonia, Hungary, Latvia, Slovakia, and Slovenia during 2000-2014. In CEE countries, the telecommunications subsector stands as the predominant source of vertical specialization. The rise of vertical specialization in telecommunications outpaces that in other sectors.

Keywords: *Vertical Specialisation, Information and Communication Technologies (ICTs), Input-Output Analysis, Central and Eastern European Countries (CEEs), Global Production Network*

Jel Codes: *C67, D57, F10, F14, F15*

Orta ve Doğu Avrupa Ülkeleri Bilgi ve İletişim Teknolojileri Sektörlerinde Dikey Uzmanlaşma

Öz

Küreselleşme ile dünya ticaretinde üretimin uluslararası parçalanması gündeme gelmiş ve artık üretim sürecinin her bir aşaması farklı bir ülkede gerçekleştirilmeye başlamıştır. Ülkeler nihai bir mal veya hizmet üretmekten ziyade üretim sürecinin belirli bir aşamasında uzmanlaşma politikası izlemiştir. 2000'li yıllarda düşük maliyet sağlayan teknolojik gelişmeler ve Bilgi ve İletişim Teknolojileri (BİT) alanındaki gelişmeler ile üretimin uluslararası parçalanma süreci daha fazla önem kazanmıştır. Çalışmanın temel amacı 2004 yılında Avrupa Birliği'ne (AB) üye olan Orta ve Doğu Avrupa (ODA) ülkeleri BİT sektörlerinin küresel üretim ağı içindeki konumunu analiz etmektir. Bu amaçla Hummels, Rapoport & Yi (1998) ve Hummels, Ishii & Yi (2001) tarafından geliştirilen Hummesl, Ishii & Yi (HIY) yöntemi ile dikey uzmanlaşma oranı hesaplanmıştır. Analizde Dünya Girdi-Çıktı Veri tabanında (WIOD) yer alan 2000-2014 dönemini kapsayan girdi-çıktı tabloları kullanılmıştır. Elde edilen bulgulara göre, 2000-2014 döneminde bütün ülkelerde toplam ekonomide dikey uzmanlaşma artış göstermesine rağmen, ICT sektöründe bütün ülkelerde dikey uzmanlaşma aynı eğilimi göstermemiştir. BİT sektöründe 2000-2014 döneminde dikey uzmanlaşma oranı Çek Cumhuriyeti, Litvanya ve Polonya'da yükselmiş, Estonya, Macaristan, Letonya Slovakya ve Slovenya'da düşmüştür. CEE ülkelerinde dikey uzmanlaşmanın en önemli bileşeni ve kaynağı telekomünikasyon alt sektörüdür. Bu alt sektörün dikey uzmanlaşmasındaki artış diğer sektörlere göre daha yüksektir.

Anahtar Kelimeler: *Dikey Uzmanlaşma, Bilgi ve İletişim Teknolojileri (BİT), Girdi-Çıktı Analizi, Orta ve Doğu Avrupa Ülkeleri (ODA), Küresel Üretim Ağı*

Jel Kodu: *C67, D57, F10, F14, F15*

[1] **Sorumlu Yazar/Corresponding Author:** Dr. Öğr. Üyesi, Şırnak Üniversitesi, İktisadi ve İdari Bilimler Fakültesi, Yönetim Bilişim Sistemleri, Şırnak, Türkiye. **E-Mail:** snas@sirnak.edu.tr **Orcid no**: 0000-0003-3267-4432

[2] Dr., Bağımsız Araştırmacı, Mersin, Türkiye. **E-Mail:** mayamoalla@hotmail.com **Orcid no:** 0000-0003-4076-2790

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INTRODUCTION

In post-1980, a significant structural change happened in the world economy (Rodrik, 2011:59-77; Soydan, 2018:381-385). After the Second World War, import substitution and inward-oriented policies (Taymaz & Voyvoda, 2017:13-17) were replaced by the outward-oriented (or export) ones (Pamuk, 2015:263-265; Yeldan, 2016:19-25). Economies have given much significance to open policies, especially with the increasing globalisation trends. The applied policies fragmented the process of producing goods and services to operating across countries, regions, and geographies; the matter that raised the importance of global production networks gradually (Coe & Hess, 2013:4; Hess & Yeung, 2006:1). Since the early 1990s, global production has become much more fragmented and spatially dispersed (Yeung & Coe, 2015:30). In the 2000s, global production networks have become more organised in the world economy and significantly shaped world trade. Since this period, multinational companies have played a prominent role, especially in the expansion and management of global production networks (Coe et al., 2014:762; Neilson et al., 2014:4). Ensuring cost, flexibility, and speed are among the main dynamics behind the international fragmentation process of production. When markets and competitors expand globally, firms and countries are more likely to utilise their competitive advantages in these dynamics to gain more competitiveness. Thus, the production chains of goods and services are becoming increasingly global (Coe & Yeung, 2015:4). Information and communication technologies (ICT), technological change, digitalisation, and e-commerce are among the most important dynamics that accelerate and shape globalisation and accordingly the international fragmentation process of production (Butollo et al., 2022:586-587; Coe & Yeung, 2019:777; Henderson et al., 2002:443-447). The emergence and rapid development of ICTs have put significant pressure on the competitiveness of countries and multinational companies, concomitant with the gradual liberalisation of foreign trade. ICT accumulation has played an important role in shaping the world economy and organising global production (Pekarčík et al., 2022:1; Jiang & Liu, 2015: 2), enabling many different countries to participate in the process of producing any goods and services (Tham et al., 2016:681) through low-cost technologies (Butollo et al., 2022:586-587; Vrh, 2017:407-409). The acceleration and development of tech & ICTs coincide with the acceleration of globalisation trends and the global production process (Olczyk & Kordalska, 2017:91). Concurrently with these developments, a transition was made from the developed countries that control, to a significant extent, the production process of goods and services to different geographies of the world. Thus, more than one country may participate in previously integrated production activities to produce a final good (Coe & Yeung, 2015:3-4). Along with developed countries, developing ones also significantly participate in the fragmentation process of production (Coe et al., 2010:140-144). Moreover, developing countries struggle to adapt and be involved in the global production process. Central and Eastern European (CEE) countries are some of the developing countries involved in this change in global production. CEE countries, known as post-socialist countries, maintained the centralised command economy during the period since World War I (Cieślik et al., 2021:3589). However, these countries have undergone a serious change and transformation in the post-1980 period (Gerőcs & Pinkasz, 2019:172). The dissolution of the Soviet Union in 1991 accelerated the change and transformation in these countries. During this process, CEE countries began to replace the centralised command economy with a market-oriented system (Cieślik 2022c; Soyyigit, 2019:378). Moreover, they have integrated into the global economy and played a more active role in global production chains (Cieślik 2022c; Szymczak et al., 2022:2). To adapt to the global production networks and the market environment, the CEE countries offered companies with low wages, flexible

working, tax incentives, and production facilities (Gerőcs & Pinkasz, 2019:172).

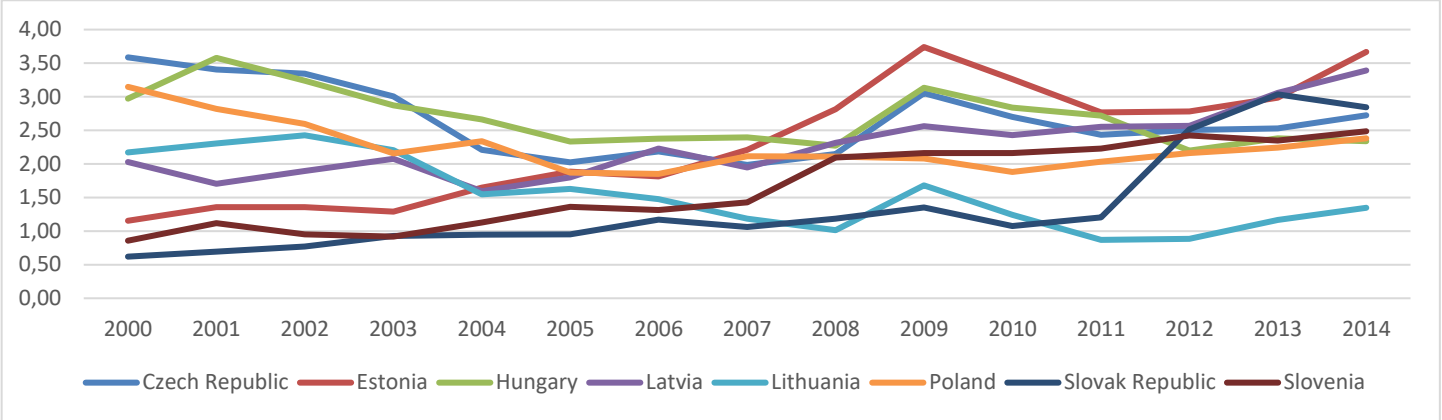

Figure 1: Share of ICT in Total Exports, 2000-2014 (%)

Source: WIOD

Figure 1 depicts the share of the ICT sector in total exports in CEE countries. The share of the ICT sector in total exports is variable among nations. Till 2005, the contribution of the ICT sector to total exports had dropped in the Czech Republic, Hungary, Poland, and Lithuania, but in other nations, this percentage was inconsistent. From 2008-2009 onward, excluding Lithuania, the ratio of the ICT sector to total exports has ascended in virtually all countries. During the 2000-2014 period, the percentage of the ICT sector in total exports was 2.66% in the Czech Republic, 2.32% in Estonia, 2.69% in Hungary, 2.28% in Latvia, 1.54% in Lithuania, 2.25% in Poland, 1.36% in Slovakia, and 1.67% in Slovenia

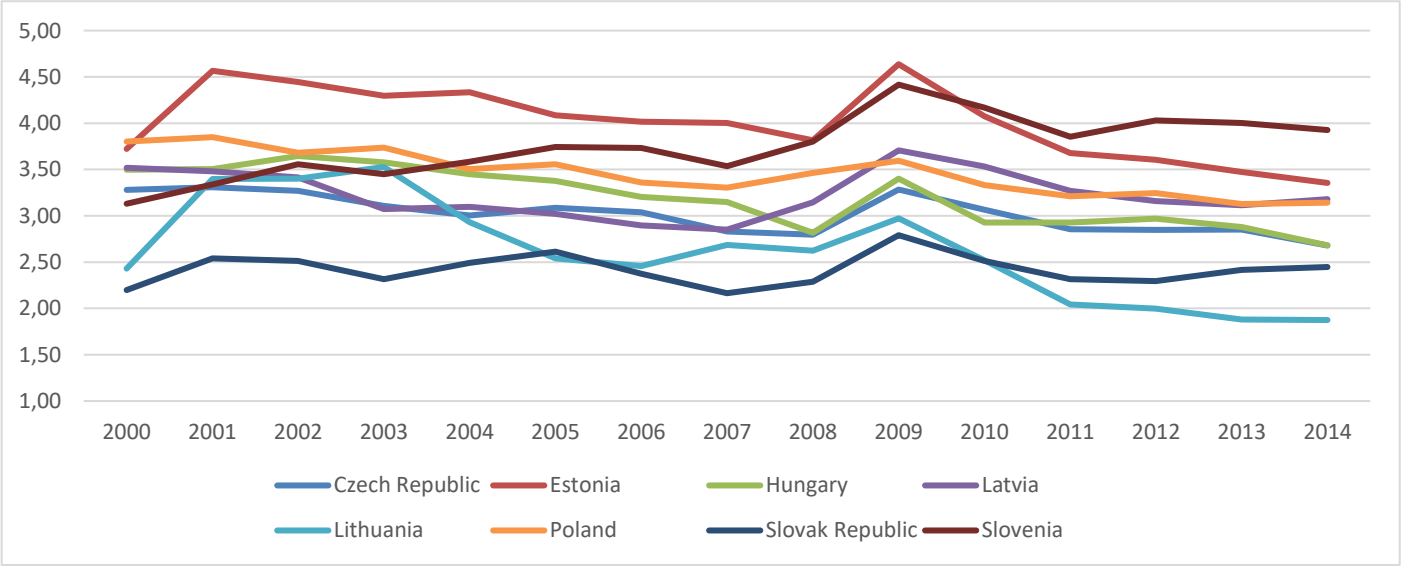

Figure 2: Share of ICT in Total Intermediate Input Usage, 2000-2014 (%)

Source: WIOD

Figure 2 depicts the share of the ICT sector's intermediate input in the total intermediate input usage in CEE countries. Barring Lithuania, other nations exhibit a similar pattern regarding the share of the ICT sector's intermediate input in the total intermediate input consumption. As per the findings, Estonia and Slovenia demonstrate the greatest intermediate input consumption. From 2000 through 2014, the mean percentage of intermediate input from the ICT sector of total intermediate input in CEE countries stands at: 3.02% in the Czech Republic, 4.01% in Estonia, 3.20% in Hungary, 3.23% in Latvia,

2.62% in Lithuania, 3.46% in Poland, 2.42% in Slovakia, and 3.75% in Slovenia.

Post 1990s, CEE countries witnessed profound economic and political alterations. These evolutions sped up CEE countries' assimilation into the global economy. Considering this scenario, the selection of CEE countries for this examination stems from their marked transition, their geographical nearness to Western European countries, which are major actors in the global economy, and their subsequent integration into the European Union (EU). With this respect, the main purpose of this paper is to analyse the extent to which the CEE countries that joined the European Union (EU) in 2004 (Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Slovakia, Slovenia) are involved in the global production process. In this context, vertical specialization acts as a significant measure to gauge the place of CEE countries in the global production cycle. The cause behind choosing the ICT sector is that it significantly affected the fragmentation of the global production process, which accelerated and expanded during the post-1980 period. In this evolving process, ICTs offer notable economic benefits. They accelerate innovation processes, fosters productive operational climates, and enhances the spectrum of output (Li & Wu, 2022; Liu & Saam, 2022). Moreover, ICTs undoubtedly enhance a nation's involvement in the universal production chain (Cieslik, 2022c; Pekarčík, Ďurčová & Glova, 2022). In light of these nuances, the ICT sector is the focal point of this research. The prominence of vertical specialization in ICTs offers insights into a country's alignment with technology-driven output. The principal thrust of this exploration is to delve into the role of the ICT sector in the CEE nations, EU members since 2004, within the global production matrix. Input-output models have been utilised to detect the position of CEE countries in the global production process. The national input-output tables (NIOTs) of CEE countries available at the World Input-Output Database (WIOD) for the period from 2000 to 2014 were employed to achieve our goal. The most updated input-output table released by WIOD is 2016. Therefore, tables compiled for 2016 were employed in the analysis. The Hummels, Ishii & Yi (HIY) method proposed by Hummels, Rapoport & Yi (1998) and Hummels, Ishii & Yi (2001) has been employed to reveal the position of CEE countries in the global production process. This method was employed for the reason that input-output models are more suitable for estimating the vertical specialisation ratio (Hummels et al., 2001:78-81). To the best of our knowledge, there are limited studies in the literature concerning either CEE countries or using input-output models; thus, this study is expected to contribute to the literature by providing an up-to-date investigation of the vertical specialisation of the ICT sector in CEE countries. This work is made up of five sections. The first section includes the introductory part in which the general features of the global production processes, ICTs, and the developments linked to the participation of CEE countries are summarised. In the second section literature review and theoretical framework are structured. The third section includes data and methodology. The fourth section includes findings. And the fifth section is about evaluating the results and conclusion.

1. BACKGROUND AND LITERATURE REVIEW

During the period of globalisation, national markets were integrated into different value chains and production networks organised by international lead firms and spanning diverse national and regional economies (Yeung, 2014). The production of a good and service take their final form through different stages in different countries or regions. Each country or region specialises in a particular production stage of goods and services. In the global trade literature, this process is called vertical specialisation (Coe & Yeung, 2015). Vertical specialisation is based on importing intermediate products and services to be produced for export. Three basic conditions should be met for vertical specialisation. 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 et al., 1998; Hummels et al., 2001). With this respect, vertical specialisation emerges once imported intermediate inputs are employed in any country's production process for export purposes (Dağıstan, 2019). Vertical specialisation has been considered one sign when investigating the impact of global production fragmentation on a country's trade. High vertical specialisation shares denote a country's greater degree of participation in international production chains (Dean et al., 2011). The works of Hummels et al. (1998) and Hummels et al. (2001) became the pioneering studies that applied the HIY method to input-output tables to estimate the vertical specialisation rate which measures the degree of countries' participation in the global production process. In this framework, the literature shows that the studies that investigate vertical specialization often span the entire economy instead of pinpointing specific sectors. However, the manufacturing sector garners attention. To quantify vertical specialization, the common approach is using input-output models. A prevalent observation from these studies points to a sustained increase in vertical specialization, possibly influenced by the globalization wave that started in the 1980s. This surge is generally perceived as advantageous for countries since nations can carve a niche in production, easing their path into global manufacturing. But there's a caveat. An escalating vertical specialization might mean more reliance on imported intermediate goods when focusing on exports. This could potentially destabilize the domestic inter-firm dynamics, a notion supported by Dağıstan's (2019) findings.

In their investigations on the Organisation for Economic Co-operation and Development (OECD) countries, Hummels et al. (1998) and Hummels et al. (2001) indicate that, since 1970, the participation of OECD countries in the global production network has risen. Dean, Fung & Wang (2008; 2011) revealed similar results. Dean et al. (2008; 2011) revealed that China's participation in the global production network had increased significantly from 1997 to 2002. Yang et al. (2015) supported these results and stated that the foreign value added to Chinese exports increased significantly from 2002 to 2007. Kwon & Ryou (2015) stated that vertical specialisation has proceeded in the major exporting industries in China, Japan, and Korea. This seems to reflect that, in general, East Asian countries became more deeply integrated into the process of international fragmentation of production. Amador, Cappariello & Stehrer (2015) provided evidence that the foreign value-added content of exports had increased in the US, China, Japan, and the European Region during the period (2000-2011). Amador et al. (2015) and Jiang & Liu (2015) emphasised that vertical specialisation had increased in developing countries. Kersan-Škabić (2017) emphasises that the rate of vertical specialisation in the new EU member states increased from 20% to 49% in the period 1995-2011. The authors stated that Hungary had the highest vertical specialisation rate, but Croatia had the lowest one. Moreover, the ratio of vertical specialisation increased in the Czech Republic, Hungary, Poland, Slovakia, Slovenia, Bulgaria, Latvia, and Romania but decreased in Estonia and Lithuania. Likewise, Kordalska & Olczyk (2018) revealed that the CEE countries' participation in the global production network was higher than other EU countries during the period from 1995 to 2011. But according to Olczyk & Kordalska (2016) except for Estonia, the domestic added value of exports in the manufacturing industry decreased in other CEE countries during the period from 1995 to 2011. Nas & Mualla (2022) concluded that vertical specialisation showed an upward trend in the CEE countries during the period from 2000 to 2014. Cieślik (2022a) emphasised that the role of the CEE countries in the global economy changed during the period from 2005 to 2015 since they had to face strong competition from Chinese and other low-cost producers. In time,

they became more and more dependent on foreign value added. For this reason, the CEE countries modified their production patterns and became dependent on global production chains, especially in the manufacturing sector. Pekarčík et al. (2022) confirmed that the volume of the foreign value added in exports rose in the EU countries during the period from 2000 to 2015. Ali & Gninigue (2022) suggested that participation in the global value chains was subject to an increase in 41 African countries during the period from 1990 to 2018. They revealed that the rate of the foreign value added in exports in the observed countries accounted for about 20% during the studied period. Moreover, their findings suggested that participation in the global value chains positively affected the structural transformation in African countries.

Dean et al. (2008; 2011) postulated that the Chinese manufacturing sectors had greater vertical specialisation shares in the global production networks. According to their findings for the CEE countries, Olczyk & Kordalska (2016) revealed that except for Estonia, the domestic added value of exports in the manufacturing industry decreased in other CEE countries during the period from 1995 to 2011. That is to say, the vertical specialisation rate in these countries' manufacturing industries increased during the studied period. Furthermore, the largest vertical specialisation increase occurred in Poland and Hungary. Therefore, Poland and Hungary are more involved and integrated into global value chains. Moreover, the domestic value added in Poland, Hungary, the Czech Republic, and Slovakia had decreased, especially in the medium-high and high-tech sectors. Overall, Olczyk & Kordalska (2016) argued that export performance had been positively affected in the CEE countries that had become more integrated into the global production networks. Cieślik (2019) revealed that though the CEE states have become more reliant on Chinese value-added in the electronics industry, the EU's value-added is still significant in most countries, barring the Czech Republic and Slovakia. However, the dependence on Chinese added value increased in CEE countries. Nas & Mualla (2022) stated that the manufacturing industries' vertical specialisation rate in Estonia, Hungary, Latvia, and Poland was higher than that of the entire economy. Moreover, the findings revealed a higher vertical specialisation rate in medium-high and high technology sectors for Estonia, Hungary, Slovakia, and Slovenia. Cieślik (2022a) emphasised that the role of the CEE countries in the global economy changed during the period from 2005 to 2015 since they had to face strong competition from Chinese and other low-cost producers. In time, they became more and more dependent on foreign value added. For this reason, the CEE countries modified their production patterns and became dependent on global production chains, especially in the manufacturing sector. Despite this, however, the position of manufacturing industries in global value chains has been steadily flagging.

According to Dean et al. (2008: 2011), China's information technology (IT) and communication-related sector vertically specialized at a pace of roughly 59%. Jiang & Liu (2015) argued that developing countries obtained significant benefits by involving ICT final products in the global production chain. Moreover, they reported that China and emerging economies had significantly obtained more added value from the ICT final product exports. Likewise, Lin et al. (2016) stated that foreign value added to Korean exports of ICT components increased from 20% to 25% but decreased from 35% to 29% in Taiwan from 1995 to 2011. Cieślik (2022a) and Zaninović (2022) emphasised that technological developments and ICTs empowered the position of the CEE countries in the global value chains. Gopalan et al. (2022) and Pekarčík et al. (2022) reported that digital developments, especially in ICT components, can generally foster the participation of firms in the global value chains. However, Cieślik (2022b) stated that the ICT sector's vertical specialisation position in CEE countries deteriorated. Kordalska & Olczyk (2022) stated that, unlike other CEE countries, Poland and Slovakia had an adverse global

value chains (GVC) position and specialised in low-value-added activities from 2000 to 2014. Their results revealed that while Slovenia and the Baltic states achieved high value-added in management services, the Czech Republic had competitive advantages in research and development (R&D). Liu & Saam (2022) documented the insignificant contribution of ICT capital deepening to labour productivity growth along global value chains. Kordalska & Olczyk (2018) emphasised that CEE countries should support service-led export growth. They argued that this path might act as the largest prospect for CEE economies to foster producing more productive participation in the global value chains and shrinking their gaps with the most developed economies.

The theoretical and empirical literature showed that the participation of economics in the global value chains increased since the mid-1980s (Butollo et al., 2022; Peng & Zhang, 2020; Pahl & Timmer, 2019; Lamonica et al., 2020; Yin & Liu, 2019). Based on literary sources, it's widely accepted that after the global shifts in the 1980s, vertical specialization has been beneficial for the economy. Most research predominantly zeroes in on the overall economy or the manufacturing sector, leaving other sectors somewhat overlooked. In the setting of the 2nd century, there's an apparent scarcity of research delving into the ICT sector's evolving significance in global production. In today's scenario, there's a palpable surge in ICT-centric production, with a potential inference that developing countries might be subdued compared to advanced nations. This study computes the vertical specialization metrics for CEE countries. Post the Soviet Union's dissolution, there's a discernible shift in CEE countries towards open-market strategies, seemingly to merge more with the global economic fabric. They eventually became part of the EU. The crux of our research is to ascertain the positioning of these CEE nations in the international economy once they became EU members. A scrutiny of the literature seems to indicate that there's a discernible gap in this domain. Currently, ICT-driven production processes have accelerated. Furthermore, the vertical specialization rate in the ICT sector might be an indicator that measures the velocity of an economy to integrate into international markets and benefit from global technology production.

This paper investigated the positioning and development of the ICT industry in the global value chains in CEE countries during the period from 2000 to 2014. To the best of our knowledge, limited studies have been conducted for the ICT sector and CEE countries. Moreover, the studies that investigate the vertical specialisation of the ICT sector in the CEE countries are limited. Thus, we try to fill at least a small part of this gap in ICT sector's vertical specialisation in the CEE countries.

2. DATA AND METHODOLOGY

Input-output tables have been employed to estimate the vertical specialisation rate for the CEE countries (Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Slovakia, and Slovenia) in the ICT sector. Based on the WIOD, the national Input-Output Tables (NIOTs) have been utilised. The most updated input-output table released by WIOD is 2016. Therefore, tables compiled for 2016 are employed in the analysis. Input-Output tables compiled for 2016 are classified according to International Standard Industrial Classification Revision 4 (ISIC Rev.4). This version has been disaggregated into 56 sub-sectors from 2000 to 2014[3]. Table (1) shows the national input-output table for the analysed countries. Table (1) fundamentally includes three parts and is structured in a 120x63 format. The first part displays the mutual intermediate goods flow between sectors, where both domestic intermediate inputs (Z) and imported intermediate inputs (M) are

[3] See also: Dietzenbacher et al., (2013), and Timmer at al., (2015)

included. The second part consists of the components of the final demand (F) for goods and services produced by sectors. Final demand involves both domestic and foreign final demand (E). Domestic final demand involves final consumption expenditure by households (C), final consumption expenditure by non-profit organizations serving households (N), final consumption expenditure by the government (G), gross fixed capital formation (I), and changes in inventories and valuables (IN). The third part involves payments made for primary inputs. In this table, the ICT sector comprises four (4) sub-sectors; publishing activities (J58), motion picture, video and television programme production, sound recording and music publishing activities; programming and broadcasting activities (J59_J60), telecommunications (J61), computer programming, consultancy and related activities; information service activities (J62_J63)[4]. In table (1), while the exponential of the variables *d* denotes the domestic demand, *m* denotes the imports.

Table 1: National Input-Output Table

	Intermediate Inputs	**Final Demand (F)**						**Total Output**
		Domestic					**Foreign**	
	Sectors (1, . . ., n)	***C***	***N***	***G***	***I***	***IN***	***E***	
(Domestic) Sectors (1, …, n)	*Z*	C^d	N^d	G^d	I^d	IN^d	E^d	***X***
(Import) Sectors (1, …, n)	*M*	C^m	N^m	G^m	I^m	IN^m	*0*	*0*
Basic Inputs	*v*							
Total Output	$\widehat{\boldsymbol{X}}$							

Source: Miller & Blair (2019) and WIOD (2022).

$$VS = \frac{[1\ldots1].\begin{bmatrix} a_{11}^m & \cdots & a_{1n}^m \\ \vdots & \ddots & \vdots \\ a_{n1}^m & \cdots & a_{nn}^m \end{bmatrix}.\begin{bmatrix} l_{11} & \cdots & l_{1n} \\ \vdots & \ddots & \vdots \\ l_{n1} & \cdots & l_{nn} \end{bmatrix}.\begin{bmatrix} e_1 \\ \vdots \\ e_n \end{bmatrix}}{Ex_t} \qquad (3)^5$$

If we condense equation (3) to matrix notation, then equation (4) will be obtained as follows (Dağıstan, 2019:10; Pahl & Timmer, 2019:461):

$$VS = \frac{\mu.A^m.[I-A^d]^{-1}.E_x}{Ex_t} \qquad (4)$$

Where; μ 1xn denotes the summation vector**,** A^m nxn represents the imported coefficient matrix, A^d nxn denotes the domestic technical coefficients matrix[6], *Ex* nx1 denotes the vector of exports, $[I - A^d]^{-1}$ denotes the Leontief inverse

[4] See also WIOD (2022).
[5] Since the input-output tables utilized in the analysis include 56 sectors, the matrix is structured as 56x56.
[6] The technical coefficients matrix is made up of the sum of the domestic intermediate input technical coefficients matrix (A^d) and the imported intermediate inputs coefficient matrix ($A = A^d + A^m$). The imported coefficient matrix is calculated as $\mathbf{A^m = M.\widehat{X}^{-1}}$; $\mathbf{A^m} = \sum \boldsymbol{a^m_{ij}}$. The domestic coefficients matrix is calculated as $\mathbf{A^d = Z.\widehat{X}^{-1}}$; $\mathbf{A^d} = \sum \mathbf{a^d_{ij}}$. See Aydoğuş (2015) and Miller & Blair (2009).

matrix[7], and Ex_t denotes the country's total exports. Equation (4) measures the rate of the imported intermediate inputs produced for export. By dividing this rate by the value of total exports, any country's or sector's vertical specialisation rate could be obtained (directly and indirectly). This rate also denotes the foreign added value embodied in exports. The increase in the vertical specialisation rate indicates the increase in the imports of the intermediate goods that become embodied in exported goods. Moreover, a higher vertical specialisation rate indicates a higher degree of participation in the global production networks (Dean et al., 2008:5; Dean et al., 2011:613-612).

3. ESTIMATING VERTICAL SPECIALISATION IN INFORMATION AND COMMUNICATION TECHNOLOGIES SECTORS

Based on the WIOD, the HIY method proposed by Hummels et al., (1998) and Hummels et al., (2001) is applied to the national input-output tables (NIOTs) of CEE countries to estimate the vertical specialisation rate in ICT subsectors during the period from 2000 to 2014. Table (2) depicts the entire economy's vertical specialisation rates in the countries that joined the EU in 2004. During the period from 2000 to 2014, the entire economy's average vertical specialisation rate was equivalent to 0.396 in the Czech Republic, 0.389 in Estonia, 0.492 in Hungary,0.275 in Latvia, 0.308 in Lithuania, 0.289 in Poland, 0.454 in Slovakia, 0.358 in Slovenia. During the studied period, Hungary had the highest vertical specialisation rate, but Latvia was the country with the lowest one. During the 2008-2009 financial crisis, the rate of vertical specialization decreased in all countries. In this regard, based on the periodic changes in Table (2), it is evident that the rate of increase in vertical specialization was either negative or very low in all countries during the period from 2005 to 2009. The vertical specialization rate increased in all countries, excluding Hungary in the 2000-2004 period and Slovenia in the 2010-2014 period. The rate of increase in vertical specialization was positive in CEE countries, between 2000 and 2014. Results in Table (2) revealed that in CEE countries, the rate of increase in vertical specialization was higher before 2004. In other periods, the lower rate of increase might be attributed to the 2008-2009 global financial crisis. Lamonica, Salvati & Carlucci (2020) claim that, particularly in smaller European countries, vertical specialization is higher. This is because, compared to larger nations, smaller countries are more dependent on imported intermediate goods. With this respect, the conclusions in Table (2) partially support those revealed by Lamonica et al. (2020). Despite the fact that among these nations, Poland is the largest country in terms of GDP and total added value according to UNCTAD (2023) data, between 2000 and 2014 its average vertical specialization rate was lower than other countries, except for Latvia.

Table 2: Vertical Specialisation Rates in CEE Countries, 2000-2014

Year	Czech Republic	Estonia	Hungary	Latvia	Lithuania	Poland	Slovak Republic	Slovenia
2000	0.315	0.355	0.478	0.239	0.231	0.247	0.383	0.330
2001	0.323	0.355	0.458	0.246	0.252	0.238	0.391	0.325
2002	0.325	0.356	0.445	0.234	0.231	0.249	0.398	0.316
2003	0.338	0.346	0.456	0.242	0.243	0.274	0.418	0.317
2004	0.379	0.362	0.468	0.262	0.281	0.278	0.435	0.341
2005	0.395	0.380	0.475	0.266	0.315	0.274	0.447	0.364
2006	0.407	0.389	0.510	0.289	0.328	0.301	0.478	0.375
2007	0.416	0.379	0.509	0.282	0.292	0.310	0.480	0.382
2008	0.407	0.388	0.510	0.274	0.361	0.313	0.467	0.372

[7] For detailed information about the Leontief inverse matrix and how it is obtained, see Miller & Blair (2009) and Thirlwall (1983).

2009	0.392	0.348	0.477	0.245	0.294	0.276	0.467	0.341
2010	0.429	0.405	0.515	0.285	0.336	0.310	0.478	0.376
2011	0.445	0.439	0.526	0.309	0.370	0.326	0.514	0.390
2012	0.454	0.452	0.521	0.328	0.363	0.315	0.494	0.387
2013	0.453	0.445	0.512	0.314	0.368	0.309	0.485	0.377
2014	0.460	0.435	0.519	0.310	0.357	0.310	0.481	0.374
Average	**0.396**	**0.389**	**0.492**	**0.275**	**0.308**	**0.289**	**0.454**	**0.358**
				Periodic Percentage Change				
2000-2004	20	2	-2	9	22	13	14	3
2005-2009	-1	-8	0	-8	-7	1	5	-6
2010-2014	7	7	1	9	6	0	1	-1
2000-2014	46	22	9	30	55	25	26	13

Source: Authors' Calculation based on Input-Output Tables.

Table (3) shows the rate of vertical specialisation in the ICT sector during the period from 2000 to 2014. While the ICT vertical specialisation rate increased in the Czech Republic, Lithuania, and Poland, it decreased in Estonia, Hungary, Slovakia, and Slovenia. The average vertical specialisation rate in the ICT sector was 0.152 in the Czech Republic, 0.330% in Estonia, 0.317 in Hungary, 0.211 in Latvia, 0.145 in Lithuania 0.242 in Poland, 0.179 in Slovakia, and 0.319 in Slovenia. Table (3) shows that from 2000 to 2014, the country with the highest average vertical specialisation rate was Hungary, but that the lowest one was Latvia. Based on the periodic changes shown in Table (3), the vertical specialization rate in the ICT sector is more vulnerable. Particularly, there was a considerable decrease in the vertical integration rate in the ICT sector during the 2005-2009 period. Following the 2008-2009 financial crisis, only the Czech Republic and Lithuania experienced a positive increase in vertical specialization during the period from 2010 to 2014. Compared to the results obtained in Table (2), the rate of vertical specialization in the ICT sector is lower. This is due to the global production process placing more emphasis on the manufacturing sector rather than the services sector (Cieslik, 2022c; Lamonica et al., 2020). With this respect, the conclusions obtained by Nas & Mualla (2022) corroborate this observation. Their research reveals that CEE countries have seen an increase in vertical specialization in the manufacturing sector, and the vertical specialization in manufacturing is greater than the entire economy's vertical specialization.

Both Table (2) and Table (3) show that there is a positive percentage increase in the vertical specialization rate in CEE countries, particularly during the 2000-2004 period. Cieslik (2022c) and Kordalska & Olczyk (2018) indicated that the reasons for this might be the increased integration of CEE countries with the EU, their efforts to engage in global production, and dynamics like EU-based firms pursuing to decrease production costs and benefit from comparative advantages. However, in later periods, this pattern seems to have been interrupted due to the global financial crisis. Another possible reason might be the intense competition coming from Asian countries, primarily China.

Table 3: ICT Sector's Vertical Specialisation Rates in CEE countries, 2000-2014

Year	Czech Republic	Estonia	Hungary	Latvia	Lithuania	Poland	Slovak Republic	Slovenia
2000	0.117	0.500	0.308	0.197	0.079	0.197	0.254	0.411
2001	0.110	0.462	0.343	0.224	0.078	0.211	0.253	0.340
2002	0.114	0.449	0.325	0.187	0.082	0.228	0.237	0.405
2003	0.136	0.431	0.351	0.180	0.085	0.278	0.196	0.412
2004	0.169	0.383	0.375	0.238	0.115	0.225	0.193	0.350

2005	0.172	0.351	0.374	0.231	0.114	0.253	0.200	0.323
2006	0.158	0.380	0.340	0.217	0.136	0.294	0.183	0.357
2007	0.178	0.314	0.358	0.252	0.172	0.265	0.202	0.360
2008	0.162	0.256	0.341	0.203	0.202	0.267	0.183	0.270
2009	0.134	0.197	0.310	0.191	0.114	0.239	0.164	0.253
2010	0.146	0.237	0.291	0.217	0.154	0.250	0.196	0.269
2011	0.162	0.264	0.293	0.219	0.236	0.220	0.126	0.271
2012	0.169	0.281	0.255	0.224	0.240	0.233	0.103	0.264
2013	0.181	0.250	0.249	0.203	0.194	0.238	0.092	0.259
2014	0.176	0.201	0.249	0.188	0.172	0.226	0.100	0.239
Average	0.152	0.330	0.317	0.211	0.145	0.242	0.179	0.319
				Periodic Percentage Change				
2000-2004	45	-23	22	20	46	14	-24	-15
2005-2009	-22	-44	-17	-17	0	-6	-18	-22
2010-2014	20	-15	-14	-13	12	-9	-49	-11
2000-2014	50	-60	-19	-5	118	15	-61	-42

Source: Authors' Calculation based on Input-Output Tables.

Table (4) shows the ICT's vertical specialisation rates during the period from 2000 to 2014. Table (4) shows that the sub-sectors with the highest average vertical specialization during the period of 2000-2014 are as follows: publishing activities (J58) in the Czech Republic, Estonia, Latvia, and Slovakia, telecommunications (J61) in Poland and Slovenia; motion picture, video, and television program production; sound recording and music publishing activities; programming and broadcasting activities (J59_J60) in Hungary; and computer programming, consultancy, and related activities; information service activities (J62_J63) in Lithuania,

Table 4: ICT Sub-sectors' Vertical Specialisation in CEE countries, 2000-2014

		2000	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**Average**
Czech Republic	J58	0.241	0.238	0.225	0.222	0.227	0.235	0.237	0.218	0.221	0.235	0.247	0.254	0.238	0.239	0.233	0.234
	J59_J60	0.194	0.188	0.165	0.130	0.141	0.141	0.149	0.139	0.130	0.139	0.153	0.178	0.155	0.170	0.157	0.155
	J61	0.144	0.135	0.114	0.123	0.129	0.124	0.123	0.119	0.120	0.124	0.146	0.161	0.174	0.176	0.197	0.141
	J62_J63	0.136	0.140	0.124	0.121	0.134	0.124	0.128	0.129	0.117	0.117	0.132	0.127	0.126	0.126	0.137	0.128
Estonia	J58	0.251	0.234	0.229	0.220	0.225	0.234	0.242	0.240	0.237	0.221	0.241	0.241	0.257	0.245	0.231	0.237
	J59_J60	0.155	0.187	0.189	0.166	0.161	0.143	0.166	0.168	0.172	0.151	0.167	0.152	0.180	0.184	0.189	0.169
	J61	0.132	0.182	0.168	0.164	0.187	0.196	0.214	0.215	0.205	0.197	0.219	0.231	0.245	0.230	0.232	0.201
	J62_J63	0.184	0.182	0.186	0.172	0.172	0.170	0.159	0.153	0.132	0.110	0.124	0.128	0.137	0.133	0.130	0.151
Hungary	J58	0.313	0.288	0.251	0.267	0.255	0.243	0.244	0.228	0.230	0.245	0.234	0.239	0.229	0.215	0.230	0.247
	J59_J60	0.293	0.347	0.292	0.253	0.284	0.268	0.242	0.224	0.205	0.246	0.223	0.273	0.248	0.244	0.246	0.259
	J61	0.170	0.159	0.137	0.137	0.135	0.138	0.162	0.163	0.148	0.155	0.160	0.171	0.172	0.179	0.181	0.158
	J62_J63	0.183	0.176	0.157	0.168	0.159	0.154	0.168	0.163	0.159	0.168	0.165	0.169	0.165	0.162	0.173	0.166
Latvia	J58	0.145	0.183	0.154	0.145	0.183	0.190	0.223	0.236	0.209	0.216	0.213	0.229	0.242	0.241	0.237	0.203
	J59_J60	0.124	0.137	0.129	0.126	0.132	0.127	0.126	0.111	0.139	0.132	0.156	0.149	0.155	0.164	0.160	0.138
	J61	0.074	0.065	0.071	0.074	0.087	0.104	0.116	0.125	0.129	0.124	0.136	0.152	0.161	0.162	0.158	0.116
	J62_J63	0.160	0.124	0.100	0.101	0.135	0.132	0.169	0.150	0.124	0.103	0.130	0.145	0.133	0.121	0.120	0.130
Lithuania	J58	0.089	0.093	0.101	0.098	0.102	0.108	0.116	0.118	0.149	0.115	0.133	0.133	0.137	0.138	0.134	0.118

	J59_J60	0.033	0.038	0.040	0.035	0.042	0.051	0.066	0.064	0.077	0.065	0.070	0.075	0.074	0.074	0.074	0.059
	J61	0.038	0.055	0.055	0.056	0.059	0.072	0.076	0.075	0.085	0.077	0.087	0.100	0.103	0.092	0.089	0.075
	J62_J63	0.106	0.126	0.124	0.131	0.143	0.188	0.184	0.182	0.224	0.195	0.188	0.205	0.194	0.173	0.169	0.169
Poland	J58	0.166	0.162	0.166	0.184	0.169	0.162	0.176	0.159	0.158	0.154	0.168	0.171	0.167	0.164	0.166	0.166
	J59_J60	0.154	0.135	0.121	0.129	0.126	0.121	0.141	0.131	0.127	0.125	0.133	0.137	0.141	0.137	0.138	0.133
	J61	0.190	0.162	0.144	0.156	0.146	0.155	0.175	0.190	0.197	0.189	0.209	0.217	0.217	0.214	0.214	0.185
	J62_J63	0.154	0.140	0.136	0.142	0.139	0.135	0.150	0.155	0.154	0.146	0.159	0.159	0.159	0.158	0.160	0.150
Slovak Republic	J58	0.263	0.281	0.285	0.273	0.292	0.280	0.306	0.262	0.250	0.238	0.246	0.229	0.148	0.186	0.158	0.247
	J59_J60	0.168	0.184	0.193	0.195	0.211	0.231	0.177	0.119	0.162	0.143	0.177	0.157	0.174	0.227	0.187	0.180
	J61	0.085	0.098	0.086	0.081	0.088	0.090	0.099	0.105	0.105	0.097	0.098	0.092	0.125	0.131	0.129	0.101
	J62_J63	0.114	0.125	0.134	0.108	0.106	0.126	0.125	0.098	0.103	0.087	0.092	0.114	0.122	0.144	0.149	0.116
Slovenia	J58	0.143	0.138	0.152	0.151	0.167	0.178	0.187	0.197	0.205	0.189	0.204	0.209	0.206	0.200	0.202	0.182
	J59_J60	0.085	0.081	0.112	0.107	0.111	0.127	0.135	0.147	0.150	0.144	0.154	0.168	0.169	0.178	0.180	0.136
	J61	0.162	0.168	0.149	0.139	0.151	0.168	0.179	0.183	0.198	0.196	0.206	0.212	0.216	0.211	0.212	0.183
	J62_J63	0.127	0.125	0.135	0.134	0.145	0.148	0.149	0.152	0.155	0.141	0.149	0.152	0.156	0.154	0.146	0.145

Source: Authors' Calculation based on Input-Output Tables.

Comparing findings from Table (4) with those from Table (5), it can be inferred that ICT sub-sectors exhibit a fragile and fluctuating vertical specialisation trend. With the exception of the telecommunications (J61) sub-sector, there has been a decline in vertical specialisation across all other sub-sectors in the Czech Republic. In Estonia, the telecommunications (J61) and motion picture, video, and television program production; sound recording and music publishing activities; programming and broadcasting activities (J59_J60) sub-sectors have seen an increase throughout all periods, while other sub-sectors have witnessed a decrease. A similar pattern emerges with an increase in the telecommunications (J61) sub-sector and a decrease in other sectors in Hungary. However, the scenario is different in Latvia where, excluding the computer programming, consultancy, and related activities; information service activities (J62_J63) sub-sector, all other sectors have experienced an increase in vertical specialisation. Both Lithuania and Slovenia have seen vertical specialisation grow across all sub-sectors. In Slovakia, all sectors, excluding motion picture, video, and television program production; sound recording and music publishing activities; programming and broadcasting activities (J59_J60), have experienced growth in vertical specialisation. Finally, in Poland, while there's been an increase in the telecommunications (J61) and computer programming, consultancy, and related activities; information service activities (J62_J63) sub-sectors, other sectors have seen a decrease. As a result, it can be revealed that in CEE countries, the primary sub-sector that stimulates vertical specialisation in the ICT sector is telecommunications (J61).

Table 5: Change in Vertical Specialisation Percentage Across ICT Sectors Over Time

		2000-2004	**2005-2009**	**2010-2014**	**2000-2014**
Czech Republic	J58	-5.6	-0.1	-5.4	-3.1
	J59_J60	-27.3	-1.8	2.6	-19.1
	J61	-10.2	0.3	35.3	36.9
	J62_J63	-2.0	-5.5	3.3	0.3
Estonia	J58	-10.2	-5.7	-4.0	-7.8
	J59_J60	4.1	5.4	13.1	22.2

	J61	42.2	0.6	6.1	76.0
	J62_J63	-6.8	-35.0	4.6	-29.3
Hungary	J58	-18.7	0.5	-1.8	-26.7
	J59_J60	-3.3	-8.1	10.3	-16.1
	J61	-20.5	12.5	12.7	6.0
	J62_J63	-12.9	9.3	4.6	-5.3
Latvia	J58	26.0	14.1	11.6	63.2
	J59_J60	7.0	4.3	2.7	29.7
	J61	18.2	19.1	16.8	114.8
	J62_J63	-15.3	-21.8	-8.1	-25.2
Lithuania	J58	14.4	6.4	1.0	50.3
	J59_J60	26.4	27.4	5.2	120.6
	J61	57.2	7.4	2.2	136.6
	J62_J63	34.9	4.2	-10.0	59.5
Poland	J58	1.8	-5.0	-1.2	-0.3
	J59_J60	-18.1	2.7	3.7	-10.4
	J61	-22.9	21.6	2.6	12.7
	J62_J63	-9.8	8.0	0.4	4.1
Slovak Republic	J58	10.7	-14.8	-35.6	-39.9
	J59_J60	25.9	-38.3	5.5	11.5
	J61	3.8	7.3	32.3	52.4
	J62_J63	-7.3	-31.4	61.5	30.3
Slovenia	J58	16.7	6.1	-1.1	40.8
	J59_J60	30.9	13.8	16.7	111.6
	J61	-6.8	17.2	3.0	31.2
	J62_J63	13.8	-5.2	-2.3	14.2

Source: Authors' Calculation based on Input-Output Tables.

CONCLUSION

To cope with the challenges of globalisation, an economic and political transformation had been experienced in the CEE countries. This transformation replaced the command economy with a market-oriented system after the dissolution of the Soviet Union. Since their EU membership in 2004, the CEE countries have achieved developments that ensured intensive participation in cross-border production chains. The basic factors that played an important role in developing the global production network were: the lower input costs provided by technological developments and the developments in ICT manufacturing. This study estimated the extent to which CEE countries are involved as a part of the vertical specialisation chain. The results revealed that the CEE countries' vertical specialisation rate increased during the period from 2000 to 2014 but decreased during the 2008-2009 global financial crisis. After 2004, the vertical specialisation rate continued to increase rapidly. During the studied interval, the highest average vertical specialisation rate was respectively accounted for in Hungary, Slovakia, Czech Republic, Estonia, Slovenia, Lithuania, Poland, and Latvia. The ICT sectors' vertical specialisation rates were lower than those of the entire economy. The ICT sectors' vertical specialisation rates decreased

significantly in Estonia, Hungry, Latvia, Slovakia, and Slovenia. However, it increased in the rest of the countries. The telecommunications (J61) sub-sector is the primary source of vertical specialisation in the ICT sector for CEE countries. When considering sub-periods, during the 2000-2004 period, it's evident that there was a higher percentage increase in vertical specialisation. However, this rate has decreased in the 2005-2009 and 2010-2014 periods. In the 2000-2004 period, the increase in vertical specialisation can be attributed to the CEE countries' integration with the EU, strategies of aligning with international markets, and free trade strategies initiated in the 1990s. Strategies fostering low wages for international production, flexible labour regulations, and tax incentives also boost vertical specialisation. In the 2005-2009 and 2010-2014 periods, the decrease in the rate of increase of vertical specialisation is likely stemmed from the 2008-2009 global financial crisis and the strong competition from emerging economies in East Asia, primarily China. The vertical specialisation of ICT sector in the CEE countries is more fragile and significantly lower compared to the entire economy. The reason for this is the higher vertical specialisation in manufacturing sub-sectors, with the service sector often being overlooked. In general, the results revealed that, except for Slovakia and Slovenia, in the 2000-2004 period, there was an increase in vertical specialisation. Moreover, all countries experienced a decrease in vertical specialisation in the 2005-2009 period. In the subsequent 2010-2014 and 2000-2014 periods, all countries, excluding Czechia and Lithuania, have witnessed a decreased rate of increase in vertical specialization.

Globalisation affects the world economy by accelerating the process of international fragmentation of production. Rapid participation in the global production process has been observed, especially in developing countries. This study revealed an important dimension of participation in the global production process for the studied CEE countries. In a globalising world, important skills endowments can be acquired from participation in the global production network. Since the digital world is gaining importance with the intensive use of digital technologies in production, participation in the global production network offers important advantages, such as closing the digital inequality between developed countries and developing ones. However, participation in the global production process can also reveal some disadvantages, such as increasing exporters' degree of reliance on imported goods. Furthermore, economic dependency may increase between developed and developing countries. Moreover, the crisis that may occur in any country may adversely affect the export policies of especially the developing countries. Therefore, the participation of developing countries in the global production network should be built on strengthening their export structures over time, increasing high-technology shares in their exports, incentivising high-technology production, and reducing mutual economic dependence. Moreover, these countries should develop policies that lead to improvements in information and communication technologies. To enhance effectiveness in the global production process within CEE nations, it is necessary to bolster the synergy between manufacturing and services (with an emphasis on ICT), with substantial investments should be directed towards the ICT sector. Since there are limited studies on CEE countries and since there are limited studies utilising input-output models as an analysing tool, this study will make an important contribution to future studies by providing an up-to-date investigation of vertical specialisation in CEE countries.

ETİK BEYAN VE AÇIKLAMALAR

Etik Kurul Onay Bilgileri Beyanı

Çalışmada etik kurul onayı gerektirecek herhangi bir bilimsel faaliyette (anket, görüşme vb.) bulunulmamıştır.

Yazar Katkı Oranı Beyanı

Yazarlar çalışmaya eşit oranda katkı yapmışlardır.

Çıkar Çatışması Beyanı

Yazarlar arasında çıkar çatışması bulunmamaktadır.

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