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Upgrading low value-added activities in global value chains: a functional specialisation approach

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ABSTRACT

This paper aims to identify patterns of functional specialisation (FS) in global value chains (GVCs) and determinants of upgrading them for selected Central Eastern European (CEE) economies. By combing the World Input-Output Database with data on occupations, we reveal a new FS pattern among subgroups of CEEs. Poland and Slovakia have an unfavourable GVC position and specialise in low value-added fabrication function. In contrast, other CEEs have competitive advantages in high value-added tasks: the Baltic countries and Slovenia in management services, the Czech Republic and Slovenia in R&D. We identify upgrading factors for different types of FS in GVCs. The wages convergence of CEEs with developed economies, and strong GVC backward linkages support the path to higher value-added in almost all business functions. Higher GDP per capita and lower economic distance to Germany allow CEEs to escape from 'factory economies' status and also generate higher value-added in R&D activities.

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KEYWORDS
Functional specialisation; global value chains; economic upgrading; occupations; CEE countries

1. Introduction

We investigate patterns of functional specialisation in global value chains (GVCs) in Central Eastern European (CEE) countries, focusing on what determines the ability to generate greater added value. We also provide a broader picture of functional specialisation approaches and measures, emphasising the connection between functional specialisation and upgrading concepts, all in the context of GVC changes.

The development of GVCs over the last two decades has radically changed the global economy. It has affected global trade mainly by significantly increasing trade in intermediate goods. Currently, two-thirds of world trade takes place via global value chains, in which products cross at least one border before final assembly (Degain et al., 2017). The development of global value chains has accelerated economic growth and reduced world poverty (UNIDO, 2018). For example, in Mexico and Vietnam, which have recorded marked increases in their shares in GVCs, faster increases in income have also been recorded (Kowalski et al., 2015). Moreover, the most significant poverty decrease has occurred in countries that have become integral parts of GVCs. These include China, Vietnam and

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Bangladesh (World Bank, 2021). Global value chains are related to productivity growth and job creation in many countries (Criscuolo & Timmis, 2017). This is manifested primarily in the growing access of women and young people to the labour market and increases in employment and wages in developing countries. Employment increases mainly occur in the export sector and among domestic companies cooperating with exporters (Hollweg, 2019). On the other hand, production for GVCs is associated with high capital intensity, and exports become less labour-intensive, which in some countries contributes to a decrease in employment (Farole, 2016).

The benefits listed above are not distributed evenly among participants in global value chains (Chong-Sup et al., 2019). Although countries can benefit from participation in GVCs in multiple ways, the gains appear to be more significant for middle- and high-income countries (Ignatenko et al., 2019). This can be represented as a smile curve showing where value is added in a typical industrial value chain, i.e. there are high value-added service activities at the two edges, such as innovation, R&D, design and branding (usually located in developed countries, called headquarters economies), while at the centre are assembly lines, which typically add little value (and are located in developing and emerging countries, called factory economies). This division of the benefits from GVCs raises the following questions. First, are factory countries locked into the low part of the GVC smile? Second, what policies can help these countries keep or improve their competitiveness in the smile curve? Third, what factors determine that factory economies can integrate into GVCs more successfully and move up from the low to the high part of the smile curve?

To answer these questions, we use the concept of functional specialisation. It is based on the works of Koopman et al. (2014) and Los et al. (2016), greatly extended by Timmer et al. (2019). The idea is to combine detailed occupational and wage data with a world input–output database to track value-added trade flows across countries. Based on the revealed comparative advantage index, this approach allows identifying the four types of activities performed in global value chains, such as fabrication, R&D, marketing, and management. This paper's novelty is not only the extension of the analysis period compared to Timmer et al. (2019) and the use of a new WIOD database (Timmer et al., 2015), but mainly linking the concept of functional specialisation with the upgrading process.

The literature on clusters and GVCs distinguishes four upgrading categories: product, process, inter-chain, and functional upgrading (Humphrey & Schmitz, 2002; Schmitz, 2006). We focus on functional upgrading, which relates to the acquisition of new functions associated with activities performed within a particular GVC (Dalle et al., 2013). Functional upgrading refers to the situation where companies take on new functions in the chain (and often abandon existing ones) in order to increase the added value of the activities performed. Therefore, we aim to identify patterns of functional specialisation in GVCs and factors that determine the upgrading of this pattern.

In the paper we focus on eight CEE countries (the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Slovakia and Slovenia). It is a group of post-transition countries that joined the European Union on 1 May 2014 and show similar levels of economic development (Table 1). These countries form a homogenous group due to their specific growth path during a transitional period. They have many things in common, such as geographical proximity to Germany and cultural similarity, a long-standing industrial tradition and a large share of industrial production in GDP, a significant share of foreign capital in manufacturing and the financial sector, an economic model based on exports

Table 1. Selected economic indicators of CEE countries.

	GDP per capita, PPP, 2019 (100 = EU15)	GDP growth in 2019 (100 = 2010)	Germany position in TOP 5 trade partners (% share of the German market in country's exports);in year2020	TOP 3 export product groups in the year 2020
Czech Republic	86	122	1 (32.6%)	Machinery (including computers); Electrical machinery; Vehicles
Estonia	78	138	5 (6.6%)	Electrical machinery; Fuels, Wood
Hungary	69	130	1 (28%)	Electrical machinery; Machinery (including computers); Vehicles
Latvia	66	135	4 (6.8%)	Wood; Electrical machinery; Machinery (including computers)
Lithuania	78	138	3 (8%)	Machinery (including computers); Furniture, Mineral fuels
Poland	68	137	1 (28.9%)	Machinery (including computers); Electrical machinery; Vehicles
Slovakia	73	128	1 (22.2%)	Vehicles; Electrical machinery; Machinery (including computers)
Slovenia	82	118	1 (16.6%)	Pharmaceuticals; Vehicles; Electrical machinery

Source: Statistical Annex of European Economy, Autumn 2019, ec.europa.eu.

with a substantial share of foreign corporations, low or insignificant reserves of raw materials and high dependence on their import, an energy system based on coal and nuclear power plants, whose fuels are displaced increasingly from the EU, significant resources of skilled workers with lower salary expectations than in Western Europe and relatively good economic performance against the backdrop of the EU during the global financial crisis and the Eurozone crisis.

Given the purpose of this paper, it is vital that analysed CEE countries are the economies tightly connected with European trade partners, especially with Germany in the case of Visegrad Group countries. The relatively high labour cost differential has led many German companies to relocate parts of their production to CEEs at the beginning of the 1990s. This process transformed into a structural relationship between Germany and CEE countries called by IMF (2013) the 'German-Central European Supply Chain Cluster' or the 'Central European Manufacturing Core', according to Stehrer and Stöllinger (2015). Furthermore, Kordalska and Olczyk (2019) confirmed that analysed CEE countries play the role of factory economies in regional GVCs.

The literature shows that the CEE countries are going through upgrading, mainly the 'process' upgrading. Previous studies are often related to technological and innovation processes in CEE countries. Radosevic (2017), based on indicators from Innovations Survey, identified a slow technological upgrading in CEE countries compared to the EU-15, which has a source in the import of new equipment and management practices. According to the author, CEE economies do not grow through domestic research that generates innovation but rely on the interaction between domestic R&D and more advanced technology from imported equipment and inputs. In turn, Jindra et al. (2015) analysed CEE countries' intensity of technology upgrading using patent data. The authors indicate a very similar pattern among CEE countries in the technology upgrading: CEE are characterised by a very open innovation system, in which foreign entities use local inventions. Between 2008 and 2016, CEE countries focused more on upgrading the production capacities, not the technological ones. It is probably related to the extensive participation of transnational corporations in economic upgrading processes in CEE countries, with limited spillover effects to local firms (Plank & Staritz, 2013). The question that is still open is whether the CEE countries are upgrading GVCs and which factors are likely to determine it?

The remainder of the paper is organised as follows. Section 2 provides an overview of the main literature on the subject. Section 3 describes the methodology of the empirical analyses, with a particular focus on the measure of functional specialisation. This section also presents the specification of the empirical model and its estimation strategy. Section 4 is devoted to the description of the data on functional specialisation in CEE countries. Then, the results of the estimation of the models are presented. The last section concludes the paper.

2. Functional specialisation in trade – a literature review

Specialisation in trade was the central idea in Adam Smith's theory (1776), in which gains from trade are explained by a division of labour even if all individuals are identical *ex-ante*. This concept was developed further by Ricardo (1817), who emphasised the role of exogenous comparative advantage in explaining trade patterns and the division of labour between countries. The specialisation concept was popularised by Balassa (1965), who proposed a standard tool to analyse specialisation patterns employing revealed comparative advantage (RCA). Recently, the idea of specialisation in trade has been connected with the increasing importance of production fragmentation in GVCs (Jones & Kierzkowski, 1990), with offshoring (Arndt, 1997) and outsourcing activities (Grossman & Helpman, 2002), vertical specialisation (Hummels et al., 2001; Yi, 2003), vertical production networks in GVCs (Hanson et al., 2003) and with trade in of different tasks in GVCs (Grossmann & Rossi-Hansberg, 2008). Nowadays, a typical production process can be split into separate parts with each able to be done in different locations. Imported goods are used as inputs to produce a country's export goods and simultaneously companies move some of their activities to another country. To understand and identify the benefits gained by these countries and industries through their activities in global trade, the smile curve concept can be used.

The concept of the smile curve was proposed by Shih (1996), founder of Acer, who observed that the two ends of a value chain (pre- and post-production service activities) add higher value to the product than the middle part (fabrication activities). The smile curve analogy has been widely used and discussed in the context of GVCs, but mostly in firm-level analyses (Mudambi, 2008; Shin et al., 2012). A few recent analyses on the 'macro smile curve' show that it is becoming steeper (Hyeon-Wook & Qureshi, 2020). This is connected with a greater income elasticity of services, larger adoption of increasingly sophisticated products by consumers and growth in embedded services in manufacturing goods, which allows more value added to be generated from post-production services. In addition, activities such as product design, research and development, market research and software development are becoming more and more important in pre-production processes and thus more significant in creating value added. The shape of the smile curve indicates that pre- and post-production service activities are crucial phases in adding more value. In our empirical analysis, we strongly rely on the construction of the smile curve. We assume that climbing the smile curve is associated with higher value added creation. Of course, in the future, advanced robotics, investments in Industry 4.0 technologies and their high availability of skill could enable developed countries to leave fabrication activities at home rather than outsourcing them to developing countries. Therefore, a country's ability to generate more value added depends strongly on activities and business functions within industries rather than the level of whole industries or products. Thus, comparative advantage should not be defined in terms of products or sectors but tasks and functions. This kind of specialisation is called functional specialisation.

Fragmentation theory in the literature has thus far largely neglected functional specialisation and the importance of pre- and post-production activities. The functional specialisation concept was first used in the urban economics framework by Duranton and Puga (2005). They observed the tendency for services to be more likely located in big cities while production plants tend to dominate in small and low-wage cities. As a result, they proposed transforming urban structures from a mainly sectoral specialisation to functional specialisation. Defever (2006) uses functional specialisation to analyse the location choices of non-European multinationals in the enlarged European Union. He states that apart from the case of headquarters, the location of service activities is more affected by functional than sectoral specialisation. The roots of functional specialisation in trade analyses are related to research on the adaption of RCA measures to GVC specifics and studies concerning a country and industry positions in GVCs. However, traditional RCA ignores the fact that value added by country sectors may be exported indirectly via the country's exports in other sectors and that the gross exports by a sector of a country's economy may partly carry foreign value added content. Therefore, Koopman et al. (2014) proposed referring RCA indices to the domestic value added in exports. In turn, Wang et al. (2013) developed an RCA indicator that uses value-added contributions to exports, i.e. forward linkage-based measure of domestic value added in exports instead of gross exports.

Various analyses of position measures of countries or industries in GVCs have contributed to developing the functional specialisation concept. We can find many country/sector measures of position in GVCs in the literature, beginning with average propagation length as introduced by Dietzenbacher et al. (2005), followed by the measure of upstreamness proposed by Antràs et al. (2012) and finally developed into the additive decomposition of average production length measures by Wang et al. (2017b). Furthermore, measures are used by Baldwin et al. (2014) to identify functional specialisation at the country level and the sector level, and finally at the firm level by Rungi and Del Prete (2018). These all confirm the smile curve shape and indicate that upstream and downstream industries generate more value added.

However, none of these analyses can properly show whether a country/industry specialises in fabrication activity or pre- or post-fabrication activity. This is for two reasons. The first weakness is connected with the measures used and the increasing difficulty in disentangling manufacturing from service activities. Goods are produced with services, and services are produced with goods, and companies tend to sell solutions to customers by bundling goods and services together (Miroudot, 2019). The servicification of manufacturing means that firms classified as manufacturers sell more services than goods, as in the case of 40% French firms (see Crozet & Milet, 2017) and that of the increase in numbers of factory-less goods producers (a strong tendency in the US economy – see Bernard & Fort, 2015). All the position measures of countries or industries in GVCs are unfortunately based on the classification of sectors. Second, value added by manufacturing industries should be equated with fabrication activities and value added by service industries with supporting activities. However, functions are different from industries and there is no simple one-to-one mapping. On the basis of an analysis of US industrial statistical systems, Fontagné and Harrison (2017) state that a mere statistical classification of industries cannot be relied on. Although administrative data is organised by classifying establishments (or firms) according to their primary activity, which is the activity that makes the most significant contribution to value added, in reality, establishments perform various activities and combine them in-house. For example, firms that design goods and coordinate production networks are often registered as manufacturers, but they are not *de facto* engaged in fabrication activity (Bernard et al., 2017).

To remove both weaknesses, the functional specialisation concept has started to develop in two completely new directions. The first approach, proposed by Stöllinger (2019), relates to the revealed comparative advantages concept in the trade literature, but it is applied to value chain functions of inward FDI projects. Thus, functional specialisation is measured as the share of inward greenfield FDI projects in a given country x serving a particular function y in the total number of inward projects in the country relative to the corresponding share at the world level. Stöllinger calculates a functional specialisation index based on FDI market cross-border investment monitoring data and confirms a general pattern of functional specialisation among countries, i.e. more value added intensive value chain functions remain in 'headquarters economies' while factory economies specialise in fabrication activity.

The second approach, proposed by Timmer et al. (2019), is connected with workers' occupations. Occupations are mapped onto activities and combined with information on inter-industry, and inter-country trade flows from the world input–output database. In this approach, workers' occupations provide information on the nature of the activity performed. Timmer et al. (2019) propose using a traditional Balassa index and measure the ratio of the share of each function in overall income from the country's exports to the income share of this function for all countries in their total exports. Their empirical analysis for six countries confirms that headquarters countries specialise in pre- and post-production activities and simultaneously do not specialise in fabrication, while factory economies specialise in fabrication activity. Some explanations for it can be found in de Vries et al. (2019), who analyse Dutch firm-level data, showing that firms specialising in R&D and marketing are identified as being significantly more productive than firms specialized in fabrication. In our analysis, to identify the functional specialisation pattern among CEE countries, we use the newest WIOD database (Timmer et al., 2015) and follow the methodology proposed by Timmer et al. (2019).

Functional specialisation in GVCs is a fairly new term, so we formulate a conceptual proposal to assess prospects for generating more value added of CEE economies. As it is mentioned above we follow Timmer et al. (2019) approach, and the concept of the smile curve, but we also address the ‘upgraded’ nature of FS. Our framework of functional specialisation is strongly rooted in the upgrading concept of firms (Gereffi, 1999), which is often defined as a successful hierarchical sequence of upgrading processes, products or functions at the firm level (Dalle et al., 2013; Humphrey & Schmitz, 2002)). Firms start with assembly, then move on to manufacturing, and then to design or marketing. Finally, they focus on R&D and may also move to a new chain (Gereffi & Fernandez-Stark, 2010). Dalle et al. (2013) point out the experience of East Asian firms as a good example of upgrading paths. They have built their success on the transition from original equipment assembling (OEA), i.e. thin value added on behalf of a global buyer, to original equipment manufacturing (OEM), i.e. manufacturing a product that bears the multinational firm’s label and is designed by it, and then to own design manufacturing (ODM).

Our point of departure is the proposition that functional specialisation is not only a process of climbing the smile curve to obtain more value added, but also a process accompanied by a necessary upgrading. In the conceptualisation of functional specialisation, we also refer to the concept of functional upgrading, which is known in the cluster and GVC literature and defined as the integration or movement of workers into more sophisticated business functions in GVCs (Lee & Gereffi, 2015; de Vries et al., 2021; Pellényi, 2020). de Vries et al. (2021) indicate that during the functional upgrading in GVCs, a faster increase is observed in upstream activities, such as R&D and design, and downstream activities, such as sales and marketing, compared to fabrication activities.

Moreover, we state that to measure functional specialisation well, it should be measured in relative terms. Following the Timmer et al. (2019) approach we use the relative comparative advantage index (RCA). In international trade theories, RCA is consistent with Ricardian and Heckscher-Ohlin models of international trade and measures a country’s comparative advantage to the performance of a group of other countries (the world or a national association) with which the county shares some common characteristics. In our case, RCA is defined based on value chain functions, instead of industries.

The main question in this paper is: what factors determine the changes in functional specialisation. To find possible determinants of FS, we refer to the concept of structural development in GVCs formulated by Milberg et al. (2014). According to the authors, two types of GVCs evolve in the process of GVC development and modernisation, namely producer-driven chains and buyer-driven chains. Producer-driven chains apply to capital- and technology-intensive industries such as the automotive, electronics, and pharmaceutical industries. Multinational corporations (MNCs) control the entire production process, and intra-firm trade is widespread. Foreign direct investment (FDI) and capital flow play a crucial role in the upgrading of producer-controlled chains. In turn, buyer-driven chains are controlled by commercial capital (large retailers and marketers), not industrial MNCs, and thus international subcontracting networks replaced FDI to a significant degree. Domestically owned firms play the crucial role of suppliers and are engaged first in assembly production, then in the upgrading process, and, finally, with design and branding. Price-, and then quality-competitiveness of domestic firms determines the adoption of higher value-added functions in GVCs.

A massive inflow of FDI into the CEE’s in 1990–2008 and the central role of the automotive industry in some CEEs (especially in the four Visegrád countries as well as in Slovenia and Romania) confirm the strong development of producer-driven chains in some CEE countries (Bykova et al., 2021). Therefore, we hypothesise that the inflow of FDI and the capital intensity in the CEE countries have a strong influence on their functional specialisation patterns (Hypothesis 1). We find some indirect evidence for this in the empirical literature. OECD (2013b) shows that knowledge-based capital stimulates upgrading as measured by the intangible capital stock in GVCs. Moreover, Manova and Yu (2016) show that access to capital is a key driver of high value-added functions in GVCs, i.e. credit-constrained exporting firms from China are likely to engage in low value-added pure assembly activities (and thus earn low profits) compared to less credit-constrained firms. Using industry- and country-level data, Vrh (2018) confirms that intangible capital investment plays an important role in GVC upgrading for EU-15 countries, while the results for CEE-10 countries are negative. Finally, using a sample of European countries, Adarov and Stehrer (2021) found the importance of capital accumulation in generating higher value added in GVCs. Also, FDI flow is indicated in the empirical literature as a potential determinant of upgrading activities in GVCs. FDI is a channel for importing high-value inputs (OECD, 2013a), intensifies the fragmentation of cross-border production between countries (Stöllinger, 2016; Head & Mayer, 2017), and supports the participation of domestic firms in GVCs (Martınez-Galan & Fontoura, 2019). The best example is Vietnam, where Samsung has invested in cell phone production since 2009, bringing the country into the global electronics manufacturing market (Tong et al., 2019).

The importance of FDI in the intensification of global value chains makes it necessary to look for the determinants of functional specialisation in theories of FDI because FDI has increased the interdependencies between global value chains and trade. Considering the four traditional motives for FDI proposed by Dunning (1993), two of them have dominated in the CEE countries: 'market search' and 'input search' (Jones et al., 2020). Foreign investors, especially European multinationals, are mainly attracted by the comparatively low wage levels (compared to the rest of Europe) and the well-educated workforce in the EU (Drahokoupil & Piasna, 2018). For this reason, for many years after the transition, the CEE region has served mainly as a location for labour-intensive manufacturing production (Voica et al., 2021). This stylised fact is in line with the concept of the functional division of labour proposed by Baldwin and Lopez-Gonzalez (2015), which indicates the asymmetry of technology as the reason why factory economies (such as CEEs) are responsible for providing labour, while headquarter economies create production chains. In turn, the newest analyses of FDI motives show that foreign investment 'in capabilities' starts to play a more relevant role in CEE economies and investment supportiving business functions emerge as important building blocks in GVCs (Andrenelli et al., 2019). For that reason, CEE countries have become attractive as regional headquarters or for other value chain activities such as design, R&D, marketing and a range of advanced business services, but factors that cause the upgrading of functions in GVCs are wages and employee skills. Therefore, we hypothesise that the wages and employee skills support the modernisation of functional specialisation patterns (Hypothesis 2).

Already Wood and Berge (1997) indicated that a highly skilled workforce might imply a comparative advantage in skill-intensive activities. Furthermore, Eichengreen et al. (2013), in their analysis on countries avoiding the middle-income trap, underline that skilled workers are needed to move up the value chain from low value-added industries to develop higher value-added activities. Additionally, Farole (2016) analysed the relationship between GVCs and labour markets, indicating that profiting from GVC integration depends on a company's position in GVCs and may also contribute to the skilled-unskilled labour divide. In turn, Wang et al. (2018), based on Melitz (2003) and the fair-wage hypothesis of Amiti and Davis (2011), link the wage premium with GVC upgrading. The shift to upstream sectors in GVCs requires higher productivity of skilled workers, which improves company profits and increases the wages of skilled workers. This positive relationship between wages and economic upgrading is confirmed in several analyses, most recently by Duc (2019) for Vietnam, and Gagliardi et al. (2021) for Belgium.

To find the determinant of functional specialisation, we also refer to the concept of vertical specialisation (VS) and vertically specialised industrialisation (VSI). Vertical specialisation is often defined as the share of imports in export products (Balassa, 1967). It tends to be high when production is organised in GVCs and leads to an increase in trade in intermediate goods (Hummels et al., 2001). VSI, in turn, is related to the concept of economic development and has taken the form of upgrading to higher value-added functions in GVCs (Milberg et al., 2014). In the GVC literature, both VS and VSI are measured in terms of backward linkages, which together with forward linkages (share of domestic value added in exports) are the two best-known measures of industry integration in GVCs (Koopman et al., 2008; Johnson & Noguera, 2012; Johnson, 2014). In the empirical GVC literature, Sydor (2011) and Kowalski et al. (2015) have already pointed to a higher domestic share in exports (forward linkages) as a driver of high-value activities in many countries. Ignatenko et al. (2019), in turn, use the Eora MRIO database to calculate various measures of GVC participation and linkages for 189 countries, and confirm that countries with strong forward linkages tend to be upstream in GVCs. Moreover, backward linkages can enhance a country's comparative advantage in generating higher value added in GVCs. Bartelme and Gorodnichenko (2015) find that growth in developed countries is generally correlated with stronger backward linkages, but the impact of backward linkages on GVC upgrading can vary significantly across countries and industries. In turn, Tian et al. (2019) also point to backward and forward linkages as potential determinants of moving up in GVCs. Therefore, we hypothesise that the stronger the GVC integration across industries, the stronger the functional specialisation (Hypothesis 3).

Finally, we added two variables to our analysis, namely proximity to major production hubs and economic development level as potential FS determinants based on observed trends and stylised facts in the literature on GVC development. We hypothesise that lower distance to the GVC hub and higher GDP per capita support functional specialisation (Hypothesis 4). According to Xiao et al. (2020), today's production systems are not configured like chains as a linear sequence of production stages, but consist of complex networks of nodes and spokes. This means that value chains are organised regionally rather than globally. The empirical analysis confirms that the global economy is regionally divided into three economic centres (hubs): factory Asia, factory Europe, and factory North America (Baldwin & Lopez-Gonzalez, 2015). Moreover, Stöllinger et al. (2018) show that EU countries participate 50% in GVCs and 50% in regional value chains and that the countries of CEE form a strong regional chain called the Central European Manufacturing Core. Inomata (2013) confirms that a country's proximity to a hub increases its prospects for integration into GVCs and the observed process of shifting towards more and more complex activities within regional value chains supports the upgrading processes in business functions.

We also add GDP per capita and GDP gap (between the GDP of each analysed country and that of the EU) as explanatory variables of FS. UNCTAD (2013) found that countries that have managed to upgrade in GVCs over the past 20 years have average GDP per capita growth of 3.4%, compared to 2.2% for countries that have not upgraded their domestic value added. The correlation between GVC integration and GDP per capita depends on income status (Boffa et al., 2016). Stöllinger (2019) estimates that incomes in a factory economy range from about $11,500 to $14,800 and that a typical functional specialisation pattern in a factory economy is associated with lower growth rates. Our analysis focuses on CEE countries that are at relatively similar levels of development and all have incomes above Stöllinger's threshold. Ignatenko et al. (2019) find in their analysis of 189 countries that changes in GVC participation and a potential move up in GVCs are strongly associated with income convergence.

To sum up, the paper is an attempt to verify four research hypotheses: (1) the inflow of FDI and the capital intensity in the CEE countries have a strong positive influence on their functional specialisation patterns, (2) the wages and employee skills support the modernisation of functional specialisation patterns, (3) the stronger the integration of GVCs across industries, the stronger the functional specialisation, (4) lower distance to the GVC hub and higher GDP per capita support functional specialisation.

3. Research methodology and the model

3.1. The measurement of functional specialisation

To meet the aim of our study, we employ a research procedure that consists of several steps. The first step is devoted to the identification of functional specialisation (FS) indices. To do this end, we follow the novel methodology proposed by Timmer et al. (2019). Their approach takes a country's exports perspective and thus allows us to track different business activities which country carries out along GVCs. Adopting Balassa's (1965) revealed comparative advantage index, the FS measure for business function k in country i is a follows:

$$FS_i^k = \frac{f_i^k / \sum_k f_i^k}{\sum_i f_i^k / \sum_i \sum_k f_i^k} \tag{1}$$

The functions k which we consider are linked to four types of firm activities in the production process: research and development services, and technology development (RD), pure fabrication (FAB), management (MGT) and marketing services consisting in sales and distribution activities (MAR).

The approach proposed in Timmer et al. (2019) is based on the assumption that particular functions and their contribution to a country's exports can be identified by measuring the income of the domestic workers who carry out these functions. Thus, formula (1) describes the relationship between the share of function k in the overall income in the country's exports and the income share of function k for all countries in their total exports.

In order to calculate f_i^k – the domestic value-added by function k in country i's exports – two sources of data and two steps are needed. First, with the aid of the input–output tables, the decomposition of gross exports and identification of domestic value-added is done. For

G industries in country i, the $G\times 1$ gross output vector $\mathbf{x}$ is:

$$\begin{bmatrix} x_1 \\ x_2 \\ \vdots \\ x_G \end{bmatrix} = \begin{bmatrix} 1-a_{11}^D & -a_{12}^D & \dots & -a_{1G}^D \\ -a_{21}^D & 1-a_{22}^D & \dots & -a_{2G}^D \\ \vdots & \vdots & \ddots & \vdots \\ -a_{G1}^D & -a_{G2}^D & \dots & 1-a_{GG}^D \end{bmatrix}^{-1} \begin{bmatrix} e_1 \\ e_2 \\ \vdots \\ e_G \end{bmatrix} \tag{2}$$

Thus, in a matrix notation, we have:

$$\mathbf{x} = (\mathbf{I} - \mathbf{A}^{\mathrm{D}})^{-1}\mathbf{e} \tag{3}$$

where $\mathbf{A}^{\mathrm{D}}$ is a $G\times G$ domestic intermediate input coefficient matrix and $\mathbf{I}$ is a $G\times G$ identity matrix with 1s on the diagonal. $\mathbf{e}$ refers to a $G\times 1$ vector of gross exports. Finally, in this step, domestic value-added in exports $\mathbf{d}^{\mathrm{E}}$ is expressed as:

$$\mathbf{d}^{\mathrm{E}} = \mathbf{V}\mathbf{x} \tag{4}$$

with the $G\times G$ matrix $\mathbf{V}$ of value-added shares of gross output on the diagonal and zero otherwise:

$$\mathbf{V} = \begin{bmatrix} v_1 & 0 & \dots & 0 \\ 0 & v_2 & \dots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \dots & v_G \end{bmatrix} \tag{5}$$

In the second step required to identify FS indices, we focus on the labour market. Information about workers' occupations (Timmer et al., 2019; Buckley et al., 2020) is fully mapped onto the four business functions mentioned above, as presented in Appendix A, Table A.1. It is done for each industry and each economy. Next, combining both the sources, an equation for G industries that allows the domestic value-added by function k in country i's total exports to be tracked takes the following form:

$$\mathbf{f} = \mathbf{W}\mathbf{d}^{\mathrm{E}} \tag{6}$$

In the above formula, matrix $\mathbf{W}$ is a $K\times G$ matrix with w_{kg} elements, which reflect the income of all workers who carry out function k in industry g as a share of the value-added generated by industry g. Vector $\mathbf{f}$ of dimension $K\times 1$ represents the f_i^k – the domestic value-added by function k in country i's exports.

3.2. Model and the estimation strategy

Bearing in mind the aim of our study, we propose the econometric model for functional specialisation indices obtained as above later in this article. Using primary FS indices, we keep the complexity of the phenomenon and maintain its variability at the same time. Thus, our model allows us to answer which factors support specialisation growth in particular business functions. We estimate separate models for these business functions which are linked to pre- and post-production activities and are treated as being responsible for creating high value-added, i.e. for RD, MGR and MAR. We also present the model for fabrication function to show a complex picture of this phenomenon. Our empirical model for business functions (k), countries (i), industries (j), and for the period 2000-2014, takes the following form:

$$\begin{aligned} FS_{ijt}^{k} = {} & \beta_0^k + \beta_1^k \times LabComp_{ijt} + \beta_2^k \times CapInt_{ijt} + \beta_3^k \times EmpSkills_{ijt} + \beta_4^k \times GVC_{ijt} \\ & + \beta_5^k \times GDP_{it} + \beta_6^k \times FDIinflow_{it} + \beta_7^k \times distMP_{it} \\ & + \beta_8^k \times manuf_j + \delta_i^k + \delta_j^k + \delta_t^k + \xi_{ijt}^k \end{aligned} \tag{7}$$

On the basis of the literature review, we select a wide range of factors as potential drivers of the phenomenon analysed. The vast majority of variables are observed at the sectoral level. *Lab-Comp* reflects the compensation of employees and *Cap-Int* shows the relation between capital stock and the number of persons engaged. Both variables are expressed in 2011 US dollars. In our model, we also consider the skill structure of employment (*Emp-Skills*). The *GVC* variable reflects a group of variables linked to country-sector GVC involvement. It allows us to control for the impact of GVC trade measured from the perspective of sellers (*GVC-forward*) and the perspective of buyers (*GVC-backward*), on the other hand. All the GVC variables are represented as a percentage of gross exports.

In our model, we also employ a group of variables measured at the country level. This group includes *GDP* measured in two ways – as *GDP per capita* – and alternatively as a share of the particular CEE country's GDP per capita, in German GDP per capita (*GDP-gap-DEU*). This last variable reflects an economic distance between analysed countries and Germany as a hub of Factory Europe. The next variable – *FDI-inflow* – is net FDI inflows as a percentage of GDP, and finally, in this group, we consider the distance to the main trading partner (*dist-MP*). As Table 1 shows, Germany plays a dominant role for Visegrad countries and Slovenia. For the Baltic states, a significant role is also played by Russia, Finland or Sweden and the Baltic countries themselves. The overwhelming majority of explanatory factors in our model describe characteristic features of CEE countries. We also incorporate the external component in our model, considering the economic distance to Germany (*GDP-gap-DEU*) and physical distance to main trading partners (*dist-MP*).

The last variable – *manuf* – is a dummy variable that takes the value of 1 for manufacturing sectors and 0 for service sectors. δ_i and δ_j are dummy variables to control for sector and country heterogeneity, and δ_t is a dummy for time periods. ξ_{ijt} is a random disturbance. All exact definitions of explanatory variables used in the model (7) and data sources are included in Appendix A, Table A.2.

To check the robustness of our results, we test these results in a few ways – using different estimation techniques, taking into account a problem of potential endogeneity, and using alternative measures for particular explanatory variables.

As a baseline estimator for formula (7), we use the OLS estimator with fixed effects. However, we are aware of the endogeneity problem due to the potential simultaneous relationship between FS indices and selected explanatory variables. Because the empirical literature on reverse relationships between phenomena is very scarce the decision on which determinants can be treated as endogenous is taken on the basis of endogeneity tests.

To address the problem of endogeneity, we use a two-fold approach. In the first step, we use lagged explanatory variables that are suspected to be endogenous. In the second step, we employ instrumental variable (IV) techniques using external instruments supported by lagged explanatory variables. The quality of instruments is confirmed by weak identification and underidentification tests.

To check the validity of the results, we also use alternative measures of selected variables that vary in their definition. Next to GDP per capita derived from the WDI (World Bank, 2021), we test GDP per capita from the Penn World Table (Feenstra et al., 2015) and, as mentioned before, the difference between GDP per capita for particular CEE countries and GDP per capita for Germany to catch a specific relationship between CEE countries and the Factory Europe hub. We also use substitutes for backward and forward GVC participation. In the first step, we use measures proposed by Borin and Mancini (2019). Next, we employ Wang et al. (2017a) backward and forward GVC participation indices which have a different character and are related to final production and value-added, respectively.

4. Empirical analyses

4.1. Descriptive results

In this section, we track functional specialisation indices for eight selected CEE countries: the Czech Republic, Estonia, Hungary, Lithuania, Latvia, Poland, Slovakia and Slovenia. A sectoral disaggregation based on NACE 2 covers nineteen manufacturing industries and twenty-one service sectors (Appendix A, Table A.3).[1] The time span is the period 2000-2014, and this is connected strictly to the WIOD database (Timmer et al., 2015) availability.

The primary data for calculating domestic value-added in exports by business functions and thus functional specialisation indices comes from the WIOD database, release 2016 and from the Occupations Database built by Timmer et al. (2019) and Buckley et al. (2020).[2]

When the structure of domestic value-added by business functions is considered, the visible importance of fabrication function for all CEE countries is observed (Figure 1). In 2000, the value-added share related to FAB varied between 38% for Latvia and 48% for Lithuania, but over the period and all countries analysed, this share decreased – from 4 p.p. for Latvia to 11 p.p. for Slovenia. For comparison, this figure also contains data for Germany as a hub of Factory Europe and, at the same time, the most important trading partner for majority of CEE countries. For this country, at the beginning of the period considered, the FAB function also plays a crucial role; however, the drop in its importance makes the marketing function dominant. The rise of MAR function significance is noticeable for all CEE countries, but the German pattern is observed for Latvia only. Domestic value-added in MGT accounts for a much lower share in total value-added in comparison to FAB or MAR. It fluctuates between 9% (Hungary) and 21% (Estonia) in 2014. Finally, an interesting pattern is revealed for RD function – its share in total domestic value-added is relatively constant over time, both for CEE countries and Germany, and varies from 10% for Latvia to 15% for the Czech Republic and Slovenia and 21% for Germany.

The FS indices calculated for the four main business functions define the patterns of functional specialisation of the countries analysed (Figure 2). Similar to Figure 1, next to

[1] We use only services which are treated as tradable: G (trade), H (transport), J (information services), K (financial and insurance activities), and M-N (other business services)

[2] Data for European countries are collected from the harmonised individual-level European Union Labour Force Surveys.

Figure 1. Structure of domestic value-added in exports by business functions in CEE countries and Germany
Source: authors' elaboration based on the decomposition in Timmer et al. (2019).

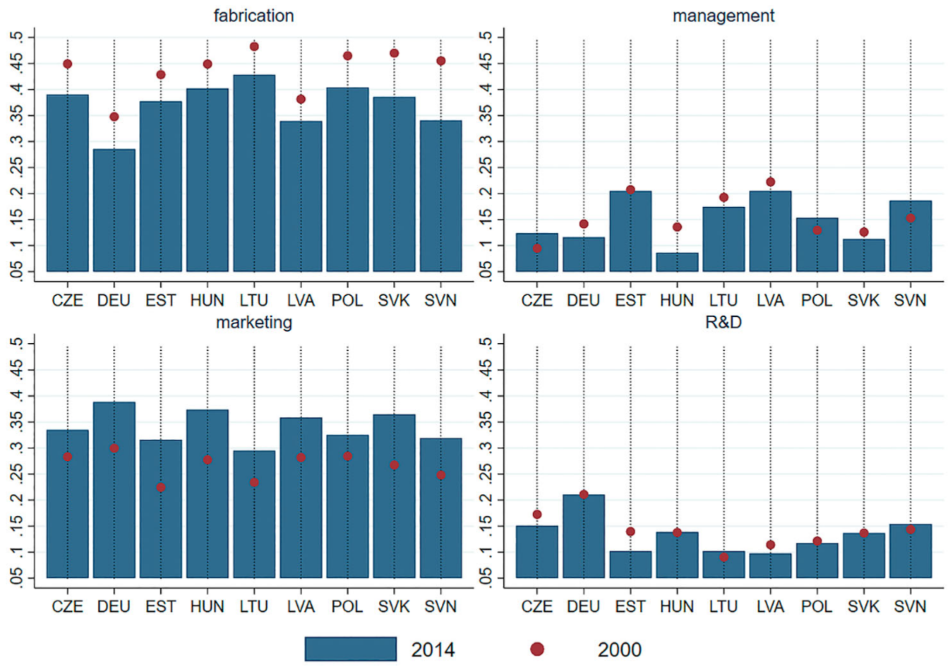
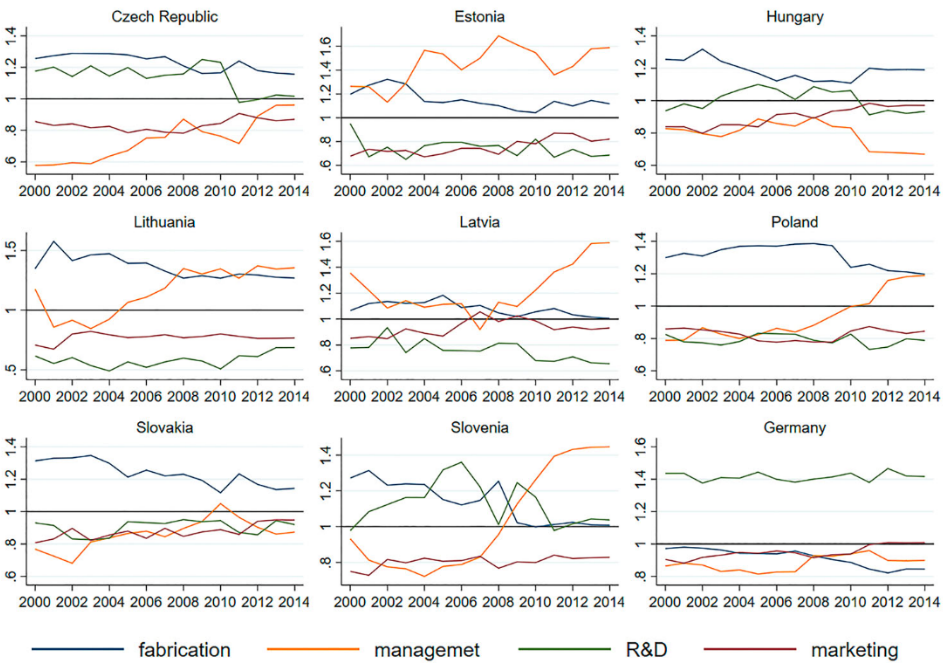


Figure 2. Functional specialisation of CEE countries and Germany
Source: authors' calculations based on the decomposition in Timmer et al. (2019).



the FS indices for CEE countries, we present analogous measures for Germany, which form a very characteristic specialisation pattern with a strong RD specialisation. However, CEE countries' patterns are far from that observed for Germany. The dominant specialisation in these countries is related to fabrication. This is particularly evident for Slovakia, which is a pure factory economy with a strongly dominant fabrication function and a lack of any other comparative advantages in terms of FS indices. This result is in line with the findings of Stöllinger (2021). A similar pattern is demonstrated for Poland. For the other countries, fabrication still plays a key role, but its importance decreases over time in favour of other business activities. Moreover, during the period analysed, all the economies except Slovakia also reveal advantages in other functions. The second most important activity is related to management. In this area, Estonia leads in all the years analysed, but also the other Baltic states and Slovenia appear to be specialised in this kind of services. At the end of the period, Poland joins this group as well. Although in the structure of domestic value-added, the importance of research and development services and technology development activities is not that high (Figure 1). The comparative advantages in RD are revealed for three countries: the Czech Republic, Slovenia and partially for Hungary. Among the CEEs, these countries have the highest share of domestic value-added in RD in relation to total domestic value-added. In opposite to domestic value-added in RD, that for marketing constitutes a significant part of total value-added, but it is not reflected in functional specialisation measures. None of the CEE countries reveal comparative advantages in marketing.

4.2. Estimation results

In this section, we present the regression analyses based on equation (7) and the estimation strategy described in Section 3. In addition, a correlation table for all explanatory variables is included in Appendix A, Table A.4. All models are estimated on balanced panel data, which include 40 industries in eight CEE countries and cover the period 2000-2014.

The construction of the external instruments bases on our observation that some of the remaining WIOD countries reveal a similar functional specialisation pattern in terms of the importance of fabrication function. These countries are Bulgaria, Brazil, China, Japan, Mexico, Romania, Russia and Turkey (Appendix B, Figure B.1). The instruments for variables mentioned in Section 3 take the form of a weighted average for the countries listed above. Additionally, as it has been said before, we support such instruments with lagged explanatory variables.

In order to identify which variables are endogenous we test them with the aid of external instruments and lagged values of explanatory variables, separately. The results are shown in Appendix A, Table A.5. On the basis of these results, we confirm the endogeneity of labour compensation (*Lab-Comp*), and thus our results will be interpreted in terms of interdependencies rhater than causal relations.[3]

According to our research strategy, we estimate models for each functional specialisation type separately. Each of our specifications controls for sector and time heterogeneity.

[3] Additionally, apart from the results of endogeneity tests and confirmed endogeneity of labour compensation, we test the robustness of the estimates assuming that GDP per capita is not exogenous (Appendix C, Table C.2). Admittedly, in CEE countries, the correlation between GDP per capita and labour compensation is very low (0.086-0.097, Appendix A, Table A.5), but stylised facts show that in developed countries the growing GDP per capita goes together with the growth of labour compensation in the long-run. That is why the robustness check of the estimates is done with the assumption of endogeneity of GDP per capita as well.

Table 2 reports the results of estimations for research and development business function.

On the basis of these models, we find strong evidence of the importance of selected variables. We observe the interdependence between the growth in labour compensation, the capital intensity measured by the relation between capital and total hours worked, and the growth of comparative advantages in R&D activities in the analysed countries.

Functional specialisation in RD is also positively related to growth in GDP per capita. This business function is the only one among the analysed (Tables 3–5) for which the interrelationship with GDP per capita is strongly positive and significant. This is in line with Timmer et al. (2019) results obtained for all WIOD countries. Similarly, the GDP gap has a positive linkage.[4] The smaller the distance between particular CEEs and Germany regarding their GDP per capita, the higher the specialisation in RD activity. Next to the positive relation between decreasing economic distance and RD specialisation, we also observe an inverse relationship between distance to main trading partners and analysed business activity.

We find empirical support for integration in global value chains. However, when we decompose the GVC participation into GVC backward and forward participation, only backward participation remains positive and reveals to be important.

The last statistically significant variable is the dummy variable which takes value of 1 for manufacturing. It is easier to achieve a comparative advantage in manufacturing industries.

The results concerning specialisation in management function (Table 3) reveal a different pattern. Our findings show that the presence of FDI inflows and the growing share of highly skilled workers in remaining groups of workers, correspond with growing specialisation in management in CEE economies. Surprisingly, we do not find evidence for the dependence between MGT specialisation and GDP per capita/GDP gap. In Timmer et al. (2019), the effect of GDP per capita on FS indices of management is positive in all WIOD economies, but its strength is weakest compared to the other sectors of the economy. This difference in results may be due to the different sectoral structure of high income countries and CEE economies. Hagemejer and Ghodsi (2017) point out that although the share of services in output has increased in CEE countries, it is still far below that of the EU-15. Thus, even if the GDP per capita in CEE countries grows, the CEEs will probably not take on management tasks in chains due to insufficient market power.

Estimation results for functional specialisation in marketing are presented in Table 1. The analysis of FS patterns (Section 4.1) shows that there is no country specialising in this business function in CEE countries. Our results are in line with Hagemejer and Ghodsi (2017) who highlight the upstreamness strategy of CEEs in moving along the smile curve. They show that in order to gain a better position in GVCs (offering more value-added), CEE countries try to move upstream along the smile curve, i.e. to where the R&D activities are located, and CEEs are interested in going down, where the marketing and sales activities are located. Our estimates show that the main factor strongly related to this functional specialisation is labour compensation; however, the coefficient is $^1/_3$ times lower in comparison to this in the RD model. Our results also show a strong interaction between GVC participation and comparative advantages in marketing activity.

[4] *GDP-gap-DEU* is constructed as a relation between GDP per capita for particular CEE countries and GDP per capita for Germany (Appendix A, Table A.2). The gap decreases if the share of CEE country's GDP in German GDP increases.

Table 2. Functional specialisation in research and development.

Dependent Variable **RCA-RD**	OLS	OLS (with lagged explanatory variable)	IV-GMM	OLS	OLS (with lagged explanatory variable)	IV-GMM
	(1)	(2)	(3)	(4)	(5)	(6)
Lab-Comp	0.0629***	0.0648***	0.0637***	0.0626***	0.0646***	0.0635***
	[0.0186]	[0.0194]	[0.0190]	[0.0186]	[0.0194]	[0.0190]
Cap-Int	0.2936	0.3834*	0.4156**	0.2938	0.3834*	0.4157**
	[0.1818]	[0.2087]	[0.2072]	[0.1818]	[0.2087]	[0.2072]
Emp-Skills	0.0001	0.0000	0.0000	0.0001	0.0000	0.0000
	[0.0003]	[0.0003]	[0.0003]	[0.0003]	[0.0003]	[0.0003]
GVC-backward (BM)	0.0101***	0.0087***	0.0091***	0.0101***	0.0087***	0.0091***
	[0.0028]	[0.0028]	[0.0028]	[0.0028]	[0.0028]	[0.0028]
GVC-forward (BM)	0.0019	−0.0001	0.0022	0.0019	−0.0001	0.0023
	[0.0050]	[0.0051]	[0.0051]	[0.0050]	[0.0051]	[0.0051]
GDP-per-Cap (WB)	0.0187***	0.0193***	0.0211***			
	[0.0060]	[0.0063]	[0.0063]			
GDP-gap-DEU				0.7398***	0.7708***	0.8428***
				[0.2364]	[0.2500]	[0.2480]
FDI-inf-GDP	−0.0104	−0.0123	−0.0134*	−0.0104	−0.0123	−0.0134*
	[0.0076]	[0.0080]	[0.0079]	[0.0076]	[0.0080]	[0.0079]
dist-MP	−0.0001*	−0.0002**	−0.0002**	−0.0001*	−0.0002**	−0.0002**
	[0.0001]	[0.0001]	[0.0001]	[0.0001]	[0.0001]	[0.0001]
manuf	0.8608***	0.8139***	0.8351***	0.8619***	0.8150***	0.8357***
	[0.1420]	[0.1484]	[0.1034]	[0.1419]	[0.1483]	[0.1034]
N	4799	4479	4479	4799	4479	4479
R2	0.3861	0.3846	0.3831	0.3862	0.3847	0.3831
K-P rk LM			146.984			146.748
p for K-P rk LM			0.0000			0.0000
K-P rk Wald F			2508.775			2507.980

Notes: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Robust standard errors in parentheses. In all specifications, constant, sector and time effects are included. Specifications (2) and (5) include one year lagged labour compensation. K-P refers to Kleibergen-Paap test statistics. BM refers to Borin and Mancini (2020) decomposition. WB refers to the World Bank data.
Source: authors' calculations.

Table 3. Functional specialisation in management.

Dependent Variable **RCA-MGT**	OLS (1)	OLS (with lagged explanatory variable) (2)	IV-GMM (3)	OLS (4)	OLS (with lagged explanatory variable) (5)	IV-GMM (6)
Lab-Comp	–0.0317	–0.0241	–0.0199	–0.0311	–0.0236	–0.0195
	[0.0218]	[0.0235]	[0.0229]	[0.0218]	[0.0235]	[0.0229]
Cap-Int	0.022	0.0281	0.0277	0.0227	0.0294	0.0291
	[0.1245]	[0.1494]	[0.1484]	[0.1243]	[0.1492]	[0.1481]
Emp-Skills	0.0012***	0.0012***	0.0014***	0.0012***	0.0012***	0.0014***
	[0.0004]	[0.0004]	[0.0004]	[0.0004]	[0.0004]	[0.0004]
GVC-backward (BM)	0.0055	0.0041	0.0036	0.0056	0.0041	0.0037
	[0.0036]	[0.0037]	[0.0036]	[0.0036]	[0.0037]	[0.0036]
GVC-forward (BM)	–0.0119*	–0.0135**	–0.0133**	–0.0119*	–0.0136**	–0.0133**
	[0.0064]	[0.0066]	[0.0065]	[0.0064]	[0.0066]	[0.0065]
GDP-per-Cap (WB)	–0.0462***	–0.0451***	–0.0440***			
	[0.0099]	[0.0105]	[0.0105]			
GDP-gap-DEU				–1.8671***	–1.8409***	–1.8044***
				[0.3825]	[0.4102]	[0.4073]
FDI-inf-GDP	0.0324**	0.0336**	0.0340**	0.0323**	0.0334**	0.0338**
	[0.0145]	[0.0152]	[0.0151]	[0.0145]	[0.0152]	[0.0151]
dist-MP	–0.0005***	–0.0006***	–0.0006***	–0.0005***	–0.0006***	–0.0006***
	[0.0001]	[0.0001]	[0.0001]	[0.0001]	[0.0001]	[0.0001]
manuf	0.8838***	0.8690***	0.6694***	0.8787***	0.8646***	0.6673***
	[0.1735]	[0.1827]	[0.1266]	[0.1736]	[0.1828]	[0.1267]
N	4799	4479	4479	4799	4479	4479
R2	0.3757	0.3784	0.3779	0.3759	0.3787	0.3782
K-P rk LM			146.984			146.748
p for K-P rk LM			0.0000			0.0000
K-P rk Wald F			2508.775			2507.980

Notes: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Robust standard errors in parentheses. In all specifications, constant, sector and time effects are included. Specifications (2) and (5) include one year lagged labour compensation. K-P refers to Kleibergen-Paap test statistics. BM refers to Borin and Mancini (2020) decomposition. WB refers to the World Bank data.
Source: authors' calculations

Table 4. Functional specialisation in marketing.

Dependent Variable **RCA-MAR**	OLS	OLS (with lagged explanatory variable)	IV-GMM	OLS	OLS (with lagged explanatory variable)	IV-GMM
	(1)	(2)	(3)	(4)	(5)	(6)
Lab-Comp	0.0473**	0.0502**	0.0509**	0.0476**	0.0505**	0.0511**
	[0.0197]	[0.0207]	[0.0203]	[0.0197]	[0.0207]	[0.0203]
Cap-Int	0.0814	0.1270	0.1257	0.0809	0.1267	0.1255
	[0.0992]	[0.1195]	[0.1188]	[0.0991]	[0.1194]	[0.1187]
Emp-Skills	−0.0001	−0.0001	0.0001	−0.0001	−0.0001	0.0001
	[0.0003]	[0.0003]	[0.0003]	[0.0003]	[0.0003]	[0.0003]
GVC-backward (BM)	0.0075***	0.0065***	0.0066***	0.0074***	0.0064***	0.0066***
	[0.0023]	[0.0024]	[0.0024]	[0.0023]	[0.0024]	[0.0024]
GVC-forward (BM)	−0.0016	−0.0026	−0.0032	−0.0017	−0.0027	−0.0032
	[0.0036]	[0.0037]	[0.0036]	[0.0036]	[0.0037]	[0.0036]
GDP-per-Cap (WB)	−0.0170***	−0.0198***	−0.0171***			
	[0.0060]	[0.0064]	[0.0063]			
GDP-gap-DEU				−0.6612***	−0.7822***	−0.6816***
				[0.2321]	[0.2482]	[0.2451]
FDI-inf-GDP	−0.0008	−0.0032	−0.0031	−0.0008	−0.0032	−0.0031
	[0.0074]	[0.0078]	[0.0078]	[0.0074]	[0.0078]	[0.0078]
dist-MP	−0.0002***	−0.0003***	−0.0003***	−0.0002***	−0.0003***	−0.0003***
	[0.0001]	[0.0001]	[0.0001]	[0.0001]	[0.0001]	[0.0001]
manuf	0.6360***	0.6482***	0.6010***	0.6354***	0.6475***	0.6006***
	[0.1167]	[0.1179]	[0.0786]	[0.1167]	[0.1179]	[0.0787]
N	4799	4479	4479	4799	4479	4479
R2	0.3897	0.3921	0.3917	0.3897	0.3921	0.3917
K-P rk LM			146.984			146.748
p for K-P rk LM			0.0000			0.0000
K-P rk Wald F			2508.775			2507.980

Notes: * p < 0.10, ** p < 0.05, *** p < 0.01. Robust standard errors in parentheses. In all specifications, constant, sector and time effects are included. Specifications (2) and (5) include one year lagged labour compensation. K-P refers to Kleibergen-Paap test statistics. BM refers to Borin and Mancini (2020) decomposition. WB refers to the World Bank data.
Source: authors' calculations

Table 5. Functional specialisation in fabrication.

Dependent Variable **RCA-FAB**	OLS	OLS (with lagged explanatory variable)	IV-GMM	OLS	OLS (with lagged explanatory variable)	IV-GMM
	(1)	(2)	(3)	(4)	(5)	(6)
Lab-Comp	0.0743***	0.0768***	0.0742***	0.0746***	0.0771***	0.0744***
	[0.0179]	[0.0188]	[0.0185]	[0.0179]	[0.0188]	[0.0185]
Cap-Int	0.1607	0.2162	0.2234	0.1603	0.216	0.2234
	[0.1296]	[0.1518]	[0.1508]	[0.1295]	[0.1517]	[0.1508]
Emp-Skills	0.0001	0.0001	0.0002	0.0001	0.0001	0.0002
	[0.0003]	[0.0002]	[0.0002]	[0.0002]	[0.0002]	[0.0002]
GVC-backward (BM)	0.0092***	0.0082***	0.0087***	0.0092***	0.0082***	0.0087***
	[0.0027]	[0.0027]	[0.0027]	[0.0027]	[0.0027]	[0.0027]
GVC-forward (BM)	0.0021	0.0016	0.0012	0.002	0.0016	0.0012
	[0.0044]	[0.0044]	[0.0044]	[0.0043]	[0.0044]	[0.0044]
GDP-per-Cap (WB)	−0.0214***	−0.0235***	−0.0228***			
	[0.0065]	[0.0069]	[0.0068]			
GDP-gap-DEU				−0.8422***	−0.9342***	−0.9118***
				[0.2563]	[0.2703]	[0.2686]
FDI-inf-GDP	0.0064	0.0045	0.0034	0.0064	0.0045	0.0034
	[0.0084]	[0.0088]	[0.0087]	[0.0084]	[0.0087]	[0.0087]
dist-MP	−0.0002**	−0.0002***	−0.0002***	−0.0002**	−0.0002***	−0.0002***
	[0.0001]	[0.0001]	[0.0001]	[0.0001]	[0.0001]	[0.0001]
manuf	1.0272***	1.0399***	0.9432***	1.0261***	1.0388***	0.9426***
	[0.1301]	[0.1339]	[0.0999]	[0.1302]	[0.1340]	[0.0999]
N	4799	4479	4479	4799	4479	4479
R2	0.4587	0.4651	0.4649	0.4587	0.4651	0.4649
K-P rk LM			146.984			146.748
p for K-P rk LM			0.0000			0.0000
K-P rk Wald F			2508.775			2507.980

Notes: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Robust standard errors in parentheses. In all specifications, constant, sector and time effects are included. Specifications (2) and (5) include one year lagged labour compensation. K-P refers to Kleibergen-Paap test statistics. BM refers to Borin and Mancini (2020) decomposition. WB refers to the World Bank data.
Source: authors' calculations.

The literature (de Vries et al., 2019; Stöllinger, 2020) puts specialisation in RD and fabrication in terms of creating value-added on opposite poles. According to our results, the most crucial difference between them concerns the interrelation between economic output and both functional specialisations. The increase of GDP per capita or the decrease of economic distance to German GDP per capita is negativiely correlated with comparative advantages in pure fabrication function. The factors that positively correlate with the development of FAB function are labour compensation and involvement in GVC backward relations. Similarly to other business functions, it is easier to reach higher comparative advantages in manufacturing industries than in service sectors; however, that gap between industries is the most visible in fabrication activity.

In order to check the quality of our estimates (Tables 2–5), we use alternatively measured GDP per capita and GVC involvement measures as is described in Section 3.2. We replace particular variables sequentially and re-estimate our model (7) with the aid of instrumental variable approach and instruments constructed as in Section 4.2. The results are presented in Appendix C, Table C.1.

We confirm that differently measured GDP per capita keeps the estimation results robust for all business functions, and all factors included in the regression (7). When we replace GVC participation indices with these proposed by Wang et al. (2017a), the coefficients for all factors apart from GVC measures remain robust. The difference is observed for GVC backward and forward participation. The comparative advantages for management and marketing show a slightly stronger positive interaction with GVC backward index. Opposite to the models presented in Tables 2–5 we observe a low, but positive and significant correlation with GVC forward participation. We should be aware that this GVC alternative variable is constructed in a different way and is related to the value-added decomposition on the contrary to gross exports decomposition as in Borin and Mancini (2019). The results of the supplementary robustness check related to the potential endogeneity of GDP per capita (Appendix C, Table C.2) also confirm that this modification does not alter our general findings.

To sum up, the results of our analysis do not provide a full support for four research hypotheses for each business function. However, it can be concluded that the wages, i.e. the wage convergence of the CEE economies with the most developed economies strongly supports the growth of value-added in each business function, except for MGT. Also, the strong links to GVCs (backward linkages) and the location of CEE countries support these countries on the path to higher value-added in all business functions analysed.

5. Conclusions

This paper combines IO tables with jobs data classified by business function to analyse the functional specialisation pattern of CEEs in global value chains. We also identified factors, which determine this specialisation based on two concepts: the smile curve and the economic upgrading. Our results reveal 'new' patterns of CEE specialisation in the world economy. The findings indicate that some CEE countries (Poland, Slovakia) might be in a function trap. This could be due to two reasons.

First, as suggested in Stöllinger (2021) analysis, it might be related to the too strong participation of the CEE countries in regional value chains built around one node – Germany. We recommend implementing economic policy instruments that support CEE firms to participate more in cross-regional value chains. National economic policies in CEE countries should adopt a GVC function perspective instead of the previously dominant sectoral policy. Domestic enterprises should also attempt meta-strategic activities, i.e. they should be oriented towards changing relationships with other entities in GVCs, especially with the leader, or they should look for new chains or create their own regional chains. Second, the 'functional trap' of some CEE countries could result from an insufficient functional upgrading of CEE industries and the inability of CEE countries to shift their functional specialisation patterns towards more knowledge-intensive value-added functions, especially in pre- and post-production. This requires a transformation of underlying capabilities in CEE countries or even creating an innovative system in CEE countries. Domestic companies might also try to upgrade their tasks slowly, looking for new tasks that leading corporations would like to discard. The cases of southeast Asian countries show that such a strategy leads to national success. The key factor is national companies' ability to economic upgrade. So our results present new challenges for CEE trade and competitiveness policies, especially as CEE countries are sometimes negatively connected in public debates with 'developmental drift', 'dependent development' or 'low labour-cost development'.

In our analysis, we identify different upgrading factors for different types of functional specialisation in GVCs. According to the smile curve concept, the most desirable specialisation pattern that generates the most value added is R&D activities. Our research shows that GDP level and economic distance to Germany are the most important determinants. This finding has a fundamental implication for the economic policy of CEE countries, i.e. they cannot climb the smile curve without significant economic convergence to high-income countries. In the CEE region, the reliance on foreign direct investment and still cheap labour is reaching its limits, and a development miracle/jump is needed. Some good examples may be the paths taken by Taiwan and South Korea, where growth was based on domestic multinationals, state-led banking and technology policies, industrial policies, massive state investment in infrastructure and human capital.

Especially the development of human capital could be treated as a core of the new policy in climbing the smile curve by the CEE countries. Our results show that a development model based on comparative advantage in relatively high skilled labour allowed some CEE countries to achieve specialisation in management activities within GVCs. Hence, we recommend strengthening existing revealed comparative advantages in management by continuing to investments in human capital. Estonia, Latvia, Lithuania and Slovenia may, in the future, follow the paths of some Asian countries (Vietnam, Philippines or Malaysia). They are a good example of countries, which have moved up the production chain from being a giant assembly hub in GVCs for Japan and Korea to the leading exporters of high technology intermediates to advanced economies (de Vries et al., 2019).

Additionally, our results indicate labour compensation as main determinant of upgrading CEE countries' positions in marketing activities. Still, none of the CEEs countries has comparative advantages in activities closest to the consumer. They could upgrade their positions in GVCs in conditions of raising wages but without a requirement for higher skills. These findings should be treated as great future opportunities for CEE countries.

Further analyses are needed. This paper provides conclusions and policy implications at the country level. Still, it would also be advisable to conduct in-depth analysis from the sectoral perspective. This would complete the picture of business functions performed by

CEE economies. In further analyses, we should also be aware of the impact of the Covid-19 pandemic on the global economy resulting from its far-reaching supply and demand shocks. New data will be needed to answer the question of necessary adjustments in the functional specialisation concept.

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