Domestic Supplier Spillovers of Global Value Chains in Central and Eastern European Countries

Knez, Klemen

15 March 2022

Domestic Supplier Spillovers of Global Value Chains in Central and Eastern European Countries

Klemen Knez*

Abstract

The article extends existing sectoral analyses of the internationalisation process in the EU by complementing qualitative studies of supplier linkages with a novel aggregate input-output approach to measuring the structure of supplier linkages. Examining changes in the structure of domestic and global supplier linkages over the period 2000 to 2014, we find that the new Central and Eastern European EU Member States exhibit a specific pattern that differs from that of the old EU countries. Above-average decreases in purely domestic value chains and a decrease in the share of global integration with complex domestic supplier linkages combined with an above-average increase in global integration with no domestic supplier linkages show the uneven pattern of the internationalisation process in the European Union and reveal the structural position of the European Eastern integrated peripheries.

Keywords: European integration, integrated periphery, supplier linkages, input-output analysis, middle-income trap
JEL F1, F4, F6, R1

Introduction

The region of Central and Eastern Europe has experienced profound economic and political structural changes over the last 3 decades. After the collapse of socialism, most countries in the region underwent radical changes in economic policy through more or less gradual liberalisation, deregulation and privatisation with the aim of accelerating integration into the Western European market. The prevailing theories supported these state policy choices. The concept of economic convergence was at the forefront of economic growth and development theories and offered a theorization of a capitalist economy as structurally leading to equal long-term development as long as countries were comparable in terms of institutional structure, human capital development, and other exogenous factors (Acemoglu et al., 2005; Barro & Sala-i-Martin, 1992, 2004; Lucas, 1988; Mankiw et al., 1992; Mello & Perrelli, 2003; Romer, 1990; Solow, 1957; Swan, 1956). The process of economic and political integration led to formal EU enlargement, which brought the region into the single market, resulting in a removal of most of the trade barriers and barriers to the movement of capital and labour, as well as additional institutional convergence. This was bound to lead to a process of economic catching-up according to mainstream theory.

However, during the period 2000-2008, although there was some nominal and real convergence in industrial output between the core EU15 and CEE countries (Kutan & Yigit, 2004, 2005, 2007; Matkowski & Próchniak, 2004, 2007), structural differences remained, especially in terms of technology gap, the functional division of labour, productivity, dependence on foreign capital and vulnerability to external

*Centre of International Relations, University of Ljubljana, Ljubljana, Slovenia, mail: Klemen.Knez@fdv.uni-lj.si

shocks (Bohle & Greskovits, 2012; Califano & Gasperin, 2019; Drahokoupil, 2009; Galgóczi et al., 2015; Kordalska & Olczyk, 2021; Kuc-Czarnecka et al., 2021; Palan & Schmiedeberg, 2010; Poznanska & Poznanski, 2015; Reurink & Garcia-Bernardo, 2020). After the onset of the global crisis in 2008 even the prospect of nominal catching-up diminished (Cieślik & Wciślik, 2020), reigniting debates on the development traps, path-dependent development and club convergence (Azariadis, 1996; Cutrini, 2019; Dyba et al., 2018; Eichengreen et al., 2013; Galor, 1996; Hartmann et al., 2021; Myant, 2018; Żuk & Savelin, 2018).

Recently, the concept of integrated periphery has been used in several occasions in the studies on the structural position of the CEE new EU member states (Brincks et al., 2018; Krpec & Hodulák, 2018; Pavlínek, 2018, 2020). It is a refinement of the static world-systems division into core, semi-periphery and periphery, which differs from the original division of world-systems theory by the contrasting concepts of integrated periphery and dominated periphery (Arrighi & Drangel, 1986; Reynaud, 1984; Shields, 2009), as well as integrating theoretical elements of the production network approach (Coe et al., 2004; Coe & Yeung, 2015, 2019; Henderson et al., 2002) and Harvey's attempt to theorise uneven development within the Marxist tradition (2005, 2007).

The integrated periphery represents a specific type of economic integration characterized by proximity to and access to large consumer markets with high aggregate demand through membership in regional trade agreements, an abundant supply of low-cost labour power, a high degree of economic integration in terms of high inward foreign direct investment, high participation in the global value chains, and high dependence on foreign markets for both intermediate supplies and final demand (Pavlínek, 2018, 2020). The theorization of the structural forces leading to the development of an integrated periphery is based on the exact opposite argument as the core-periphery models of mainstream economic geography of the 1990s (Krugman, 1991; Krugman & Venables, 1995). These core-periphery models primarily describe agglomeration mechanisms that create uneven development between urban centres and rural areas driven by falling transportation costs and economies of scale introduced in the Dixit-Stiglitz model of monopolistic competition (Dixit & Stiglitz, 1977). In contrast, the integrated periphery is driven by the same process of falling transport costs (Glaeser & Kohlhase, 2003) and lowering trade barriers, but with the opposite effect. The spatial proximity between the core and the integrated periphery allows for the fracturing of the production process and the reallocation of its parts within global production networks and global value chains, with differences in the cost of labour power being the main mechanism determining the international division of labour (da Silveira, 2014; Davis & Naghavi, 2011; Grodzicki & Skrzypek, 2020; Maskell et al., 2007; Milberg & Winkler, 2013; Reurink & Garcia-Bernardo, 2020). Competition forces profit-maximising firms to relocate labour-intensive parts of the production process to regions with lower labour power costs, while maintaining control within the established production network either through direct ownership or dependent supplier networks. Such specific internationalisation leads to limited prospects for upgrading within value chains and limited spillover effects in the form of knowledge and technology transfers due to the nature of the labour-intensive parts of the production process, which are often limited to assembly or production of technologically simple components, as well as due to limited cooperation between domestic firms and foreign-controlled firms. The effect of such integration is dependent development, with the integrated periphery remaining structurally trapped in the development trap of low value-added functional specialisation within the international division of labour (Grodzicki & Skrzypek, 2020; Hartmann et al., 2021; Pleticha, 2021). The characterization of the integrated periphery can be summarized by the three main factors: (1.) significantly lower wages, (2.) proximity to final demand[1], and (3.) dependent structure of subcontracting relationships within the international division of labour.

[1]The influence of final demand markets is reflected by the pattern of roughly linearly decreasing levels of regional development in CEE countries as one moves eastward from western borders (Dyba et al., 2018).

The article aims to explore the changing structure of supplier linkages for the whole European manufacturing sector. In the view of the recent findings, that domestic industrial and service linkages are important factor in technological upgrading, productivity growth and thus economic catch-up (Drahokoupil & Fabo, 2020; Rodrik, 2018b), we put specific focus of our approach on the changes of the structure of domestic supplier linkages, that were brought by heterogeneous internationalisation patterns, especially in the CEE region. To achieve this goal, we draw on the conceptualization of global value chains (Gereffi, 2019; Gereffi et al., 2001, 2005), in particular the part of the field that focuses on the input-output dimension of GVC research (Antràs et al., 2012; Arto et al., 2019; Borin & Mancini, 2019; Dietzenbacher & Romero, 2016; Johnson & Noguera, 2012; Koopman et al., 2014; Miller & Temurshoev, 2015; Miroudot & Ye, 2021; Stehrer, 2012; Wang et al., 2017). We utilize an input-output methodology of value chain analysis which disaggregates total output on country-sector level with respect to all value chain paths including downstream linkages, upstream linkages as well as their combination (Knez et al., 2021).[2] We construct a novel empirical typology that disaggregates value chains into: (1.) domestic value chains, (2.) global value chains with no domestic cooperation, (3.) global value chains with simple domestic cooperation, and (4.) global value chains with complex domestic cooperation. The domestic value chain represents production within domestic clusters where domestic firms cooperate to bring the product to final demand, with all stages of production occurring domestically. The global value chain represents cross-border production fragmentation, which is further subdivided in terms of different levels of domestic cooperation. A global value chain with no domestic cooperation represents an isolated domestic firm involved in global production with no domestic supplier linkages or cooperation, while a global value chain with complex domestic cooperation represents a cluster of domestic firms with multi-level domestic supplier linkages that are part of the global production fragmentation. The idea is that the proposed disaggregation might capture the structural differences in the process of internationalisation, which might differently affect less developed countries compared to core countries in terms of changing role of domestic and global supplier linkages, especially in the cases of high FDI flows and spatial proximity that characterise the integrated periphery.

The primary objective is to contribute to the empirical and theoretical study of CEE countries as integrated peripheries. On the one hand, this study complements broader macroeconomic analyses that examine CEE countries as integrated peripheries (Horvath & Grabowski, 1999; Krpec & Hodulák, 2018) and explore their structural dependence or the mechanism of their specific middle-income trap (Califano & Gasperin, 2019; Cieślik & Wciślik, 2020; Cutrini, 2019; Grodzicki & Skrzypek, 2020; Kuc-Czarnecka et al., 2021; Kutan & Yigit, 2007; Landesmann & Stöllinger, 2019; Myant, 2018; Onaran & Stockhammer, 2008; Palan & Schmiedeberg, 2010; Reurink & Garcia-Bernardo, 2020). On the other hand, it complements the more qualitative approaches that focus on the qualitative dimension of supplier linkages, which are mostly analysed within the production network approach. As the structure of supplier relationships, in particular the governance within production networks, is difficult to capture at the macroeconomic level, these analyses use qualitative research methods and are therefore necessarily limited to specific industries and spatially to one or a few countries, often analysing the automotive industry (Brincks et al., 2018; Castelli et al., 2011; Frigant & Layan, 2009; Joshi et al., 2013; Pavlínek, 2018, 2020; Pavlínek & Žížalová, 2016). Our approach is novel in that it seeks to capture the changing structure of domestic and global supplier linkages at an aggregate macroeconomic level - for all European countries and sectors - and thus explore a further long-term structural imbalance that potentially contributes to the perpetuation of uneven development within the EU.

[2]The main advantage of the used methodology is the ability to separately track both domestic and global supplier linkages and their changes in each sector and country, as well as their interconnectedness and interdependence, using the block matrix structure of the international input-output data which tracks all the supplier and inter-industry linkages, albeit on a relatively aggregated sectoral level.

Using the proposed typology and empirical input-output framework, we aim to investigate the specific integration patterns of the eight CEE countries that joined the EU on 1.5.2004: Czech Republic , Estonia, Hungary, Latvia, Lithuania, Poland, Slovakia and Slovenia. The main objective of the article is to contribute to the assessment of their specific form of integration into the EU from the perspective of the changing relationship between domestic and global supplier linkages in the process of production fragmentation. We examine the following hypotheses in the time frame of 2000-2014 using WIOD data:
1.) The economic integration of the 8 CEE countries into the European single market has been accompanied by an above-average decline in domestic value chains.
2.) The substantial increase in economic internationalisation of the 8 CEE countries after the integration into the European market occurred simultaneously with above average increase in integration into global value chains with no domestic cooperation.
3.) The process of significant decrease of domestic value chains and simultaneous increase of global value chains with no domestic cooperation in the 8 CEE new EU member states is primarily determined by lower labour costs and high inward FDI, which takes specific form in the CEE countries. These dynamics are characteristic of the development of the integrated periphery and reflect its unequal position in the international division of labour.

By evaluating hypotheses, we aim to increase knowledge and theoretical understanding of the specific type of economic integration known as the integrated periphery. Our research aims to further clarify the relationship between the quantity of domestic and global supplier linkages and technology and knowledge spillover effects, in particular whether the structure and quantity of domestic supplier linkages and their dynamic evolution within global value chains is a relevant factor reflecting a specific form of integration of small and open CEE countries.

1 Methodology

In our methodological approach, we use the basic idea of simultaneous upstream and downstream decomposition of total output of each country-sector as proposed by Knez et al. (2021). A is a matrix of technical Leontief coefficients, x is a vector of total output, f is a vector of aggregate demand, and v_c is a vector of value added coefficients. Vectors with hat stand for a diagonal matrix, $\mathbf{1}$ for a vector of ones, and $\vec{e_i}$ for an orthonormal basis of $\mathbb{R}^n$. We start with the Leontief identity:

$$x = Ax + f \tag{1.1}$$

$$x = (I - A)^{-1}\hat{f}\mathbf{1} \tag{1.2}$$

The normalized matrix $\hat{x}^{-1}(I - A)^{-1}\hat{f}\mathbf{1}$ represents a disaggregation of total output shares with respect to upstream value chain paths. The ij-th element of this matrix represents the share of total output of country-sector i that reaches final consumption as the final product of country-sector j through all possible upstream value chain paths in the economy. That is, the i-th row of this matrix represents the decomposition of the upstream value chain paths of the i-th country-sector. For the downstream part of the disaggregation, we start with the following identity:

$$x^T = \mathbf{1}^T\hat{x} = \mathbf{1}^T(I - A)(I - A)^{-1}\hat{x} \tag{1.3}$$

$$x^T = \mathbf{1}^T\hat{v}_C(I - A)^{-1}\hat{x} \tag{1.4}$$

The normalized matrix $\mathbf{1}^T\hat{v}_C(I - A)^{-1}$ complements the first normalized matrix, as it represents a disaggregation of the total output shares with respect to the downstream value chain paths. The ki-th element represents the share of total output of country-sector i that is primarily produced in k along any downstream value chain path. The ith column of this matrix thus represents the decomposition of the output of

the ith country-sector along its downstream value chain paths.

By combining the two decompositions (direct product of i-th column of $\mathbf{1}^T\hat{v}_C(I-A)^{-1}$ and i-th row of $\hat{x}^{-1}(I-A)^{-1}\hat{f}\mathbf{1}$) we obtain the basic object of our disaggregation - a value chain tree matrix. This matrix is specific for each country and sector and captures the structure of both downstream and upstream structure of supplier linkages:

$$\tau_i = \hat{v_C}(I-A)^{-1}\vec{e_i} \otimes \vec{e_i}^T\hat{x}^{-1}(I-A)^{-1}\hat{f} \tag{1.5}$$

The disaggregation of total output of each country-sector is characterized by decomposition of the two Leontief inverses in each τ_i, which can be interpreted as the decomposition of the downstream part and the upstream part of each value chain path. Due to the block-matrix structure of the international input-output data, where block-diagonal matrices A_D represent domestic supplier linkages and block-off diagonal matrices A_{CB} represent international supplier linkages, we can structure value chain paths with respect to the structure of supplier linkages.[3] The decomposition can thus be structured according to our typology using the criteria of the number, position and structure of cross-border and domestic transactions between firms along the entire value chain to enable the investigation of our research questions and hypotheses regarding the role of domestic supplier linkages in the study of different types of internationalisation processes. More detailed derivation of the decomposition is given in Appendix B.

We propose an empirical typology of value chains based solely on the structure of linkages between firms. We will empirically evaluate the following structures of value chain paths:

Definition 1.1 Domestic value chain path
Domestic value chain (DVC) path is a value that involves *at least 1 production-sharing transaction between domestic firms* and involves *only domestic production-sharing transactions* between firms along its path.

Definition 1.2 Global value chain path
Global value chain (GVC) path is a value that involves *at least 1 cross-border production-sharing transaction* between firms along its path. We further disaggregate global value chain path on the following elements:

Definition 1.2.1 Global value chain path with no domestic cooperation
Global value chain path with no domestic cooperation is a value that involves *at least 1 cross-border production-sharing transaction* between firms anywhere along its path and includes *exactly 0 production-sharing transactions between domestic firms*.

Definition 1.2.2 Global value chain path with simple domestic cooperation
Global value chain path with simple domestic cooperation is a value that involves *at least 1 cross-border production-sharing transaction* between firms anywhere along its path and includes *exactly 1 production-sharing transaction between domestic firms*.

[3]We analyse the structure of supplier linkages in terms of the structure of the value chain paths of the total output of each country-sector, from downstream value added to final demand. Due to the limitation of the accounting data, it is impossible to follow concrete value chain path of each concrete firm and its product. Nevertheless, it is possible to analyse average sectoral structure of value chain paths, especially if decomposition is based on differentiating domestic and cross-border production sharing transactions. When using terminology of "transactions between firms" we refer to information that is captured by the aggregated sectoral international I-O data regarding the average structure of value chain transactions. Because accounting rules, which are the basis for the structure of international I-O datasets, capture transactions between domestic firms of the same sector as well as between different sectors, I-O data represents sufficient data to differentiate average sectoral value chain paths.

Definition 1.2.3 Global value chain path with complex domestic cooperation
Global value chain path with complex domestic cooperation is a value that involves *at least 1 cross-border production-sharing transaction* between firms anywhere along its path and includes *at least 2 production-sharing transaction between domestic firms*.

The novel disaggregation of global value chains by the degree of domestic cooperation relative to the amount of domestic supplier linkages aims to capture the heterogeneity and spatial differences in the process of internationalisation. The share of global value chains with no domestic cooperation attempts to capture the most dependent form of internationalisation that excludes domestic cooperation and domestic supplier linkages, while global value chains with complex domestic cooperation represent multi-tier domestic value chains that are integrated into the global value chain. The empirical assessment of global value chains with complex domestic cooperation aims to capture the type of internationalisation that exhibits significant spillover effects on domestic suppliers in terms of the quantity of supplier linkages. The typology serves to distinguish different internationalisation processes with regard to changes in the supplier structure. Have existing domestic value chains retained their complexity in the course of internationalisation and only expanded globally through the inclusion of various international partners in the production process? Or did domestic value chains become fragmented and technologically downgraded, leading to a decline in domestic cooperation, while each domestic firm became increasingly dependent on foreign-controlled production networks or even integrated as a subsidiary? The proposed typology can also shed light on whether foreign subsidiaries and FDI-induced growth lead to further demand for intermediates in domestic supply markets or mainly increase imports of intermediates.

We decompose each τ_i matrix describing all possible value chain paths of the output of the i-th country-sector into a matrix consisting of only domestic value chain paths, a matrix containing all global value chain paths with no domestic cooperation, a matrix containing all global value chain paths with simple domestic cooperation and a matrix containing all global value chain paths with complex domestic cooperation.

Definition 2.1 Domestic value chain tree τ_i^{DVC}

$$\begin{aligned}\tau_i^{DVC} = &\hat{v_C} A_D (I - A_D)^{-1} \vec{e_i} \otimes \vec{e_i}^T \hat{x}^{-1} \hat{f} + \\ &+ \hat{v_C} \vec{e_i} \otimes \vec{e_i}^T \hat{x}^{-1} A_D (I - A_D)^{-1} \hat{f} + \\ &+ \hat{v_C} A_D (I - A_D)^{-1} \vec{e_i} \otimes \vec{e_i}^T \hat{x}^{-1} A_D (I - A_D)^{-1} \hat{f}\end{aligned}$$

The domestic value chain tree represents all value chain paths which are part of the domestic value chains according to definition 1.1. The first element ($\hat{v_C} A_D (I - A_D)^{-1} \vec{e_i} \otimes \vec{e_i}^T \hat{x}^{-1} \hat{f}$) includes the downstream domestic value added (downstream domestic path), which ends in final consumption (no upstream path), the second element ($\hat{v_C} \vec{e_i} \otimes \vec{e_i}^T \hat{x}^{-1} A_D (I - A_D)^{-1} \hat{f}$) covers the domestic country-sector value added (no downstream path) that is transferred via the upstream domestic value chain (upstream domestic path), and thirdly ($\hat{v_C} A_D (I - A_D)^{-1} \vec{e_i} \otimes \vec{e_i}^T \hat{x}^{-1} A_D (I - A_D)^{-1} \hat{f}$) comprises the downstream domestic value added that is used as an intermediate product in production of i and then used as intermediary further in the upstream domestic value chain until it reaches final demand (both downstream and upstream domestic path). All three cases meet the definition of the domestic value chain 1.1.

Definition 2.2 Global value chain tree τ_i^{GVC}

$$\begin{aligned}\tau_i^{GVC} = &\hat{v_C} (I - A_D)^{-1} \vec{e_i} \otimes \vec{e_i}^T \hat{x}^{-1} \big[(I - A)^{-1} - (I - A_D)^{-1}\big] \hat{f} + \\ &+ \hat{v_C} \big[(I - A)^{-1} - (I - A_D)^{-1}\big] \vec{e_i} \otimes \vec{e_i}^T \hat{x}^{-1} (I - A_D)^{-1} \hat{f} + \\ &+ \hat{v_C} \big[(I - A)^{-1} - (I - A_D)^{-1}\big) \vec{e_i} \otimes \vec{e_i}^T \hat{x}^{-1} \big[(I - A)^{-1} - (I - A_D)^{-1}\big] \hat{f}\end{aligned}$$

The global value chain tree represents all value chain paths which are part of global value chains according to definition 1.2. The first element ($\hat{v_C}(I-A_D)^{-1}\vec{e_i}\otimes\vec{e_i}^T\hat{x}^{-1}\left[(I-A)^{-1}-(I-A_D)^{-1}\right]\hat{f}$) covers the domestic value added and downstream domestic value chain paths, which have global upstream linkages, second element ($\hat{v_C}\left[(I-A)^{-1}-(I-A_D)^{-1}\right]\vec{e_i}\otimes\vec{e_i}^T\hat{x}^{-1}(I-A_D)^{-1}\hat{f}$) covers downstream global linkages, which either end in final consumption or have an upstream domestic value chain path and a third element ($\hat{v_C}\left[(I-A)^{-1}-(I-A_D)^{-1}\right]\vec{e_i}\otimes\vec{e_i}^T\hat{x}^{-1}\left[(I-A)^{-1}-(I-A_D)^{-1}\right]\hat{f}$) covers the value that has both upstream and downstream global paths. All these cases correspond to our definition of the global value chain 1.2.

Definition 2.2.1 Global value chain tree with no domestic cooperation $\tau_i^{GVCwNDC}$

$$\begin{aligned}\tau_i^{GVCwNDC} =& \hat{v_C}\vec{e_i}\otimes\vec{e_i}^T\hat{x}^{-1}A_{CB}(I-A)^{-1}\hat{f}+\\ &\hat{v_C}(I-A)^{-1}A_{CB}\vec{e_i}\otimes\vec{e_i}^T\hat{x}^{-1}\hat{f}+\\ &\hat{v_C}(I-A)^{-1}A_{CB}\vec{e_i}\otimes\vec{e_i}^T\hat{x}^{-1}A_{CB}(I-A)^{-1}\hat{f}\end{aligned}$$

The global value chain tree with no domestic cooperation represents all value chain paths that have global cross-border production sharing but no domestic production sharing. The disaggregated set of matrices corresponds to definition 1.2.1. The first element represents the share of domestic sector value added that is directly absorbed as an intermediate output in production abroad without domestic production sharing. The second element represents the share of output that enters and is refined as imported intermediate good and finalised for consumption without any domestic production linkages. And the last element of the decomposed matrix set represents the share of output that consists of imported intermediate goods, which are further processed without domestic production linkages and the product is exported as an intermediate good for further production abroad. The last element thus represents a global production fragmentation of the following form: foreign-domestic-foreign, where domestic is reduced to only one stage of production, while the value chain can have arbitrarily complex foreign production fragmentation on both sides of the value chain. With all three elements, we cover all value chain paths that have a global production fragmentation and no domestic production linkages.

Definition 2.2.2 Global value chain tree with simple domestic cooperation $\tau_i^{GVCwSDC}$

$$\begin{aligned}\tau_i^{GVCwSDC} =& \hat{v_C}(I-A)^{-1}A_{CB}A_D\vec{e_i}\otimes\vec{e_i}^T\hat{x}^{-1}\hat{f}+\\ &+\hat{v_C}(I-A)^{-1}A_{CB}A_D\vec{e_i}\otimes\vec{e_i}^T\hat{x}^{-1}A_{CB}(I-A)^{-1}\hat{f}+\\ &+\hat{v_C}A_D\vec{e_i}\otimes\vec{e_i}^T\hat{x}^{-1}A_{CB}(I-A)^{-1}\hat{f}+\\ &+\hat{v_C}\vec{e_i}\otimes\vec{e_i}^T\hat{x}^{-1}A_DA_{CB}(I-A)^{-1}\hat{f}+\\ &+\hat{v_C}(I-A)^{-1}A_{CB}\vec{e_i}\otimes\vec{e_i}^T\hat{x}^{-1}A_DA_{CB}(I-A)^{-1}\hat{f}+\\ &+\hat{v_C}(I-A)^{-1}A_{CB}\vec{e_i}\otimes\vec{e_i}^T\hat{x}^{-1}A_D\hat{f}\end{aligned}$$

The global value chain tree with simple domestic cooperation represents all value chain paths that have global cross-border production sharing and only simple domestic production sharing that is limited to one vertical transaction between domestic firms, which corresponds to definition 1.2.2. The first three elements of disaggregation represent downstream simple domestic cooperation and the last three represent upstream simple domestic cooperation. The first element represents the share of downstream simple domestic cooperation that depends on imports of intermediaries and flows directly into final consumption. The second element comprises the share of output that consists of imported intermediates and downstream simple domestic cooperation, leading to the export of the intermediate produced for further production abroad. The third element represents the share of value produced in simple domestic cooperation that leads to the export of the intermediate good produced for production abroad. Conversely, the last three elements represent the similar structure according to definition 1.2.2, only with upstream simple domestic cooperation.

The fourth element represents the share of value added of the country sector that has upstream simple domestic production linkages followed by the export of the resulting intermediate product for production abroad. The fifth element comprises the share of output produced using imported foreign intermediates that has an upstream simple domestic linkages, followed by the export of the produced intermediate good for further production abroad. The last element represents the share of output that covers the value chain path that starts with imported intermediates and leads to direct final consumption with upstream simple domestic cooperation leading to direct final consumption. These combinations cover all value chain paths that have the structure of a global value chain with simple domestic cooperation.

Definition 2.2.3 Global value chain tree with complex domestic cooperation $\tau_i^{GVCwCDC}$

$$\tau_i^{GVCwCDC} = \tau_i^{GVC} - \tau_i^{GVCwNDC} - \tau_i^{GVCwSDC}$$

Global value chain tree with complex domestic cooperation represents all the global value chain paths, excluding global value chains with no domestic and simple domestic cooperation.

The set of matrices τ_i with elements t_{ijk} represent the structure of value chain paths that meet the criteria of our definitions. The summation along the j and k indices results in a real number (formally between 0 and 1) for each country-sector i representing the share of production that corresponds to the disaggregation criteria (Knez et al., 2021; Appendix B). For example, DVC_i represents the domestic value chain share of country-sector i - the share of production of country-sector i that meets the definition, that it consists of at least one domestic transaction between firms and only domestic transactions between firms. Therefore, after summation along the j and k indices we get a set of vectors $DVCs \in \mathbb{R}^n$ - domestic value chain share, $GVCs \in \mathbb{R}^n$ - global value chain share, $GVCwNDCs \in \mathbb{R}^n$ - global value chain share with no domestic cooperation, $GVCwSDCs \in \mathbb{R}^n$ - global value chain share with simple domestic cooperation and $GVCwCDCs \in \mathbb{R}^n$ - global value chain share with complex domestic cooperation. All the vectors inform us about the share of each specific type of domestic and global linkage structure of each country-sector.

$DVCs_i = \sum_{j=1}^{n}\sum_{k=1}^{n} t_{ijk}^{DVC}$;
$GVCs_i = \sum_{j=1}^{n}\sum_{k=1}^{n} t_{ijk}^{GVC}$;
$GVCwNDCs_i = \sum_{j=1}^{n}\sum_{k=1}^{n} t_{ijk}^{GVCwNDC}$;
$GVCwSDCs_i = \sum_{j=1}^{n}\sum_{k=1}^{n} t_{ijk}^{GVCwSDC}$;
$GVCwCDCs_i = \sum_{j=1}^{n}\sum_{k=1}^{n} t_{ijk}^{GVCwCDC}$

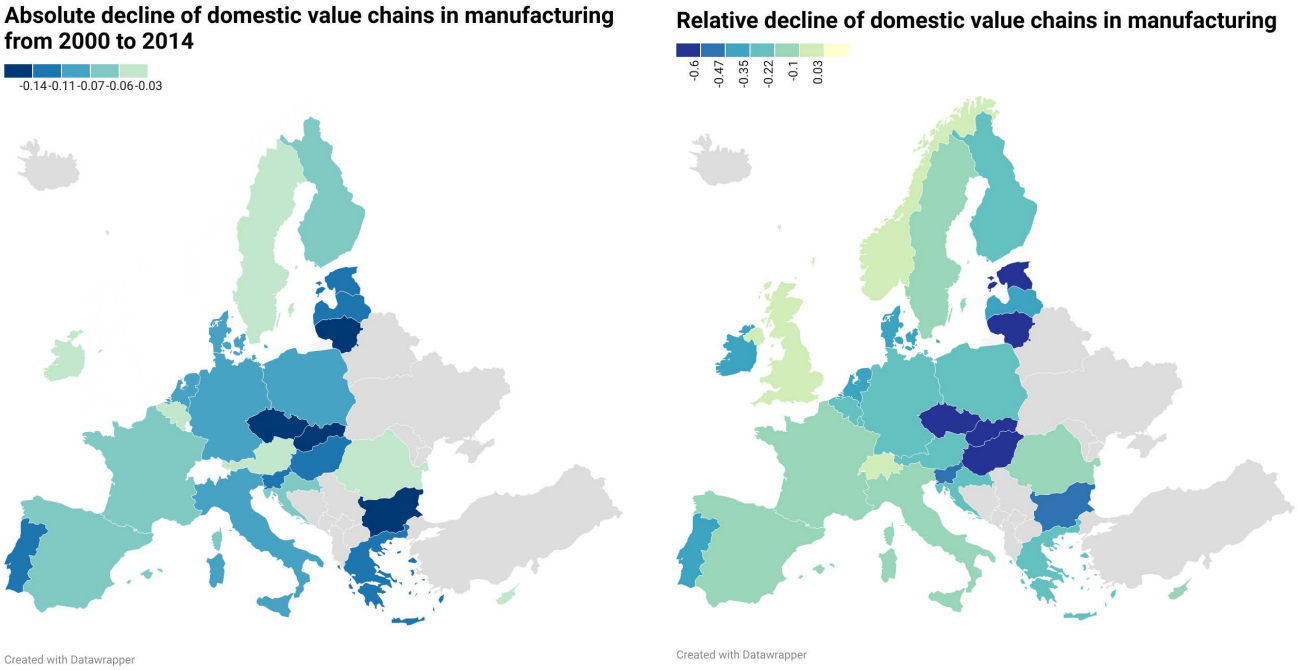
The end result is a cross-section country-sector data with 4 variables (out of 5, 1 is collinear by definition). Using WIOD data (Los et al., 2015; Timmer et al., 2015), we obtain a panel data extending from 2000 to 2014 with 43 countries and 56 sectors (full panel data attached). We present the data using value added weighted averages to obtain country level data for the manufacturing sector and also present absolute and relative changes of the obtained variables.[4]

2 Results

We focus on the analysis of the shares of manufacturing in each value chain element of the proposed typology. The absolute total manufacturing output shares within each value chain structure of supplier

[4]Each disaggregated type represents the share of production that unfolds in the assumed form of supplier linkage structure. The absolute difference is expressed as $VC(t_2) - VC(t_1)$ and relative difference as $(VC(t_2) - VC(t_1))/((VC(t_1) + VC(t_2))/2)$. The absolute difference is expressed in percentage points of GDP of each country (since each absolute element is expressed as a share of GDP) and relative share is expressed as a ratio of absolute change with respect to the average value.

Figure 1: Absolute and relative changes in domestic value chain shares in manufacturing from 2000 to 2014



linkages in 2014 are presented in Table 1. The average role of domestic value chains in 8 studied CEE countries is below the sample average, in contrast to the old EU15 core countries, which have slightly above average domestic value chain shares. The CEE countries are more internationalised and have an above average global value chain share, more than 8 percentage points above the average. Most of this difference can be attributed to the differences in the importance of global value chains with no domestic cooperation, whose share in the CEE countries is more than 7 percentage points above average, indicating a particular form of internationalisation in the CEE countries. We continue with the investigation of the dynamics of the internationalisation process and examine the spatial distribution of absolute and relative changes in the value chain structures over the period 2000-2014.

2.1 Decline of domestic value chains

Changes in the role of domestic value chain structures over the period 2000-2014 took place mainly in manufacturing. In Europe, the national share of domestic value chains decreased on average by $8,6$ percentage points in manufacturing. This represents an average relative decline of $32,7\%$. The decline in the share of domestic value chains in manufacturing and other sectors reflects the internationalisation processes before and after EU enlargement and the inclusion of new Member States in the single market, as well as the increasing overall fragmentation of the production process (Los et al., 2015).

However, the dynamic restructuring of domestic value chains and internationalisation were not spatially homogeneous. This might reflect the complexity and heterogeneity of the specific forms of international integration processes. The new EU Member States, especially the small, open and export-oriented economies of Central and Eastern Europe show an above-average decline of their domestic value chain share in manufacturing, both in absolute and relative terms. For the 8 new CEE EU member states, the importance of domestic value chains fell by $57,7\%$ in relative terms, equivalent to a decline of $14,1$ percentage points of GDP. Domestic value chains in the old 15 EU member states decreased by $27,6\%$ on average over the same period, equivalent to a decrease of $7,3$ percentage points of GDP. The 8 studied CEE countries have thus experienced more than twice the relative and absolute decline in their domestic

Table 1: Value chain shares in manufacturing in 2014

Country	Domestic value chain	Global value chain	GVC with no domestic cooperation	GVC with simple domestic cooperation	GVC with complex domestic cooperation
AUT	19,1%	67,5%	37,8%	16,4%	13,3%
BEL	13,6%	75,5%	48,5%	15,6%	11,4%
BGR	25,6%	58,8%	27,5%	16,3%	15,0%
CHE	31,1%	56,0%	23,6%	15,3%	17,2%
CYP	35,3%	50,2%	22,1%	14,1%	13,9%
CZE	16,1%	73,6%	40,3%	18,0%	15,3%
DEU	26,9%	57,4%	28,1%	15,8%	13,4%
DNK	21,4%	56,8%	33,7%	13,2%	9,9%
ESP	38,9%	50,4%	18,2%	13,1%	19,1%
EST	13,7%	75,9%	47,6%	16,2%	12,1%
FIN	25,7%	62,6%	25,1%	17,6%	19,9%
FRA	34,6%	51,3%	22,6%	14,0%	14,7%
GBR	39,9%	46,8%	18,5%	12,8%	15,4%
GRC	41,3%	41,4%	20,1%	11,7%	9,6%
HRV	26,6%	52,1%	31,0%	12,7%	8,3%
HUN	11,3%	76,2%	52,7%	14,9%	8,7%
IRL	7,8%	73,6%	60,0%	10,1%	3,5%
ITA	39,0%	50,1%	16,1%	13,7%	20,3%
LTU	18,2%	63,3%	42,4%	13,9%	7,1%
LUX	7,0%	81,4%	57,9%	15,6%	7,9%
LVA	20,9%	64,1%	31,9%	15,6%	16,6%
MLT	19,4%	62,6%	34,8%	15,0%	12,8%
NLD	16,3%	72,3%	40,9%	16,9%	14,5%
NOR	38,6%	50,6%	16,9%	16,5%	17,3%
POL	31,1%	58,1%	23,0%	16,4%	18,7%
PRT	29,8%	56,1%	26,5%	15,5%	14,1%
ROU	33,5%	46,6%	19,6%	13,0%	14,0%
SVK	16,6%	73,8%	40,6%	19,1%	14,2%
SVN	19,1%	68,3%	38,4%	16,9%	13,0%
SWE	24,2%	60,1%	29,9%	15,9%	14,2%
Average	24,8%	61,1%	32,5%	15,1%	13,5%
New CEE average	18,4%	69,2%	39,6%	16,4%	13,2%
EU15 average	25,7%	60,2%	32,3%	14,5%	13,4%

value chains compared to the EU core countries. The extent of structural change is most pronounced in Hungary, Czech Republic, Slovakia, Lithuania and Estonia, where the relative decline in domestic manufacturing value chains is even larger than the average decline in the CEE countries. For these countries, the relative decline in domestic value chains amounts to $66,6\%$ on average across the country. The only exception among the 8 CEE countries studied is Poland, which shows a similar relative decline in domestic value chains and an absolute decline only $2,6$ percentage points of GDP higher compared to the average of the EU15 core countries.

2.2 Increase in the share of global value chains with no domestic cooperation

During the same period, the role of declining domestic value chains in economies was replaced by the increase in the share of global value chains in general. The overall fragmentation of production increased, therefore the increase in the share of global value chains was larger than the decrease in the share of domestic value chains in the economy. In this part, we examine the specific form of globalization of value chains in terms of the changes in domestic supplier linkages. The largest changes in the share of GVCs with no domestic supplier connections occurred in manufacturing. In Europe, the national share of GVCs with no domestic cooperation increased by $8,4$ percentage points of GDP on average, corresponding to a relative increase of this type of integration by $30,2\%$ over the period 2000-2014. The spatial patterns of the changes of GVC with no domestic cooperation are almost exactly opposite to the changes in domestic value chains.

The new EU member states, especially the small, open and export-oriented economies of the Central and Eastern Europe show above-average relative increases in the share of manufacturing, which integrates into GVCs without domestic cooperation. The 8 CEE countries studied had an average increase in the share of GVCs with no domestic cooperation of $52,1\%$, which corresponds to an average absolute increase of $16,6$ percentage points of GDP. Compared to the 15 old EU core countries, this represents more than double the increase in this type of GVCs in both relative and absolute terms ($24,5\%$ relative increase and $6,2$ percentage points increase of GDP for EU15). Similarly to the changes in domestic value chains, Poland is the only CEE new EU member country that shows a nearly average relative and absolute increase in GVCs with no domestic cooperation.

2.3 Changes in the share of global value chains with simple and complex domestic cooperation

Comparing the old core countries of the EU15 with the 8 new CEE countries, the dynamics of the share of production organized in global value chains with complex domestic cooperation differs not only in magnitude but also in the direction of change. With the exception of Poland and Latvia, the studied CEE countries show a decrease in the share of GVCs with complex domestic cooperation, while the majority of EU15 countries either stagnate or increase their share of internationally linked production with complex domestic supplier linkages. On average, the share of GVCs with complex domestic cooperation is more or less stagnant. On the one hand, the new CEE EU member states show an average decline of $2,5$ percentage points of GDP, with an average relative decline of $20,3\%$ of this type of value chain structure. On the other hand, the old EU core countries show a slight increase of 0.8 percentage points of GDP, with an average relative increase of $3,3\%$.

The results for the dynamics of global value chains with simple domestic cooperation are less spatially heterogeneous. The new CEE countries show above-average increases in this type of global integration, with the exception of Hungary (significant relative decrease of $57,6\%$), while the EU core countries show below-average increases, with the exception of Italy ($23,8\%$ relative increase).

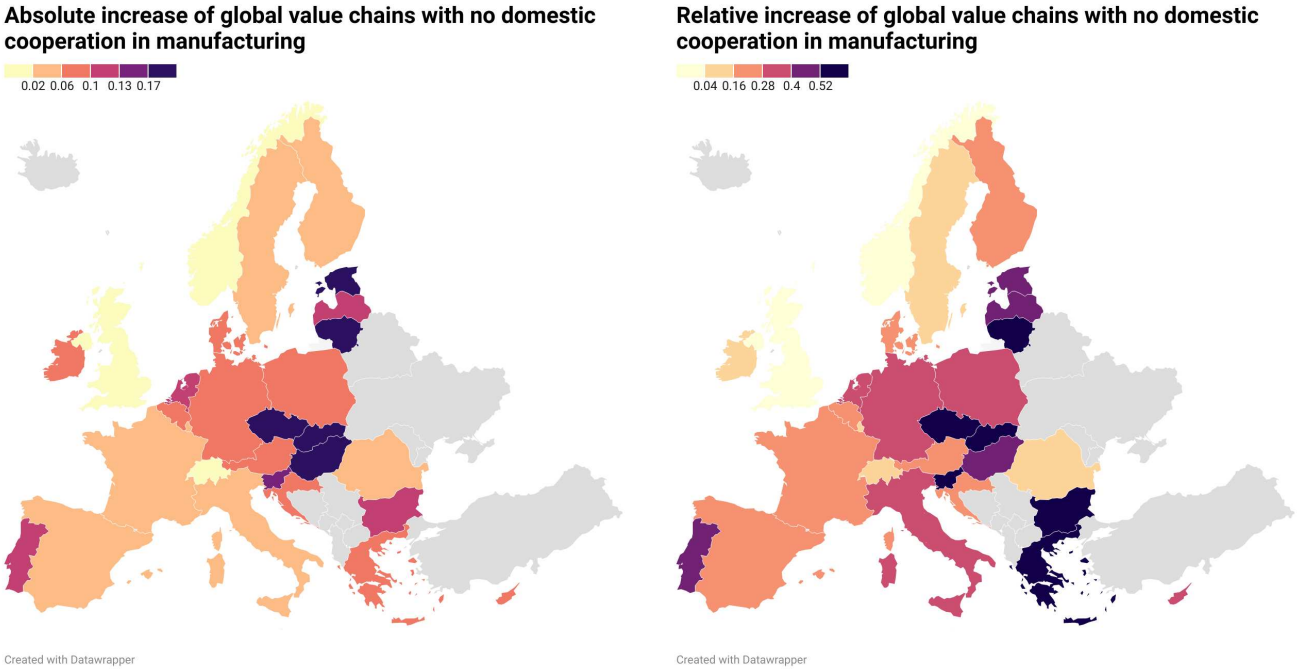
Table 2: Absolute and relative changes in domestic value chain shares and global value chain share with no domestic cooperation in manufacturing from 2000 to 2014

Country	Relative change in domestic value chain share	Absolute change in domestic value chain share	Relative change in global value chain share with no domestic cooperation	Absolute change in global value chain share with no domestic cooperation
AUT	-26,9%	-5,9 pp	17,3%	6,0 pp
BEL	-34,7%	-5,7 pp	20,9%	9,2 pp
BGR	-48,3%	-16,3 pp	52,3%	11,4 pp
CHE	-9,0%	-2,9 pp	4,5%	1,0 pp
CYP	-14,8%	-5,6 pp	32,8%	6,2 pp
CZE	-66,2%	-15,9 pp	63,4%	19,4 pp
DEU	-33,2%	-10,7 pp	38,2%	9,0 pp
DNK	-35,7%	-9,3 pp	26,2%	7,8 pp
ESP	-15,5%	-6,5 pp	24,1%	3,9 pp
EST	-63,9%	-12,9 pp	50,8%	19,3 pp
FIN	-24,2%	-7,1 pp	22,4%	5,1 pp
FRA	-16,6%	-6,3 pp	21,8%	4,5 pp
GBR	-2,2%	-0,9 pp	1,9%	0,4 pp
GRC	-25,9%	-12,3 pp	57,7%	9,0 pp
HRV	-22,5%	-6,8 pp	27,0%	7,4 pp
HUN	-68,7%	-11,8 pp	49,0%	20,7 pp
IRL	-45,5%	-4,6 pp	13,1%	7,3 pp
ITA	-21,6%	-9,4 pp	33,8%	4,6 pp
LTU	-72,2%	-20,5 pp	63,7%	20,5 pp
LUX	-33,0%	-2,8 pp	5,0%	2,8 pp
LVA	-46,6%	-12,7 pp	40,2%	10,7 pp
MLT	2,8%	0,5 pp	-2,8%	-1,0 pp
NLD	-46,2%	-9,8 pp	29,5%	10,5 pp
NOR	2,3%	0,9 pp	-8,1%	-1,4 pp
POL	-27,5%	-9,9 pp	31,3%	6,2 pp
PRT	-35,5%	-12,9 pp	45,0%	9,7 pp
ROU	-16,0%	-5,8 pp	15,5%	2,8 pp
SVK	-61,9%	-14,9 pp	62,9%	19,4 pp
SVN	-54,7%	-14,4 pp	55,5%	16,7 pp
SWE	-17,4%	-4,6 pp	10,7%	3,0 pp
Average	-32,7%	-8,6 pp	30,2%	8,4 pp
New CEE average	-57,7%	-14,1 pp	52,1%	16,6 pp
EU15 average	-27,6%	-7,3 pp	24,5%	6,2 pp

Table 3: Absolute and relative changes in global value chain share with simple and complex domestic cooperation in manufacturing from 2000 to 2014

Country	Absolute change in global value chain share with complex domestic cooperation	Relative change in global value chain share with complex domestic cooperation	Absolute change in global value chain share with simple domestic cooperation	Relative change in global value chain share with simple domestic cooperation
AUT	1,2 pp	9,6%	1,1 pp	7,1%
BEL	-1,2 pp	-10,3%	-0,7 pp	-4,6%
BGR	0,6 pp	4,0%	5,1 pp	36,7%
CHE	0,1 pp	0,4%	1,5 pp	10,0%
CYP	1,6 pp	12,2%	3,7 pp	29,6%
CZE	-4,8 pp	-27,4%	2,5 pp	15,0%
DEU	-0,5 pp	-3,7%	2,6 pp	17,6%
DNK	-1,1 pp	-10,5%	0,3 pp	2,0%
ESP	3,3 pp	18,7%	1,1 pp	8,7%
EST	-3,8 pp	-27,3%	1,4 pp	9,3%
FIN	0,0 pp	0,1%	1,7 pp	10,2%
FRA	1,2 pp	8,8%	1,2 pp	9,3%
GBR	3,3 pp	24,3%	1,6 pp	12,9%
GRC	0,7 pp	7,3%	1,7 pp	16,0%
HRV	-1,7 pp	-18,8%	0,4 pp	2,9%
HUN	-7,0 pp	-57,6%	-2,2 pp	-13,9%
IRL	-1,8 pp	-40,2%	-1,5 pp	-13,7%
ITA	4,3 pp	23,8%	3,3 pp	26,8%
LTU	-4,7 pp	-50,2%	1,3 pp	9,7%
LUX	0,2 pp	2,8%	-0,9 pp	-5,6%
LVA	3,4 pp	22,8%	3,2 pp	23,2%
MLT	2,6 pp	22,5%	-1,9 pp	-11,7%
NLD	2,1 pp	15,6%	1,8 pp	11,2%
NOR	-1,1 pp	-6,4%	0,4 pp	2,5%
POL	4,5 pp	27,4%	4,0 pp	27,9%
PRT	0,5 pp	3,9%	3,2 pp	22,9%
ROU	1,8 pp	13,8%	1,7 pp	14,2%
SVK	-5,2 pp	-30,9%	4,3 pp	25,2%
SVN	-2,7 pp	-18,8%	1,9 pp	12,2%
SWE	-0,2 pp	-1,2%	0,9 pp	5,6%
Average	-0,1 pp	-2,8%	1,5 pp	10,6%
New CEE average	-2,5 pp	-20,3%	2,1 pp	13,6%
EU15 average	0,8 pp	3,3%	1,1 pp	8,4%

Figure 2: Absolute and relative changes in global value chain shares with no domestic cooperation in manufacturing from 2000 to 2014



Among the old EU15 countries there are some consistent offshoots. One is Ireland, which may have an unrealistic supplier relationship structure due to its role as a tax haven, which has a significant impact on the accounting records of multinationals based in the country. Portugal and Greece show changes in the dynamic structure of supplier relationships that do not correspond to the pattern of the majority of EU core countries, nor to the pattern of CEE countries, possibly reflecting their semi-peripheral status and technological decline. A more detailed examination of the results exposes Hungary as the extreme case of dependent development, as measured by the structure of supplier linkages. It is the only CEE country in the sample that shows a decline in GVCs with simple domestic cooperation, which is the highest decline in the sample $(13,9\%)$, while it also shows the highest decline in GVCs with complex domestic cooperation over the same period $(57,6\%)$. This, combined with the substantial relative decline in domestic value chains $(68,7\%)$ and one of the highest increases in GVCs with no domestic cooperation (49%), reflects the drastic structural change in the Hungarian economy over the examined period, which may have triggered, at least in part, the conservative-nationalist political reaction in the country (Rodrik, 2018a). Figure 4 allows a comparison of Hungary, Switzerland, Austria and Sweden - countries with similar population size and initial patterns of supplier linkages, but structurally different integration and dynamic development of supplier linkages. Poland, on the other hand, shows a much different pattern than other small and open CEE countries, relying more on the domestic supplier base and its inter-firm linkages, which might be possible due to the larger size of its economy.

2.4 Determinants of the value chain structure

In order to analyse the macroeconomic determinants of the studied value chain structures and their developments, we calculate the proposed value chain indicators at the individual country and sector level, obtaining a strongly balanced panel for all EU countries and manufacturing sectors (NACE2) for the period 2000-2014. We combine the value chain panel with Eurostat labour cost panel data and Eurostat research panel data, as well as with OECD FDI panel data.

Figure 3: Absolute and relative changes in global value chain shares with complex domestic cooperation in manufacturing from 2000 to 2014

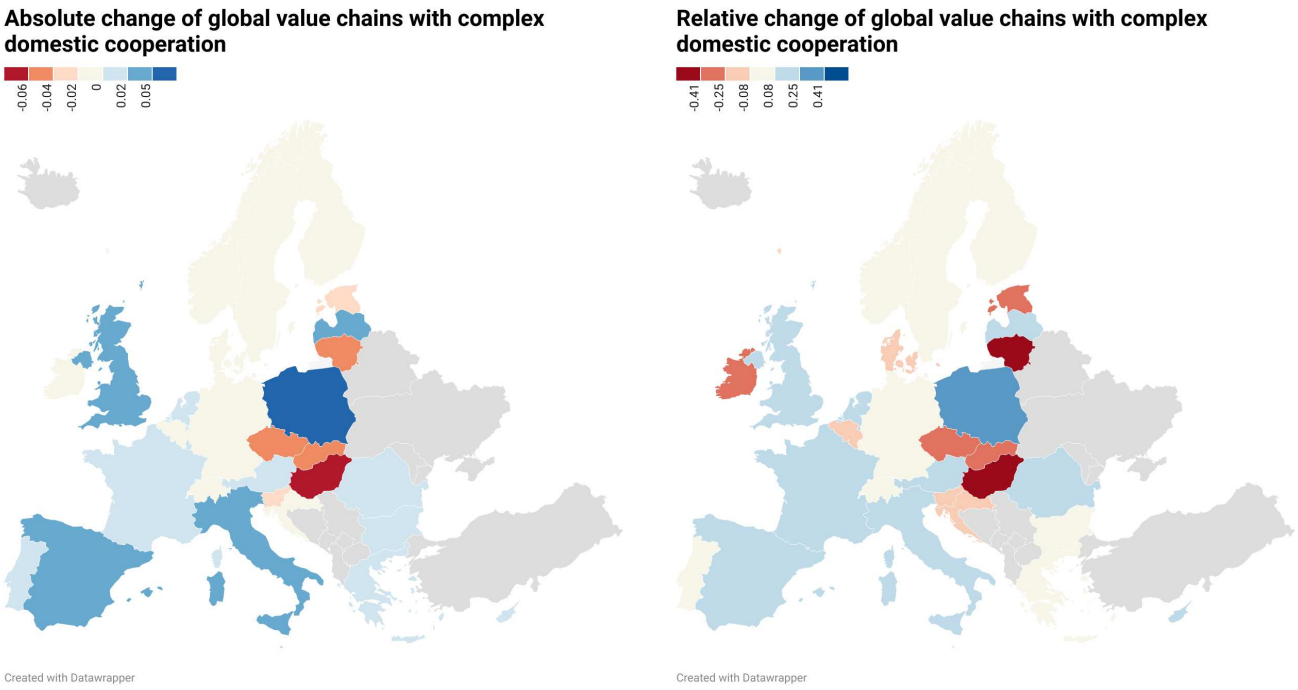
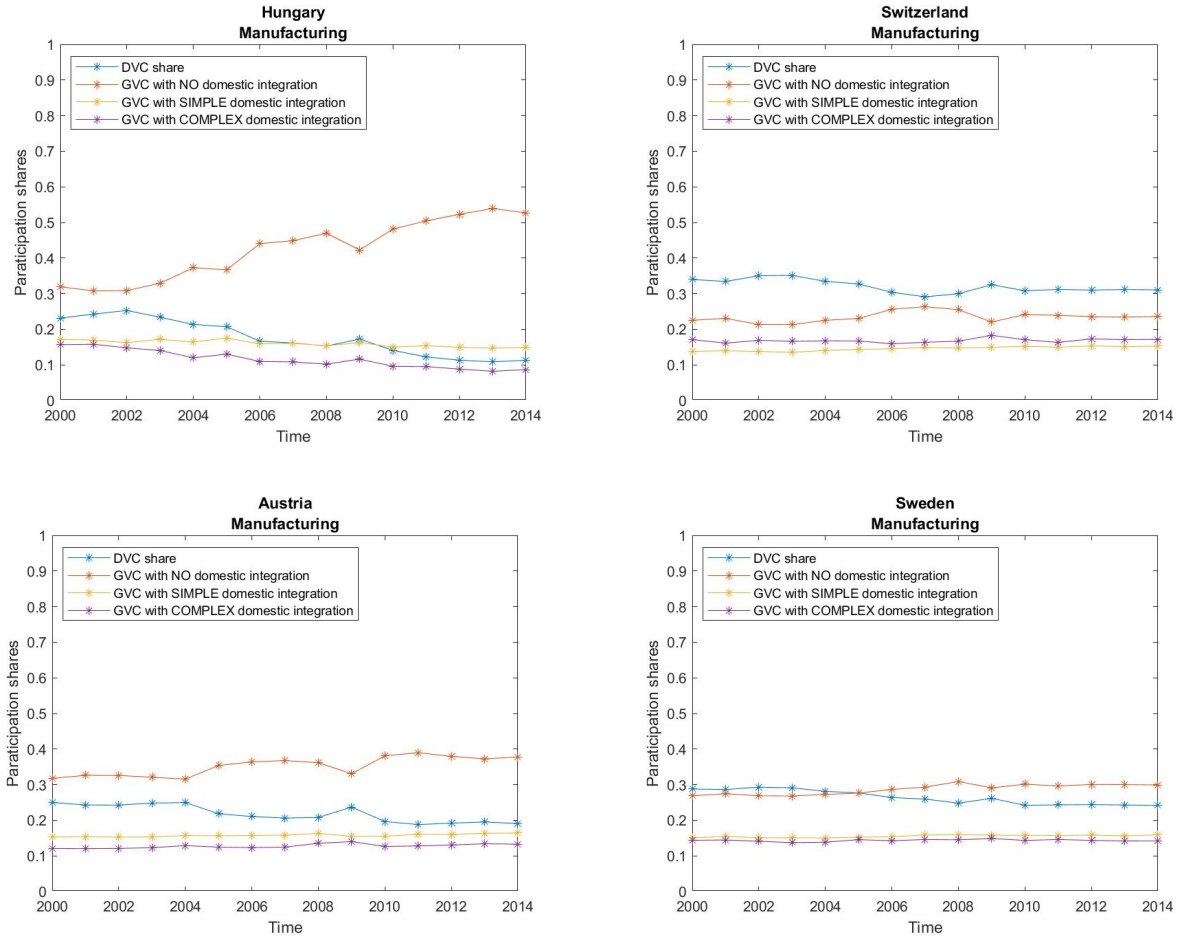


Figure 4: Comparison of the development of supplier linkages in similarly sized countries: Sweden, Hungary, Austria and Switzerland



We first test the determinants of change in the two most salient value chain structures, namely the domestic value chain and the global value chain with no domestic cooperation in European manufacturing. The variable LC stands for average sectoral labour costs expressed as wages, social contributions and taxes net of subsidies.[5] $IFDI$ represents the GDP share of the stock of inward FDI, while $NewEU$ is a categorical variable that is equal to 1 for the 8 new member states CEE EU member states.$\Delta GVC0DVC$ and ΔDVC represent the absolute annual change in global value chains with no domestic cooperation and domestic value chains, respectively. We use the between effects panel model to examine how differences in labour costs and IFDI explain long-run patterns of structural change in value chain structures. We also examine whether FDI has differential effects in the new EU member states. The main regression equations with between effects are derived from a general panel data model, with the line representing a time average:

$$\Delta GVC0DVC_{it} = \alpha_i + LC_{it}\beta_1 + IFDI_{it}\beta_2 + NewEU_i * IFDI_{it}\beta_3 + NewEU_i\beta_4 + \epsilon_{it}$$

$$\overline{\Delta GVC0DVC_i} = \alpha + \overline{LC_i}\beta_1 + \overline{IFDI_i}\beta_2 + NewEU_i * \overline{IFDI_i}\beta_3 + NewEU_i\beta_4 + (\alpha_i - \alpha + \overline{\epsilon_i})$$

$$\Delta DVC_{it} = \alpha_i + LC_{it}\beta_1 + IFDI_{it}\beta_2 + NewEU_i * IFDI_{it}\beta_3 + NewEU_i\beta_4 + \epsilon_{it}$$

$$\overline{\Delta DVC_i} = \alpha + \overline{LC_i}\beta_1 + \overline{IFDI_i}\beta_2 + NewEU_i * \overline{IFDI_i}\beta_3 + NewEU_i\beta_4 + (\alpha_i - \alpha + \overline{\epsilon_i})$$

The results (Table 4) confirm that differences in labour costs are the driving force behind the dynamic restructuring of value chains. Lower labour costs are associated with a decline in domestic value chains and an increase in global value chains with no domestic cooperation. Inward FDI has the opposite effect in the newly integrated EU member states than in the old EU Member States. In the CEE new EU member states, FDI is associated with positive changes in global value chains with no domestic cooperation and negative changes in the share of domestic value chains.

Second, we test the impact of value chain structure on the 3 determinants of research and development capability: research and development expenditure as a share of GDP, number of researchers per capita, and number of patents per capita. Thus, we aim to capture the impact of value chain structure on the ability to capture high value added parts of the production process. The variables $GVC2DVC$, $GVC0DVC$ and DVC represent the value chain shares of GVCs with complex domestic cooperation, GVCs with no domestic cooperation, and domestic value chains, respectively. RD, RES and PAT represent the share of GDP spent on R&D, the number of researchers per capita, and the number of patents per capita. GDP represents control variable for GDP per capita. We separately test for the effect of domestic value chains and different global value chains with respect to domestic cooperation. Similar to the first regression, we want to test whether long-run differences (across countries) in value chain structures affect research and development capacity. For this objective, the between effects panel model is most appropriate. The main regression equations are:[6]

$$R_{it} = \alpha_i DVC_{it}\beta_1 + GDP_i\beta_2 + \epsilon_{it}$$
$$\overline{R_i} = \alpha + \overline{DVC_i}\beta_1 + \overline{GDP_i}\beta_2 + (\alpha_i - \alpha + \overline{\epsilon_i})$$

$$R_{it} = \alpha_i GVC2DVC_{it}\beta_1 + GVC0DVC_{it}\beta_2 + GDP_i\beta_3 + \epsilon_{it}$$
$$\overline{R_i} = \alpha + \overline{GVC2DVC_i}\beta_1 + \overline{GVC0DVC_i}\beta_2 + GDP_i\beta_2 + \overline{GDP_i}\beta_3 + (\alpha_i - \alpha + \overline{\epsilon_i})$$

The results (Table 5,6) show a consistent effect of value chain structure on all three elements of research

[5] Absolute differences in labour costs at the country and sector level are calculated for the reference year 2016, and the panel is constructed by multiplying the absolute differences by the annual relative labour cost index.

[6] R covers all three research indicators in three separate sets of panel regressions.

Table 4: Determinants of value chain structure dynamics

	(1) $\Delta GVC0DVC$ Change in global value chains with no domestic cooperation	(2) ΔDVC Change in domestic value chains
LC (labour costs)	-0.106***	0.185***
	(0.03)	(0.02)
$NewEU$	-753.094***	618.402***
	(115.78)	(77.43)
$IFDI$	-2.252***	2.752***
	(0.33)	(0.22)
$NewEU \times IFDI$	21.633***	-9.491***
	(2.00)	(1.34)
constant	945.096***	-1292.389***
	(83.33)	(55.73)
r2	0.494	0.546
F	100.914	124.327
No. of obs.	3553	3553

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 5: Effect of domestic value chain structure on research and development

	(1) R&D spending	(2) Researchers	(3) Patents
DVC	0.155	-0.970	8.904
	(0.36)	(1.29)	(10.29)
GDP	0.000***	0.000***	0.001***
	(0.00)	(0.00)	(0.00)
constant	0.604***	4.559***	-15.332***
	(0.16)	(0.57)	(4.46)
r2	0.221	0.171	0.366
F	64.359	46.568	141.979
No. of obs.	6707	6498	7410

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

and development capacity. The global value chain with complex domestic cooperation is significantly positively associated with research capacity, in contrast to the domestic value chain structure and the global value chain with no domestic cooperation, both of which have an insignificant effect on research capacity. A simple explanation for this could be that domestic value chains face less competitive pressure and have fewer incentives to conduct research, while global value chains with no domestic cooperation reflect hierarchical or captive supplier relationships that do not contribute to research capacity.

Table 6: Effect of global value chain structure on research and development

	(1) R&D spending	(2) Researchers	(3) Patents
$GVC2DVC$	9.311***	26.319***	99.851**
	(1.24)	(4.59)	(35.09)
$GVC0DVC$	0.073	1.379	-22.622*
	(0.38)	(1.40)	(11.22)
GDP	0.000***	0.000***	0.001***
	(0.00)	(0.00)	(0.00)
constant	-0.838***	-0.229	-23.429***
	(0.25)	(0.93)	(6.98)
r2	0.332	0.235	0.395
F	74.947	46.276	106.777
No. of obs.	6707	6498	7410

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

3 Discussion

Examining the internationalisation of European manufacturing through the prism of the changing structure of value chains and supplier linkages reflects two distinct patterns that developed over the period 2000-2014. The first is a feature of the developed core European countries and the other a feature of the small, open and export-oriented new CEE EU Member States. The question remains: What do the studied changes in the structure of the supplier linkages tell us about the development of CEE compared to the core EU15 in terms of technological upgrading, spillover effects and potential long-term convergence? We argue that the distinct pattern of the studied supplier linkages and their changes during the period of most intensive internationalisation of the CEE economies reflect the middle-income development trap and the structural position of the new small CEE EU member states of an integrated periphery.

We used a panel regression model to relate the changing structure of supplier linkages to differences in labour costs and inward FDI. Specific macroeconomic determinants of internationalisation of CEE countries can help us link the studied structure of supplier linkages with the position of countries in the international division of labour. The most important feature of the internationalisation of CEE in the period 2000-2014 is that it was primarily driven by lower unit labour costs (da Silveira, 2014; Grodzicki & Skrzypek, 2020; Maskell et al., 2007; Pavlínek, 2020; Reurink & Garcia-Bernardo, 2020). The resulting high level of inward FDI significantly altered the governance structure of GVCs and the functional division of labour, and had complex effects on employment structure and wages (Hunya & Geishecker, 2005; Mencinger, 2003; Onaran & Stockhammer, 2008). These changes in supplier linkages, ownership structure and governance structure can help us understand the heterogeneous effects of value chain structures on research and development capabilities, as shown in the results in Table 5 and 6.

The investigated 8 CEE new EU member states show a dynamic development pattern of the structure of supplier linkages, which differs significantly from the other European countries, especially the old EU core countries. On the one hand, the decline of the role of domestic value chains is much more drastic for small and open CEE countries in the period studied. On the other hand, integration into global value chains in CEE countries takes a much more dependent form, with a significant increase in the share of global value chains with no domestic cooperation and a simultaneous decrease in the shares of global value chains with complex domestic cooperation. The two processes - the decline of domestic value chains and the growth

of global value chains with no domestic cooperation - are interrelated. This can be demonstrated by a high and negative correlation of $\rho = -0,87$ between the absolute changes in the two value chain structures over the period studied.

We identify several reasons that might offer an explanation for the changes in the structure of supplier linkages in the CEE countries:
1. High inward FDI directly increased GVC shares and decreased DVC shares, reflecting an absolute increase in GVC employment (*ceteris paribus*).
2. Foreign subsidiaries relied primarily on imports rather than domestic suppliers, as reflected in the larger increase in GVCs with no domestic cooperation compared to GVCs with simple and complex domestic cooperation (Figure 2,3). Of the two opposing movements - first, to replace traditional domestic suppliers with imports, and second, to increase the number of local suppliers within foreign-controlled networks due to further cost-cutting strategies - the first dominated.
3. Domestic firms were exposed to various types of functional downgrading that led to changes in supplier linkages. Passive downgrading is a well-documented process in which leading firms consolidate their supplier network by reducing the number of their direct suppliers, which can lead to technological downgrading or even complete market loss for their former supplier base (Blažek, 2016; Pavlínek & Žížalová, 2016). Adaptive downgrading was more common in the early days of internationalisation of countries from CEE countries. It is a process of restructuring of domestic companies due to increased competitive pressure caused by internationalisation. Some of the domestically integrated industries were integrated into foreign production networks through direct acquisitions, while some of the uncompetitive domestic firms and domestic value chains adapted by breaking up and specialising in component manufacturing and organising production as part of a foreign-controlled production network, both of which reflect the significant growth of global value chains with no domestic cooperation and the simultaneous decline of domestic value chains (Blažek, 2016, Pavlínek, 2008).

The general decline of domestic value chains, as well as the decline of domestic cooperation within global value chains, point to an increasing dependence on foreign capital and the inability of the economies of small and open CEE countries to produce value along the larger part of the value chain. These findings suggest that economic development in highly internationalised and open CEE economies may increasingly fall into a development trap, both in terms of technology and the share of value added within the value chain. As profit maximisation leads to fragmentation and reallocation of different parts of the production process mainly due to differences in labour power costs, regional differences in labour power costs also determine the functional division of labour and the potential for upgrading and technological or knowledge spillover effects.

The presented novel macroeconomic empirical investigation of the changing structure of supplier linkages complements numerous macroeconomic studies on the uneven development between CEE and the EU15 countries. It shows that the structure of supplier linkages is important for understanding the developmental middle-income trap in CEE EU member states. Understanding the impact of economic integration, FDI and the growth of global value chains and production networks on productivity, wages and development thus depends on our understanding of the structural changes in supplier linkages, which for CEE countries imply increasing dependence on intermediate product imports and the crowding out of the domestic supplier base, combined with the fragmentation and downgrading of the technological capabilities of domestic firms. Significant dynamic changes in both domestic value chains and global integration with no domestic cooperation, analysed in the cases of Hungary, Czech Republic, Slovakia, Slovenia and the Baltic States, coincide with the gradual establishment of the European integrated periphery throughout the manufacturing sector of these countries. We conclude that the development of the integrated periphery is directly reflected in the proposed empirical typology and measures. We confirm our hypotheses.

The presented empirical study generalises some of the findings of previous studies on the integrated periphery, which focused on specific sectors, mostly the automotive industry (Brincks et al., 2018; Castelli et al., 2011; Frigant & Layan, 2009; Grodzicki & Skrzypek, 2020; Joshi et al., 2013; Pavlínek, 2008, 2018, 2020; Pavlínek & Žížalová, 2016). One interesting result is that the sector-specific value chain pattern of the automotive industry identified by our methodology does not differ significantly from the structure of other manufacturing sectors. This could open a debate on the relationship between the qualitative aspect (the various governance aspects measured by qualitative methods combined with the ownership information) and the quantitative aspect of supplier linkages measured by the proposed I-O methodology, as well as on the typology and role of each of the aspects in determining specific patterns of internationalisation, the potential for knowledge and technology spillovers and the general prospects for growth and development.

4 Conclusion

In the article, we evaluate the aggregate structure of supplier linkages in the dynamic process of internationalisation of European countries. We use a novel approach in international input-output methodology to disaggregate value chain paths in terms of their global and domestic linkages and their interdependence. The proposed disaggregation attempts to extract the information on the changes in domestic cooperation between firms due to globalisation processes and distinguishes between domestic value chains, global value chains with no domestic cooperation, and global value chains with simple or complex domestic cooperation.

The results show a distinct pattern of development in all elements of disaggregation. The small and open CEE new EU member states exhibit almost twice the average decline in domestic value chains and also almost twice the average increase in global value chains with no domestic cooperation, while at the same time experiencing a decline in global value chains with complex domestic cooperation. We conclude that this pattern of internationalisation is characteristic of the development of the integrated periphery. The uneven development of domestic and global supplier linkages in Europe reflects the increasing dependence of the small and open CEE new EU member states and their technological and developmental structural position trapped in the middle income trap.

The typology and methodology studied open up relevant research questions on the role and relationship between quantity and quality of supplier linkages in the global division of labour. Further research is possible with a more detailed sectoral examination of the results as well as further empirical extensions of the temporal dimension of the same approach with the integration of new accounting data into harmonised international input-output data with a longer time span. Additional inclusion of other macroeconomic variables, especially labour skills, occupational data, technology and functional specialisations, would also present a way to further knowledge of uneven development.

5 Declarations

5.1 Availability of data and materials

The main datasets analysed during the current study are available at http://www.wiod.org.

5.2 Competing interests

The author declares that he has no competing interests.

5.3 Funding

The author of this article acknowledges the financial support received from the Slovenian Research Agency (research core funding No. 52075).

References

[1] Acemoglu, D., Johnson, S., & Robinson, J. (2005). Institutions as a Fundamental Cause of Long-Run Growth. In Handbook of Economic Growth (1st ed., pp. 385–472). Elsevier.

[2] Antràs, P., Chor, D., Fally, T., & Hillberry, R. (2012). Measuring the Upstreamness of Production and Trade Flows. American Economic Review, 102(3), 412–416. https://doi.org/10.1257/aer.102.3.412

[3] Arrighi, G., & Drangel, J. (1986). The Stratification of the World-Economy: An Exploration of the Semiperipheral Zone. Review, X(1), 9–74.

[4] Arto, I., Dietzenbacher, E., & Rueda-Cantuche, J. M. (2019). Measuring bilateral trade in terms of value added. Publications Office of the European Union. https://doi.org/10.2760/639612

[5] Azariadis, C. (1996). The economics of poverty traps part one: Complete markets. Journal of Economic Growth, 1(4), 449–486. https://doi.org/10.1007/BF00150197

[6] Barro, R. J., & Sala-i-Martin, X. (1992). Convergence. Journal of Political Economy, 100(2), 223–251.

[7] Barro, R. J., & Sala-i-Martin, X. I. (2004). Economic Growth, Second Edition — The MIT Press (2nd ed.). The MIT Press. https://mitpress.mit.edu/books/economic-growth-second-edition

[8] Blažek, J. (2016). Towards a typology of repositioning strategies of GVC/GPN suppliers: The case of functional upgrading and downgrading. Journal of Economic Geography, 16(4), 849–869. https://doi.org/10.1093/jeg/lbv044

[9] Bohle, D., & Greskovits, B. (2012). Capitalist Diversity on Europe's Periphery. Cornell University Press. https://cadmus.eui.eu//handle/1814/24382

[10] Borin, A., & Mancini, M. (2019). Measuring What Matters in Global Value Chains and Value-Added Trade. World Bank, Washington, DC. https://doi.org/10.1596/1813-9450-8804

[11] Brincks, C., Domański, B., Klier, T., & Rubenstein, J. M. (2018). Integrated peripheral markets in the auto industries of Europe and North America. International Journal of Automotive Technology and Management, 18(1), 1. https://doi.org/10.1504/IJATM.2018.090170

[12] Califano, A., & Gasperin, S. (2019). Multi-speed Europe is already there: Catching up and falling behind. Structural Change and Economic Dynamics, 51, 152–167. https://doi.org/10.1016/j.strueco.2019.08.009

[13] Castelli, C., Florio, M., & Giunta, A. (2011). How to cope with the global value chain: Lessons from Italian automotive suppliers. Int. J. of Automotive Technology and Management, 11, 236–253. https://doi.org/10.1504/IJATM.2011.040870

[14] Cieślik, A., & Wciślik, D. R. (2020). Convergence among the CEE-8 economies and their catch-up towards the EU-15. Structural Change and Economic Dynamics, 55, 39–48. https://doi.org/10.1016/j.strueco.2020.07.006

[15] Coe, N. M., Hess, M., Yeung, H. W. C., Dicken, P., & Henderson, J. (2004). 'Globalizing' regional development: A global production networks perspective. Transactions of the Institute of British Geographers, 29(4), 468–484. https://doi.org/10.1111/j.0020-2754.2004.00142.x

[16] Coe, N. M., & Yeung, H. W. (2015). Global Production Networks: Theorizing Economic Development in an Interconnected World. In Global Production Networks. Oxford University Press. https://oxford.universitypressscholarship.com/view/10.1093/acprof:oso/9780198703907.001.0001/acprof-9780198703907

[17] Coe, N. M., & Yeung, H. W. (2019). Global production networks: Mapping recent conceptual developments. Journal of Economic Geography, 19(4), 775–801. https://doi.org/10.1093/jeg/lbz018

[18] Cutrini, E. (2019). Economic integration, structural change, and uneven development in the European Union. Structural Change and Economic Dynamics, 50, 102–113. https://doi.org/10.1016/j.strueco.2019.06.007

[19] da Silveira, G. J. C. (2014). An empirical analysis of manufacturing competitive factors and offshoring. International Journal of Production Economics, 150, 163–173. https://doi.org/10.1016/j.ijpe.2013.12.031

[20] Davis, C., & Naghavi, A. (2011). Offshoring Production: A Simple Model of Wages, Productivity, and Growth. Economic Inquiry, 49(2), 334–348. https://doi.org/10.1111/j.1465-7295.2010.00293.x

[21] Dietzenbacher, E., & Romero, I. (2016). Production Chains in an Interregional Framework: Identification by Means of Average Propagation Lengths: International Regional Science Review. https://doi.org/10.1177/0160017607305366

[22] Dixit, A. K., & Stiglitz, J. E. (1977). Monopolistic Competition and Optimum Product Diversity. The American Economic Review, 67(3), 297–308.

[23] Drahokoupil, J. (2009). Globalization and the State in Central and Eastern Europe. Routledge.

[24] Drahokoupil, J., & Fabo, B. (2020). The limits of foreign-led growth: Demand for skills by foreign and domestic firms. Review of International Political Economy, 1–45. https://doi.org/10.1080/09692290.2020.1802323

[25] Dyba, W., Loewen, B., Looga, J., & Zdražil, P. (2018). Regional Development in Central-Eastern European Countries at the Beginning of the 21st Century: Path Dependence and Effects of EU Cohesion Policy. Quaestiones Geographicae, 37, 77–92. https://doi.org/10.2478/quageo-2018-0017

[26] Eichengreen, B., Park, D., & Shin, K. (2013). Growth Slowdowns Redux: New Evidence on the Middle-Income Trap (NBER Working Paper No. 18673). National Bureau of Economic Research, Inc. https://econpapers.repec.org/paper/nbrnberwo/18673.htm

[27] Frigant, V., & Layan, J.-B. (2009). Modular Production and the New Division of Labour Within EuropeThe Perspective of French Automotive Parts Suppliers. European Urban and Regional Studies, 16, 11–25. https://doi.org/10.1177/0969776408098930

[28] Galgóczi, B., Drahokoupil, J., Bernaciak, M., & Pavlinek, P. (2015). Foreign investment in eastern and southern Europe after 2008. Still a lever of growth? Faculty Books and Monographs. https://digitalcommons.unomaha.edu/facultybooks/311

[29] Galor, O. (1996). Convergence? Inferences from Theoretical Models. The Economic Journal, 106(437), 1056. https://doi.org/10.2307/2235378

[30] Gereffi, G. (2019). Economic upgrading in global value chains. In Handbook on Global Value Chains (pp. 240–254). Edward Elgar Publishing.

[31] Gereffi, G., Humphrey, J., Kaplinsky, R., & Sturgeon*, T. J. (2001). Introduction: Globalisation, Value Chains and Development. IDS Bulletin, 32(3), 1–8. https://doi.org/10.1111/j.1759-5436.2001.mp32003001.x

[32] Gereffi, G., Humphrey, J., & Sturgeon, T. (2005). The Governance of Global Value Chain. Review of International Political Economy, 12, 78-104-78–104. https://doi.org/10.1080/09692290500049805

[33] Glaeser, E., & Kohlhase, J. (2003). Cities, Regions and the Decline of Transport Costs. Review of Economic Design, 83, 197–228. https://doi.org/10.2139/ssrn.431741

[34] Grodzicki, M. J., & Skrzypek, J. (2020). Cost-competitiveness and structural change in value chains – vertically-integrated analysis of the European automotive sector. Structural Change and Economic Dynamics, 55, 276–287. https://doi.org/10.1016/j.strueco.2020.08.009

[35] Hartmann, D., Zagato, L., Gala, P., & Pinheiro, F. L. (2021). Why did some countries catch-up, while others got stuck in the middle? Stages of productive sophistication and smart industrial policies. Structural Change and Economic Dynamics, 58, 1–13. https://doi.org/10.1016/j.strueco.2021.04.007

[36] Harvey, D. (2005). Spaces of neoliberalization: Towards a theory of uneven geographical development (2nd ed.). Franz Steiner Verlag. https://elibrary.steiner-verlag.de/book/99.105010/9783515115223

[37] Harvey, D. (2007). The Limits to Capital (Updated edition). Verso.

[38] Henderson, J., Dicken, P., Hess, M., Coe, N., & Yeung, H. W. C. (2002). Global Production Networks and the Analysis of Economic Development. Review of International Political Economy, 9(3), 436–464.

[39] Horvath, J., & Grabowski, R. (1999). Core and Periphery in the World Economy: An Empirical Assessment of the Integration of the Developing Countries Into the World Economy. International Economic Journal, 13, 35–51. https://doi.org/10.1080/10168739900080027

[40] Hunya, G., & Geishecker, I. (2005). Employment Effects of Foreign Direct Investment in Central and Eastern Europe (No. 321). The Vienna Institute for International Economic Studies. https://wiiw.ac.at/employment-effects-of-foreign-direct-investment-in-central-and-eastern-europe-dlp-348.pdf

[41] Johnson, R., & Noguera, G. (2012). Accounting for intermediates: Production sharing and trade in value added. Journal of International Economics, 86(2), 224–236.

[42] Joshi, D., Nepal, B., Rathore, A. P. S., & Sharma, D. (2013). On supply chain competitiveness of Indian automotive component manufacturing industry. International Journal of Production Economics, 143(1), 151–161. https://doi.org/10.1016/j.ijpe.2012.12.023

[43] Knez, K., Jaklič, A., & Stare, M. (2021). An extended approach to value chain analysis. Journal of Economic Structures, 10(1), 13. https://doi.org/10.1186/s40008-021-00244-6

[44] Koopman, R., Wang, Z., & Wei, S.-J. (2014). Tracing Value-Added and Double Counting in Gross Exports. American Economic Review, 104(2), 459–494. https://doi.org/10.1257/aer.104.2.459

[45] Kordalska, A., & Olczyk, M. (2021). New patterns in the position of CEE countries in global value chains: Functional specialisation approach. Oeconomia Copernicana, 12(1), 35–52. https://doi.org/10.24136/oc.2021.002

[46] Krpec, O., & Hodulák, V. (2018). The Czech economy as an integrated periphery: The case of dependency on Germany. Journal of Post Keynesian Economics, 42, 1–31. https://doi.org/10.1080/01603477.2018.1431792

[47] Krugman, P. (1991). Increasing Returns and Economic Geography. Journal of Political Economy, 99(3), 483–499. https://doi.org/10.1086/261763

[48] Krugman, P., & Venables, A. (1995). Globalization and the Inequality of Nations. The Quarterly Journal of Economics, 110(4), 857–880.

[49] Kuc Czarnecka, M., Saltelli, A., Olczyk, M., & Reinert, E. (2021). The opening of Central and Eastern European countries to free trade: A critical assessment. Structural Change and Economic Dynamics, 58, 23–34. https://doi.org/10.1016/j.strueco.2021.04.005

[50] Kutan, A. M., & Yigit, T. M. (2004). Nominal and real stochastic convergence of transition economies. Journal of Comparative Economics, 32(1), 23–36. https://doi.org/10.1016/j.jce.2003.09.008

[51] Kutan, A. M., & Yigit, T. M. (2005). Real and nominal stochastic convergence: Are the new EU members ready to join the Euro zone? Journal of Comparative Economics, 33(2), 387–400. https://doi.org/10.1016/j.jce.2005.03.001

[52] Kutan, A. M., & Yigit, T. M. (2007). European integration, productivity growth and real convergence. European Economic Review, 51(6), 1370–1395. https://doi.org/10.1016/j.euroecorev.2006.11.001

[53] Landesmann, M. A., & Stöllinger, R. (2019). Structural change, trade and global production networks: An 'appropriate industrial policy' for peripheral and catching-up economies. Structural Change and Economic Dynamics, 48, 7–23. https://doi.org/10.1016/j.strueco.2018.04.001

[54] Los, B., Timmer, M. P., & Vries, G. J. de. (2015). How Global Are Global Value Chains? A New Approach to Measure International Fragmentation. Journal of Regional Science, 55(1), 66–92. https://doi.org/10.1111/jors.12121

[55] Lucas, R. E. (1988). On the mechanics of economic development. Journal of Monetary Economics, 22(1), 3–42. https://doi.org/10.1016/0304-3932(88)90168-7

[56] Mankiw, Romer, D., & Weil, D. (1992). A Contribution to the Empirics of Economic Growth. Quarterly Journal of Economics, 107(May), 407–437.

[57] Maskell, P., Pedersen, T., Petersen, B., & Dick-Nielsen, J. (2007). Learning Paths to Offshore Outsourcing: From Cost Reduction to Knowledge Seeking. Industry and Innovation, 14(3), 239–257. https://doi.org/10.1080/13662710701369189

[58] Matkowski, Z., & Próchniak, M. (2004). Real Economic Convergence in the EU Accession Countries. International Journal of Applied Econometrics and Quantitative Studies, 1(3), 5–38.

[59] Matkowski, Z., & Próchniak, M. (2007). Economic Convergence between the CEE-8 and the European Union. Eastern European Economics, 45(1), 59–76.

[60] Mello, M., & Perrelli, R. (2003). Growth equations: A quantile regression exploration. The Quarterly Review of Economics and Finance, 43(4), 643–667. https://doi.org/10.1016/S1062-9769(03)00043-7

[61] Mencinger, J. (2003). Does Foreign Direct Investment Always Enhance Economic Growth? Kyklos, 56(4), 491–508. https://doi.org/10.1046/j.0023-5962.2003.00235.x

[62] Miller, R. E., & Temurshoev, U. (2017). Output Upstreamness and Input Downstreamness of Industries/Countries in World Production. International Regional Science Review, 40(5), 443–475. https://doi.org/10.1177/0160017615608095

[63] Miroudot, S., & Ye, M. (2021). Decomposing value added in gross exports. Economic Systems Research, 33(1), 67–87. https://doi.org/10.1080/09535314.2020.1730308

[64] Myant, M. (2018). Dependent capitalism and the middle-income trap in Europe na East Central Europe. International Journal of Management and Economics, 54, 291–303. https://doi.org/10.2478/ijme-2018-0028

[65] Onaran, Ö., & Stockhammer, E. (2008). The effect of FDI and foreign trade on wages in the Central and Eastern European Countries in the post-transition era: A sectoral analysis for the manufacturing industry. Structural Change and Economic Dynamics, 19(1), 66–80. https://doi.org/10.1016/j.strueco.2007.11.003

[66] Palan, N., & Schmiedeberg, C. (2010). Structural convergence of European countries. Structural Change and Economic Dynamics, 21(2), 85–100. https://doi.org/10.1016/j.strueco.2010.01.001

[67] Pavlínek, P. (2008). A Successful Transformation?: Restructuring of the Czech Automobile Industry. Physica-Verlag Heidelberg. https://doi.org/10.1007/978-3-7908-2040-9

[68] Pavlínek, P. (2018). Global Production Networks, Foreign Direct Investment, and Supplier Linkages in the Integrated Peripheries of the Automotive Industry. Economic Geography, 94(2), 141–165. https://doi.org/10.1080/00130095.2017.1393313

[69] Pavlínek, P. (2020). Restructuring and internationalization of the European automotive industry. Journal of Economic Geography, 20(2), 509–541. https://doi.org/10.1093/jeg/lby070

[70] Pavlínek, P., & Žížalová, P. (2016). Linkages and spillovers in global production networks: Firm-level analysis of the Czech automotive industry. Journal of Economic Geography, 16(2), 331–363. https://doi.org/10.1093/jeg/lbu041

[71] Pleticha, P. (2021). Who Benefits from Global Value Chain Participation? Does Functional Specialization Matter? Structural Change and Economic Dynamics, 58, 291–299. https://doi.org/10.1016/j.strueco.2021.06.005

[72] Poznanska, J., & Poznanski, K. (2015). Comparison Of Patterns Of Convergence Among "Emerging Markets" Of Central Europe, Eastern Europe And Central Asia. Comparative Economic Research, 18. https://doi.org/10.1515/cer-2015-0001

[73] Reurink, A., & Garcia-Bernardo, J. (2020). Competing for capitals: The great fragmentation of the firm and varieties of FDI attraction profiles in the European Union. Review of International Political Economy, 1–34. https://doi.org/10.1080/09692290.2020.1737564

[74] Reynaud, A. (1984). Disuguaglianze regionali e giustizia socio-spaziale. https://www.dimanoinmano.it/it/cp174969/scienze-umane/sociologia/disuguaglianze-regionali-e-giustizia-socio-spaziale

[75] Rodrik, D. (2018a). Populism and the economics of globalization. Journal of International Business Policy, 1(1–2), 12–33. https://doi.org/10.1057/s42214-018-0001-4

[76] Rodrik, D. (2018b). New Technologies, Global Value Chains, and Developing Economies (No. w25164; p. w25164). National Bureau of Economic Research. https://doi.org/10.3386/w25164

[77] Romer, P. M. (1990). Endogenous Technological Change. Journal of Political Economy, 98(5), 71–102.

[78] Shields, S. (2009). CEE as a New Semi-Periphery: Transnational Social Forces and Poland's Transition. In O. Worth & P. Moore (Eds.), Globalization and the 'New' Semi-Peripheries (pp. 159–176). Palgrave Macmillan UK. https://doi.org/10.1057/9780230245167_10

[79] Solow, R. M. (1957). Technical Change and the Aggregate Production Function. The Review of Economics and Statistics, 39(3), 312–320. https://doi.org/10.2307/1926047

[80] Stehrer, R. (2012). Trade in Value Added and the Valued Added in Trade (Working Paper 81; pp. 1–19). Vienna Institute for International Economic Studies.

[81] Swan, T. W. (1956). Economic Growth and Capital Accumulation. Economic Record, 32(2), 334–361. https://doi.org/10.1111/j.1475-4932.1956.tb00434.x

[82] Timmer, M. P., Dietzenbacher, E., Los, B., Stehrer, R., & Vries, G. J. de. (2015). An Illustrated User Guide to the World Input–Output Database: The Case of Global Automotive Production. Review of International Economics, 23(3), 575–605. https://doi.org/10.1111/roie.12178

[83] Wang, Zhi, Shang-Jin Wei, Xinding Yu, and Kunfu Zhu. 2017. "Characterizing Global Value Chains: Production Length and Upstreamness." w23261. Cambridge, MA: National Bureau of Economic Research. https://doi.org/10.3386/w23261.

[84] Żuk, P., & Savelin, L. (2018). Real convergence in central, eastern and south-eastern Europe. (ECB Occasional Paper Series No. 212). Publications Office. https://data.europa.eu/doi/10.2866/747750

Appendix A - notations

$n_S \in \mathbb{N}$ number of sectors.
$n_C \in \mathbb{N}$ number of countries.
$n \in \mathbb{N}$; $n = n_S * n_C$ number of country-sectors.

$\mathbf{1} \in \mathbb{R}^n$ vector of ones.
$\vec{1} \in \mathbb{R}^{n_C}$ vector of ones.
$\vec{e_i} \in \mathbb{R}^n$; $e_{ij} = \delta_{ij}$ standard orthonormal basis of $\mathbb{R}^n$.
$I \in \mathbb{R}^{n \times n}$ identity matrix.

$x \in \mathbb{R}^n$ total output vector.
$\hat{x} \in \mathbb{R}^{n \times n}$; $\hat{x} = diag(x)$ total output matrix.
$C \in \mathbb{R}^{n \times n}$ intermediate consumption matrix.
$F \in \mathbb{R}^{n \times n_C}$ final consumption matrix on country level.[7]
$f \in \mathbb{R}^n$; $f = F\vec{1}$ total final consumption vector.
$\hat{f} \in \mathbb{R}^{n \times n}$; $\hat{f} = diag(f)$ total final consumption matrix.

$A \in \mathbb{R}^{n \times n}$; $A = C\hat{x}^{-1}$ Leontief technical coefficient matrix.
$G \in \mathbb{R}^{n \times n}$; $G = \hat{x}^{-1}C$ Ghosh technical coefficient matrix.

$v \in \mathbb{R}^n$; $v^T = x^T - \mathbf{1}^T C = \mathbf{1}(\hat{x} - A\hat{x}) = \mathbf{1}^T(I - A)\hat{x}$ vector of total value added.
$\hat{v} \in \mathbb{R}^{n \times n}$; $\hat{v} = diag(v)$ total value added matrix.
$v_C \in \mathbb{R}^n$; $v_C^T = v^T\hat{x}^{-1} = \mathbf{1}^T(I - A)$ vector of value added coefficients - value added share in total output.
$\hat{v}_C \in \mathbb{R}^{n \times n}$; $\hat{v}_C = diag(v_C)$ value added coefficients matrix.

C, A and G have block matrix structure $\mathbb{R}^{(n_S \times n_S) \times (n_C \times n_C)}$, while F has a block vector structure $\mathbb{R}^{n_S \times (n_C \times n_C)}$. Diagonal block elements with respect to countries represent domestic intermediate transfers and domestic consumption and off diagonal block elements represent transactions that crossborder either for intermediate use or final consumption.

$C = C_{CB} + C_D$
$A = A_{CB} + A_D$
$G = G_{CB} + G_D$
$F = F_{CB} + F_D$
$f_{CB} \in \mathbb{R}^n$; $f_{CB} = F_{CB}\vec{1}$ total final consumption by exporting.
$f_D \in \mathbb{R}^n$; $f_D = F_D\vec{1}$ total final consumption by domestic transactions.
$\hat{f}_{CB} \in \mathbb{R}^{n \times n}$; $\hat{f}_{CB} = diag(f_{CB})$ total final consumption by exporting matrix.
$\hat{f}_D \in \mathbb{R}^{n \times n}$; $\hat{f}_D = diag(f_D)$ total final consumption by domestic transactions matrix.

[7] In international I-O framework F is usually disaggregated on country level as well as in additional dimension of final consumption (household, government and non-profit consumption, fixed capital formation and changes in inventories), which is in our derivation irrelevant and left out. Disaggregation by countries is relevant to enable separation of domestic final consumption and export.

Appendix B - τ_i derivation and decomposition

The set of matrices τ_i represent the output of each country sector, produced through all possible upstream and downstream value chain paths. Summation along the dimensions of each matrix gives a share of output produced in any value chain structure.

The derivation starts with the Leontief demand driven model:

$$x = Ax + f \tag{5.1}$$
$$x = (I - A)^{-1} f \tag{5.2}$$
$$x = (I - A)^{-1} \hat{f}\mathbf{1} \tag{5.3}$$
$$\hat{x}^{-1}(I - A)^{-1} \hat{f}\mathbf{1} = \mathbf{1} \tag{5.4}$$

The matrix $\hat{x}^{-1}(I - A)^{-1}\hat{f}$ represents the upstream output decomposition along all upstream value chain paths. The i-th row of this matrix represents the disaggregation of the total output of the i-th country-sector into output shares according to the upstream value chain path leading to final demand. For the downstream part we begin with identity:

$$x^T = \mathbf{1}^T \hat{x} \tag{5.5}$$
$$x^T = \mathbf{1}^T (I - A)(I - A)^{-1} \hat{x} \tag{5.6}$$
$$x^T = v_C^T (I - A)^{-1} \hat{x} \tag{5.7}$$
$$x^T = \mathbf{1}^T \hat{v_C} (I - A)^{-1} \hat{x} \tag{5.8}$$
$$\mathbf{1}^T = \mathbf{1}^T \hat{v_C} (I - A)^{-1} \tag{5.9}$$

The matrix $\hat{v_C}(I - A)^{-1}$ represents the downstream output decomposition along all downstream value chain paths. The i-th column of this matrix represents the disaggregation of the total output of the i-th country-sector into output shares along according to value added - therefore along the downstream value chain paths.

Because decompositions of downstream and upstream value chain paths are independent, they can be combined (basic argumentation given by Arto et al., 2019; Knez et al., 2021), by direct product of the i-th row of matrix $\hat{x}^{-1}(I - A)^{-1}\hat{f}$ and i-th column of matrix $\hat{v_C}(I - A)^{-1}$, which spans a whole matrix of value chain paths leading from value added to final consumption, conditional on being part of total output of the country-sector i. Because $\sum_{j=1}^{n} w_{ij} = 1 \; \forall i$ and $\sum_{k=1}^{n} z_{ki} = 1 \; \forall i$, the decomposition of value chain tree matrices thus consistently starts with a unity:

$$\tau_i = \hat{v_C}(I - A)^{-1} \vec{e_i} \otimes \vec{e_i}^T \hat{x}^{-1} (I - A)^{-1} \hat{f}; \qquad \tau_i \in \mathbb{R}^{n \times n}$$

$$\mathbf{1}^T \tau_i \mathbf{1} = 1; \qquad \forall i$$

The set of matrices τ_i is decomposed on global value chain and domestic value chain following the definitions 1.1 and 1.2. Because generally not all the output is part of a value chain (some value added reaches final demand without production fragmentation) we end up with the matrix τ_i decomposed on global value chain part, domestic value chain part and a residuum of no value chain part of output:

$$\tau_i = \hat{v_C}(I - A)^{-1} \vec{e_i} \otimes \vec{e_i}^T \hat{x}^{-1} (I - A)^{-1} \hat{f} =$$
$$\hat{v_C}(I-A)^{-1}\vec{e_i}\otimes\vec{e_i}^T\hat{x}^{-1}(I-A)^{-1}\hat{f} - \hat{v_C}(I-A_D)^{-1}\vec{e_i}\otimes\vec{e_i}^T\hat{x}^{-1}(I-A_D)^{-1}\hat{f} + \hat{v_C}(I-A_D)^{-1}\vec{e_i}\otimes\vec{e_i}^T\hat{x}^{-1}(I-A_D)^{-1}\hat{f} =$$
$$= \tau_i^{GVC} + \hat{v_C}(I - A_D)^{-1} \vec{e_i} \otimes \vec{e_i}^T \hat{x}^{-1} (I - A_D)^{-1} \hat{f} =$$
$$= \tau_i^{GVC} + \hat{v_C} A_D (I - A_D)^{-1} \vec{e_i} \otimes \vec{e_i}^T \hat{x}^{-1} \hat{f} + \hat{v_C} \vec{e_i} \otimes \vec{e_i}^T \hat{x}^{-1} A_D (I - A_D)^{-1} \hat{f} +$$

$$+\hat{v_C}A_D(I-A_D)^{-1}\vec{e_i}\otimes\vec{e_i}^T\hat{x}^{-1}A_D(I-A_D)^{-1}\hat{f}+\hat{v_C}\vec{e_i}\otimes\vec{e_i}^T\hat{x}^{-1}\hat{f}=$$
$$=\tau_i^{GVC}+\tau_i^{DVC}+\hat{v_C}\vec{e_i}\otimes\vec{e_i}^T\hat{x}^{-1}\hat{f}=$$
$$=\tau_i^{GVC}+\tau_i^{DVC}+\tau_i^{NVC}=\tau_i$$

A residuum is interpreted as part of output that has neither downstream nor upstream value chain path and is the share of direct value added that is at the same time also the final stage of the production process:

$$\tau_i^{NVC}=\hat{v_C}\vec{e_i}\otimes\vec{e_i}^T\hat{x}^{-1}\hat{f}$$

The τ_i^{GVC} is further decomposed on global value chains with different structure of domestic cooperation according to definitions 1.2.1, 1.2.2 and 1.2.3, which concludes the value chain decomposition:

$$\tau_i=\tau_i^{GVCwNDC}+\tau_i^{GVCwSDC}+\tau_i^{GVCwCDC}+\tau_i^{DVC}+\tau_i^{NVC}$$

The final results represent the share of output that was produced in a each defined value chain structure for each country-sector. It is expressed as a vector of output shares $GVCwNDCs$, $GVCwSDCs$, $GVCwCDCs$, $DVCs$ and a residuum of no value chain shares $NVCs\in\mathbb{R}^n$:

$$DVCs=\begin{bmatrix}\mathbf{1}^T\tau_1^{DVC}\mathbf{1}\\ \mathbf{1}^T\tau_2^{DVC}\mathbf{1}\\ \vdots\\ \mathbf{1}^T\tau_n^{DVC}\mathbf{1}\end{bmatrix}\ NVCs=\begin{bmatrix}\mathbf{1}^T\tau_1^{GVC}\mathbf{1}\\ \mathbf{1}^T\tau_2^{GVC}\mathbf{1}\\ \vdots\\ \mathbf{1}^T\tau_n^{GVC}\mathbf{1}\end{bmatrix}\ GVCwNDCs=\begin{bmatrix}\mathbf{1}^T\tau_1^{GVCwNDC}\mathbf{1}\\ \mathbf{1}^T\tau_2^{GVCwNDC}\mathbf{1}\\ \vdots\\ \mathbf{1}^T\tau_n^{GVCwNDC}\mathbf{1}\end{bmatrix}$$

$$GVCwSDCs=\begin{bmatrix}\mathbf{1}^T\tau_1^{GVCwSDC}\mathbf{1}\\ \mathbf{1}^T\tau_2^{GVCwSDC}\mathbf{1}\\ \vdots\\ \mathbf{1}^T\tau_n^{GVCwSDC}\mathbf{1}\end{bmatrix}\ GVCwCDCs=\begin{bmatrix}\mathbf{1}^T\tau_1^{GVCwCDC}\mathbf{1}\\ \mathbf{1}^T\tau_2^{GVCwCDC}\mathbf{1}\\ \vdots\\ \mathbf{1}^T\tau_n^{GVCwCDC}\mathbf{1}\end{bmatrix}$$

All the output share vector, together with the residuum of no value chain share consistently amount to a vector of ones. With this we conclude the disaggregation of each country-sectors' total output, with respect to its specific value chain structure, which was differentiated based on linkages between firms. We can summarize our decomposition in the simple vector form:

$$DVCs+GVCwNDCs+GVCwSDCs+GVCwCDCs+NVCs=\mathbf{1}$$