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Decomposition analysis of global value chains: Uncovering vulnerable spots in a selected economy (the example of Czechia)

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ABSTRACT

Recent global turmoil has added to the importance of food security issues and the sustainability of production processes worldwide. This study aims to uncover the degree of domestic industries' dependence on the international fragmentation of production processes and identify the countries of origin of those producers who have managed to displace domestic producers in corresponding Global Value Chains. Using data retrieved from the World Input-Output Database, we studied Czechia's example via demarcation of domestic value-added (DVA) shares from foreign ones in final domestic products. A declining trend in DVA signalises an ever-increasing dependence on foreign inputs. The conducted analysis allowed a VA-structure (and its dynamics for a sequence of years) to be clearly identified for final domestic products among 30 industries that virtually cover the entire economy. The most alarming finding is the marked reduction of DVA in food manufacturing, which points to a weakening of Czech food security. Realising all the connections within GVCs may help to identify vulnerable spots in domestic production processes and prepare adequate response mechanisms in potential situations of possible interruptions from the foreign side. The detailed explanation of the decomposition technique provided in the study can be used in similar analyses of other economies to reveal noteworthy trends and prepare response measures.

1. Introduction

In modern globalised economic circumstances where everything depends on everything else to an ever-increasing extent, structural changes in any global value chain (GVC) would certainly translate into certain changes in other GVCs. The natural question that naturally arises in this regard is: what consequent effect(s) can be expected and to what extent? The occurrence of the global COVID-19 pandemic has also given renewed emphasis to these questions.

The adverse effects of the COVID-19 pandemic on all economic sectors is becoming more and more evident. A number of experts from all over the world predict that the negative economic impact of lockdowns will have long-term effects. Many analysts (representing the International Labour Organization (ILO), Food and Agriculture Organization (FAO), International Fund for Agricultural Development (IFAD) and World Health Organization (WHO) [1]) have written about a global recession, highlighting that tens of millions of people are at risk of falling into extreme poverty [2]. At the same time, figures show that the pandemic has impacted various economic sectors differently. As Bagchi et al. assert [3], some industries have been seriously affected, while others, at least so far, have barely been influenced by pandemic restrictions. If we look at the events through the prism of industry indices of virtually any stock

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exchange in the world, their numbers can reveal the most affected sectors: the transportation sector (the pandemic has obviously damaged the transportation and travel sector first of all - airlines were cancelling flights, passengers were flying less), the oil and gas sector (problems with the transportation sector resulted in difficulties with oil and gas storage), as well as the electricity sector, financial services, telecommunications, metals and mining, and also the consumer sector [3,4]. This situation in general may obviously become even worse due to the current military conflict in Ukraine.

A review of the existing data and literature suggests that the heaviest burden of the pandemic consequences and ongoing military conflict in Ukraine is placed upon agricultural value chains [5–7]. In this light, the issue of how the production processes of certain agri-food industries can be more sustainable, especially when exposed to unpredictable turmoil, becomes more vital and worth studying. The unobservable directly changes in the structure of value-added within a GVC may explain relative sustainability, resilience and/or competitiveness of certain industries compared to others.

2. Literature review

The most recent academic studies on how individual economies and industries react to different shocks and adjust to them (i.e., pandemic restrictions) mainly focus on post-factum analysis of their various consequences, and this approach has provided important results. As Poonia et al. [8] rightly point out, in attempt to implement precautionary measures such as restriction of mobility to stop the spread of the disease, nations have vastly affected one of the major economic sectors: the food and agricultural industry. The authors highlight how "travel restrictions disrupt the food production, distribution, and supply chain network". The impact has been widely witnessed, for example, on livestock and aquaculture farming, "which threatens the food security and calls for immediate policy interventions from the government" [8]. As food and agriculture is considered a core industry the world over, the importance of the associated issues has been discussed from various angles and viewpoints: (i) Hossain [9] analyses food security policies of Asian Productivity Organization members; (ii) farm diversification, as a potential success factor for small-scale farmers constrained by COVID-related lockdowns in selected EU countries was studied by Benedek et al. [10]; (iii) Zhang [11] addresses how Chinese livestock farms struggled under pandemic restrictions; (iv) Elleby et al. [12] discusses the overall impacts of the recent pandemic on the global agricultural markets; (v) by reviewing the most prominent advances made recently in the literature on household resilience and humanitarian crises that are closely linked to food security, Béné [13] identifies a series of lessons in the context of the pandemic and other shocks that can be used to "better realize the complexity of the situation and the potential ripple effects that may pass through the entire food system once one component is affected" [13]; (vi) Nasereldin et al. [14] highlight the main challenges faced by the global food supply chains in terms of their resilience; (vii) and finally Ehpstejn et al. [15] emphasises the idea that the viability of agri-food value chains is closely linked to integration processes. Furthermore, another important issue is connected to the necessity of strengthening agricultural productivity while reducing environmental impact [16].

In this light, GVCs, understood in the present research in line with Timmer et al. [17], can serve as a means for uncovering the interconnection among economies and industries, and comprehending the degree to which the fragmentation of production processes has affected the distribution of value-added (VA) in GVCs. For that reason, the main focus of the present study is to be shifted away from analysing the consequences of different shocks towards the roots of corresponding reactions on them. As Yang Lianling & Yang Cuihong [18] point out, these roots are associated with underlying structural proportions in VA and their changes. Once they occur these changes trigger subsequent shifts in other related spheres and so on. By applying the decomposition technique as suggested by Timmer et al. [17,26]; Johnson and Noguera [19]; Koopman et al. [20]; and Dietzenbacher et al. [21] (specified in the next section) we can trace these shifts. This can be done via demarcation of DVA from FVA in final domestic products of the selected industries that virtually cover the entire economy, and in our case the Czech economy specifically. If the DVA for the final products of a particular industry declines or appears critically low, it logically reveals a potential vulnerable spot in this economy in terms of maintaining resilience of corresponding production processes with respect to sudden shocks, such as disruptions to distribution chains due to, for example, pandemic restrictions or local military conflicts. Having compared the decomposition results for a sequence of years (though limited by the availability of data from the World Input-Output Database (WIOD)), we can disclose certain tendencies in the proportions of VA shares and consequently identify hidden structural changes that have happened in the Czech economy after 2000 (if any). Our empirical analysis is nevertheless limited by the availability of data (unfortunately the last release of the World Input-Output tables includes observations until 2014 only), although the suggested step-by step method can be replicated with similar data for other periods as soon as new data available. At the same time, the importance of this analysis has increased, namely in light of all the recent turmoil resulting from the COVID-19 pandemic and the military conflict in Ukraine, which threatened to disrupt distribution and supply chain networks worldwide.

Since in modern globalised economic circumstances everything depends on everything else, changes occurring in a particular industry (due to a fragmentation of production processes in GVCs) trigger subsequent shifts in other industries. Having demarcated DVA shares from foreign ones in the VA structure of a final product for a sequence of years, we can identify countries that managed to displace domestic producers within corresponding GVCs over the analysed period. We can also observe a particular development trend in the considered VA structures. A declining trend in DVA signalises an increasing dependence of a particular domestic industry on international fragmentation of production processes. This aspect questions the very sustainability of this industry in comparison to other domestic industries with relatively high portions of DVA. Since the recent pandemic and the current military conflict in Ukraine have heightened the urgency with which the sustainability of GVCs and food security issues are discussed worldwide, this study seeks to answer the following research questions:

1. What are the proportions between DVA and FVA components in final domestic products of key economic industries (including agri-food ones)?
2. What significant changes (if any) have taken place in the VA structure of selected for the analysis GVCs over time?
3. The partners from which countries have managed to displace domestic producers within corresponding GVCs?

In the following sections, we first introduce the methods and data used in the present analysis, then presenting and discussing the results of the VA decomposition, which are discussed mainly in light of the dynamics and interrelation between DVA and FVA components. In addition, according to the grading of foreign components' values, key partners of Czechia within individual GVCs are identified. The paper concludes by presenting the most alarming findings regarding food security and suggests possible ideas for future research.

3. Materials and methods

As its core, the present analysis is based on the Leontief's methodology, the materials (the data for GVCs) that were extracted from the WIOD, and the methods that were suggested by Timmer et al. [17,26], Johnson and Noguera [19], Koopman et al. [20], and Dietzenbacher et al. [21]. In this section, using specified materials and methods we will analyse, the value-added content of Czech final products of 30 key for the economy industries in harmony with WIOD classification, at the two-digit ISIC rev.4 level. To estimate a VA portion of a particular country in a selected GVC, it is necessary to trace the stream of intermediates through all industries and countries involved with this value chain. The WIOD has been designed namely for such kind of analyses [17,23].

Before we start the examination of the Czech final products in terms of their multi-national VA content, some key terminologies, as well as the methods and data that will be used in the present research are worth clarifying. A global value chain of a final product (GVC) is understood here in line with Marcel P. Timmer et al. [17] as the "value added of all activities that are directly and indirectly needed to produce it. This global value chain is identified by the country-industry where the last stage of production takes place before delivery to the final user". "A final product is called final since it is consumed, unlike intermediate one that is used in a production process further … Consumption is understood here in a wider meaning to incorporate both private and public consumption along with investment" [17]. Other possible definitions of GVC that exist in the scientific literature essentially transmit a very similar idea based on the empirical comprehension of value chains. The latter represents the complete range of activities that enterprises participate in to bring a product from its conception to its end use and beyond. This comprises designing, producing, marketing, distributing, and supporting the final consumer. The activities that constitute a value chain can be held within a single enterprise or divided among different companies. "Value chain activities can produce goods or services and can be contained within a single geographical location or spread over wider areas" [23].

The WIOD contains detailed data on national production activities, including data related to international trade (between regions, not within). Available WIOD data covers 43 countries, including all 27 countries of the European Union, 16 other major economies (Australia, Brazil, Canada, China, India, Indonesia, Japan, Mexico, Norway, Russia, South Korea, Switzerland, Taiwan, Turkey, the United Kingdom and the United States) and the "rest of the world" group of countries (RoW) to have the information about the final output complete. At the same time, these 43 countries namely represent more than 85% of global GDP. World Input-Output Tables (WIOT) are designed to reflect how much of each of the 56 products is produced and used by each of the 56 industries, thus covering the entire economy, including agriculture, mining, construction, utilities, 14 manufacturing industries, and 17 service industries. These tables were designed by combining national input-output tables with bilateral international trade data, following the conventions of the System of National Accounts [17, 23]. The first release of the WIOD was in 2012, revisions in 2013, and the second (and final one) in 2016 representing data as of 2014.

Authors of numerous studies i.e., [17, 24, 25] point out how economically developed countries, having delivered capital and high-skilled labour, have captured most of the value, whereas, in the end developing ones, having contributed low-skilled activities, add little value. To better understand the position of individual countries in a particular GVC and their importance in corresponding production processes, we will focus on demarcating DVA shares from FVA. To carry out this task the following steps will be undertaken:

1. After extracting the latest available data from the WIOT (Fig. 1 represents a schematic outline of the WIOT) upon total outputs and intermediate use of these outputs by 56 industries in 44 countries (i.e., all over the world), the matrix **A** [2464 × 2464] containing

Fig. 1. Schematic outline of a WIOT.
Source: [26].

global intermediate input coefficients was constructed. It consists of the elements that describe the output from s-sector in i-country used as intermediate input by t-sector in j-country as a share of output in the latter sector:

$$a_{ij(s,t)} = m_{ij(s,t)} \Big/ y_{j(t)} \tag{1}$$

The matrix **A** describes how the products of each country-sector are produced using a combination of various intermediate products, both of domestic and foreign origin [26].

2. Since output is used to satisfy both intermediate inputs during production (either at home or abroad) and final demand (also domestic and foreign) and product market clearing is assumed (changes in inventories are considered as part of investment demand), by definition, the quantity of a product produced in a particular country-sector must equal the quantities of this product used domestically and abroad [17]:

$$y_{i(s)} = \sum_j f_{ij(s)} + \sum_j m_{ij(s,t)} \tag{2}$$

where $y_{i(s)}$ – is the value of output in s-sector of i-country; $f_{ij(s)}$ – is the value of goods shipped from s-sector of i-country for final use in any j-country; $m_{ij(s,t)}$ – is the value of goods shipped from s-sector of i-country for intermediate use by t-sector in j-country.

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

Knowing the content of matrix A (1), we can rewrite (2) in a matrix form:

$$y = Ay + f \tag{3}$$

Then, rearranging (3) we arrive at the fundamental input-output identity:

$$y = (I - A)^{-1} f \tag{4}$$

where $(I - A)^{-1}$ – is the Leontief's inverse matrix, in which each element in x-row and z-column gives the total production value of the x-sector needed to produce one unit of final output of z-product; I – is the identity matrix [27].

Thus, within step-2 we found the elements of the Leontief's inverse.

3. Then, following the technical application of the decomposition method introduced by Timmer et al. [17,26], we trace the VA by different countries that is directly and indirectly needed for production of final product in the selected country (in our case the Czech Republic):

$$V = \widehat{p}(I - A)^{-1} C \tag{5}$$

where C – is a vector of consumption levels (i.e. all final demand, including investment demand); V – is a vector of the value added by all factors that are involved in any stage of the production of C; $\widehat{p}$ – is a diagonal matrix of the value added to gross output ratios in all industries in all countries (VA defined here in the standard way as gross output value (at basic prices) minus the cost of intermediate goods and services (at purchaser's prices) and calculated in line with Koopman et al. [20], so that it includes net taxes on intermediate inputs as well as international trade margins).

4. To decompose the VA structure of any final product in any country we should multiply $\widehat{p}(I - A)^{-1}$ with a corresponding vector of final demand levels.

In other words, having applied this method, we can find out what VA levels of both domestic and foreign origin are attributed to this particular set of final demand levels.[1]

According to Timmer et al. [26], the "domestic contribution to the output value of a particular consumption good is traced by appropriately choosing the final demand vector **C** in equation (5)". In our case, where **C** refers to the consumption of products delivered solely by Czech industries, this decomposition provides the value added by all labour and capital that was needed in any stage of the production of namely Czech products. "This consumption can be either domestic or foreign, as we are interested in analysing production process itself, irrespective of where final products are ultimately consumed" [26].

Following the accounting framework suggested by Timmer et al. [26], the WIOT, as displayed in Fig. 1, can be reorganised so that GVCs can be represented by columns, each of them for each final product. All final products will be represented by the country-industry-of-completion, where cells of each column (industries delivering intermediate inputs) indicate the origin of the VA, which could be both foreign and domestic. The rearranged table is given in Fig. 2, where individual cell values represent the VA generated in the country–industry given in the row, within the GVC corresponding to the country–industry of completion given by the column.

It must be noted that in contrast to a row in the WIOT (Fig. 1), the row in Fig. 2 indicates the flow of VA, and not the value of

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[1] The complete data set in Excel format (to replicate the results of this research) can be shared upon request.

Fig. 2. An accounting framework for global value Chains.
Source: [26].

intermediate inputs. Moreover, it includes VA delivered directly to the industry-of-completion, but also indirectly through other industries [27].

5. After applying the explained above procedure (steps 1.-4.) to WIOTs representing data from earlier periods, we can trace the dynamics in both DVA and FVA. This allows us to first identify key partners (countries) with the highest VA contributions to a Czech final product, and secondly the dynamics of domestic VA shares in individual sectors. The latter will shed light on the issue of unobservable directly structural changes in the Czech economy (if any) over the last decades by detecting industries with declining and growing domestic VA shares. At the same time, the FVA portion can be taken as a certain metric of international fragmentation of domestic production processes [28]. Analysing the production fragmentation, we can get insight into the degree of a selected country's dependence on contributions from other countries during the production process of final domestic products.

This analysis will cover the period from 2000 to 2014 (which is unfortunately, the latest available in WIOD data), and will be focused on key economic industries (30 in total, according to WIOD classification, see details in Table 1) in order to better understand structural changes and corresponding development trends in the Czech economy.

4. Results

The conducted decomposition analysis of all the selected GVCs for the 2000–2014-time span allowed us to distinctly separate domestic VA components from foreign ones in final Czech product of the 30 key industries, including agri-food related ones. We first present a general discussion of the obtained results from all the selected industries together to reflect a complete picture of the Czech economy. It is important to be aware of such a picture, since it contributes to a better comprehension of circumstances in which all domestic producers are supposed to work.

The results reveal that the DVA share in the final products of 21 out of 30 industries declined (this decline was different, changing from an insignificant one to a dramatic change), while, in contrast, the DVA share of the remaining 9 industries showed an upward trend within the analysed period. None of the agri-food sectors, however, were among them. The percentage shares of DVA in final Czech products of all the 30 industries is provided below in Table 2. The evolution of DVA for all the 30 industries is represented by Fig. 3. We divided the available time frame (2000–2014) into several smaller but equivalent time periods, i.e. 2000, 2005, 2010 and 2014, to see the very trend in evolution of individual DVAs. Having done the decomposition analysis it became clear that the vast majority of the studied components were showing a clear and steady trend over the selected years (either growing or declining) with no dramatic fluctuations (probably except for just H50). Also, 2005 and 2010 years can be seen as important milestones in the Czech economy because in 2004 Czechia became a member of the EU, and 2010 can be seen as a first relatively stable year after the world financial crisis over 2008–2009.

On the other hand, at the end of the analysed period the following 10 sectors (including agri-food one) had the highest (greater than 60%) DVA components: Q, P85, I, M74-M75, D35, A02, K66, E37-E39, H53, and A01. At the same time, it is worth mentioning that in the beginning of the analysed period, i.e., in 2000, the top-10 values of DVA components were on average 6–9% points higher compared to those in 2014. This fact confirms an ever-increasing fragmentation of production processes across almost all sectors.

As can be seen from, the most radical change in DVA was registered in the H51 sector, where it increased 40.4 times compared to the beginning of the analysed period. Another industry with a significant change in the VA structure is K66, its DVA increased by 41.4 p. p., from 22.53% in 2000 to 63.97% in 2014. Noticeable, however negative changes were also registered in the VA structure of the sectors C17 and C21, where the DVA declined by 41.4 p. p. and 38.3 p. p. respectively. The next sector is C26, where the DVA in final products declined 22.6 times, followed by sector C13-15 with a 11.7-fold decline; C21 (eight-fold decline); C28 and A03 (with approx. a five-fold reduction of the DVA in both cases).

The obtained results allow us to conclude that the industries with the growing dynamism of DVA (H51, K66, H50, H53, M69–70, M74–75, H49, B) appear to be more attractive for investing national capital and efforts. As evident, there is unfortunately no agri-food related industry among them. For instance, H51 (the air transport industry), which shows the most rapid growth of DVA over the period from 2000 to 2014, appeared to be the most attractive for Czech producers' domestic industry. This finding is in line with assertions made by M. Janečka in 2020: "The Czech Republic is one of very few countries in the world, whose airplane production – from start to finish – is manufactured within a single country. The same can be said about the industry's aircraft engine development

Table 1
The list of industries selected for the analysis.

Code	Industry
A01	Crop and animal production, hunting and related service activities
A02	Forestry and logging
A03	Fishing and aquaculture
B	Mining and quarrying
C10–C12	Manufacture of food products, beverages and tobacco products
C13–C15	Manufacture of textiles, wearing apparel and leather products
C16	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials
C17	Manufacture of paper and paper products
C20	Manufacture of chemicals and chemical products
C21	Manufacture of basic pharmaceutical products and pharmaceutical preparations
C22	Manufacture of rubber and plastic products
C23	Manufacture of other non-metallic mineral products
C24	Manufacture of basic metals
C26	Manufacture of computer, electronic and optical products
C28	Manufacture of machinery and equipment n.e.c.
D35	Electricity, gas, steam and air conditioning supply
E37-E39	Sewerage; waste collection, treatment and disposal activities; materials recovery; remediation activities and other waste management services
H49	Land transport and transport via pipelines
H50	Water transport
H51	Air transport
H53	Postal and courier activities
I	Accommodation and food service activities
J58	Publishing activities
J62-63	Computer programming, consultancy and related activities; information service activities
K66	Activities auxiliary to financial services and insurance activities
M69-70	Legal and accounting activities; activities of head offices; management consultancy activities
M72	Scientific research and development
M74-M75	Other professional, scientific and technical activities; veterinary activities
P85	Education
Q	Human health and social work activities

Source: authors' compilation according to the classification of industries used in WIOD [23].

and production capacity. < … > The efforts of domestic businesses to make their mark on the global aviation industry are supported by the business and investment development agency CzechInvest" [29].

In contrast, some industries reveal the dramatic negative dynamics of DVA in Czech final products, among them industry C26 (the manufacturing of computer, electronic and optical products) recorded the most radical decline, from 31.12% in 2000 to 1.38% in 2014. The DVA in Czech final products of industry C21 (the manufacturing of basic pharmaceutical products and pharmaceutical preparations) also significantly declined; from 43.73% in 2000 to a critical 5.47% in 2014. In fact, all of the industries with critically low DVAs (as of 2014, the last available data period), such as C13–C15 (1.49%), C21 (5.47%), C28 (6.20%), A03 (6.79%) etc. (see), should obviously face the strongest dependence on inputs/intermediates from abroad for the production of their final products. Being substantially dependent on foreign partners, these Czech industries logically end up being the most vulnerable ones to unpredicted disruptions in production and distribution processes abroad. In this regard it makes sense to take a closer look at their FVA components in order to identify the origin of individual VA shares (countries they came from) and, thus, to reveal the corresponding core partners.

Having considered the overall picture, we would like to narrow our analysis down to just manufacture-related sectors, whose successful functioning usually contributes to economic growth. Thus, for the next group of industries our focus was on the following nine sectors: C13–C15, C16, C17, C20, C21, C22, C24, C26 and C28. The analysis revealed that at the end of the analysed period DVA share in all of these sectors declined compared to values in 2000: 11.7, 1.5, 4.2, 3.4, 8.0, 2.3, 1.5, 22.6 and 5.1 times, respectively (see Table 2). In the year 2000, the Czech contribution to the production of final domestic goods in the sectors C16, C17, C20 and C24 higher than 50% (50%–69%), but in 2014 only 14 %–41% of VA in the final products of these sectors were of Czech origin. Thus, this finding also confirms the existence of the ever-increasing speed of international fragmentation of production processes. As for manufacturing industries, such a tendency may not be an existential problem, however, it may be an issue in the case of agri-food production, where such a trend may to a large extent endanger the very possibility of ensuring and keeping national food security.

In this regard, being crucial for any economy, the group of agri-food GVCs representing Czech final products (that is sectors A01, A03, and C10-12) is to be subject to a more in-depth study. Having demarcated DVA from FVA, the latter was demarcated further to separate individual components that represent different countries. Table 3 below provides the results of such decomposition analysis of FVA solely as individual components. We sorted all the foreign components by their value and provided the top-10 values representing country-partners in corresponding production process in a particular year. The contributions of these 10 countries constitute in different years from 75.00% to 86.35% of total FVA. In the same vein, the values shown in Fig. 4 "b" were recalculated to be expressed in % of total FVA in a particular year.

The obtained numbers are evidence that the DVA in the final Czech products from all agri-food sectors had noticeably declined over the analysed period. At the same time, it should be mentioned that in industries representing crop and animal production (A01), the DVA in 2014 still prevail over the FVA, meaning Czechia has remained relatively more self-reliant in crop and animal production. This

Table 2
The dynamics of DVA in final Czech products of 30 key industries.

Industry[a]	DVA in final Czech product, in % to total						Overall change, (+increase/-decrease)	
	2000		2005	2010	2014			
	VA	Rank	VA	VA	VA	Rank	in p.p.	times
A01	72.30	7	62.27	61.60	60.10	10	−12.2	−1.2
A02	75.45	3	73.26	68.96	66.43	6	−9.0	−1.1
A03	33.36	23	14.94	27.13	6.79	26	−26.6	−4.9
B	55.70	15	50.46	62.39	57.87	12	2.2	1.0
C10–C12	67.31	11	55.38	46.91	35.31	19	−32.0	−1.9
C13–C15	17.42	28	13.33	4.68	1.49	29	−15.9	−11.7
C16	68.92	10	66.95	55.21	46.03	15	−22.9	−1.5
C17	54.40	16	27.30	15.05	12.98	25	−41.4	−4.2
C20	50.10	17	27.12	15.17	14.59	24	−35.5	−3.4
C21	43.73	18	35.25	7.95	5.47	28	−38.3	−8.0
C22	33.83	22	26.13	20.49	14.45	18	−19.4	−2.3
C23	34.48	21	32.46	35.67	38.05	17	3.6	1.1
C24	63.11	12	56.96	55.82	40.98	16	−22.1	−1.5
C26	31.12	25	4.24	2.13	1.38	30	−29.7	−22.6
C28	31.55	24	10.08	7.89	6.20	27	−25.3	−5.1
D35	72.93	6	73.15	70.51	66.79	5	−6.1	−1.1
E37-E39	73.03	5	74.23	69.53	63.55	8	−9.5	−1.1
H49	43.58	19	54.23	52.40	47.10	14	3.5	1.1
H50	7.42	29	4.56	32.18	21.91	23	14.5	3.0
H51	0.73	30	18.36	31.63	29.48	21	28.8	40.4
H53	41.67	20	48.51	58.42	62.31	9	20.6	1.5
I	73.94	4	73.38	71.66	69.18	3	−4.8	−1.1
J58	58.74	14	50.44	24.01	22.37	22	−36.4	−2.6
J62–63	72.11	8	63.74	59.22	55.47	13	−16.6	−1.3
K66	22.53	27	43.87	68.07	63.97	7	41.4	2.8
M69–70	22.65	26	35.52	45.52	29.78	20	7.1	1.3
M72	71.23	9	68.59	64.39	59.92	11	−11.3	−1.2
M74-M75	62.90	13	66.99	66.69	68.46	4	5.6	1.1
P85	76.18	1	75.20	72.58	69.94	2	−6.2	−1.1
Q	75.91	2	75.05	72.85	70.21	1	−5.7	−1.1

[a] Full titles of all the industries are listed in Table 1.
Source: Authors' calculation using Matlab; raw data were retrieved from Ref. [23].

finding is also supported by the results of another analysis based on a longer time series with data until 2020 [30]. As for foreign partners, the highest VA shares belong to Germany – 19.25%, Slovakia – 13.68%, ROW – 10.97%, Russia – 8.03%, and Poland – 7.32% (in % to total FVA). These countries can namely be considered as the closest partners of Czechia in the field of crop, animal production, hunting and related service activities, as per 2014. The top-10 partners in 2000 were represented by almost the same group of countries, however some of them had noticeably increased their involvement in production of Czech final products by 2014; these countries are Slovakia, China, and Poland. The role of Austria and USA, in turn, became less important.

A considerable reduction in DVA was registered for A03 sectors dealing with fishing and aquaculture. Since Czechia does not have sea, this is not a surprising finding as this sector never was a strong side of the Czech economy. The composition of key partners over the analysed period for this sector has also noticeably changed. France, for example, the top-1 partner for the Czech A03 sector in 2000, but by the end of the analysed period it was already below the list of top-10 countries. The leading position was later occupied by Germany, with Bulgaria and Romania appearing among the top-5 partners in 2014 for the first time as well (see Fig. 4).

As for the key partners within the industries C10-12, they mainly remained the same. Displaying the hugest VA shares, Germany, Slovakia, and the RoW (rest of the world group of countries) have kept their leading positions over the analysed period, except for the USA, which in 2000 was on the top-5 list, but in 2014 it was already below the top-10. At the same time, the role of Italy and Poland has gradually strengthened in this sector (see Fig. 4). As for Czech manufacturing industries of food products, the most alarming finding regarding them is the marked reduction of DVA (by 32.00 p. p.) over the analysed period. A more in-depth analysis allowed us to identify the countries whose producers managed to displace Czech producers in these agri-food GVCs; these results are illustrated in Fig. 5.

As can be seen, a decline in DVA (designated as CZE) was almost fully compensated (75.7%–100.0% of total change) for an increase in FVA among the 10 key partners. Some of these countries appeared in the list of the top-10 in 2014 only, their values are coloured green. At the same time, the role of some stable partners representing, for example, Austria (AUT), Germany (DEU), Great Britain (GBR) or the USA, had noticeably weakened giving space to new partners from Hungary (HUN), Italy (ITA), Bulgaria (BGR), Romania (ROU), and China (CHN).

The conducted analysis reveals a steadfast downward trend for DVA in the production of final products within all agri-food sectors (A01, A03, C10-12) in Czechia over the period from 2000 to 2014. This fact is logically accompanied by a relatively low and in addition declining contribution of agriculture to the Czech Republic's GDP [31].
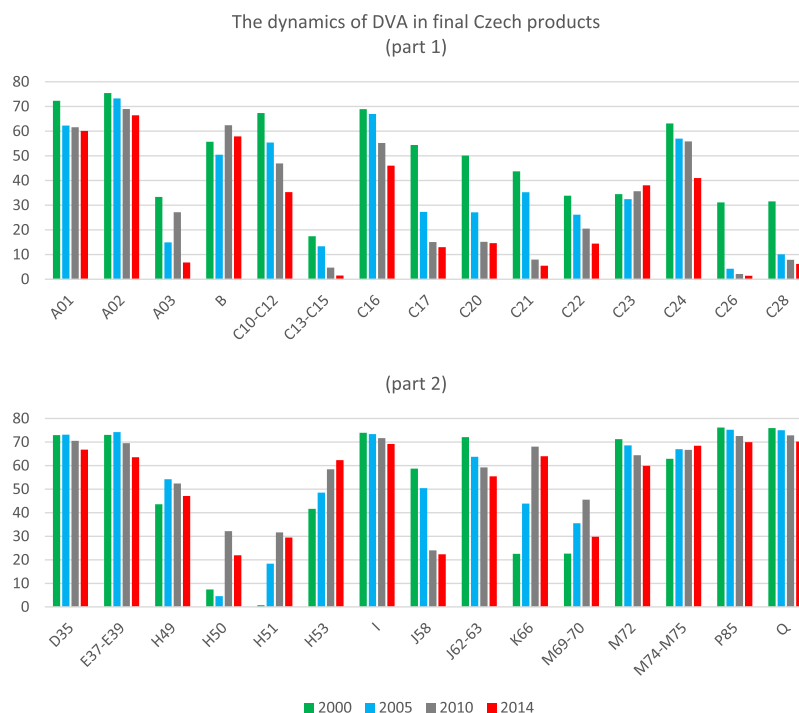
The dynamics of DVA in final Czech products
(part 1)

(part 2)

■ 2000 ■ 2005 ■ 2010 ■ 2014

Fig. 3. The dynamics of DVA in final Czech products of 30 key industries.
Source: Authors' elaboration; raw data were retrieved from Ref. [23].

As can be seen from Table 4, since this trend was negative for agricultural industries from 2000 to 2014, and then remained negative for them after 2014 as well, we may conclude that DVA in these industries continued to fall. This alarming fact may signalise an ever-decreasing self-reliance of Czechia from the perspective of achieving and keeping national food security, since foreign producers, capturing most of the value, have been gradually displacing domestic ones in these production processes. The deeper reasons and triggers of this tendency is worth studying further.

To reveal key foreign partners who displaced domestic producers in manufacturing-related sectors, we applied the same approach as before for the agri-food sectors; Fig. 6 illustrates the results. As can be seen, the importance of individual countries in the production processes of Czech final goods is different. Some countries became less important (e.g., Germany (DEU) lost the significant part of its VA for sectors C13-15), while others had intensively increased their involvement in the production of Czech final products (e.g., China (CHN), Denmark (DNK), Poland (POL), etc.).

Since with an ever-increasing fragmentation of production around the globe, the task-content of jobs is also changing, the knowledge of occupational structure of the workforce in various countries may allow for a better understanding of occurring structural changes. The used methodology does not unfortunately allow for considering occupational structure of the workforce. Among the other shortcomings of the used methodology the following aspects may be listed:

- it does not allow for estimations of substitution across inputs and rates of technological change because input–output tables, that were provided in the WIOD so far, are not constant-price tables;
- being expressed in basic prices the WIOTs are appropriate for most applications. However, this may have some implications for deeper analyses of VA structures because recording of profits may depend on different price concepts: basic (production) prices or market (retail) prices;
- the WIOTs were constructed based on so-called "fixed product sales" model, which assumes that each product has its specific use structure, irrespective of the industry that produced it [26].

5. Discussion

Very similar findings were discussed in the analysis by Ševčíková [32] already in the beginning of 2000s, i.e., the period when the process of globalisation had already been largely formed and more intensive fragmentation of production processes involving a growing number of countries began. Indeed, numerous studies have found exponential growth in the number of industries and activities encompassed by global supply chains since the early 2000s [36–38]. During that period, the GVC concepts became popular tools to investigate various effects of globalisation on production and trade. Global outsourcing along with outsourcing innovation and

Table 3

Top-10[a] countries with the highest VA share in Czech final agri-food products, in % of total FVA.

A01	2000		2005		2010		2014	
	26.64	DEU	23.09	DEU	18.17	SVK	19.25	DEU
	11.07	ROW	15.28	SVK	17.84	DEU	13.68	SVK
	8.70	RUS	7.79	RUS	9.55	RUS	10.97	ROW
	6.49	USA	5.98	POL	7.86	ROW	8.03	RUS
	6.13	AUT	5.41	ROW	6.01	POL	7.32	POL
	5.37	GBR	4.46	HUN	3.65	AUT	4.18	CHN
	4.28	FRA	4.27	AUT	3.28	CHN	3.61	USA
	3.92	POL	3.99	FRA	3.20	USA	3.33	FRA
	3.18	ITA	3.33	ITA	3.07	FRA	3.28	AUT
	3.17	SVK	3.33	GBR	3.04	ITA	3.18	ITA
	78.95	*Sum*	*76.92*	*Sum*	*75.66*	*Sum*	*76.82*	*Sum*
A03	2000		2005		2010		2014	
	20.90	FRA	33.22	DEU	21.26	DEU	20.26	DEU
	17.87	DEU	12.99	ROW	17.86	ROW	13.70	ROW
	9.26	ROW	12.46	FRA	11.27	SVK	10.19	BGR
	7.84	BEL	7.02	SVK	8.06	AUT	10.01	ROU
	6.76	SVK	6.25	AUT	7.02	HUN	9.89	HUN
	6.45	ITA	4.45	ITA	5.07	ITA	6.54	GRC
	4.81	AUT	3.33	BEL	3.92	RUS	5.06	ITA
	4.63	GBR	2.31	USA	3.18	BGR	4.53	AUT
	2.91	USA	2.18	RUS	2.34	USA	2.20	USA
	2.47	RUS	2.14	HUN	2.20	FRA	1.77	SVK
	83.91	*Sum*	*86.35*	*Sum*	*82.17*	*Sum*	*84.15*	*Sum*
C10–12	2000		2005		2010		2014	
	21.53	DEU	21.13	DEU	17.67	DEU	17.18	DEU
	12.44	ROW	16.23	SVK	14.22	SVK	15.70	SVK
	11.48	SVK	7.19	ROW	7.48	ROW	8.37	ROW
	8.16	RUS	6.96	RUS	7.38	ITA	8.22	ITA
	5.70	USA	5.53	POL	6.75	RUS	7.00	POL
	5.41	GBR	4.51	GBR	6.25	POL	4.30	FRA
	4.53	POL	4.50	ITA	4.62	GBR	4.19	GBR
	4.29	AUT	4.32	AUT	4.06	FRA	3.83	RUS
	3.35	FRA	3.29	FRA	3.50	AUT	3.12	AUT
	2.77	ITA	3.11	USA	3.32	HUN	3.09	HUN
	79.66	*Sum*	*76.76*	*Sum*	*75.26*	*Sum*	*74.99*	*Sum*

[a] Country abbreviations: AUT – Austria, BEL – Belgium, BGR – Bulgaria, CHN – China, DEU – Germany, FRA – France, GBR – Great Britain, GRC – Greece, HUN – Hungary, ITA – Italy, POL – Poland, ROU – Romania, ROW – Rest of the World, RUS – Russia, SVK – Slovakia, USA – United States of America.

Source: Authors' calculations using Matlab; raw data were retrieved from Ref. [23].

their impact on international competitiveness was studied by Engardio et al. [33,34]; René A. Hernández et al. [35] stated that "innovation is a necessary but insufficient condition for increasing value added" [35]; Gereffi et al. [36] confirmed that "integration into global trading systems could have both positive and negative effects" [36]; in this regard Dicken et al. [37] advocated for a network methodology as a potential framework to incorporate some contradicting concerns of how the global economy is understood; Henderson et al. [38] outlined such a framework for the analysis of "economic integration and its relation to the asymmetries of economic and social development" [38]; Gereffi et al. [39] focused on identifying the main determinants of how global value chains are governed and change; Gereffi [40] later identified the key transformations that are reshaping the governance structures of GVCs. Thus, the essence of a GVC's phenomenon and its place in global and national economies has been the focus of numerous studies surrounding the various aspects of the emergence of GVCs and their functioning. Overall, the authors of these and other studies expressly or by implication come to a very similar conclusion that GVC participants benefit from the participation in GVCs differently depending on a position they occupy in the GVC hierarchy in terms of their tasks and specialisation: Pleticha [41] used a production function framework to study the impact of GVC participation on value added; the extent to which an increased participation in GVCs can lead to higher economic growth (if any) was examined by Fagerberg et al. [42]; the position of the new EU member states within the GVCs was discussed by Hagemejer and Ghodsi [43]; and according to Lee and Gereffi [44], the effect of rising geographic and organisational concentration in GVCs "leads to the uneven distribution of upgrading opportunities for participating economies".

As for agriculture and food security in particular, Bosc et al. [45] emphasise that we should remember a widely accepted fact, that liberalisation policies have fundamentally changed the economic and institutional contexts in which agricultural producers work. Sojkova and Stehlíková [46] argue that "there is a requirement to perceive the tendency towards the downgrading status of agriculture in national economies of the EU countries", though taking into account "the differences in the importance of agriculture mainly in the countries that are the new EU members". Benešová et al. [47] confirm a declining significance of agriculture in more developed countries. Bórawski et al. [48] also register a declining VA of the food industry over the years 2011–2015, but in Czechia (- 6.9%), the Netherlands (- 2.1%) and Spain (- 3.5%) only. The matter is that as time goes by, higher product differentiation and value adding has noticeably changed the price spread between the farm value of products and the retail value [49]. Despite the EU's Common
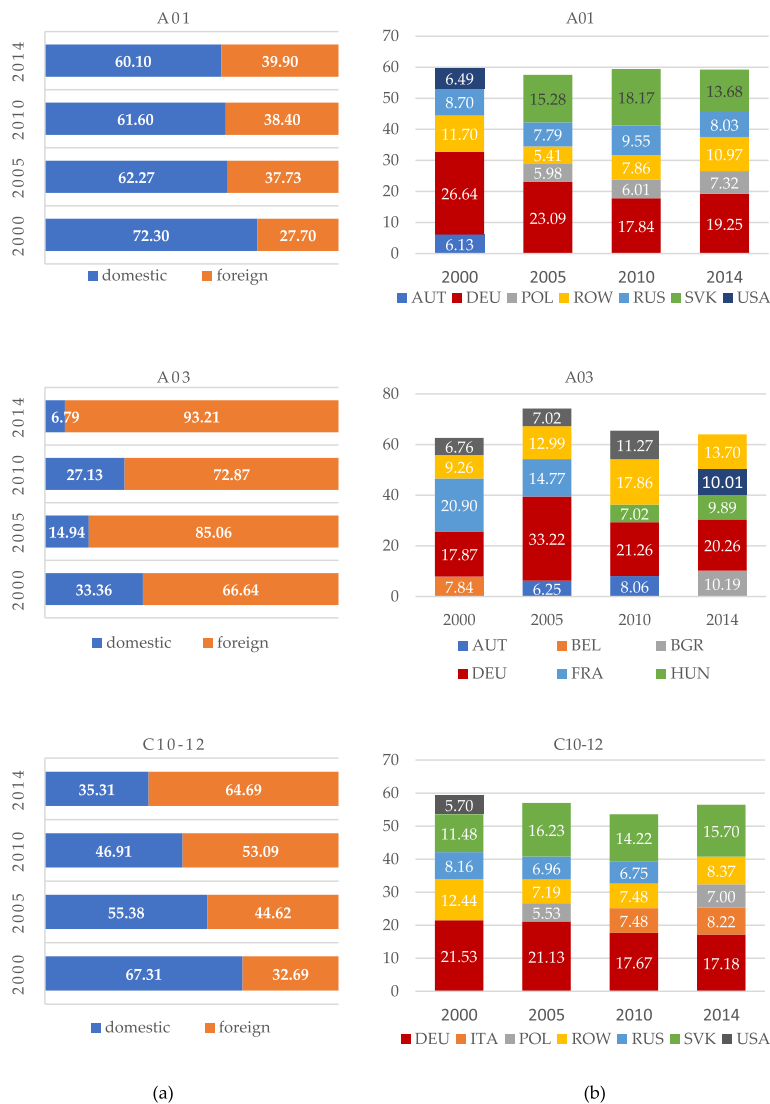
Fig. 4. Value-added components in Czech final agri-food product: a) in % of total; b) Top-5 countries with the highest VA, in % of total FVA in each year.
Source: Authors' calculations using Matlab; raw data were retrieved from Ref. [23].

Agricultural Policy (CAP) having put a lot of actions in place for achieving sustainable agricultural development, there are still significant differences among the EU countries [16]. Ehpstejn et al. [50] highlight the idea that resiliency of agri-food companies is closely linked to integration processes. For that reason, namely GVCs that reflect the results of these integration processes, were chosen as a tool to uncover interdependencies among the involved economies. Radosevic [51] interestingly points out that GVCs participants should implement so called Smart Specialisation (SS) strategy. On the one hand, "GVCs are the key to technology upgrading". The matter is that in a globalized context, it makes little sense to form local clusters; instead, being plugged into a GVC is sufficient. On the other hand, a country or region should connect to GVCs only if they can benefit from the linkages. "Therefore, regions should first build endogenous technological capability and only then link up" [51]. In this regard, the downward trend in the presence of domestic producers of key for any country industries, among which is undoubtedly agri-food production, is indeed alarming.

The most recent meeting of the Expert Group on the European food security crisis preparedness (held March 9, 2022) confirmed that, in general, Europe's food security is under threat. The topics of food production chains' disruption and the imminent increase in the price of food were touched upon during this meeting as well. According to Michael Scannell, Deputy Director of the European Commission's Directorate General for Agriculture, Russia and Ukraine supply more than a third of grain and a significant share of fertilisers to the world market. Because of the war in Ukraine, in the near future Europe may be threatened not only by a sharp rise in prices for grain and other agricultural products, but also by an acute shortage of food. The rise in the price of grain and feed for livestock automatically leads to an increase in prices for meat and dairy products, which inevitably affects the entire food sector of the

Fig. 5. Changes[1] in domestic and Top-10 foreign[2] VA shares of Czech final products in 2014 compared to the VA of these countries in 2000, in p. p.[3]. [1] Negative numbers (orange) stand for a loss of VA; positive (blue) – represent an increase in VA compared to values in 2000. [2] "Top-10" in terms of the amount of their VA share; countries are ranged according to the amount of their VA in 2014. [3] VA shares given in green designate countries that were not in the list of Top-10 countries in 2000. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

Source: Authors' calculations using Matlab; raw data were retrieved from Ref. [23].

EU [52]. Higher product differentiation and value adding over time has substantially changed the spread of prices between the farm value of products and the retail value. In addition to other factors, resilience of domestic production and exports is mainly linked to effective allocation of cost and accessibility of the final producers and consumers abroad. In this light, the importance of inter-country engagement in production processes has significantly increased. The process of globalisation or more intensive fragmentation of production processes involving a growing number of countries has obviously accelerated. The results of the present analysis confirm this tendency: DVA noticeably declined in the vast majority of the analysed sectors (21 out of 30, see Table 2 and Fig. 3) pointing to an increasing presence of foreign companies in production of domestic final goods. A number of other studies [i.e., 22, 32, 53] also confirm this tendency. Liberalisation policies have fundamentally changed the economic and institutional contexts in which agricultural producers work.

The conducted analysis for the selected 30 industries, that virtually cover the entire Czech economy, helped to shed the light on the degree of Czechia's dependence on international fragmentation production processes by identifying key changes that have occurred in the structure of VA of Czech final products over the last decades. These changes are associated with the shifts in the proportions between FVA and DVA that are not directly observable in the production of final goods and services in Czechia. A declining trend in DVA signalises, firstly, an ever-increasing degree of dependence of a particular industry on the international fragmentation of production processes, secondly, weakening competitiveness and the resilience of a specific industry in comparison to other industries with relatively higher portions of DVA in their final products. This aspect questions the very sustainability of corresponding national industries in the case of sudden shocks.

The obtained results allowed us to answer the research questions raised in the beginning of the study. The first question was: what are the proportions of DVA and FVA components in final domestic products of agri-food industries (along with the rest of the key industries)? Having decomposed the VA structure of selected GVCs, we clearly demarcated DVA components from FVA components in

Table 4
Resources comprising the Gross Domestic Product of the Czech Republic, in % of total.

Year/ Quarter	Agriculture, forestry and fishing	Manufacturing, mining and quarrying and other industry		Construction	Trade, transportation, accommodation and food service	Information and communication	Financial and insurance activities	Real estate activities	Professional, scientific, technical and administrative activities	Public administration, education, health and social work	Other service activities
		Total	of which: Manufacturing								
2000	3.25	27.90	23.41	5.62	20.29	3.91	2.87	7.16	5.41	12.41	2.27
2005	2.29	27.54	22.57	6.03	18.65	4.38	2.84	7.30	6.04	13.29	2.09
2010	1.54	26.74	20.91	6.38	16.97	4.65	4.19	8.28	6.16	13.48	2.09
2014	2.41	28.73	23.70	5.10	16.31	4.59	3.86	7.96	6.23	13.32	1.95
2020	1.91	25.58	21.92	5.19	15.93	6.04	3.69	8.93	6.36	15.31	2.02
2021	1.90	27.05	23.19	5.11	15.33	6.11	3.75	8.95	6.15	15.19	1.84

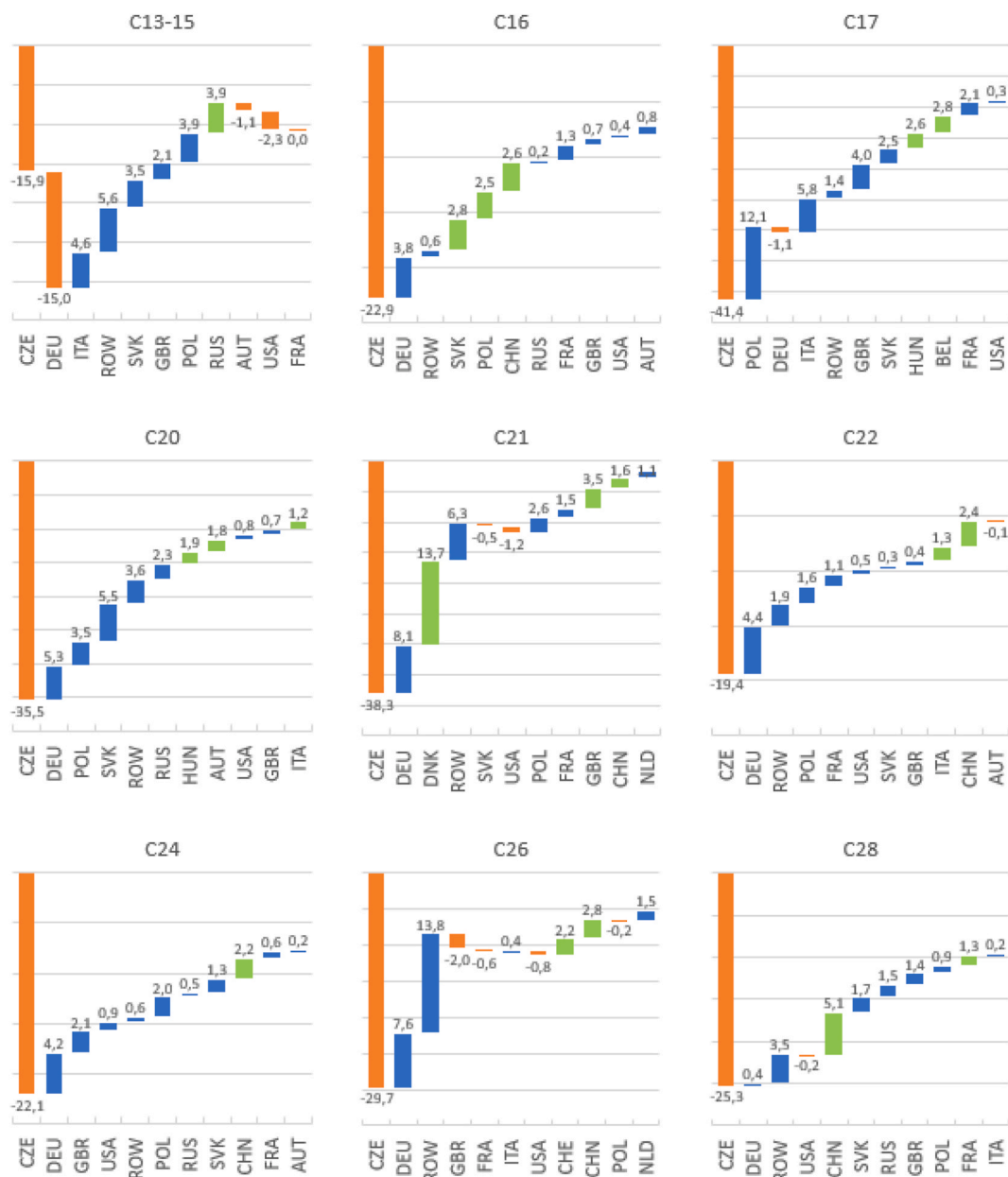Source: Authors' processing; data were retrieved from the Czech Statistical Office [31].

Fig. 6. Changes[1] in DVA and Top-10 FVAs[2] of Czech final products in 2014 compared to the VA of these countries in 2000, in p. p.[3]. [1] Negative numbers (orange) stand for a loss of VA; positive (blue) – represent an increase in VA compared to values in 2000. [2] "Top-10" in terms of the amount of their VA share. Countries are arranged according to the amount of their VA in 2014. [3] VA shares given in green designate countries that were not in the list of the Top-10 countries in 2000. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)
Source: Authors' calculation using Matlab; raw data were retrieved from Ref. [23].

final Czech products of 30 GVCs, including agricultural ones. It was revealed that the DVA component in these GVCs varied from 0.73% to 76.18% of total VA. As for agri-food industries, the minimum values of the domestic VA accounted for 6.79% (A03, in 2014) to a maximum of – 72.30% (A01, in 2000). In general, the DVA component in the Czech final products of all the agri-food sectors had noticeably declined over the analysed period. However, in the industries representing crop and animal production (A01), the DVA share in 2014 still prevailed over the foreign one, meaning Czechia remains relatively more self-reliant in Crop and animal production. The most alarming point to note is the marked reduction (by 32.00 p. p.) of Czech VA in domestic manufacturing of food products, beverages and tobacco products (C10-12). The most considerable reduction in DVA was registered for the A03 sector dealing with fishing and aquaculture (an almost fivefold one).

To paint a whole picture of the Czech economy, among the top five industries with the highest DVA, the same three sectors, P85, Q and I were identified, both at the beginning of the analysed period, in 2000, and at the end, in 2014: (see Tables 1 and 2). As for the year 2000, the top five industries with the lowest DVA were H51, H50, C13–15, K66, and M69-M70. This situation changed in 2014 and the top five industries with the lowest DVA were represented by a completely different composition of industries: C26, C13–15, C21, C28, A03, except for C13-15, which proved to be the consistently weakest industry in the Czech economy over the analysed period.

It should be noted that the ratio between FVA and DVA noticeably changed over the analysed period. This finding confirms the existence of an ever-increasing trend in the international fragmentation of production processes. In 2000 the average value of the five lowest DVA was 14.15%, however in 2014 it constituted just 4.27% of total VA. Similar conclusions were derived by Brennan et al. [22], Ševčíková [32], and Los et al. [53]. In this regard the analysis of corresponding tendencies in the dynamics of corresponding GVCs has become topical.

For that reason, the second research question was focused on identifying significant changes (if any) that have taken place in the VA structure of the selected GVCs for this analysis over time. The results of the conducted analysis indicate that the DVA share in Czech final product has declined in the vast majority of the analysed industries (21 out of 30, see Table 2). The most alarming finding is the marked reduction of DVA in food manufacturing industries, which signalises an ever-decreasing self-reliance of Czechia in achieving and keeping national food security. In turn, a positive trend was revealed for the following nine industries: H51, K66, H50, H53, M69–70, M74–75, H49, and B. The most dramatic changes in the structure of the VA were identified for the industries of H51, K66, C21, C17, C26, C20, A03 and C26. The most radical change in the VA structure was registered for H51, and this finding is also supported by Janečka [29].

Among other important results of the study is the detection of the core partners (countries) of the Czech economy within individual GVCs that managed to displace domestic producers. This finding allowed us to answer the third research question. Among such countries we can list CHN, DEU, HUN, SVK, POL, ITA, BGR and some others (see Fig. 3). In this regard, partners from China appeared the most successful among all the rest. They increased their presence in several GVCs of Czech final products simultaneously: C16, C21, C22, C24, C26, C28, and A01. Countries such as Slovakia and Germany always were and remain the closest partners of Czechia because of their geographical proximity. Companies naturally look for cooperation with low transaction costs, both in terms of transportation and communication [41,54]. Such cooperation was historically formed due to a limited set of potential trading partners. As time went on, advances in technology and the removal of legal obstacles decreased transaction costs, and new trade opportunities appeared worldwide [41,55]. For the case of Czechia, new partners that started playing a more important role in the Czech agri-food industries are from ITA, POL, BGR, ROW, CHN, and HUN.

Czech companies, having been displaced by foreign partners, were obviously forced to find their niche in other markets and to embed themselves into other GVCs. The results obtained by this study may be indicative of a gradual shift of Czech specialisation in GVCs from one to another. The following question remains, however: has this shift had been a result of focused actions or a forced change in production priorities in the context of new institutional and economic circumstances when adapting to them? The underlying reasons behind these tendencies are beyond the scope of the present study, nevertheless, they're undoubtedly worth further careful examination. Subsequent research may focus on revealing these reasons.

6. Conclusion

The XXI century has been characterised by the formation of a new paradigm of foreign trade in which countries specialise more on particular objectives and functions of doing business rather than on just the production of certain goods. The unfolding situation has given rise to new opportunities, new risks and new challenges for all the participants of Global Value Chains. The ever-growing international fragmentation of production processes in almost all sectors has led to an increased interdependence among the parties involved. This interdependency makes all the participants of production processes within GVCs sensitive to any shocks, and especially unexpected ones, such as the current military conflict in Ukraine, or the recent global COVID-19 pandemic. In light of this, the analysis of GVCs in terms of their VA-content (by demarcation of domestic VA shares from foreign ones and tracing their proportions over a sequence of years), may help to uncover unobservable structural changes that are not directly observable and identify "weak points" of a considered economy or industries that are more dependent on foreign contributions. Essentially, these "weak points", or rather potentially "vulnerable sides", are considered weak conditionally. A high degree of fragmentation in production processes and their high dependence on VA-contributions from abroad may mainly lead corresponding industries to turmoil when faced with unpredictable shocks, e.g., pandemic restrictions, economic sanctions, or local military conflicts. Realising which industries and which production processes are potentially more exposed to shocks may help to prepare adequate response mechanisms.

The conducted analysis allowed us to demarcate DVA from FVA, and to trace changes in the proportions of Czech final products from key economic industries over the period from 2000 to 2014 (the latest available data from the WIOD). The obtained results confirm the existence of an increasing trend in the international fragmentation of production processes. The average value of the five lowest DVA was 14.15% in the beginning of the analysed period, however at the end it constituted just 4.27% of total VA. Depending on a concrete industry, the DVA ranged from 0.73% to 76.18% of total VA. Overall, the results indicate that the DVA in Czech final products had declined in the vast majority of the analysed sectors (21 out of 30, see Table 2). The most alarming finding is the marked reduction of DVA in food manufacturing industries which signalises an ever-decreasing self-reliance of Czechia in achieving and keeping national food security. Among other important results of the study is the detection of the core Czech economy partners (countries) within individual GVCs that managed to displace domestic producers. Among such countries are BGR, DEU, SVK, POL, HUN, CHN, ITA, and some others (see Figs. 4 and 5). However, partners from China appeared the most successful among all the others; they have managed to increase their presence in several GVCs of Czech final products simultaneously.

These findings, on the one hand, may help to better comprehend the underlying structural changes in the selected for the analysis economy, while on the other (having identified tendencies in the proportions of VA that reflect gradual shifts from one specialisation to another in corresponding GVCs) they may help to formulate adequate optimization policies. Such policies can potentially be formulated after investigating and comparing institutional frameworks of production processes in corresponding countries, mainly those whose producers managed to displace domestic producers in the considered production processes. Such analyses may contribute to better understanding the barriers and limits in achieving greater sustainability of these production processes. The detailed instruction for the decomposition of GVCs described in the paper can be used for a similar analysis of other economies (countries) and the identification of core partners (countries) that managed to displace domestic producers within corresponding GVCs. Such an analysis may help to uncover the factual situation in individual economic sectors in terms of their self-reliance and to reveal the developmental trends of inter-country engagement in considered production processes.

Funding

Data availability statement

Data were extracted from WIOD database http://www.wiod.org/database/wiots16 (accessed on 25.01.2021) and Czech Statistical office: http://apl.czso.cz/pll/rocenka/rocenkavyber.kvart?mylang=EN&j=Tab_ZS (accessed on February 20, 2022).

Supplementary materials

Not applicable.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

[1] UN News, Time for global solidarity' to overcome COVID's health, social and economic challenges, Available online: https://news.un.org/en/story/2020/10/1075322. (Accessed 7 January 2021). accessed on.
[2] UN News, The virus that shut down the world: economic meltdown, Available online: https://news.un.org/en/story/2020/12/1080762. (Accessed 7 January 2021). accessed on.
[3] B. Bagchi, S. Chatterjee, R. Ghosh, D. Dandapat, Coronavirus Outbreak and the Great Lockdown: Impact on Oil Prices and Major Stock Markets across the Globe, vol. 112, Springer, Heidelberg; Singapore, 2020, https://doi.org/10.1007/978-981-15-7782-6.
[4] Z. Machmuddah, S.t. Utomo, E. Suhartono, S. Ali, W.A. Ghulam, Stock market reaction to COVID-19: evidence in customer goods sector with the implication for open innovation, J. Open Innov.: Technol. Mark. Complex. 6 (4) (2020) 99, https://doi.org/10.3390/joitmc6040099.
[5] UNDP assessment reports, Available online: https://www.undp.org/content/undp/en/home/coronavirus/socio-economic-impact-of-covid-19.html. (Accessed 7 January 2021). accessed on.
[6] FAO Members Gateway, FAO's Engagement in Ukraine, Available online: https://www.fao.org/members-gateway/news/detail/en/c/1475427/. (Accessed 10 March 2022). accessed on.
[7] European Commission, Agri-food supply chain. "Meeting of the expert group on the European food security crisis preparedness and response mechanism", Available online: https://ec.europa.eu/info/food-farming-fisheries/key-policies/common-agricultural-policy/market-measures/agri-food-supply-chain/contingency-plan_en. (Accessed 10 March 2022). accessed on.
[8] V. Poonia, M.K. Goyal, C.A. Madramootoo, A.K. Gupta, C. Saraswat, Impact of COVID-19 on agro-food industry and transitions towards food security. Indian institute of technology, national institute of disaster management (eds) integrated risk of pandemic: covid-19 impacts, resilience and recommendations, in: Disaster Resilience and Green Growth, Springer, Publisher, 2020, pp. 255–273, https://doi.org/10.1007/978-981-15-7679-9_12. Singapore.
[9] S.T. Hossain, Impacts of COVID-19 on the agri-food sector: food security policies of asian productivity organization members, J. Agric. Sci. 15 (2020) 116–132.
[10] Z. Benedek, I. Fertő, C. Galamba Marreiros, P.M.D. Aguiar, C.B. Pocol, L. Čechura, A. Põder, P. Pääso, Z. Bakucs, Farm diversification as a potential success factor for small-scale farmers constrained by COVID-related lockdown. Contributions from a survey conducted in four European countries during the first wave of COVID-19, PLoS One 16 (5) (2021), https://doi.org/10.1371/journal.pone.0251715.
[11] X. Zhang, Chinese livestock farms struggle under COVID-19 restrictions. IFPRI book chapters, in: COVID-19 and Global Food Security, International Food Policy Research Institute (IFPRI), 2020, pp. 84–85 (chapter 19).
[12] C. Elleby, I.P. Domínguez, M. Adenauer, et al., Impacts of the COVID-19 pandemic on the global agricultural markets, Environ. Resour. Econ. 76 (2020) 1067–1079, https://doi.org/10.1007/s10640-020-00473-6.
[13] C. Béné, Resilience of local food systems and links to food security – a review of some important concepts in the context of COVID-19 and other shocks, Food Secur. 12 (2020) 805–822, https://doi.org/10.1007/s12571-020-01076-1.
[14] Y.A. Nasereldin, R. Brenya, A.P. Bassey, I.E. Ibrahim, F. Alnadari, M.M. Nasiru, Y.Q. Ji, Is the global food supply chain during the COVID-19 pandemic resilient? A review paper, Open J. Bus. Manag. 9 (2021) 184–195, https://doi.org/10.4236/ojbm.2021.91010.
[15] D.B. Ehpstejn, J. Curtiss, T. Gagalyuk, I. Unay-Gailkhard, Resilience of the agricultural organizations and the factors and integration processes influencing it (on the data of Northwest of Russia), Agribus. Sec.: Econ. Manag. 4 (2018) 4–19. ISSN 0235-2443.
[16] S.H. Pishgar-Komleh, L. Čechura, E. Kuzmenko, Investigating the dynamic eco-efficiency in agriculture sector of the European Union countries, Environ. Sci. Pollut. Control Ser. 28 (35) (2021) 48942–48954.
[17] M.P. Timmer, A.A. Erumban, B. Los, R. Stehrer, Gaaitzen J. de Vries, Slicing up global value chains, J. Econ. Perspect. 28 (2) (2014) 99–118, https://doi.org/10.1257/jep.28.2.99.

[18] Y. Lianling, Y. Cuihong, Changes in domestic value added in China's exports: a structural decomposition analysis approach, J. Econ. Struc. 6 (2017) 18, https://doi.org/10.1186/s40008-017-0079-6.

[19] R. Johnson, G. Noguera, Accounting for intermediates: production sharing and trade in value added, J. Int. Econ. 86 (2) (2012) 224–236, https://doi.org/10.1016/j.jinteco.2011.10.003.

[20] R. Koopman, W. Zhi, W. Shang-Jin, Tracing value-added and double counting in gross exports, Am. Econ. Rev. 104 (2) (2014) 459–494, https://doi.org/10.1257/aer.104.2.459.

[21] E. Dietzenbacher, M. Lenzen, B. Los, D. Guan, M. Lahr, F. Sancho, S. Suh, C. Yang, Input-output analysis: the next 25 years, Econ. Syst. Res. 25 (2013) 369–389, https://doi.org/10.1080/09535314.2013.846902.

[22] L. Brennan, R. Rakhmatullin, Transnationalizing Smart specialization strategy, in: Advances in the Theory and Practice of Smart Specialization, Publisher: Academic Press, an imprint of Elseiver, 2017, pp. 249–268, https://doi.org/10.1016/C2015-0-00922-4.

[23] WIOD, World Input Output Database, World Input Output Tables for 2000 – 2014, Release, 2016. Available online: http://www.wiod.org/database/wiots16. (Accessed 25 January 2021). accessed on.

[24] J. Ali-Yrkkö, P. Rouvinen, T. Seppälä, P. Ylä-Anttila, Who captures value in global supply chains? Case nokia N95 smartphone, J. Ind. Compet. Trade 11 (2011) 263–278, https://doi.org/10.1007/s10842-011-0107-4.

[25] J. Dedrick, K. Kraemer, G. Linden, Who profits from innovation in global value chains? A study of the iPod and notebook PCs, Ind. Corp. Change 19 (2010) 81–116, https://doi.org/10.2139/ssrn.1125024.

[26] M. Timmer, E. Dietzenbacher, B. Los, R. Stehrer, Gaaitzen J. de Vries, An illustrated user guide to the world input-output database: the case of global automotive production, Rev. Int. Econ. 23 (3) (2015) 575–605, https://doi.org/10.1111/roie.12178.

[27] W. Leontief, Quantitative input-output relations in the economic system of the United States, Rev. Econ. Stat. 18 (1936) 105–125.

[28] Robert C. Feenstra, Gordon H. Hanson, The impact of outsourcing and high-technology capital on wages: estimates for the United States, 1979-1990, Q. J. Econ. 114 (3) (1999). Oxford University Press, 907–940, http://www.jstor.org/stable/2586887.

[29] M. Janečka, Czech aviation industry: an old player making its name in new territories, Available online: https://aero-space.eu/2020/09/13/czech-aviation-industry-an-old-player-making-its-name-in-new-territories/. (Accessed 9 August 2021). accessed on.

[30] E. Kuzmenko, L. Rumánková, I. Benesova, L. Smutka, Czech comparative advantage in agricultural trade with regard to EU-27: main developmental trends and peculiarities, Agriculture (2022), https://doi.org/10.3390/agriculture12020217, 12. 2017.

[31] Czech statistical office. GDP, national accounts statistics, Available online: http://apl.czso.cz/pll/rocenka/rocenkavyber.kvart?mylang=EN&j=Tab_ZS. (Accessed 20 February 2022). accessed on.

[32] M. Ševčíková, Comparison of the value added development in the agricultural and food sectors and the efficiency of its creation, Agric. Econ. 49 (1) (2003) 22–29, https://doi.org/10.17221/5260-AGRICECON.

[33] P. Engardio, A. Bernstein, M. Kripalani, Is your job next? Bus. Week 3 (2003) 50–60. February.

[34] P. Engardio, B. Einhorn, Outsourcing Innovation, 21 March, Business-Week, 2005, pp. 47–53.

[35] René A. Hernández, Jorge Mario Martínez, Nanno Mulder, Global Value Chains and World Trade: Prospects and Challenges for Latin America", Economic Commission for Latin America and the Caribbean (ECLAC), Santiago, Chile, 2014. ECLAC Books, No. 127 (LC/G.2617-P).

[36] G. Gereffi, J. Humphrey, R. Kaplinsky, T.J. Sturgeon, Introduction: globalisation, value chains and development, IDS Bull. 32 (3) (2001) 1–8.

[37] P. Dicken, P.F. Kelly, K. Olds, H. Yeung, Chains and networks, territories and scales: towards a relational framework for analyzing the global economy, Global Network 1 (2) (2001) 89–112.

[38] J. Henderson, P. Dicken, M. Hess, N. Coe, H. Yeung, Global production networks and the analysis of economic development, Rev. Int. Polit. Econ. 9 (3) (2002) 426–464.

[39] G. Gereffi, J. Humphrey, T. Sturgeon, The governance of global value chains, Rev. Int. Polit. Econ. 12 (1) (2005) 78–104.

[40] G. Gereffi, Global value chains in a post-Washington Consensus world, Rev. Int. Polit. Econ. 21 (1) (2014) 9–37, https://doi.org/10.1080/09692290.2012.756414.

[41] P. Pleticha, Who benefits from global value chain participation? Does functional specialization matter? Struct. Change Econ. Dynam. 58 (2021) 291–299, https://doi.org/10.1016/j.strueco.2021.06.005.

[42] J. Fagerberg, B. Lundvall, M. Srholec, Global value chains, national innovation systems and economic development, Eur. J. Dev. Res. 30 (3) (2018) 533–556.

[43] J. Hagemejer, M. Ghodsi, Up or down the value chain? A comparative analysis of the GVC position of the economies of the new EU member states, Centr. Eur. Econ J. 1 (48) (2017) 1–18.

[44] J. Lee, G. Gereffi, Global value Chains, rising power firms and economic and social upgrading, Crit. Perspect. Int. Bus. 11 (3/4) (2015) 319–339.

[45] P.M. Bosc, S. Rafflegeau, H. David-Benz, S. Lemeilleur, P. Moustier, M. Peyre, Collective action in agri-chains, in: E. Biénabe, A. Rival, D. Loeillet (Eds.), *Sustainable Development And Tropical Agri-Chains*, Springer, vols. 71–81, Springer, Dordrecht, 2017, https://doi.org/10.1007/978-94-024-1016-7_6, 978-94-024-1015-0.

[46] Z. Sojkova, B. Stehlíková, Comparative analysis of the economic role of agriculture in the EU countries Komparatívna analýza ekonomického postavenia poľnohospodárstva v krajinách Európskej únie, Agric. Econ. 50 (8) (2005) 369–375, https://doi.org/10.17221/5219-AGRICECON.

[47] I. Benešová, Z. Novotná, P. Šánová, A. Laputková, Economic comparison of agricultural sector of eurasian countries – is there any potential for development through economic cooperation? AGRIS on-line Pap. Econ. Inform. 8 (2) (2016) 19–31, https://doi.org/10.7160/aol.2016.080202. ISSN 1804-1930.

[48] P. Bórawski, I. Żuchowski, J.W. Dunn, The economic situation of the food industry in EU countries, in: Economic Science for Rural Development Conference Proceedings, 48, 2018, pp. 222–231, https://doi.org/10.22616/ESRD.2018.139. ISBN 978-9984-48-294-1.

[49] M. Cucagna, P. Goldsmith, Value adding in the agri-food value chain, Int. Food Agribus. Manag. Rev. 21 (3) (2016) 293–316, https://doi.org/10.22434/IFAMR2017.0051.

[50] D.B. Ehpstejn, J. Curtiss, T. Gagalyuk, I. Unay-Gailkhard, Resilience of the agricultural organizations and the factors and integration processes influencing it (on the data of Northwest of Russia), Agribus. Sec.: Econ. Manag. 4 (2018) 4–19. ISSN 0235-2443.

[51] S. Radosevic, Assessing EU Smart specialization policy in a comparative perspective, in: Advances in the Theory and Practice of Smart Specialization, 2017, pp. 1–36, https://doi.org/10.1016/B978-0-12-804137-6.00001-2.

[52] Reuters, EU predicts pain for farmers and consumers from Ukraine crisis, Available online: https://www.reuters.com/world/uk/eu-predicts-pain-farmers-consumers-ukraine-crisis-2022-02-28/. (Accessed 10 March 2022). accessed on.

[53] B. Los, M.P. Timmer, G.J. de Vries, How global are global value chains? A new approach to measure international fragmentation, J. Reg. Sci. 55 (1) (2015) 66–92, https://doi.org/10.1111/jors.12121.

[54] D. Global Ernst, Production networks and the changing geography of innovation systems implications for developing countries, Econ. Innovat. N. Technol. 11 (6) (2002) 497–523.

[55] S. Seuring, M. Müller, Reducing information technology-based transaction costs in supply chains, Ind. Manag. Data Syst. 107 (4) (2007) 484–500, https://doi.org/10.1108/02635570710740652.