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A New Chapter in Value Chain Connections between China and Europe: Are Advanced Services a New Area of Chinese Influence in European Manufacturing?

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Abstract One way to mark the presence of Chinese companies in Europe is the servicification of manufacturing with advanced services such as information and communication (ICT). Therefore, the article aims to identify the intensification of the influx of Chinese ICT services in the manufacturing of European economies, especially regarding industries dealing with transport equipment and computers, electronic and electrical equipment. A key research question going forward is: whether technological developments in China affect the country's servicification links with European manufacturing in advanced services. Applying input-output models, the study confirmed that China is more intensively servicing manufacturing in Europe with its ICT services, and the intensity of this servitization increases with the stronger position of a value-added country in GVCs.

Keywords: servicification of manufacturing; Chinese ICT; European manufacturing, production fragmentation

JEL Classifications: F12, F14, F15

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I. Introduction

China's increasing presence in the global economy contributed to the reshaping of global value chains (GVCs) at the start of the 21st century (Horner and Nadvi, 2017). China has gradually changed its role in global production relationships, from a country producing virtually all kinds of products to one producing a significant value-added that its trading partners depend on. In recent years, China has consolidated its position in GVCs in technologically advanced industries and services, making Chine more responsible for high-value-added processes (Fu et al., 2023). In consequence, European countries were faced with fierce competition from China in many industries and services (Karkanis, 2018; Xing, 2016; Kong et al., 2016; Evenett et al., 2013).

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China's plans to include and dominate technological GVCs were even more evident with the introduction of the Belt and Road Initiative in 2013 and the Digital Silk Road[1] two years later (Mochinaga, 2021; Hillman, 2021; Dekker et. al., 2020). China has implemented this strategy as part of a long-term technology plan, in which Beijing provides assistance to its exporters, including many well-known technology companies, and develops a network of cooperation with selected countries in the area of technology, including ICT infrastructure, services, 5G networks, e-commerce, etc. These strategies are strengthening China's presence in the technological sphere, and its products and services more and more often serve the function of links in GVCs. Moreover, the strategy is compatible with the ongoing fourth industrial revolution - IR4.

To date, China has been an important supplier of added value in GVCs in terms of products. However, with the growing advancement of the economy, Chinese services will become an increasingly important component in production networks. The Chinese will be interested in promoting advanced ICT services, especially in developed economies. Given the tense relations with the US, as well as poor relations with the US's Asian allies, Europe appears to be among the most important recipients of Chinese added value from ICT services. European countries, to maintain international competitiveness, are increasing the technological advancement and strengthening market protection against Chinese technology. Until recently, the value added from China to European countries was mainly focused on medium technology industries, while value added from Europe to China focused more on advanced products and services. Today, there is a shift in Chinese value added to high-tech industries (including service industries), reflecting China's desire to create an economy conducive to innovation and IR4. In the context of Sino-European relations, servicification of manufacturing may play an important role.

The degree of servicification is expressed as the percentage of services' value-added in manufacturing exports. Service inputs are either from the domestic market or from outside countries, which are categorized by domestic servicification and foreign servicification, respectively. Using the international input-output tables from 1995 to 2018, we can estimate the degree of servicification across European countries (according to the UNCTAD classification).

The main aim of the paper is to identify the intensification of the influx of Chinese ICT services in the manufacturing of European economies, especially regarding industries dealing with transport equipment and computers, electronic and electrical equipment. The choice of these industries is the result of their participation in GVCs which is the highest among all industries. We try to present how close the connections between Chinese ICT services and European manufacturing are.

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1) In China, many state strategies are strongly interconnected. Hence, the assumptions of Digital Silk Road are also partially consistent with "Made in China 2025", five-year plans or strategies of various ministries or government agencies.

Based on the literature review and preliminary research on the Chinese role in GVCs, a key research question was formulated: whether technological developments in China affect the country's servicification links with European manufacturing in advanced services.

The subject of the study consists of 31 European economies, perceived in geographical terms, (excluding Russia). If a specific group is taken into account, e.g. Western Europe or Central and Eastern Europe (CEE), then this is indicated in the text.

The paper is divided into six sections, including the introduction and conclusions. Firstly, we justify why this topic was chosen, then we introduce the concept of links between services and production, followed by a brief description of the research method used in this paper. The next section examines the flows of Chinese value added in European production in terms of ICT servicification of manufacturing and relationships between the servicification and the role of these economies in production connections. At the end of this section are some theoretical and practical implications. In the conclusions, we discuss the research question and limitations of the study.

II. Justification of the Topic

Taking up the topic of servicification of European manufacturing with Chinese ICT stems from two issues: the gap in the literature on this issue and the latest statistics related to the influx of Chinese value added to Europe.

First, there is a great gap in the literature on the servicification of European manufacturing with Chinese value added, and the issue of servicification with ICT is not addressed at all. This was discussed in detail in the previous part of the article, where four papers were presented, showing cross-sectoral links between China and Europe or only in China itself. However, none of the articles takes into account a large number of European economies, but only selected ones, and there is a lack of research on the servicification of certain manufacturing industries, i.e. those that are particularly closely related to GVCs, such as European computer, electronic and electrical equipment industry and transport equipment industry. Moreover, there have not been conducted studies related to the flows of a specific type of service - as in the case of the article below - ICT services, as those that in the coming years may turn out to be crucial in the light of many Chinese strategies. The research questions posed in the study have also not been verified so far.

The second reason for taking up the topic is the growing role of Chinese services in GVCs in Europe (OECD 2022) (Liu and Li, 2022) and the world (UNCTAD, 2023). Moreover, The expansion of China's ICT services market has significant repercussions for the country's recent shift away from a reliance on exports and toward domestic consumption promotion (Grimes

and Sun, 2014). Although, in total terms, the absorption of total Chinese value added is still greater in the case of manufacturing, its direction is visible, especially in the last decade under study - the share of Chinese value added going to European information industries significantly exceeds the dynamics of the inflow of this value added to manufacturing (Table 1). This suggests that Chinese value added follows the assumptions of China's technological strategies, including the Digital Silk Road. In the study, it was decided to choose ICT services as the key ones in the inflows of advanced added value to European production. Since 2013, the increases in the inflow of value added from Chinese ICT services have been the highest among all business services flowing to Europe and amounted to an annual average of 22.4%, compared to 6.9% in the category of distributive trade, transport, accommodation and food services and 10.9% in the case of other business sector services. Moreover, in 2018, China was the second non-European supplier of ICT services for manufacturing, electronics and automotive industries (the US being the leader) (OECD, 2022).

In the beginning, China's investment was concentrated in energy, automobile, agriculture, real estate, industrial equipment, as well as information and communications technology. Chinese state-owned enterprises were very active. Many technological companies of strategic importance, including in Germany, the UK, France and Italy, were bought out (Corre, 2018).

By 2012, Chinese investments in the computer, electronic and electrical equipment sector accounted for only 6.8% of all investments. However, in the years 2013-2021, the intensity of these investments increased to 9.3%. It is worth noting that in the years 2013-2021, the number of transactions of Chinese investments in European technologies increased (Table 1), despite strong US pressure for Europe not to accept and monitor such investments more strongly.

China's total investment in the EU fell between 2016 and 2020. Nevertheless, China's FDI in Europe (EU-27 and the United Kingdom) increased by 17% in 2021. It was mainly driven by Chinese greenfield investments in electric vehicle batteries, which fueled the growth in automotive. This type of FDI accounted for a total of 59% of investment in these two industries (Harper, 2022).

Therefore, taking into account the direction of FDI inflows from China, it was decided to focus the study on two industries: computer, electronic and electrical equipment, as well as transport equipment.

Table 1. *Chinese Total and Services' Value-Added Share in Foreign Value Added in European Industries in 1995-2018 (%)*

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	change between 2018 and 1995
total Chinese value added																									
Manufacturing	2,7	2,9	3,6	4,0	4,0	4,8	4,9	5,8	7,1	7,9	8,3	8,8	10,4	11,8	11,0	12,5	11,8	12,1	12,8	14,4	15,9	15,7	16,0	16,5	13,8
Information industries	2,8	3,0	3,9	4,6	4,6	5,0	6,3	7,7	10,6	12,0	13,3	14,3	15,8	18,1	16,1	18,2	18,9	19,6	20,4	21,1	21,1	20,8	20,0	21,2	18,4
Chinese services' value added																									
Manufacturing	2,4	2,6	3,0	3,1	3,1	3,6	3,8	4,3	5,1	6,0	6,5	7,3	8,6	10,0	9,0	10,3	10,4	10,8	11,8	13,2	13,8	13,0	12,9	13,8	11,4
Information industries	2,1	2,2	2,6	3,0	2,8	3,1	3,8	4,5	6,3	7,5	8,2	9,1	10,6	12,3	10,4	12,2	12,5	12,8	13,7	14,3	14,3	14,2	13,2	14,7	12,6

Source: based on OECD's ICIO Database, 2022.

III. Servicification of Manufacturing Concept: Literature Review

Many activities related to the manufacturing industries also require activities from non-manufacturing industries, such as services that are conducted domestically or imported from abroad. Unlike the "classical" approach, which emphasizes that manufacturing is only involved in the value added generated by manufacturing activities, with no connection to other industries' activities. The alternative approach focuses on the value added in all production stages of the manufacturing process. It means that production consists of the sum of many activities, including services, along the production chain that is used to produce the final product, which implies that manufacturing consists of the sum of many activities (Timmer et al., 2012, 2014). Several authors refer to this process as servicification of manufacturing. Services are used throughout the manufacturing process in many ways. Typically, we apply them in the first stages of the value chain, such as R&D activities. We can also use them at the end of the chain, for instance, for maintenance or repair. In addition, we use a variety of services at every stage of production, such as IT services and telecommunications, which are also discussed in this paper.

The services industry has significantly contributed to economic growth, due to the recent advances in ICT. A variety of services have become more marketable thanks to technological advancement, digitalization and significant reductions in transportation costs. Moreover, automation has improved the labor-intensive manufacturing industries, and now services account for a much larger share of value added than manufacturing. In this literature review, we focused on studies from the last decade.

Links between manufacturing and services are included in the debate on economies of deindustrialization (Rodrik, 2016; Neuss, 2018) and the above-mentioned "servicification of manufacturing" (National Board of Trade, 2012; Lodefalk, 2013). Atolia et al. (2018) presented structural transformation theories, with a focus on the roles of the industry, deindustrialization, policy and the international environment in shaping the trajectory of structural change.

Meckstroth (2017) went one step further and applied Hirschman's model of unbalanced growth practically. He used the example of a manufacturing plant to illustrate how domestic services in the upstream supply chain work (R&D services, outsourced professional services, transportation of inputs, utilities, etc.). Lanz and Maurer (2015) provided conceptual and measurement challenges relating to services networks and evidence based on trade in value added statistics. Berger (2015) argued that certain industries, such as R&D and manufacturing, are closely linked to each other. It is a part of the whole process of manufacturing. Similarly, Pisano and Shih (2012) stated that we should not separate manufacturing from services. 'Industrial commons' was a new term coined by the authors, defined as the R&D and manufacturing infrastructure, experience, process-development skills, and engineering capabilities embedded in companies, universities and other organizations that support growth and

development in a variety of industries are the foundation for success and innovation.

Several empirical studies have demonstrated the importance of cross-sectoral relationships, but the bulk of these studies were not international studies. Chun et al. (2021) raised a question about changing domestic employment composition by servicification of manufacturing in South Korea with foreign value added. Their findings indicate that Korean companies that participate in GVCs both through trade and foreign direct investment have reorganized their domestic labor structure to be able to provide high-value-added headquarters services for their manufacturing factories that are closely located in foreign economies. Foster et al. (2012) demonstrated the prevalence of technology transfer between services and industry. According to them, the services are responsible for "non-negligible product effects" through R&D for manufacturing. Considering that India is well-known for its services industry, Pattnayak and Chadha (2022) in their paper investigated whether services inputs can boost exports of manufacturing firms in the region. They found that there is increasing evidence of the servicification of manufacturing firms, as services are effective at breaking down informal barriers and facilitating trade. Using data from science-based manufacturing firms in India over the period 2001-2016, they proved that the export intensity of firms increases after controlling for firm covariates such as size, exporter status, and MNE status by increasing the number of services as inputs. Reddy and Sasidharan (2022) conducted similar research. Rueda-Cantuche et al. (2012) found that the financial sector is characterized by strong forward links to other areas of the EU economy. Šidlauskaitė and Miškinis (2013) found in their report strong forward links between services and manufacturing in the Baltic States. Hansen et al. (2022) investigated servicification in firms in South Africa. They found that it is advantageous to pay particular attention to the role of services in GVC upgrades. Beverelli et al. (2016) also demonstrated strong links between domestic services and manufacturing, which resulted in a higher degree of GVCs integration. They said that this increase in labor productivity and higher "value effects" in countries' greater participation in GVCs could be attributed to higher labor productivity and higher "value effects".

Joining the global economy today also means cross-sectoral overlaps in international dimensions. Sadly, the effect of services on manufacturing exports has not been widely explored so far. Nevertheless, we have found a few studies that focus on this issue.

Wolfmayr (2012) analyzed OECD countries. He demonstrated a significant and positive effect of services on manufacturing competitiveness, which is limited to international and business services and the most skill- and technology-intensive manufacturing. Thangavelu et al. (2018) used data between 1995 and 2011 and investigated domestic and foreign servicification in 61 economies, especially those which are members of the Regional Comprehensive Economic Partnership. In these economies, they observed an obvious rise in the servicification of manufacturing with foreign servicification (higher rates than in the OECD countries). They

also identified the main factors that are influencing the evolution of service. Lodefalk (2012) argued that manufacturing in industrialized countries is more dependent on services today than ever before. The share of services' value-added in manufacturing firms across the OECD economies was about 40% of services, according to Miroudot and Cadestin (2017). According to Baldwin et al. (2015), the bulk of manufacturing value added comes from services in Asia. Landesmann and Leitner (2015) focused on the EU members, and they also found a positive effect on manufacturing competitiveness for both domestic and foreign intermediate business services. Díaz-Mora et al. (2018) examined the effect of foreign services' value-added included in manufacturing exports on export duration for 63 countries between 1995 and 2014. Similarly to previous studies, their findings demonstrated the positive effect that is more apparent in developing economies. Liu et al. (2018) found a positive effect of the development of financial and business services on the competitiveness of manufacturing export, particularly for manufacturing sectors that relied on the services intensively. Pezzotta et. al (2022) described the integration of traditional offers with digital services and called this strategy "digital servitization". During 1995-2011, Blázquez et al. (2020) investigated the phenomenon of international 'servicification' of manufacturing. They found that service inputs are a key determining factor in manufacturing competitiveness. Díaz-Mora et al. (2022) researched the impact of deep trade agreements on GVC-related services. Detailed research showed that deep trade agreements with services provisions increase embodied services' value-added from partner countries, with larger impacts for deeper agreements, according to the report. Moreover, there are heterogeneous consequences, which are particularly significant for North-North flows and for embodied services' value-added from EU countries. Consequently, these deep trade agreements seem to allow the EU to exploit its comparative advantage in services and, in turn, strengthen intra-EU GVCs and GVCs with non-EU countries. Thangavelu et al. (2018) compared Asian economic connections in servicification with OECD countries. A similar study was carried out Kwon and Ryou (2015).

When it comes to China's role in GVCs in terms of servicification, there has been only a small number of studies so far.

Du and Agbola (2022) investigated the servicification of manufacturing in China. According to them, foreign direct investment, capital intensity and institutions are improving as a result of GVC. However, the Chinese manufacturing industry's increasing global market share has reduced the GVC of manufacturing firms in China. The GVC position of the Chinese manufacturing industry was worsened by foreign servicification of manufacturing. Pomfret (2019) provided a case study of servicification as a component of increased trade between China and Europe in the 20th century, using the Eurasian Landbridge. Guo et al. (2018) constructed a model for the Chinese economy between 1981 and 2014 and performed counterfactual experiments accordingly. They proved the huge role of servicification of investment. Similarly,

Liu and Kim (2020), using the input-output model, found that the service sector is a driving force for economic development. X (2020) investigated the role of the New Eurasian Land Bridge countries in GVCs, especially ICT services' value-added inflows. She presented how close the connections were between the Chinese ICT services and the manufacturing processes.

The studies presented above have several shortcomings. First, the authors did not examine such a large number of economies and their manufacturing dependence on Chinese services in general. Second, none of the authors focused on services associated with high technology, namely ICT. Third, previous analyses have included total servicification of manufacturing, while industry analysis has been omitted. These gaps are what this study aims to fill.

IV. Description of the Data and General Study Procedure

To determine the participation and status of the analyzed economies in GVCs, as well as the flows of value added between Chinese services and these countries' manufacturing, we used the method described in detail in another paper (Cieślik, 2019). Using a multi-regional input-output model, a value-added model was developed, which included value added in industries/sectors. Several authors used this approach as a combination of approaches: (Timmer et al., 2012) (Johnson and Noguera, 2012) (Koopman et al., 2014).

In our approach, these models were extended to sector / industry analyses, as far as statistical data permitted. Value-added statistics are collected by the OECD's Inter-Country Input-Output (ICIO) Database, which contains data up to 2018. We collected the data and created an index of foreign value added embodied in a country's gross exports, which helps us determine the extent to which a country is dependent on the global/certain state's production network. In our paper, we classified ICT services according to the OECD's ISIC Revision 4.

The question of whether a nation's location in an upstream segment of the production value chain (the first stage of production) influences the likelihood of it having a high value of forward links in comparison to backward ones can be answered using the input-output model. This indicates that the nation is more dependent on its production. Assuming a nation has some expertise in the last phases of creation (downstream fragment), almost certainly, imports a great deal of middle-of-the-road products from abroad, and subsequently, it has high reverse cooperation.

Table 2 shows the composition of gross value of production from the expenditure perspective (columns) and from the income perspective (rows). It comprises from three dimensions: the intermediate input matrix (Z), the final demand matrix (y) and the value-added matrix (GVA).

Table 2. *Simplified Input-output Structure*

	Industries/ sectors	Final demand	Employment
Industries/ sectors 1 2 ...	Intermediate goods (Z)	y	GVP
Imports	Imported intermediate goods (Z^M)		
Value added	Compensation of employees Gross operating surplus Taxes - subsidies		
All resources	GVP (Gross value of production)		

The technical coefficients, which will be used to calculate the inverse Leontief matrix, the fundamental axis of the input-output analysis, can be derived from the information provided by the intermediate input matrix Z. The specialized coefficients (a_{ij}) show the amount of contribution of branch i important to create one unit of the result of area j.

$$a_{ij} = \frac{Z_{ij}}{\chi_j} \tag{1}$$

We construct the following matrix, where Z means domestic intermediate inputs, x^{-1} means diagonalized and inverted GVP, and A means A the direct contribution of a sector i in the production of the output of a sector j.

$$\mathrm{A} = \mathrm{Z}\ \mathrm{x}^{-1} = \begin{bmatrix} z_{11} \cdots z_{13} \\ \vdots \ \ddots \ \vdots \\ z_{31} \cdots z_{33} \end{bmatrix} \begin{bmatrix} \frac{1}{x_1} \cdots 0 \\ \vdots \ \ddots \ \vdots \\ 0 \ \cdots \frac{1}{x_3} \end{bmatrix} = \begin{bmatrix} \frac{z_{11}}{x_1} \cdots \frac{z_{13}}{x_3} \\ \vdots \ \ddots \ \vdots \\ \frac{z_{31}}{x_1} \cdots \frac{z_{33}}{x_3} \end{bmatrix} = \begin{bmatrix} a_{11} \cdots a_{13} \\ \vdots \ \ddots \ \vdots \\ a_{31} \cdots a_{33} \end{bmatrix} \tag{2}$$

The general rule is that A means domestic technical coefficients A^D. When the technical coefficients is set, we introduce the Leontief inverse.

Equation (3) applies the Leontief matrix to represent the key equation of the input-output analysis. This is the Leontief Open Model (Miller and Blair, 2009), where x is the total output multiplied by the Leontief inverse $(I - A)^{-1}$ and a vector of final demand, y. It shows how a country or region's output is affected by final (exogenous) demand.

$$x = (I - A)^{-1} y \tag{3}$$

The Leontief matrix $(I - A)^{-1}$ is a multiplier that reports how much the production of the entire economy needs to increment to meet a given expansion in demand. Accordingly, in the framework structure, the conventional component of the Leontief matrix l_{ij} catches the absolute demand from the area i (first addendum) to create one unit of a result of area j (second addendum) that can go to conclusive interest. An illustration of a three-sector economy is equation 4.

$$X = (I - A)^{-1} y = \begin{bmatrix} l_{11} \cdots l_{13} \\ \vdots \ \ddots \ \vdots \\ l_{31} \cdots l_{33} \end{bmatrix} \begin{bmatrix} y_1 \\ y_2 \\ y_3 \end{bmatrix} = \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} \quad (4)$$

V. Results

A. Trends in servicification of manufacturing with ICT

When analyzing European economies in terms of the concept of servicification of manufacturing from ICT in 1995-2018, we observed that all economies increased their manufacturing dependence on Chinese ICT services. However, none of them exceeded the level of 5.9% share. The largest shares were observed in Finland and Germany (5.9% each) and Estonia (5.8%). Increasing the use of Chinese value added from ICT in manufacturing services occurred with varying intensity. During the research period, the largest increases were observed in Estonia (5.3%), followed by Finland (4.9%) and the Czech Republic (4.5%). However, after the introduction of the Belt and Road Initiative, the highest increases in servicification of manufacturing were recorded in Finland, Germany and Estonia. Taking into account the average share rate growth of Chinese ICT in European countries' manufacturing, it can be seen that by 2012 it was 6.8%, compared to 14.8% in 2013-2018. This means that Belt and Road Initiative has spurred Chinese ICT flows to Europe. In the case of economies with the largest shares of Chinese added value from ICT in manufacturing services, after the introduction of the Belt and Road Initiative, this dynamic was also high (although not the highest) - for Finland it was 13.8%, Germany - 15.7%, and Estonia - 14.8%. On the other hand, the highest dynamics in 2013-2018 were recorded in Portugal (18%), the Netherlands (17.9%) and Iceland (17.6%). If we analyze individual economies, almost all, except for the Czech Republic (which recorded a slight decrease), recorded an increase in China's share in the servicification of manufacturing. Only Hungary and Croatia kept the level of China's share in the servicification of manufacturing unchanged (Table 1 in Appendix).

There was no redirection of Chinese ICT in manufacturing from the economies of Western

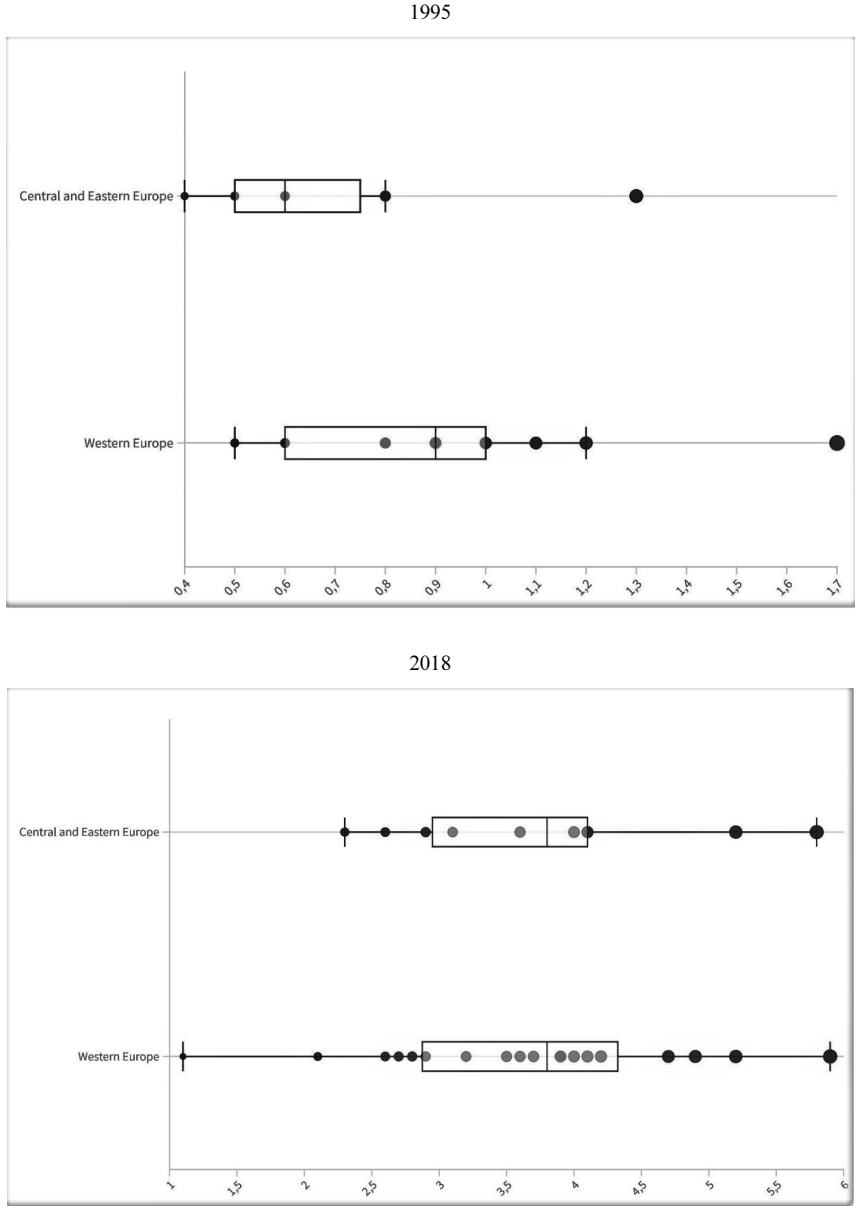
Europe to the economies of Central and Eastern Europe (CEE) after they acceded to the EU. Although some of the CEE economies have become more specialized in advanced services, e.g. Estonia, and have started to attract a lot of ICT services from China, most CEE economies have found it more difficult to transition towards more advanced GVCs (Di Berardino and Onesti, 2021).

In total, the Western European economies in 2018 relied on Chinese ICT in manufacturing services at 8.1%, while the CEE economies did so at 4.7%. The mean for the entire region increased from 0.5% in 1995 to 3.3% in 2018. On average, in the period 1995-2018, the CEE economies were characterized by almost two times lower share of domestic servicification of manufacturing with ICT (which results from their lower level of technological advancement) than the Western European economies. For Western Europe, domestic ICT services amounted to 74% of the total servicification of manufacturing with ICT in 2018 (this level has been constant for several years). In the case of CEE, these shares amounted to 42% of the total servicification of manufacturing with ICT (the lowest level in the analyzed period, which shows the increasing dependence of these economies on foreign ICT value-added, mainly from the EU-15). For both groups of countries, the shares of manufacturing servitization with Chinese ICT services reached the highest level in 2018, and a growing trend is observed. The median is almost the same for both analyzed regions (Figure 1).

The intensity of the influx of Chinese ICT services to European manufacturing resulted from the confluence of several factors favorable for China: the debt crisis in the eurozone, the fall in the euro exchange rate and deindustrialization processes in Europe (especially Western Europe). At that time, China's internationalization and economic advancement strategies involving the acquisition of technology companies in developed countries strongly intensified. Hence, it can be concluded that the inflows of Chinese added value from ICT were also related to Chinese investments in Europe. It should be emphasized that the main recipients of Chinese investments were the economies of Western Europe.

The computer, electronic and electrical equipment industry and transport equipment industry are absorbing Chinese ICT services particularly well. In general, for the EU-28 in 2018, the computer, electronic and electrical equipment industry and transport equipment industry were strongly associated with foreign added value (making them industries with some of the strongest foreign ties). For example, in 2018, Estonia, Hungary and Slovakia had the highest shares of foreign value added in the computer, electronic and electrical equipment industry (70.7%, 65.8% and 65.2%, respectively). On the other hand, Slovakia, Hungary and Slovenia dominated the transport equipment industry (70.2%, 68.8% and 64.8%, respectively) (OECD, 2022).

Figure 1. Servicification of European manufacturing with Chinese ICT in 1995 and 2018



Source: based on OECD's ICIO Database, 2022.

In the case of servicification of the European computer, electronic and electrical equipment industry with Chinese ICT in 1995-2018, significant increases were observed (the mean increased from 0.55% to 5.04%). In 1995, the share of Western Europe significantly exceeds CEE, however, by 2018, this gap has been shrinking. In 2018, the median of CEE was higher

than in the Western European economies. This is related to e.g. the aforementioned increased Chinese FDI in Western European technologies and tight connections between Western Europe production links and CEE value chains. In terms of value, the largest number of Chinese ICT services are directed to this industry by Germany, followed by the Netherlands and Switzerland. Germany is the 4th country in the world in terms of servicification of computer, electronic and electrical equipment industry with Chinese ICT. In terms of the share of Chinese ICT services in the analyzed industry, among foreign value-added providers in Europe in 2018, the first places were taken by: the Czech Republic (9.9%), Estonia (9.3%), Slovakia (8.9%) and Germany (8.4%). It should be noted that in the case of the Czech Republic, this share decreased (from a maximum of 11% in 2010). The high share of Chinese ICT services in Czech electronics should be explained not so much by Chinese investments in this country, but by a certain specificity of the Czech electronics industry. The Czech Republic's electronics industry is characterized by a large number of imported materials, components and parts for production and assembly. Almost ¾ of exports are made by imported components. Among the leading companies in this industry are On Semiconductor Czech Republic, s.r.o., Foxconn CZ s.r.o., Inventec (Czech) s.r.o., CommScope Czech Republic s.r.o., Panasonic AVC Networks Czech s. r. o., Continental Automotive Czech Republic s.r.o., Thermo Fisher Scietific Czech Republic s.r.o, TESCAN ORSAY HOLDING, a.s., and Meopta-optika s.r.o.

Figure 2. Servicification of European computer, electronic and electrical equipment industry with Chinese ICT in 1995 and 2018

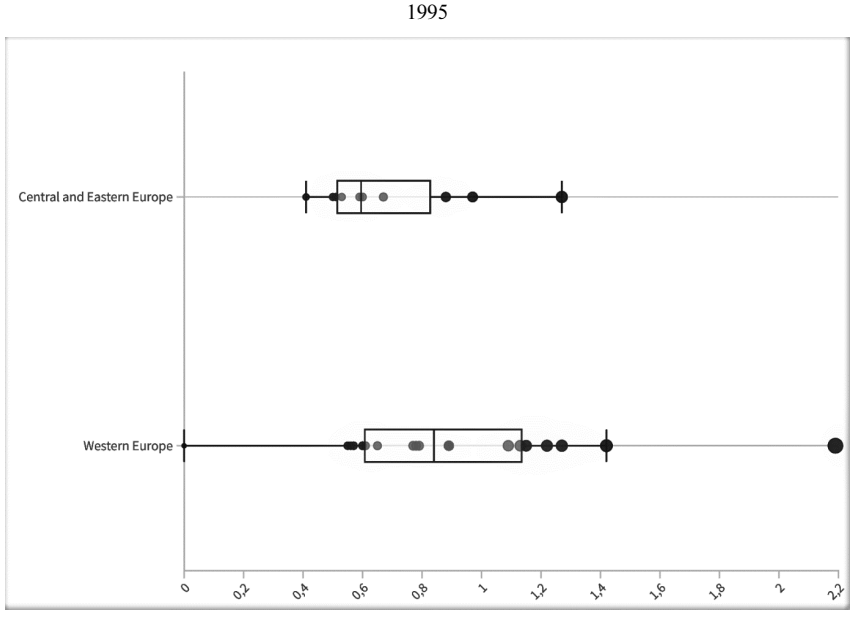
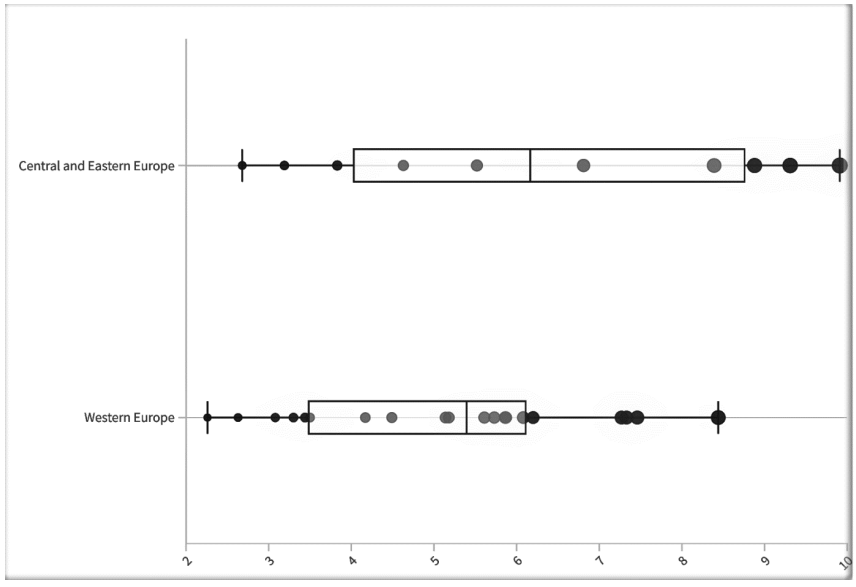


Figure 2. *Continued*

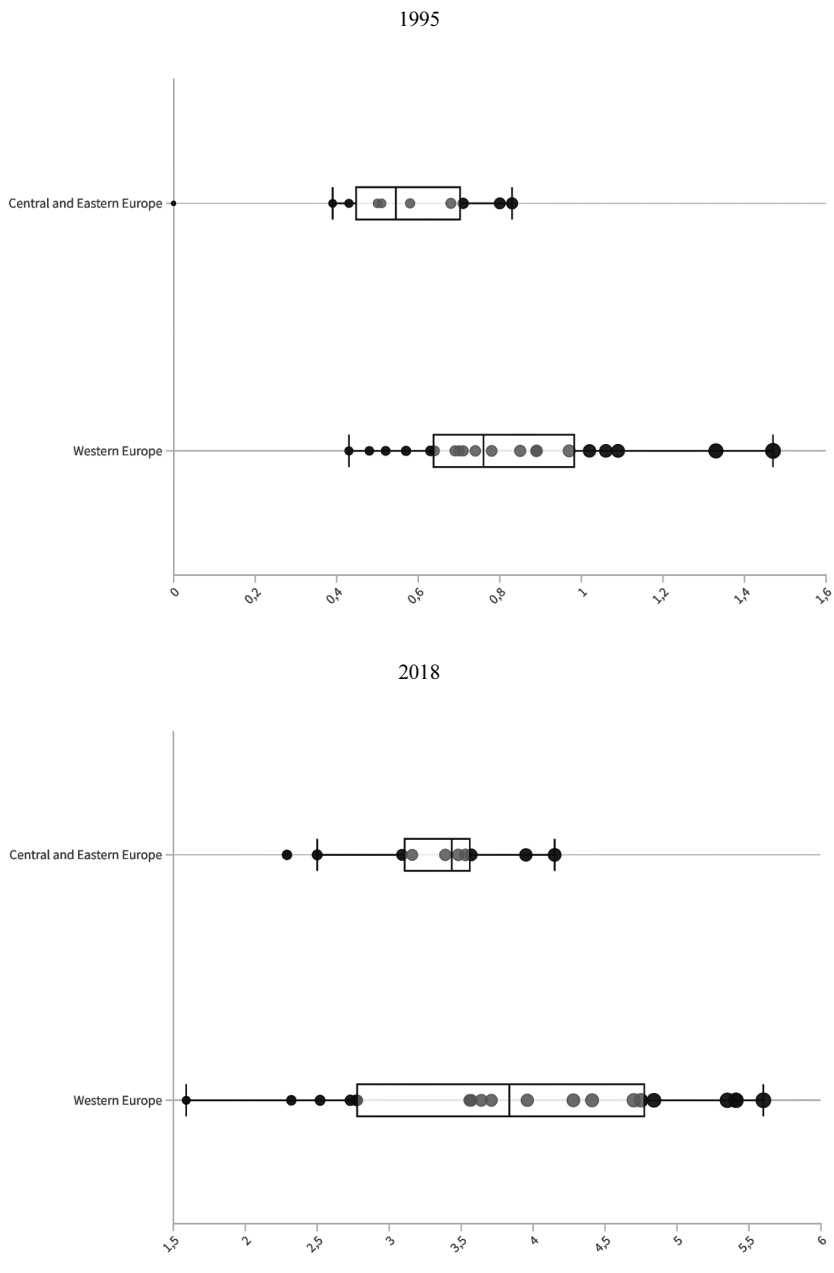
2018



Source: based on OECD's ICIO Database, 2022.

In the case of the servicification of the European transport equipment industry with Chinese ICT in 1995-2018, significant increases were observed. The share of Western Europe significantly exceeds the share of CEE, but the gap is closing (Figure 3). Compared to the share of Chinese ICT value added in the computer, electronic and electrical equipment industry, transport equipment is less dependent on Chinese ICT. However, the situation may change as China has a strong interest in the world's automotive industry. It is investing more and more intensively in the European automotive industry, but it is also developing this industry in China. In terms of value, the largest number of Chinese ICT services are directed to this industry by countries that are automotive giants, i.e. Germany, France, Spain and Sweden. Germany is a world leader in servicification of transport equipment with Chinese ICT. In 2018, it accounted for 83% of the discussed added value in the entire EU-28. In terms of the share of Chinese ICT services in the analyzed industry, the first places in Europe in 2018 were held by: Greece (5.6%), Finland and Germany (5.4% each). As for Greece, the explanation for these high shares of Chinese added value is to be found in transport equipment, but in maritime equipment. For years, the role of Greek transport equipment as a recipient of Chinese ICTs was negligible, but after taking over the port of Piraeus and many high FDI (in 2008-2021, the Chinese invested USD 10.3 billion in Greece), the share began to grow rapidly. Still, the median is higher in Western Europe, however, CEE's role in Chinese ICT services increases.

Figure 3. Servicification of European transport equipment industry with Chinese ICT in 1995 and 2018

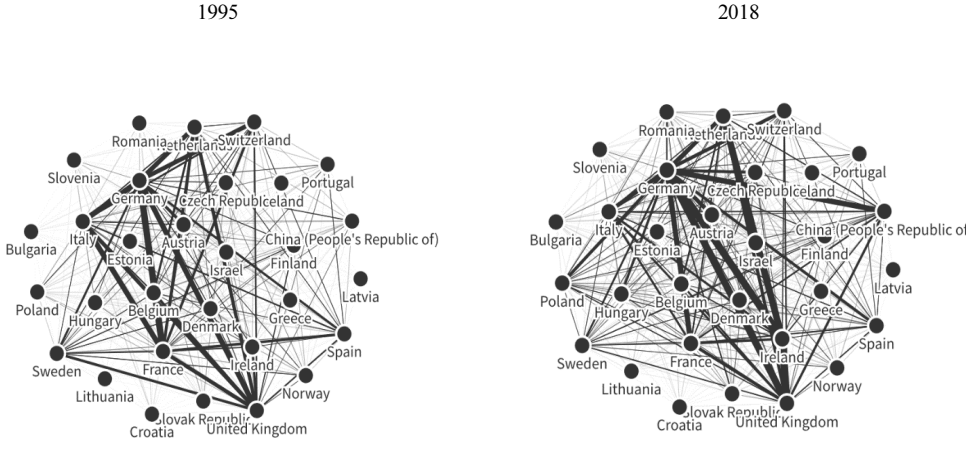


Source: based on OECD's ICIO Database, 2022.

Figure 4 shows the evolution of the forward links network from 1995 to 2018 between China and European economies. We found that in 1995, Germany was the hub of the entire DVA network of servicification of manufacturing with ICT in connecting the analyzed

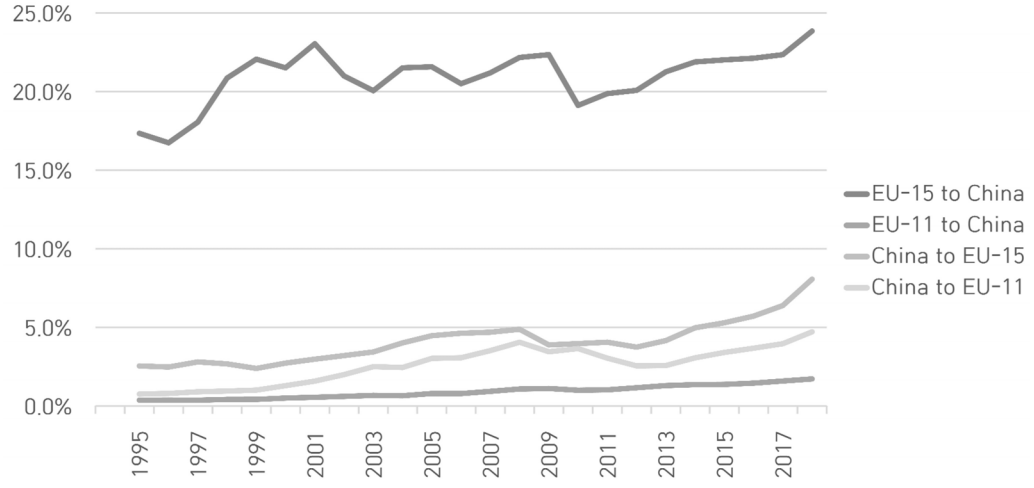
economies. However, the regional value chains in Western Europe were strong, in opposite to Eastern Europe. China's role in these networks was limited: the country's DVA supported mainly selected Western Europe economies (e.g. Germany, UK). Eastern European economies were not characterized by strong regional connections, nor by strong links to China. They were most strongly connected to Germany. Until 2018, most of these forward connections got stronger for both Western and Eastern Europe and China. Still, Germany was also the core of the region, however, the Chinese role has grown significantly. China's ICT value added increased in German, the UK, France and some Eastern European economies significantly. However, still, the role of the European value added in ICT is much larger than the role of Chinese ICT services in European manufacturing (Figure 5). Generally, comparing the manufacturing dependence of Western Europe and CEE on Chinese ICT services, an increasing convergence can be seen. Although there are quite a few deviations from the average, both regions are becoming increasingly and similarly dependent on Chinese added value (Figs. 1-3). Moreover, there is a large asymmetry between EU-15 to China flows and China's flows to EU-15. However, this gap is narrowing gradually. Unfortunately, this symptom is not visible in EU-11 flows to China and Chinese servicification of EU-11's manufacturing. Generally, EU-11's ICT services have a minor share in Chinese manufacturing and show no improvement over the years analyzed.

Figure 4. Diagram 1 Forward linkages between China and European economies in servicification of manufacturing with ICT (years 1995 and 2018)



Source: based on OECD's ICIO Database, 2022.

Figure 5. Changes in servicification of European manufacturing with Chinese ICT and Chinese manufacturing with European ICT in 1995-2018



Source: based on OECD's ICIO Database, 2022.

B. The relationships between the servicification and the role of these economies in production connections

When looking for the relationship between the servicification of European manufacturing with Chinese ICT and the role of these economies in production connections, several of them can be identified.

It was noted that there is a positive relationship between the participation of European countries in GVCs and the servicification of European manufacturing with Chinese ICT. The greater the participation in GVCs (X6), the more China servitizes manufacturing, which results from strong links between economies within production networks (Figure 6, Table 3). Such a relationship is rather unsurprising, as there is a greater probability that economies with greater production links will absorb foreign value added more strongly. Hypothetically, there may be a situation where a country only provides added value for other economies and does not rely on foreign value at all, but in practice, this situation does not occur and usually, the links are two-way, although their intensity varies[2].

The participation of a country in GVCs alone does not say much about the role of the economy in GVCs. It only indicates the strength of the connection with production networks,

2) In 2018, among the economies analyzed in the OECD's ICIO Database, the largest difference between forward and backward links was identified in Brunei Darussalam (56.9% to 9.8%), Saudi Arabia (41.2% to 3. 7%) and Kazakhstan (43.2% to 9.7%). These economies are oriented towards the export of raw materials, and hence such levels of forward linkage. In Europe, these links were at a balanced level (15.7% to 10.4%), more than in OECD countries (19.7% to 8.4%) (OECD, 2022).

but does not indicate the method of this connection. Therefore, the relationship between the relative position of European economies in GVCs (X1) and the servicification of manufacturing should be examined. According to China's technological strategy, the country should more intensively servitize ICT manufacturing in more technologically advanced economies, which should be higher in GVCs (have a higher relative position in GVCs, i.e. create products rather than rely on foreign components). Analyzing the panel data, it can be seen that the relationship between the relative positions of economies in GVCs and the servicification of manufacturing by Chinese ICT is positive (Figure 6, Table 3). This means that China, by servitizing manufacturing in Europe, is indeed following the key to entering the most technologically advanced economies with a strong position in GVCs. Such economies report a greater demand for all services, and even more so for ICT. Moreover, these economies can also be a source of diffusion of technology to China.

China is much more intensively servitizing European manufacturing in economies where the share of Chinese value added in the final demand (X2) of the European economy is higher[3]. It provides a value-added perspective of the European economy's relative connectedness to production in China (Figure 6, Table 3).

Considering that there is a negative relationship between the intensity of servicification and the gross trade balance (X3), it can be seen that this type of value-added flow has an impact on the balance (Figure 6, Table 3).

Other relationships that have been observed are positive links between the share of Chinese value added in consumption (X4) and gross fixed capital formation (X7) and servicification of manufacturing (Figure 6, Table 3). Thus, Chinese ICT services are attracted by Chinese consumer goods sold in Europe and capital goods.

The last relationship can be seen between the intensity of Chinese servicification of manufacturing in Europe and the total foreign services share in manufacturing gross exports (X5) (Figure 6, Table 3). This result is not surprising, as it shows that it is easier for China to enter the market with its ICT services, where many services servitize manufacturing anyway, i.e. there are no major barriers to entry with these services and there is a demand for them.

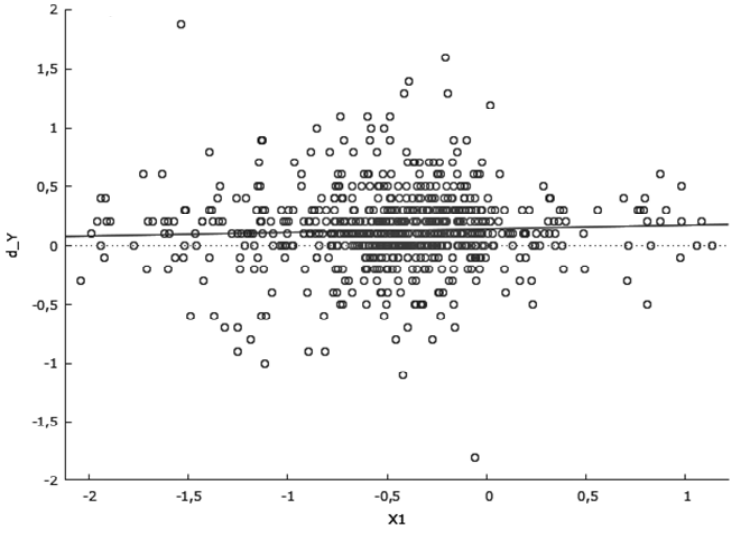
In the multivariable regression model, the Levin-Lin-Chu test was performed, which showed that only the X1 variable is stationary, while the other variables (X2-X7) are non-stationary. To reach the stationary form of mentioned variables, the first differences of these variables were counted (d_X2-d_X7), which were then used in the model. In the case of the dependent variable (Y), the same situation occurred - it had to be brought to a stationary form (d_Y). Finally, a panel model (M1) was estimated with robust standard errors (HAC) where d_Y was

3) According to the OECD's definition it: „shows foreign value added generated by industry i in country p embodied in domestic final demand of country c as a percentage of total foreign value added from industry i in domestic final demand."

the dependent variable and X1 and d_X2-d_X7 were independent. Beyond the constant, d_X2 (value added in final demand), d_X5 (foreign services share in manufacturing gross exports), and d_X6 (participation in GVCs) were statistically significant. Value added in final demand and participation in GVCs influenced positively on servicification of manufacturing in Europe, while foreign services share in manufacturing gross exports affects negatively.

Figure 6. Relation between servicification of European manufacturing with Chinese ICT and selected variables (X1, d_X2-d_X7)

M2; X1 - relative position in GVCs



M3; d_X2 - Chinese value added in final demand

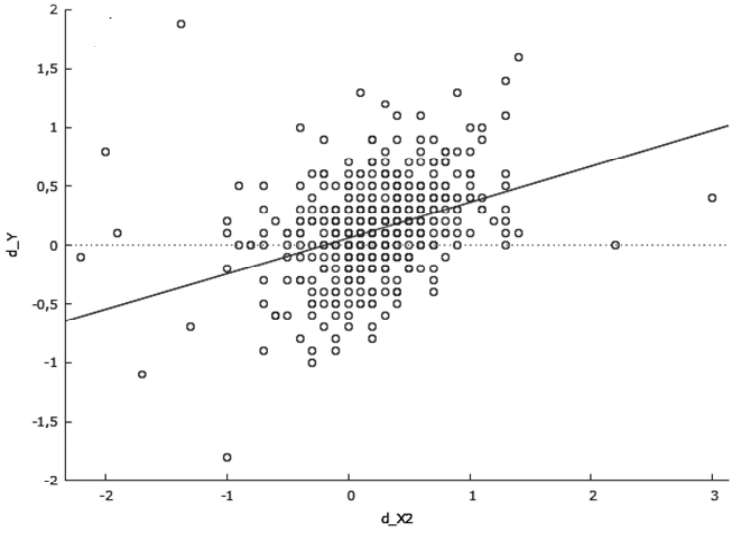
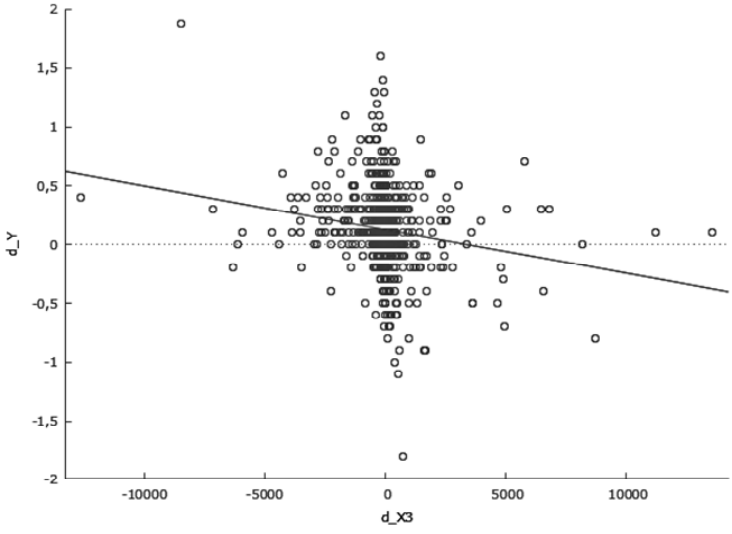


Figure 6. *Continued*

M4; d_X3 - gross trade balance with China



M5; d_X4 - Chinese value added share in country's consumption

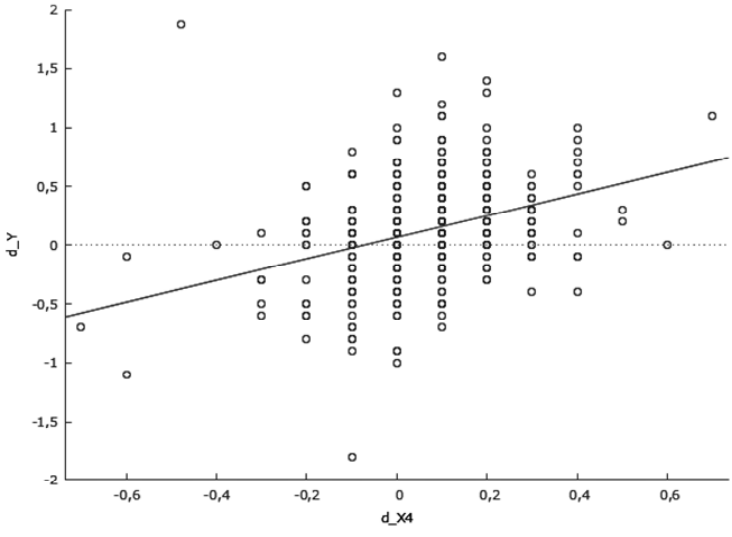
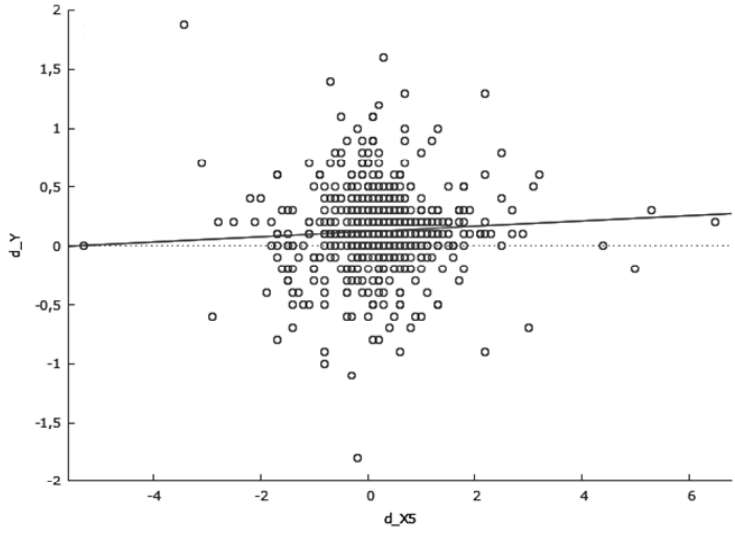


Figure 6. *Continued*

M6; d_X5 - foreign services share in manufacturing gross exports



M7; d_X6 - participation in GVCs

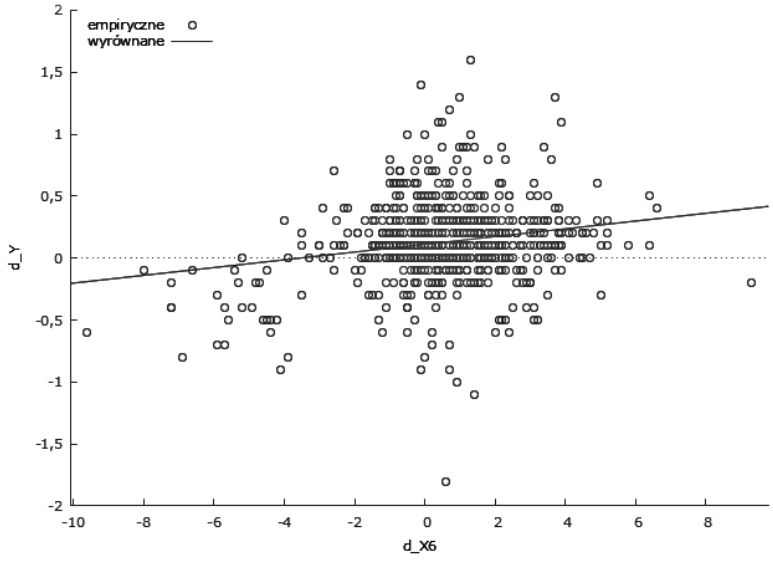
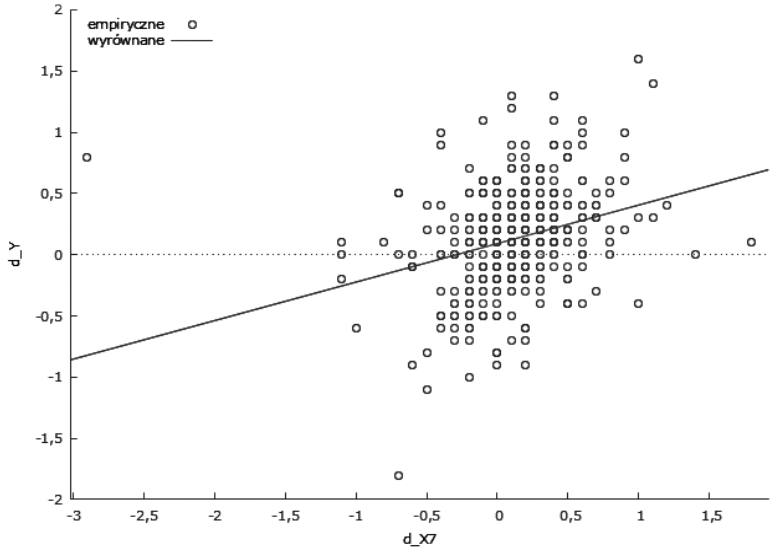


Figure 6. *Continued*

M8; d_X7 - Chinese value added share in country's gross fixed capital formation



Detailed parameters of regressions are in Table 3 models M2-M8.
Source: based on OECD's ICIO Database, 2022.

Table 3. *Regression Model Results*

	M1	M2	M3	M4	M5	M6	M7	M8
const	0.05848* (4.218)	0.14163* (16.41)	0.0605* (3.812)	0.12716* (14.54)	0.06735* (6.103)	0.12259* (15.22)	0.111297* (13.14)	0.0906815* (5.911)
X1	0.00886847 (0.7696)	0.0297* (2.289)						
d_X2	0.263838* (3.120)		0.30433* (4.534)					
d_X3	-1.18371e-05 (-1.473)			-3.73409e-05* (-2.516)				
d_X4	0.24959 (0.9815)				0.92273* (7.508)			
d_X5	-0.0221473** (-1.720)					0.02230 (0.1387)		
d_X6	0.0245284* (3.941)						0.0313* (7.253)	
d_X7	-0.0784393 (-0.7633)							0.31457* (2.593)
R2	0.181553	0.00198	0.150061	0.031917	0.128676	0.00399	0.039396	0.084044
DW	1.605101	1.86482	1.680940	1.818302	1.670875	1.84235	1.734153	1.689859
SD	0.327269	0.32727	0.327269	0.327269	0.327269	0.32727	0.327269	0.327269

*p<0.05; **p<0.10, t statistics in parentheses
(Source) based on OECD's ICIO Database, 2022.

C. Implications for theory and practice

Although there are increasingly studies on the Chinese economy and its relations with European countries in political, investment, and trade dimensions, the issues of China's influence on European economies in the context of global value chains are rarely discussed. There are no analyzes of production connections within advanced industries (including services) and cross-sectoral connections, including those related to the servicification of manufacturing. The consequence of this situation is the poor knowledge of economic ties between the Chinese and European markets.

Du and Agbola (2022), Pomfret (2019), Guo et al. (2018) and Liu and Kim (2020) analyzed the servicification of manufacturing, however, these studies focused only on some parts of Chinese-European links and none of the authors focused on ICT services as a new channel of advanced Chinese influence on European manufacturing. Therefore, to contribute to the academic discussion on global production networks and changes within GVCs over time, the study offers implications for a better understanding of both European dependence on Chinese ICT services. Comprehensive research on technological connections in value chains in terms of advanced services between Europe and China has not yet been conducted. It was crucial to divide Europe into two groups to show different patterns in inflows of Chinese ICT services in manufacturing. An extension of the method used by the cross-sectoral flows made it possible to obtain knowledge about the activities that becoming dependent on Chinese ICT services. Moreover, the analysis was a good research instrument for finding some factors that affect the intensity of Chinese ICT services inflows in Europe.

The analysis identified areas of manufacturing particularly connected to Chinese ICT services. In the era of IR4, these links are likely to strengthen. However, growing political antagonisms between Europe and China may influence a gradual disconnect with China. The study identified those industries that would be particularly affected by such decoupling in ICT services. The study found that CEE in particular would be strongly affected by decoupling or partially blocking some trade routes.

In terms of applications, the verified hypothesis is of key importance, as it will indicate changes in production connections between Europe and China in the future. Positioning countries in the international fragmentation of production, studying the dependence of their foreign trade on other countries, attempts to evaluate the competitiveness and potential of technology exports, and finally pointing to opportunities and threats resulting from the current trade ties, may constitute the starting point for formulating recommendations for more balanced economic policy of the countries towards China.

VI. Conclusions

Recently, the role of the Chinese economy in GVCs has been more determined by the advancement of value added that it provides. Nowadays, Chinese companies shift toward services and enhancements in the business model and embracing digitalization. A symptom of this novelty is a form of servicification of manufacturing and is expected to change the landscape of GVCs. By introducing many strategies, including Digital Silk Road, China has had an opportunity to broaden the value-added flows of high-tech services into manufacturing. These strategies can be seen in European manufacturing, in particular.

The flows of Chinese ICT services to European manufacturing presented in the article show a consistent strategy of China related to increasing its influence in the production of developed economies. The orientation of ICT service streams to the key industries for the development of China - electronics and recently the automotive industry - is particularly visible. It is these European industries that absorb the lion's share of Chinese ICT services. The research period saw an increasing role of China in the servicification of these two industries. However, it is difficult to say whether this trend will continue, given the current situation in the global economy and China's limited access to modern technologies.

When analyzing the statistics showing changes in the share of Chinese added value from ICT services servitizing European manufacturing, it was noticed that the intensification of servicification coincided with the introduction of the Belt and Road Initiative and Digital Silk Road and many related strategies to improve the sophistication of the economy. For all economies, an increasing share of China among the partners providing ICT services to manufacturing has been observed. At the same time, when examining the inflows separately for Western Europe and CEE, the same phenomenon also took place. This means that there were no grounds to reject the hypothesis that we observe the intensification of servicification of European manufacturing with Chinese ICT services, expressed by the increasing share of China among partners providing services to European manufacturing.

Moreover, a positive relationship was noticed between the relative position of the economy in GVCs and the servicification of European manufacturing with Chinese ICT services. This would mean that forward linkages in GVCs result in a stronger dependence on Chinese value added from ICT services.

Ultimately, we should be aware of some restrictions in the study's findings. Firstly, the period covered by the BRI is still short, and in the long run, there could be seen some significant shifts in interdependencies between the European economies and China. Secondly, the COVID-19 pandemic and now the war in Ukraine have changed the landscape of production networks, which should be considered carefully, as new data is still being gathered. Moreover, there is the danger that Europe decouples from Chinese technology. The first indication of

this phenomenon was the freezing of the Comprehensive Investment Agreement's ratification.

Declarations

Availability of data and material

Data is extracted from across OECD's databases TiVA. Processed data will be made available on reasonable request after the acceptance of the paper.

Competing interests

The author declares there is no conflict of interests.

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Appendix

Table A1. *Servicification of European Countries Manufacturing with Chinese ICT Services in 1995-2018 (%)*

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	change between 2012 and 1995	change between 2018 and 2013
Austria	0.5	0.5	0.7	0.6	0.7	0.8	0.8	0.9	0.8	1.0	1.2	1.3	1.3	1.6	1.3	1.4	1.4	1.4	1.5	1.9	2.1	2.4	2.6	3.3	0.9	1.8
Belgium	1.0	0.7	0.8	0.7	0.8	0.9	0.9	0.9	0.9	1.1	1.4	1.5	1.6	1.5	1.1	1.0	1.1	0.9	1.0	1.2	1.3	1.4	1.6	2.1	-0.1	1.1
Czechia	0.6	0.6	0.8	0.8	0.8	0.9	1.1	1.4	2.3	2.4	2.7	2.8	3.7	4.5	4.3	4.4	4.0	3.1	2.9	3.3	3.7	3.7	4.1	5.2	2.5	2.3
Denmark	0.9	0.9	0.9	0.9	0.9	1.1	1.3	1.5	1.4	1.5	1.7	1.6	1.5	1.8	1.6	1.7	2.2	2.0	2.2	2.8	3.3	3.4	3.9	4.9	1.1	2.7
Estonia	0.5	0.4	0.7	0.7	0.7	1.1	1.5	1.7	1.5	1.8	2.6	2.5	2.3	2.4	2.0	2.6	3.1	2.7	2.8	3.3	3.7	4.2	4.7	5.8	2.2	3.0
Finland	0.9	0.5	2.1	2.6	0.8	1.0	1.0	1.1	1.5	1.8	2.3	2.8	2.7	2.7	2.6	2.3	2.5	2.5	2.5	3.2	3.8	4.3	4.6	5.9	1.6	3.4
France	1.0	1.0	1.3	1.2	1.1	1.4	1.4	1.4	1.7	2.1	2.5	2.3	2.3	2.6	2.4	2.4	2.5	2.0	2.5	2.8	3.1	3.4	3.8	4.7	1	2.2
Germany	1.7	1.8	1.8	1.5	1.4	1.5	1.5	1.6	1.7	2.0	2.3	2.4	2.7	2.7	2.3	2.5	2.6	2.6	2.7	3.4	3.8	4.4	4.7	5.9	0.9	3.2
Greece	1.0	1.1	1.3	1.3	1.2	2.5	1.7	1.8	1.6	1.8	2.3	1.8	2.1	2.1	1.6	2.2	1.8	1.6	1.8	2.3	2.7	3.0	3.9	4.1	0.6	2.3
Hungary	0.5	0.7	0.7	0.9	1.0	1.5	1.9	2.6	3.5	2.9	3.8	3.6	3.8	4.3	3.5	3.9	2.9	2.3	2.3	2.6	2.8	3.1	3.4	4.1	1.8	1.8
Iceland	0.6	0.6	0.6	0.6	0.7	0.9	2.3	1.8	1.7	1.2	1.5	1.5	1.6	2.1	1.4	1.7	1.7	1.4	2.0	2.1	2.3	2.4	2.7	3.7	0.8	1.7
Ireland	0.5	0.5	0.5	0.5	0.5	0.5	0.6	0.7	1.0	1.3	1.5	2.0	1.6	1.8	0.9	0.7	0.5	0.5	0.6	0.7	0.7	0.8	0.9	1.1	0	0.5
Italy	0.8	0.9	1.0	0.9	1.0	1.3	1.3	1.6	1.5	1.8	2.0	2.1	2.2	2.6	1.9	2.2	2.2	1.8	2.1	2.5	2.9	3.0	3.2	4.0	1	1.9
Latvia	0.6	0.7	0.6	0.7	0.7	0.8	0.8	1.0	1.0	1.3	1.4	1.4	1.6	1.6	1.4	1.3	1.8	1.5	1.8	2.1	2.6	2.7	3.0	3.6	0.9	1.8
Lithuania	0.5	0.5	0.6	0.7	0.6	1.4	1.2	1.2	1.3	1.3	1.3	1.3	1.3	1.3	1.2	2.3	1.2	1.5	1.2	1.4	2.1	1.8	2.1	2.6	1	1.4
Luxembourg	1.2	1.1	1.4	1.3	0.6	1.4	0.8	1.0	1.2	1.2	1.1	1.3	1.1	1.4	1.7	1.1	1.2	1.1	1.2	1.4	1.6	1.8	2.0	2.6	-0.1	1.4
Netherlands	0.8	0.6	0.6	0.7	0.7	0.9	1.0	1.1	1.3	1.4	1.5	1.5	1.6	1.5	1.4	1.6	1.7	1.5	1.7	1.9	2.2	2.9	3.2	3.9	0.7	2.2
Norway	0.6	0.9	0.7	0.8	0.9	1.1	1.1	1.5	1.2	1.5	1.8	1.7	1.7	1.9	1.4	1.6	1.6	1.6	1.8	2.3	2.7	3.0	3.3	3.9	1	2.1
Poland	0.8	0.9	1.1	1.1	1.0	1.1	1.3	1.5	1.6	1.9	2.1	2.3	2.4	3.0	2.5	2.6	2.1	1.9	2.1	2.6	3.0	3.3	3.6	4.1	1.1	2
Portugal	0.5	0.6	0.7	0.7	0.6	0.8	0.8	0.8	0.8	1.0	1.1	1.3	1.3	1.5	1.1	1.3	1.1	1.0	1.2	1.4	1.7	1.8	2.1	2.7	0.5	1.5
Slovakia	1.3	0.8	1.0	0.8	0.9	1.1	1.2	1.3	1.3	1.5	2.0	2.3	3.3	3.5	2.6	2.9	2.5	2.3	2.5	3.3	3.6	3.7	3.8	4.0	1	1.5
Slovenia	0.6	0.6	0.7	0.7	0.8	0.9	0.9	1.0	1.1	1.3	1.5	1.5	1.6	1.7	1.3	1.6	1.4	1.3	1.4	1.9	2.2	2.3	2.5	3.1	0.7	1.7
Spain	0.9	0.9	1.0	1.0	1.0	1.4	1.4	1.5	1.5	1.8	2.2	2.3	2.3	2.7	1.9	2.2	2.0	1.8	2.1	2.5	3.2	3.2	3.5	4.2	0.9	2.1
Sweden	0.9	0.9	0.8	0.8	0.8	0.9	1.5	0.9	0.9	1.1	1.5	1.5	1.4	1.3	1.3	1.4	1.7	2.4	2.8	3.3	3.9	3.9	4.3	5.2	1.5	2.4
Switzerland	0.6	0.7	0.7	0.8	0.8	1.0	1.1	1.2	1.2	1.5	1.5	1.7	1.7	1.5	1.6	1.5	1.3	1.4	1.7	2.0	2.4	2.6	3.0	3.6	0.8	1.9

Table A1. *Continued*

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	change between 2012 and 1995	change between 2018 and 2013
United Kingdom	1.1	1.2	1.3	1.3	1.3	1.7	1.7	1.9	1.9	2.1	2.4	2.5	2.3	2.4	1.9	2.0	1.9	1.6	1.9	2.3	2.6	2.8	3.0	3.5	0.5	1.6
Bulgaria	0.8	0.6	0.7	0.7	0.8	0.9	0.9	1.0	1.1	1.3	1.9	1.6	2.2	2.4	1.8	1.3	1.3	1.2	1.3	1.7	2.0	2.2	2.3	2.9	0.4	1.6
Croatia	0.4	0.6	0.5	0.5	0.7	0.7	0.9	0.9	1.1	1.3	1.7	1.9	1.9	2.0	1.5	1.6	1.5	1.4	1.3	1.5	1.7	1.7	1.9	2.3	1	1
Cyprus	1.1	1.0	1.1	1.2	1.3	1.8	1.9	2.1	2.2	1.9	1.9	1.8	1.9	2.2	1.6	1.7	1.7	1.3	1.5	1.9	2.0	2.3	2.4	3.2	0.2	1.7
Malta	0.8	0.8	1.1	0.8	1.0	1.3	1.5	1.9	1.2	1.4	1.3	1.4	1.2	1.6	1.6	1.5	1.2	1.3	1.5	1.9	2.1	2.3	2.3	2.9	0.5	1.4
Romania	0.6	0.7	0.7	0.8	0.8	0.9	1.0	1.2	1.3	1.5	1.7	2.0	1.7	1.8	1.7	1.5	1.4	1.2	1.3	1.6	1.8	2.0	2.2	2.8	0.6	1.5

Source: based on OECD's ICIO Database, 2022.