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Central, East and Southeast European Countries in the Global Value Chain Network

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Abstract

The policy brief examines the position of Central, East and Southeast European (CESEE) countries in the global value chain (GVC) network. Effective integration in global value chains has been recognised as one of the important ingredients of economic development. The analysis uses the multi-country input-output database recently developed by the Vienna Institute for International Economic Studies, covering the period of 2005–2018, to construct and examine the topology of the GVC network focusing on the CESEE region. We show that the CESEE segment of the GVC network has a core-periphery structure with several sectoral clusters forming the closely intertwined core centred around Russia's mining, petroleum and metals industries, as well as the value-added linkages formed by Central European countries with Germany's automotive sector. While these specialisation patterns have intensified over time, the advanced CESEE countries have also managed to diversify their participation in regional value chains. At the same time, a large part of the CESEE region, particularly, the Western Balkans, remains only marginally integrated in the GVC network, calling for additional policy efforts to boost their competitiveness and unlock the potential for a more intensive participation in cross-border production sharing in the region.

Keywords: global value chains; CESEE countries; network analysis

JEL classification: F10, F14, F15

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1 Introduction

The globalisation process of the recent decades has been characterised by the emergence of global value chains (GVCs) as the coordination costs have been reduced significantly due to the progress in information and communication technologies, transportation costs have declined and regulatory improvements have facilitated international flow of goods and factors of production. While previously it was rather challenging to quantify and analyse the extent of value-chain activities between countries on the global scale, the recent advances in the input-output data compilation methodologies enabled construction of internally consistent inter-country input-output databases and computation of various metrics to measure the intensity of cross-border production sharing. Among the seminal contributions that have studied global value chains are Koopman et al. (2014), Miroudot et al. (2013), Timmer et al. (2013, 2014), Wang et al. (2013).

Within the rapidly developing literature on GVCs, much attention has been paid to proper decomposition of observable gross exports into value-added components, distinguishing domestic value added, foreign value added and double-counted value, permitting thereby a correct computation of forward and backward GVC participation of countries and their sectors—see, for instance, Hummels et al. (1998, 2001); Koopman et al. (2014), Daudin et al. (2011), Wang et al. (2013), Buelens and Tirpak (2017). More recent contributions that address certain methodological limitations of the earlier frameworks include Los and Timmer (2018) and Borin and Mancini (2019).

Comlementing the conventional methods of GVC analysis, in this policy brief we use complex network techniques to visualise the structure of the GVCs as a network of interconnected economies (more precisely, countries and their sectors—"country-sectors") and analyse its key elements and linkages from a multilateral connectivity perspective. Under a network approach, each country-sector is viewed as a node connected to other country-sector nodes by linkages representing trade in intermediate inputs. The world economy therefore can be seen as a network of all sectors in all countries intertwined via value-added trade relationships.[1] Although the network approach seems to be a natural way to the analyse GVCs as backward and forward production linkages between countries and their sectors amount globally to a weighted and directed network of value-added relationships, the literature on GVC networks is still rather thin: the recent contributions focusing on the topological properties of world input-output networks include Cerina et al. (2015), Cingolani et al. (2017), Criscuolo and Timmis (2018), Lejour et al. (2014) and Zhu et al. (2018).

In this policy brief we intend to complement this strand of the (largely interdisciplinary) literature with the focus on the economies of Central, East and Southeast European (CESEE) region. The CESEE countries have been following rather diverse patterns of structural change and economic integration during the transition period, and the extent of their integration in global value chains also differs significantly. This policy paper provides an updated review of the GVC trends in the CESEE region by taking advantage of the newly developed wiiw multi-country input-output database (wiiw MC IOD), covering 38 sectors of 51 country over the period 2005–2018. In the rest of this paper we first provide a brief review of the structure

[1] In practice, the construction of input-output databases for all countries is not feasible owing to data constraints, and the countries lacking available data are merged into a rest-of-the-world aggregate, consistent across time.

of the multi-country input-output database and introduce some basic concepts of the network theory, which is followed by visualisation of the CESEE-related GVC network and the analysis of its key structural properties and evolution of countries therein from the network perspective.

2 Sample, sectoral classification and methodology remarks

The sample of countries that is used for the construction of the GVC networks spans 38 sectors of 51 country over the period 2005–2018. Table 1 lists the countries and their ISO3 codes, identifying the group of CESEE countries, other EU countries and other non-EU countries.

Table 1: Sample of countries

CESEE countries		**Other EU countries**		**Other non-EU countries**	
ISO3	**Country name**	**ISO3**	**Country name**	**ISO3**	**Country name**
BGR	Bulgaria	AUT	Austria	AUS	Australia
CZE	Czech Republic	BEL	Belgium	BRA	Brazil
EST	Estonia	CYP	Cyprus	CAN	Canada
HRV	Croatia	DEU	Germany	CHE	Switzerland
HUN	Hungary	DNK	Denmark	CHN	China
LTU	Lithuania	ESP	Spain	IDN	Indonesia
LVA	Latvia	FIN	Finland	IND	India
POL	Poland	FRA	France	ISL	Iceland
ROU	Romania	GBR	United Kingdom	JPN	Japan
SVK	Slovak Republic	GRC	Greece	KOR	South Korea
SVN	Slovenia	IRL	Ireland	MEX	Mexico
ALB	Albania	ITA	Italy	NOR	Norway
BIH	Bosnia and Herzegovina	LUX	Luxembourg	TWN	Taiwan
MKD	Macedonia	MLT	Malta	USA	United States
MNE	Montenegro	NLD	Netherlands		
RUS	Russia	PRT	Portugal		
SRB	Yugoslavia	SWE	Sweden		
TUR	Turkey				
UKR	Ukraine				
XKX	Kosovo				

As described in Table 2, we distinguish 38 sectors that span primary, manufacturing and services sector groups. The table outlines the full description of each sector, which is based on NACE Rev. 2 classification, corresponding NACE codes, as well as the notation developed for the purposes of this paper to aid the visualisation of networks at the sectoral level—a numeric and a four-letter code.

The structure of a typical inter-country input-output table for a given year is shown in Figure 1 for a world economy comprising J countries and S sectors. Each cell in the table represents the value of intermediate input flows from countries and their sectors indicated in the leftmost column to countries and sectors importing the inputs, indicated in the top rows. The inter-country input-output tables also outline the final use by households, firms and the government, however, the our interest is in the intermediate supply and use by countries and their sectors (country-sectors), which is the partition of the input-output table indicated in the figure by the blue color. The GVC networks are constructed for each year over the period

Table 2: Sectoral classification

Sector No.	Code	Sector description	Sector group	NACE Rev.2 codes
1	agri	Agriculture, forestry and fishing	Primary	A01-A03
2	ming	Mining and quarrying	Primary	B05-B09
3	food	Food products, beverages, and tobacco products	Manufacturing	C10-C12
4	txtl	Textiles, apparel, leather and related products	Manufacturing	C13-C15
5	wood	Wood and paper products, and printing	Manufacturing	C16-C18
6	coke	Coke and refined petroleum products	Manufacturing	C19
7	chem	Chemicals and chemical products	Manufacturing	C20
8	phar	Basic pharmaceutical products and pharmaceutical preparations	Manufacturing	C21
9	plas	Rubber and plastic products, and other non-metallic mineral products	Manufacturing	C22-C23
10	metl	Basic metals	Manufacturing	C24-C25
11	comp	Computer, electronic and optical products	Manufacturing	C26
12	elec	Electrical equipment	Manufacturing	C27
13	mach	Machinery and equipment n.e.c.	Manufacturing	C28
14	motr	Motor vehicles, trailers and semi-trailers	Manufacturing	C29-C30
15	furn	Furniture; Repair and installation of machinery and equipment	Manufacturing	C31-C33
16	util	Electricity, gas, steam and air conditioning supply	Services	D35
17	watr	Water supply; sewerage, waste management and remediation activities	Services	E36-E39
18	cons	Construction	Services	F41-F43
19	trad	Wholesale and retail trade; repair of motor vehicles and motorcycles	Services	G45-G47
20	tran	Transportation and storage	Services	H49-H53
21	acco	Accommodation and food service activities	Services	I55-I56
22	medi	Publishing, audiovisual and broadcasting activities	Services	J58-J60
23	tele	Telecommunications	Services	J61
24	icts	IT and other information services	Services	J62-J63
25	finl	Financial and insurance activities	Services	K64-K66
26	real	Real estate activities	Services	L68
27	legl	Legal, accounting, management, architecture, engineering, etc.	Services	M69-M71
28	scie	Scientific research and development	Services	M72
29	prof	Other professional, scientific and technical activities	Services	M73-M75
30	admn	Administrative and support service activities	Services	N77-N82
31	publ	Public administration and defence; compulsory social security	Services	O84
32	educ	Education	Services	P85
33	hlth	Human health services	Services	Q86
34	soci	Residential care and social work activities	Services	Q87-Q88
35	arts	Arts, entertainment and recreation	Services	R90-R93
36	oser	Other service activities	Services	S94-S96
37	hown	Activities of households as employers; activities of households for own use	Services	T97-T98
38	extr	Activities of extraterritorial organisations and bodies	Services	U99

2005–2018 based on these data, followed by the computation of network measures and rendering the visuals that help understand the overall topology of the GVC networks and the position of the CESEE countries. In the context of GVCs both the value of intermediate trade and the direction of trade between nodes–country-sectors—are critical. Therefore, we construct GVC networks as directed and weighted networks. The brief overview of the related network concepts and measures used in the analysis is reported in the Appendix.

Figure 1: The structure of an inter-country input-output database

Note: The figure shows a stylized inter-country input-ouput database for J countries and S sectors. Source: own elaboration.

			Use of inputs and value added by countries and sectors									Final use (households, government, GFCF)			Total use
			Country 1			...			Country J			Country 1	...	Country J	
			Sector 1	...	Sector S	...			Sector 1	...	Sector S				
Intermediate inputs supplied by countries and sectors	Country 1	Sector 1													
		...													
		Sector S													
	...	...													
	Country J	Sector 1													
		...													
		Sector S													
Total value added															
Gross output															

More specifically, we compute (scaled) degree, weighted degree and PageRank centrality for each country-sector in the global sample (the computations include the rest-of-the-world aggregate). Degree measures the number of linkages attached to a node (in-degree and out-degree measure the number of incoming and outgoing linkages, respectively), scaled by the total number of possible linkages the node can possibly form; weighted degree measures the total value of linkages (again, weighted in-degree and weighted out-degree are also distinguished, measuring, respectively, the total value of all incoming and outgoing linkages); PageRank centrality, described in simple terms, measures the probability that a random walk traveling via the weighted directed network will arrive at a given node and takes into account the weight and direction of linkages, as well as the connectivity of the neighbouring nodes, i.e. second-order connectivity effects—see also the Appendix for additional details. While the network measures are computed for the entire GVC network, in this policy brief the analysis focuses only on the part of the network associated with the CESEE economies, that is, the GVC sub-network that includes the CESEE country-sectors as defined in the previous section with their incoming and outgoing linkages to all other country-sectors in the GVC network.

3 The CESEE segment of the GVC network

Figure 2 shows the CESEE GVC network for the year 2018.[2] The figure arranges country-sectors in a radial layout with countries positioned clockwise by ISO3. Each country "branch" includes the country's sectors sorted by their weighted degree with high-valued nodes positioned closer towards the center. Country-sectors are labelled in line with the classification described in Tables 1 and 2. Only the strongest linkages are shown for clarity with the thickness and the

[2] Python software was used to process and analyse networks and Gephi software was used for the final rendering of the images.

colour intensity of linkages proportional to their weight. The size of each node is proportional to its weighted degree—the total value of its value-added exports and imports. CESEE countries are marked in the blue colour and non-CESEE countries are marked in the orange colour.

To offer a slightly different sector-oriented perspective on the same network, in Figure 3 the country-sector nodes are arranged in a radial layout with sectors positioned clockwise by ISO3, while countries are arranged along the "branches" (those with higher weighted degree are positioned closer towards the center). These layouts jointly allow to eyeball easily which countries and sectors dominate the GVC network.

As could be seen from Figure 2, as of 2018, in terms of the number of sectors that are heavily engaged in cross-border production sharing among the CESEE countries the leading ones are Russia, Poland, Turkey and the Czech Republic. This is illustrated by the "length" of each country "branch" in the graph, which also reflects the extent of a country's sectoral diversification in production sharing. Among the non-CESEE countries, Germany and China, as well as, to a smaller extent, the USA and Italy, have the highest level of sectoral diversification as regards the engagement in the CESEE-related inwards and outward GVC linkages.

Taking a sectoral perspective in Figure 3, four sectors stand out prominently as the most integrated in the GVCs of the CESEE region: Basic metals (labelled, in line with Table 2, as metl), Coke and refined petroleum (coke), Motor vehicles manufacturing (motr) and Transportation services (tran). However, a range of other sectors of the CESEE countries are also characterised by strong participation in GVCs, e.g. Rubber and plastic products manufacturing (plas), Food products (food), Construction services (cons), Machinery manufacturing (mach), Wood and paper products (wood), Chemicals (chem), Electrical equipment manufacturing (elec). In this respect, CESEE countries as a group are well-diversified in terms of the sectors spanning primary, manufacturing and services sectors via both backward and forward GVC linkages.

Figure 2: CESEE countries in the GVC network (country arrangement), 2018

Note: The figure shows the GVC network for the CESEE countries. The size of each node is proportional to its weighted degree (the total value of value-added exports and imports). The thickness and the color intensity of linkages are proportional to their weight. The countries are arranged clockwise by ISO3 (starting with AUS in about the 5 o'clock position for an optimal layout) and each "branch" includes the country's sectors sorted by their weighted degree (high-valued nodes closer towards the center). The labels denote country-sectors as described in the previous section. CESEE countries are marked in the blue colour and non-CESEE countries are marked in the orange colour. Only linkages with the value added above 500 million USD are shown for clarity. Source: own calculations.

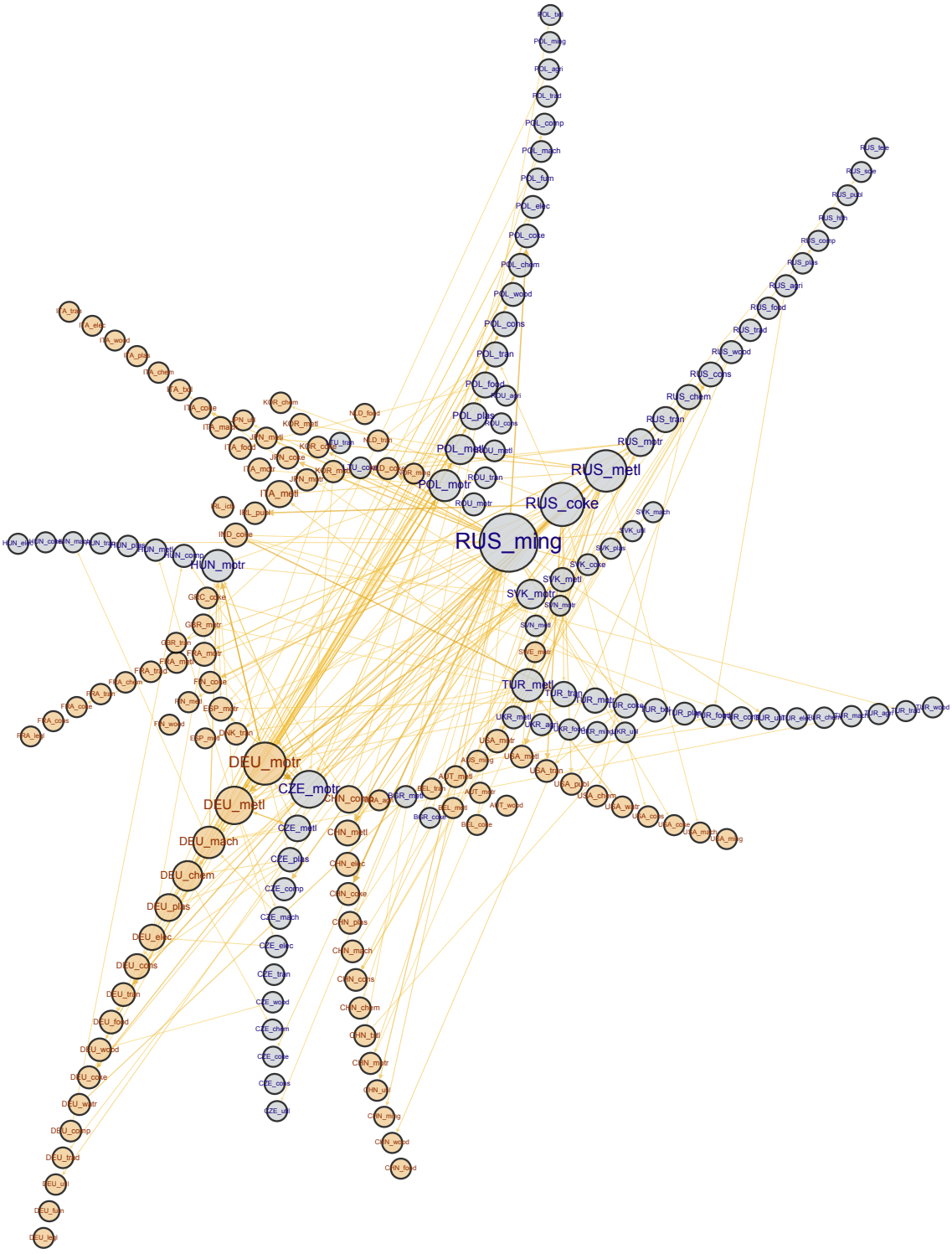
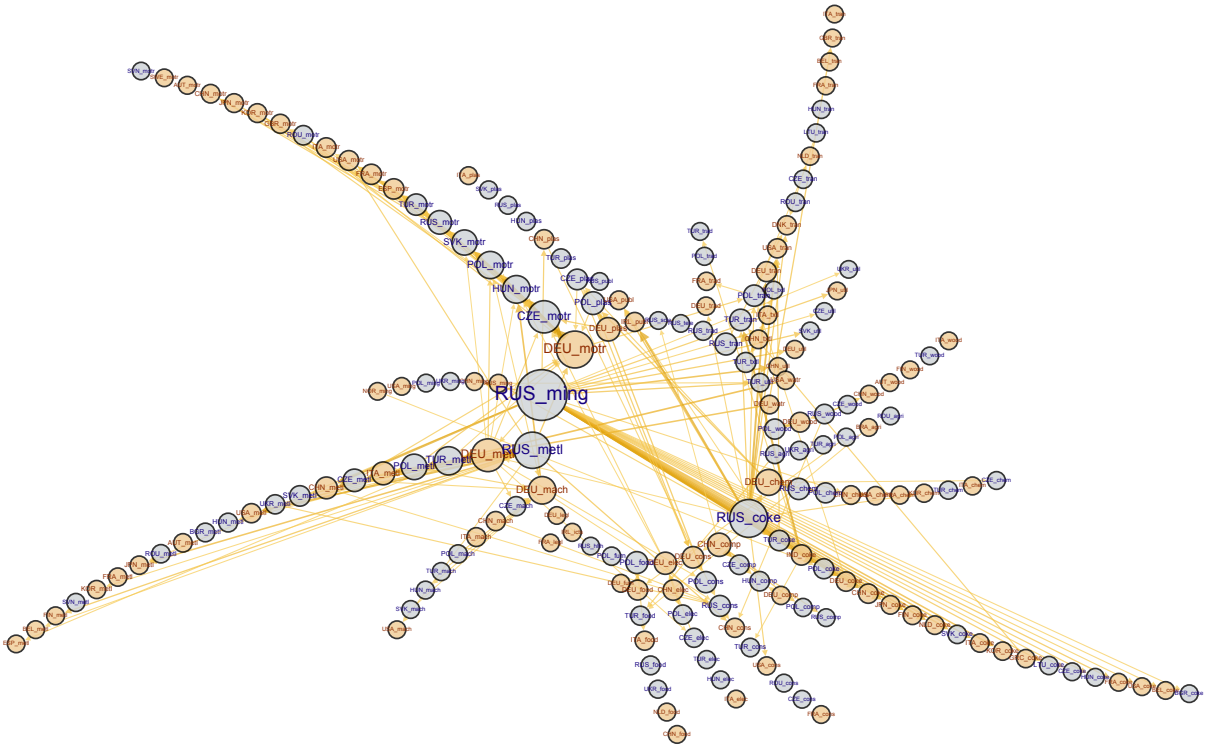


Figure 3: CESEE countries in the GVC network (sectoral arrangement), 2018

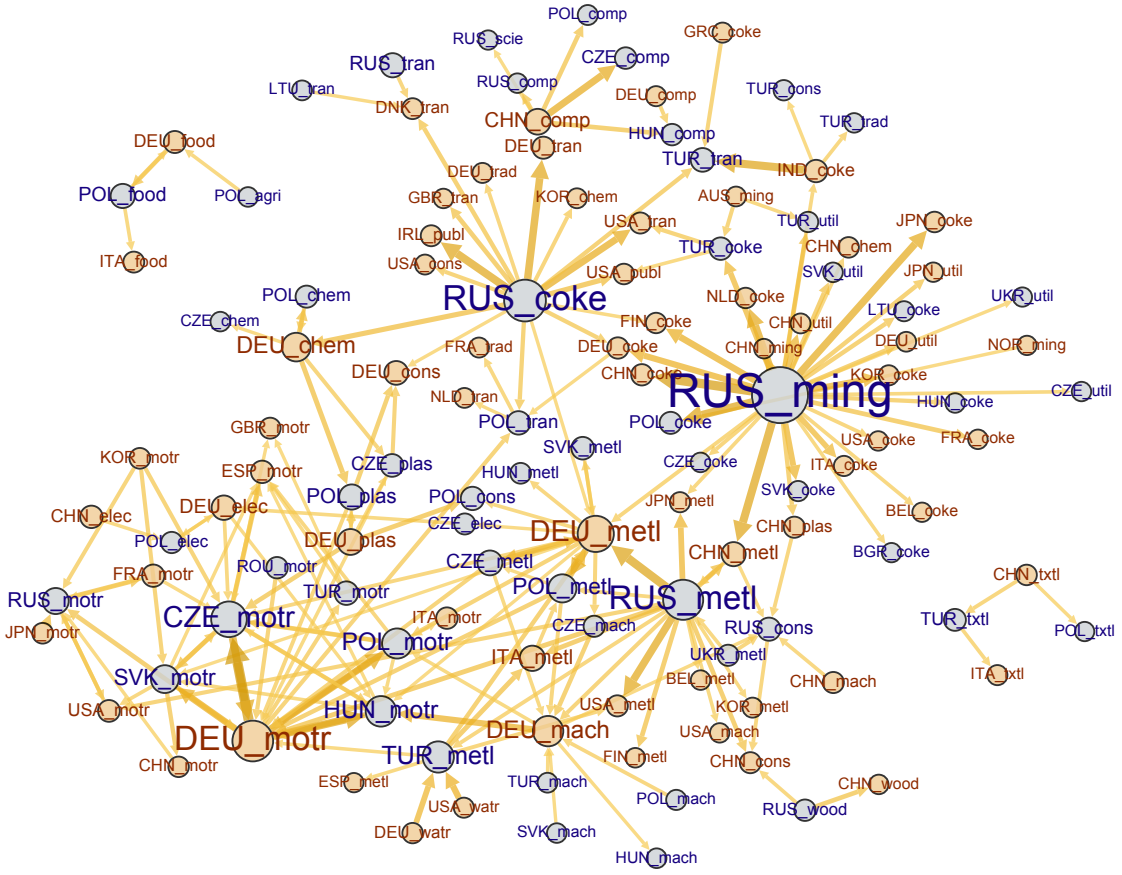
Note: The figure shows the GVC network for the CESEE countries. The size of each node is proportional to its weighted degree (the total value of value-added exports and imports). The thickness and the color intensity of linkages are proportional to their weight. The sectors are arranged clockwise by their 4-letter code (starting with agri in approximately the 3 o'clock position for an optimal layout) and each "branch" includes the countries involved in CESEE-related value-added trade in this sector, sorted by their weighted degree (high-valued nodes closer towards the center). The labels denote country-sectors as described in the previous section. CESEE countries are marked in the blue colour and non-CESEE countries are marked in the orange colour. Only linkages with the value added above 500 million USD are shown for clarity. Source: own calculations.



In addition, Figure 4 shows only the "core" of the CESEE-related GVC network using a "ForceAtlas" layout algorithm that positions nodes with the highest centrality closer towards the center of the network. For clarity and in order to emphasize the key value-added relationships, in this case only the country-sectors with the highest aggregate value of all value-added trade linkages (above 1 billion USD) and the strongest linkages (above 500 million USD) are shown.

Figure 4: CESEE GVC network–core, 2018

Note: The figure shows the subset of the GVC network involving the CESEE countries with the largest nodes and linkages. The size of each node is proportional to its weighted degree (the total value of value-added exports and imports). The thickness and the color intensity of linkages are proportional to their weight. The labels denote country-sectors as described in the previous section (sectors are also colour-coded). CESEE countries are labelled with the blue font, non-CESEE countries are labelled in the orange font. Only country-sectors with the weighted degree above 1 billion USD and the linkages with the weight above 500 million USD are shown for clarity. Source: own calculations.

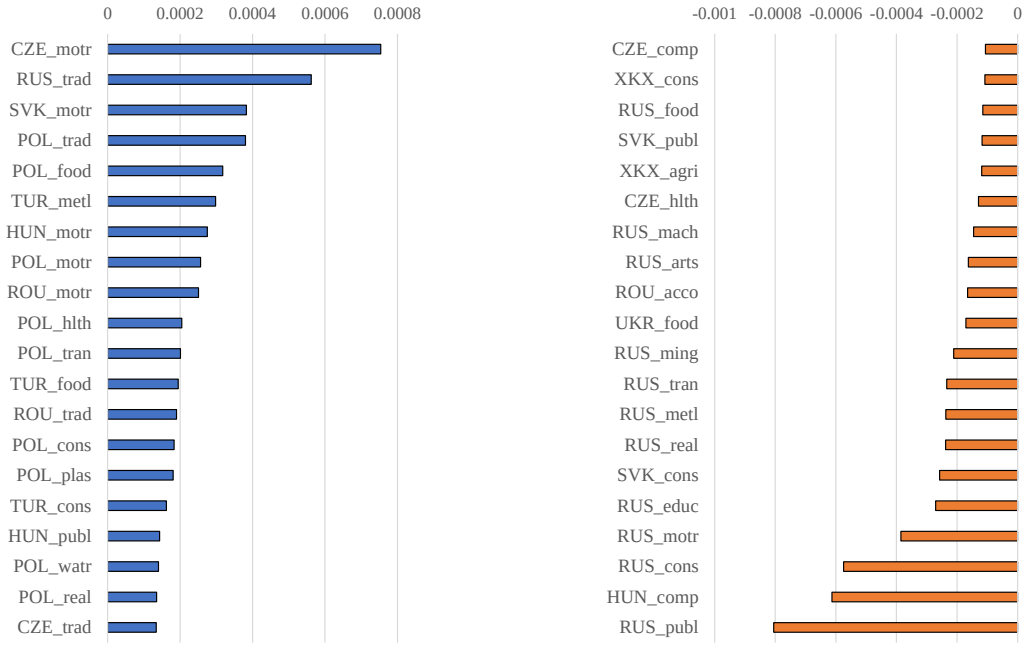


While these figures offer a convenient bird's-eye view of the topology of the CESEE GVC network, they are certainly not designed to provide detailed information on specific linkages. Therefore, Table 3 reports more explicitly the top bilateral linkages along with their dollar values, and Table 4 shows the top 30 CESEE country-sectors by their key centrality metrics,

including PageRank, weighted in-degree, out-degree and total degree.[3]

Figure 5: Change in the GVC connectivity, 2005–2018

Note: The figure shows the change in the PageRank centrality of CESEE country-sectors from the 2005–2007 average to the 2016–2018 average. The top 20 gainers (left panel) and top 20 losers (right panel) in terms of centrality are shown. Source: own calculations.



Overall, focusing on the key topological properties, the CESEE GVC network is visibly concentrated around several major hubs. The most sizable clusters are associated with several natural resource-oriented sectors dominated by Russia: Mining and quarrying (ming), Coke and refined petroleum products (coke) and Basic metals (metl) sectors. These sectors of Russia are largely upstream relative to their counterpart sectors, i.e. provide intermediate inputs to them along vertically integrated value-added chains, and span many countries and sectors globally. The total value of all GVC linkages associated with these sectors—reported in the "Weighted degree" column of Table 4—are 111 billion USD for RUS_ming, 55.8 billion USD for RUS_metl and 48.8 billion USD for RUS_coke, topping the list of the largest GVC sectors of the CESEE region by gross value. The value-added trade linkages involving these sectors also dominate the top-10 largest linkages in the entire CESEE-related GVC network (Table 3). The exports from Russian Mining sector (ming) to China's Coke and refined petroleum sector (coke) in 2018 is estimated to be over 3.7 billion USD and the exports from Russian Basic metals sector (metl) to German Basic metals sector (metl)—almost 3.3 billion USD, making them the second and third highest-ranking linkages by value in the CESEE-related GVC network.

Along with these clusters, the backbone of the CESEE-related GVC network is formed by the

[3] See the appendix for the brief discussion of these concepts.

Table 3: Top GVC network linkages of the CESEE in 2018, million USD

Rank	Exporter-sector	Importer-sector	Value	Rank	Exporter-sector	Importer-sector	Value
1	DEU_motr	CZE_motr	4189.04	26	POL_metl	DEU_metl	1837.55
2	RUS_ming	CHN_coke	3744.47	27	RUS_metl	JPN_metl	1830.12
3	RUS_metl	DEU_metl	3297.89	28	DEU_watr	TUR_metl	1814.92
4	RUS_ming	CHN_metl	3073.20	29	HUN_motr	DEU_motr	1750.28
5	RUS_ming	POL_coke	3067.21	30	DEU_metl	CZE_metl	1715.32
6	IND_coke	TUR_tran	3067.12	31	RUS_ming	TUR_coke	1702.39
7	RUS_coke	IRL_publ	2981.75	32	RUS_ming	ITA_coke	1697.34
8	DEU_motr	HUN_motr	2964.56	33	POL_motr	DEU_motr	1660.01
9	CZE_motr	DEU_motr	2914.21	34	RUS_coke	USA_publ	1505.08
10	RUS_metl	USA_metl	2802.99	35	RUS_metl	CHN_metl	1496.66
11	RUS_coke	DEU_tran	2778.98	36	CZE_metl	DEU_metl	1478.05
12	RUS_ming	NLD_coke	2633.14	37	RUS_coke	DEU_chem	1469.60
13	RUS_ming	JPN_coke	2623.68	38	DEU_chem	POL_plas	1397.52
14	DEU_motr	POL_motr	2540.10	39	RUS_ming	CHN_ming	1374.58
15	CHN_comp	CZE_comp	2469.66	40	JPN_motr	RUS_motr	1365.31
16	RUS_coke	USA_tran	2416.98	41	TUR_metl	ITA_metl	1347.80
17	DEU_metl	POL_metl	2387.71	42	RUS_metl	DEU_motr	1336.14
18	DEU_motr	SVK_motr	2295.37	43	CZE_motr	ESP_motr	1301.97
19	RUS_ming	FIN_coke	2250.57	44	DEU_chem	POL_chem	1301.02
20	USA_watr	TUR_metl	2127.39	45	CZE_motr	SVK_motr	1291.10
21	DEU_mach	HUN_motr	2066.29	46	DEU_plas	POL_cons	1283.70
22	RUS_ming	DEU_coke	2052.94	47	RUS_metl	FIN_metl	1279.27
23	RUS_ming	CHN_util	1911.33	48	RUS_motr	FRA_motr	1270.50
24	RUS_ming	SVK_coke	1895.12	49	RUS_metl	ITA_metl	1265.28
25	RUS_ming	KOR_coke	1883.62	50	RUS_ming	TUR_util	1255.77

well-known European "manufacturing core", bridging Germany's Motor vehicles manufacturing sector with that of Central European countries, seen especially well in Figure 4. Within this cluster, the exports from Germany to the Czech Republic in the Motor vehicles manufacturing sector constitute the highest-valued GVC linkage in the CESEE GVC network (over 4.1 billion USD in 2018—see Table 3). The Motor vehicles manufacturing sectors of the Visegrad countries are thus also among the most interconnected sectors in the CESEE GVC network based on both the PageRank centrality and the weighted degree measures (Table 4). Besides these, extensive CESEE linkages are formed around German Machinery manufacturing (mach), Basic metals (metl) and Chemicals (chem) sectors. All of these country-sector hubs outlined above are tightly interconnected amongst each other either directly or via bridging country-sector nodes.

A number of sectoral clusters that are relatively disconnected from the "core" of the GVC network can also be observed, e.g. the Computer and electronics manufacturing cluster bridging China, Russia, Poland, Czechia, Hungary and Germany (visually located in the 12 o'clock area of the "core" graph in Figure 4), the Food-agriculture cluster linking Italy, Poland and Germany (about 10 o'clock position in the same figure), and the Textiles manufacturing cluster linking Italy, Turkey, China and Poland (about 4 o'clock).

Among these, the ICT-related cluster has received a growing attention in the recent years in light of intensifying digitalisation and its strategic importance for competitiveness nad security. In the context of the CESEE countries, China has been playing an increasing role in the GVC relations: more specifically, among the notable linkages in the GVC network is China's sub-network bridging its Computer and electronics manufacturing sector to those of Russia, Poland, Czech Republic and Hungary. More generally, China's engagement within CESEE's GVC network has been growing not only as a prominent importer of Russia's natural resources, but also

Table 4: Top 30 CESEE country-sectors by connectivity in the GVC network

Note: The table shows top 30 CESEE country-sectors by connectivity in the GVC network based on the averages over the period 2016–2018. The country-sectors are sorted in descending order by their PageRank, weighted degree, weighted in- and out-degree in corresponding columns. For reference: the weighted degree values are in millions USD. Source: own calculations.

	PageRank centrality		**Weighted degree**		**Weighted in-degree**		**Weighted out-degree**	
	code	*value*	*code*	*value*	*code*	*value*	*code*	*value*
1	CZE_motr	0.001914	RUS_ming	110966.8	CZE_motr	25407.03	RUS_ming	105346.1
2	RUS_trad	0.001835	RUS_metl	55807.47	TUR_metl	21129.29	RUS_coke	46402.76
3	RUS_publ	0.001773	RUS_coke	48822.2	HUN_motr	20116.72	RUS_metl	43788.2
4	TUR_metl	0.00167	TUR_metl	44938.05	SVK_motr	17552.84	RUS_trad	29090.92
5	HUN_motr	0.001498	RUS_trad	40641.72	TUR_coke	17500.59	POL_trad	27825.92
6	POL_food	0.001351	CZE_motr	40262.44	RUS_motr	16655.56	TUR_metl	23808.76
7	SVK_motr	0.001297	POL_trad	37775.15	POL_motr	16158.37	RUS_tran	21946.99
8	RUS_food	0.001253	RUS_tran	32640.93	RUS_cons	14723.85	RUS_chem	16570.93
9	POL_trad	0.001231	HUN_motr	30207.06	TUR_util	13332	TUR_tran	15766.22
10	RUS_tran	0.001146	POL_motr	27040.14	RUS_food	13090.59	CZE_motr	14855.41
11	POL_motr	0.001145	SVK_motr	26334.14	RUS_metl	12019.27	POL_metl	14267.64
12	RUS_motr	0.001143	TUR_tran	25886.67	RUS_trad	11550.8	POL_tran	12766.8
13	TUR_food	0.000926	POL_metl	25678.32	POL_metl	11410.68	POL_plas	12700.5
14	RUS_cons	0.000905	RUS_motr	25268.14	POL_food	10891.79	POL_motr	10881.77
15	POL_tran	0.000757	TUR_coke	23399.27	POL_cons	10711.23	CZE_metl	10287.88
16	RUS_tele	0.000699	POL_plas	23022.44	RUS_tran	10693.94	HUN_motr	10090.34
17	TUR_motr	0.000678	POL_tran	22402.26	TUR_cons	10628.56	TUR_plas	9529.846
18	POL_cons	0.00067	RUS_chem	21630.82	POL_coke	10555.71	RUS_wood	8952.965
19	RUS_metl	0.000659	RUS_cons	20156.41	POL_plas	10321.94	CZE_plas	8913.396
20	TUR_cons	0.000619	TUR_plas	19134.95	TUR_txtl	10125.11	SVK_motr	8781.298
21	RUS_hlth	0.000618	TUR_txtl	18566.81	TUR_tran	10120.45	RUS_motr	8612.58
22	CZE_trad	0.000605	CZE_metl	18027.61	TUR_food	10032.18	TUR_txtl	8441.703
23	HUN_comp	0.000599	POL_food	17754.34	TUR_motr	10021.5	UKR_metl	8125.528
24	POL_plas	0.000592	RUS_food	16899.94	POL_trad	9949.23	RUS_agri	8117.781
25	RUS_ming	0.00059	TUR_motr	16710.04	POL_tran	9635.458	ROU_tran	8105.999
26	POL_metl	0.000581	POL_cons	15667.04	TUR_plas	9605.108	POL_wood	7707.312
27	HUN_trad	0.000544	CZE_plas	15462.1	HUN_comp	8848.219	POL_chem	7555.244
28	TUR_txtl	0.00052	POL_coke	14590.45	CZE_metl	7739.728	SVK_metl	7080.003
29	POL_furn	0.000476	POL_chem	13702.99	CZE_comp	7406.697	POL_food	6862.543
30	HUN_food	0.000464	TUR_util	13569.13	TUR_chem	7252.802	TUR_motr	6688.544

Table 5: Top GVC linkages of the Western Balkan countries in 2018, million USD

Note: The table shows the top GVC linkages (above 100 million USD) of the Western Balkan countries, sorted by value and ranked accordingly. The left panel shows outward linkages, the right panel shows the inward linkages. Source: wiiw MC IOD.

Western Balkans: exporter				**Western Balkans: importer**			
Rank	**Exporter**	**Importer**	**Value**	**Rank**	**Exporter**	**Importer**	**Value**
1	MKD_mach	DEU_chem	235.77	1	RUS_ming	SRB_coke	241.15
2	MKD_mach	DEU_mach	167.21	2	RUS_ming	SRB_util	146.52
3	SRB_metl	ITA_metl	152.41	3	GRC_coke	MKD_tran	124.56
4	MKD_mach	DEU_plas	126.41	4	RUS_ming	BIH_coke	122.95
5	SRB_txtl	ITA_txtl	108.32	5	DEU_metl	SRB_metl	116.77
6	SRB_metl	BGR_metl	103.08	6	DEU_chem	SRB_agri	113.06
7	SRB_metl	DEU_metl	100.02	7	RUS_ming	SRB_metl	104.35
				8	ITA_txtl	SRB_txtl	102.52

in many other sectors, e.g. Textiles, Construction, Chemicals, Rubber/Plastics, Machinery and Motor vehicles manufacturing and other sectors. Taking into account the gross value of GVC linkages, however, as already noted, in terms of the regional composition, Germany and Russia by far dominate the CESEE-related GVC network.

Over the period 2005–2018 the relative connectivity of countries and their sectors has been gradually transitioning. Figure 5 shows the change in the PageRank centrality from the 2005–2007 average to the 2016–2018 average (using period averages allows to smooth the effects of the business cycles and transitory segment-specific shocks). As can be seen, Central European countries have significantly intensified their connectivity in the Motor manufacturing sectors with CZE_motr sector being the leader in the connectivity improvement over the sample period. The connectivity of the Russian and Polish wholesale trade sectors has also increased. Finally, among the top 5 gainers in terms of connectivity is also the Food manufacturing sector of Poland.

Among the sectors that have lost their centrality in the GVC network over the period 2000-2018 are largely a range of Russian services sectors, including Public administration (RUS_publ), Construction (RUS_const) and Education (RUS_educ) sectors, as well as Russian Motor vehicles manufacturing sector (RUS_motr) and other sectors. This is, however, not surprising in light og the macroeconomic challenges of Russia, suffering from an oil price shock, the effects of sanctions and counter-sanctions, as well as a related turn to an import substitution strategy in the recent years. Nevertheless, as noted, Russia still remains highly interconnected in the GVC network, to a large extent owing to its dominant role as a supplier of materials to downstream sectors globally, as well as the integration of several other sectors like Motor vehicles manufacturing, Chemicals and Transportation services.

Overall, while Russia, Central European countries and Turkey are well-integrated in the global and regional GVC network, and relatively diversified in terms of sectoral composition, cross-border production sharing of most other CESEE countries is significantly lower and concentrated only in a few sectors. The Western Balkan countries are particularly weakly integrated, still remaining on the periphery of the CESEE GVC network in 2018 with only a few country-sectors integrated in GVCs with the trade values above 100 million USD (reported in Table 5). Among them, as a supplier of intermediate inputs to downstream industries the lead is taken by North Macedonian Machinery manufacturing sector, linked to German Chemicals (highest-valued linkage, 235.8 million USD), Machinery and Rubber/Plastics manufacturing sectors, as well as Serbian Basic metals sectors, linked to German, Italian and Bulgarian Basic metals sectors. From the perspective of upstream linkages, Serbia is most integrated across several sectors, heavily relying on Russian Mining sector as a supplier of intermediates (coke, util and metl sectors of Serbia) and on German Basic metals and Chemicals sectors (metl and agri sectors of Serbia). Besides that, Serbian Textiles sector is integrated in the Italian Textile manufacturing cluster both via backward and forward GVC linkages.

4 Concluding remarks

The CESEE countries have been following rather distinct development and integration trajectories over the transition period. As a result, as of 2018, the position of the countries in the GVC network also varies significantly. As shown in this policy brief, the CESEE segment of the GVC network has a core-periphery structure, dominated by Russia and the value-added linkages formed by Central European countries with Germany. This specialisation pattern seems to have intensified over time as the Visegrad countries have become more "central" in the German-oriented automotive cluster. However, these tendencies also do not imply locking-in into a narrow specialisation niche, as Central European countries have also managed to integrate into value chains in a wide range of other sectors, signifying the generally positive role of deep integration via production networks for structural upgrading and broad-based competitiveness.

From the perspective of further integration trajectories in the CESEE region, of much interest is the potential for further widening and deepening of production sharing linkages in the context of continued EU integration, as well as other major regional economic integration initiatives that directly or indirectly involve the CESEE region. In this regard, as discussed, the network analysis shows a very high connectivity of Russian natural resource-related industries serving as critical upstream sectors for a wide range of sectors globally and in the European context, especially closely intertwined with many German sectors. While these sectors remain systemic in the CESEE network, the importance of a several other Russian sectors in the GVC network has declined in the recent years, consistent with its shift towards import substitution strategy along with the general macroeconomic and policy challenges experienced following the collapse of the oil prices in 2014. In this respect, the prospects of further deepening and widening of production linkages in the context of Eurasian Economic Union appear feeble in comparison with other integration initiatives in the region[4]

At the same time, China has already gained traction as to the GVC linkages in the region, both backward and forward. With the massive investment associated with its Belt and Road initiative (BRI) it is likely that the cross-border production sharing ties between China and the region will continue to intensify, which, in turn, will fuel the continued debate on the risks associated with the BRI initiative related to the differences in technical standards and business practices, exposures of European "strategically important" sectors and debt sustainability (see Adarov, 2018b ad 2018c), as well as the optimal "EU response" to BRI (see Holzner, 2019).

While the EU integration has been generally successful in fostering deep socio-economic integration throughout the region, including both intra-EU and the countries of the CESEE region comprising its European Neighbourhood, the progress has also been uneven. On the one hand, Central European countries and other advanced CESEE economies have achieved strong results in terms of structural transformation, which has, inter alia, translated to their successful integration in the regional GVC network; on the other—the periphery of the CESEE GVC network has been making only minor headway over the examined period. In particular, the mediocre performance of the Western Balkan and the less developed countries of the EU Neighbourhood seeking closer integration in the EU calls for additional policy efforts to boost

[4] See also Adarov (2018a) for the discussion of Eurasian integration and related issues.

their competitiveness and unlock their potential for a more intensive participation in cross-border production sharing in the region (see also Reiter and Stehrer, 2021 for a discussion focusing on the Western Balkans). This is yet more important nowadays, as the protracted effects of the Great Recession in Europe further intensified by the adversities of the COVID-19 pandemic have dramatically intensified the socio-economic vulnerabilities of the less developed countries in the CESEE region.

Appendix

This section is provides a review of basic network concepts and metrics that are used in this policy brief (source: Adarov, 2021).

Figure 6 depicts a stylized weighted directed network with nodes, denoted A–H, connected among each other via weighted directed linkages (the numbers next to the linkages indicate the weight and the arrows indicate the direction of the flow).

Figure 6: Stylized weighted directed network

Note: The figure shows a stylized weighted directed network with nodes denoted by letters A–H and numbers indicating the weight of a directed link. Source: Own elaboration.

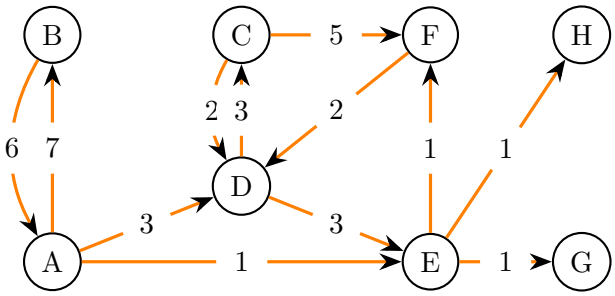


Table 6: Selected centrality measures for the network in Figure 6

Node	PageRank	Degree	In-degree	Out-degree	Weighted degree	Weighted in-degree	Weighted out-degree
A	0.12	0.57	0.14	0.43	17	6	11
B	0.10	0.29	0.14	0.14	13	7	6
C	0.13	0.43	0.14	0.29	10	3	7
D	0.22	0.71	0.43	0.29	13	7	6
E	0.14	0.71	0.29	0.43	7	4	3
F	0.15	0.43	0.29	0.14	8	6	2
G	0.07	0.14	0.14	0.00	1	1	0
H	0.07	0.14	0.14	0.00	1	1	0

As can be seen, the connectivity (or "centrality") of nodes in the network differs, e,g, nodes H and G have only one linkage, while nodes D and E have five linkages each. Using the network analysis terminology, nodes H and G each have the total degree of 1, while nodes D and E each have the total degree of 5. It is common to adjust the raw degree count by the number of possible linkages that could be formed by a node. In this simple example, node D can form a maximum span of 7 linkages and therefore its scaled degree is 0.71 (the basic centrality measures, including scaled degree are reported in Table 6). Another important metric, the weighted degree, measures the total value of incoming and outgoing linkages of a given node (weighted in-degree and out-degree are also distinguished in a similar fashion), e.. the weighed degree of node A is 17, including weighted in-degree of 6 and weighted out-degree of 11. In the context of the GVC network (constituting a weighted directed network), weights are value-added intermediate trade flows between country-sector nodes.

The network analysis may yield complementary benefits to the conventional methods of measuring GVC participation. For instance, comparing the connectivity of nodes B and D, the weighted degree of both nodes is 13 (weighted in-degree and out-degree values are also the same). However, examining visibly node D, bridging 4 other nodes, is much more important to the network in comparison with node B, bridging only node A. The importance of node D in this stylized network is even higher if one takes into account the connectivity of its neighbouring nodes, particularly, the highly-connected node E. Such second-order connectivity effects in some applications are important to correctly convey the overall multilateral connectivity of nodes and

thus their systemic importance if one considers, for instance, a shock propagation through the network or the production of a final product that is produced in sequence of tasks relying on multiple intermediate inputs along its value-added chain. We use PageRank centrality metric, developed originally in Brin and Page, 1998 and Page et al., 1999 for measuring the relative importance of webpages on the Internet, which allows to take into account the weight and direction of linkages, as well as such second-order connectivity effects, as well as other technical benefits relative to other measures. PageRank centrality conveys the probability that a random shock originating anywhere in the network and traveling through the network from one node to another via adjacent linkages (with the higher probability of choosing the linkage with a higher weight), will arrive at a given node in a given time. In this respect it shows the ultimate importance of the node to the network, taking into account its own linkages (and their weight), as well as the linkages of its adjacent nodes (neighbours) and the neighbours of the neighbours. As shown in Table 6, PageRank centrality more correctly describes node D as the most "central" node in the stylized network.

References

Adarov, Amat (2021) "Interactions Between Global Value Chains and Foreign Direct Investment Flows: a Network Approach." Vienna Institute for International Economic Studies, wiiw Working Paper No.204, July 2021.

Adarov, A. (2018a) "Eurasian Economic Integration: Impact Evaluation Using the Gravity Model and the Synthetic Control Methods", Vienna Institute for International Economic Studies Working Paper, No.150, September 2018.

Adarov A. (2018b) "The New Silk Road: companion or competitor to the EU and the EAEU?", Monthly Report No. 7-8/2018, wiiw Monthly Report, No.7-8, Vienna, July-August 2018, p. 7-13.

Adarov A. (2018c) "China's Belt and Road Initiative: opportunity or threat?". wiiw Opinion Piece. https://wiiw.ac.at/china-s-belt-and-road-initiative-opportunity-or-threat–n-338.html

Borin, Alessandro and Mancini, Michele (2019). "Measuring What Matters in Global Value Chains and Value-Added Trade," Policy Research Working Paper Series 8804, The World Bank.

Brin, S., Page, L. (1998). "The anatomy of a large-scale hypertextual web search engine." In Seventh international world-wide web conference (WWW 1998).

Buelens, Christian and Tirpak, Marcel (2017), "Reading the Footprints: How Foreign Investors Shape Countries' Participation in Global Value Chains," Comparative Economic Studies, 59, issue 4, p. 561-584.

Cerina F, Zhu Z, Chessa A, Riccaboni M (2015) "World Input-Output Network." PLoS ONE 10(7): e0134025.

Cingolani, Isabella; Panzarasa, Pietro; Tajoli, Lucia. (2017). "Countries' positions in the international global value networks: Centrality and economic performance." Applied Network Science. 2. 10.1007/s41109-017-0041-4.

Criscuolo C. and Timmis J. (2018) "The Changing Structure of Global Value Chains: Are Central Hubs Key for Productivity?" International Productivity Monitor, Centre for the Study of Living Standards, vol. 34, pages 64-80, Spring.

Daudin, G., C. Rifflart, and D. Schweisguth (2011). "Who produces for whom in the world economy?" Canadian Journal of Economics 44(4), 1403-1437.

Holzner, M. (2019). "One Trillion Euros for Europe. How to finance a European Silk Road with the help of a European Silk Road Trust, backed by a European Sovereign Wealth Fund and other financing instruments" wiiw Policy Notes 35, The Vienna Institute for International Economic Studies.

Hummels, David, Jun Ishii, and Kei-Mu Yi. (2001) "The Nature and Growth of Vertical Specialization in World Trade." Journal of International Economics 2001, 54:75-96.

Koopman, Robert, Zhi Wang and Shang-Jin Wei (2014). "Tracing Value-Added and Double Counting in Gross Ex-ports." American Economic Review, 104(2), 459-94.

Lejour A, Rojas-Romagosa H, Veenendaal P (2014). "Identifying hubs and spokes in global supply chains using redirected trade in value added. Working Paper Series 1670, European Central Bank

Los Bart and Marcel P. Timmer (2018), "Measuring Bilateral Exports of Value Added: A Unified Framework", Chapter in "The Challenges of Globalization in the Measurement of National Accounts", ed. Nadim Ahmad, Brent Moulton, J. David Richardson, and Peter van de Ven. University of Chicago Press: NBER Book Series Studies in Income and Wealth.

Miroudot, S., Spinelli, F., and Rouzet, D. (2013). "Trade policy implications of global value chains: Case studies". OECD Trade Policy Paper, No. 161

Page, L., Brin, S., Motwani, R., Winograd, T. (1999). "The PageRank citation ranking: Bringing order to the web." Technical report 1999-66, Stanford InfoLab.

Reiter, O. and R. Stehrer (2021), Value Chain Integration of the Western Balkan Countries and Policy Options for the Post-COVID-19 Period; wiiw Policy Note/Policy Report No. 48, March 2021.

Timmer M.P., B. Los, R. Stehrer and G.J. de Vries (2013) "Fragmentation, Incomes and Jobs: An Analysis of Euro-pean Competitiveness" Economic Policy, 28, 613-661.

Timmer M.P., A.A. Erumban, B. Los, R. Stehrer and G.J. de Vries (2014) "Slicing Up Global Value Chains" Journal of Economic Perspectives, 28(2), 99-118.

UNCTAD (2013) "Global Value Chains and Development: Investment and Value Added Trade in the Global Economy," 2013.

Wang Z, Wei S-J, Zhu K (2013) "Quantifying international production sharing at the bilateral and sector levels." NBER Working Paper No. 19677

World Bank et al. (2017) "Global Value Chain Development Report 2017. Measuring and analysing the impact of GVCs on economic development."

Zhu, Z., Morrison, G., Puliga, M., Chessa, A., and Riccaboni, M. (2018). "The similarity of global value chains: A network-based measure." Network Science, 6(4), 607-632.

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