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Intersectoral Linkages in European Economies: a Comparative Analysis of Germany, Poland and Slovakia

Abstract: This study provides a comparative assessment of intersectoral linkages in Germany, Poland and Slovakia, three European economies that differ in scale, structural development and integration into European production networks. Rasmussen's backward and forward linkage indices are calculated from OECD input-output tables and used to classify 45 sectors into four groups: key sectors, sectors with high backward linkages, sectors with high forward linkages and weak-linkage sectors. The study examines the hypothesis that larger, more diversified economies tend to have broader sets of sectors with high backward linkages and a lower concentration of key sectors, while smaller open economies embedded in European production networks tend to concentrate on key sectors in manufacturing and logistics. The results reveal cross-national differences. Germany has the largest share of sectors with high backward linkages (42.2%) and a relatively low share of key sectors (15.6%). Poland occupies an intermediate post-transition position, with key sectors accounting for 26.7%. Slovakia has the highest share of key sectors (31.1%), dominated by manufacturing, especially automotive-related activities, reflecting strong specialization and integration into European production networks. The findings indicate that EU industrial and regional policy should take account of differences in sectoral linkage structures.

Keywords: input-output analysis; Rasmussen method; key sectors; intersectoral linkages; cross-country analysis; global value chains

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Introduction

The structure of intersectoral linkages is a core characteristic of modern economies, shaping how demand, policy measures and technological change are transmitted through production networks. Understanding these linkages is important for industrial policy, regional development and the assessment of structural transformation. Input-output analysis, developed by Leontief (1936), remains a well-established framework for examining

these interdependencies, as it quantifies how sectors are connected through flows of intermediate goods and services.

In the European Union, the analysis of intersectoral linkages is particularly relevant because national economies differ considerably in scale, level of development and structural composition. This diversity affects economic integration, policy coordination and the prospects for structural convergence. However, despite numerous single-country input-output studies, comparative research that applies the same methodology and harmonized data to economies of different sizes remains limited.

This study addresses this gap by offering a comparative assessment of intersectoral linkages in three European economies representing distinct structural profiles: Germany as a large and highly developed economy, Poland as a medium-sized post-transition economy, and Slovakia as a small open economy. The study applies the Rasmussen method (Rasmussen, 1956), a classical and transparent approach to classifying sectors according to the intensity of their backward and forward linkages, to OECD input-output tables for 2020.

The comparison of Germany, Poland and Slovakia is based on three dimensions relevant to production structure: economic scale, structural development and integration into European and global value chains (Baldwin, 2016; Stöllinger, 2016). Germany represents a large, highly developed and diversified economy with a central role in European manufacturing networks. Poland is examined as a medium-sized post-transition economy whose production structure reflects both post-socialist transformation and integration into European value chains. Slovakia represents a small open economy with a relatively narrow domestic market, high trade openness and strong manufacturing specialization, especially in automotive-related activities. Since all three countries are EU members and are reported within a common OECD input-output framework, their sectoral structures can be compared using the same classification and methodology.

The purpose of the study is to assess and compare the intersectoral linkages of Germany, Poland, and Slovakia using the Rasmussen method, to classify sectors into four linkage groups, and to identify common and country-specific structural patterns in relation to economic scale, development stage and integration into European production networks.

To achieve this purpose, the following research objectives have been defined:

- to identify common patterns of intersectoral linkages across Germany, Poland and Slovakia;
- to determine the specific features of intersectoral linkages in Poland and Slovakia as post-transition economies in comparison with Germany as a highly developed economy;
- to interpret the observed differences in the structure of intersectoral linkages in relation to economic development, production specialization and integration into global value chains.

The main research hypothesis is that the structure of intersectoral linkages – expressed in the relative shares of key sectors, sectors with high backward linkages, sectors with high forward linkages and weak-linkage sectors – differs across European economies in relation to their economic scale, stage of structural development and position within European production networks. More specifically, a large and diversified economy is expected to have a broader group of sectors with high backward linkages and a lower

concentration of key sectors, whereas smaller and more open economies are expected to have a higher concentration of key sectors in manufacturing and logistics.

This hypothesis has both theoretical and policy relevance. Theoretically, the study provides comparable empirical evidence on how economic scale, structural development and value-chain position are associated with intersectoral architecture. From a policy perspective, the results are relevant to industrial policy, regional development strategies and EU integration initiatives, since the effectiveness of policy instruments depends partly on the underlying structure of sectoral linkages.

The remainder of the article is organized as follows. The Literature Review outlines the theoretical foundations of input-output analysis and the Rasmussen method and summarizes empirical findings from previous studies of Germany, Poland, Slovakia and other European economies. The Methodology section presents the data, the Rasmussen indices, and the sector-classification procedure. Research Results report the empirical classification of sectors into four linkage groups and compares backward and forward linkages across countries, while Discussion interprets the results in relation to the research hypothesis and the relevant literature. The Conclusions summarize the main findings, policy implications, limitations and directions for further research.

LITERATURE REVIEW

The input-output model developed by Leontief (1936) provides the theoretical basis for studying intersectoral interactions. It enables the direct and indirect effects of changes in demand or production in one sector to be assessed for the economy as a whole by representing inter-industry flows of goods and services in matrix form.

Within this framework, the Rasmussen method is widely used to assess backward and forward linkages and to classify sectors according to their position in the system of intersectoral flows. The classification distinguishes key sectors from those with predominantly backward linkages, those with predominantly forward linkages, and those with weak linkages. Its relevance lies in its conceptual clarity, established theoretical basis, and transparent classification criteria (Miller, Blair, 2009). Although the method has limitations, including the equal treatment of sectors at different scales, linearity assumptions and limited consideration of dynamic effects (Miller, Blair, 2009; Temurshoev, Oosterhaven, 2014), it remains suitable for comparative studies because it provides a consistent basis for comparing national economic structures.

The German economy has long been a focus of input-output research. Early studies documented a highly diversified structure with intensive linkages, especially in manufacturing (Vetter, 1973; Menges, Beutel, 1974). Contemporary research confirms the continuing importance of these linkages. Mrówczyńska-Kamińska et al. (2013) identify strong backward linkages in the German agro-industrial complex, which reflects the high degree of integration in the food production system. Landesmann et al. (2015) emphasize that large Western European economies, including Germany, France and Italy, have more complex production networks and closer interaction between industrial and service sectors than smaller countries.

Poland, the largest economy in Central and Eastern Europe, reflects the outcomes of the structural transformation initiated in the 1990s. Gurgul and Lach (2015) argue that the country's key sectors include both traditional heavy industries, such as metallurgy and chemicals, and service segments, including transport and communications. Olczyk (2011)

shows that EU accession in 2004 accelerated the shift towards a more service-oriented model and deepened integration into European production chains. At the same time, Górska (2015) notes that Poland maintains a specific profile: pronounced backward linkages in industry indicate the continuing importance of manufacturing, while weaker forward linkages point to a stronger orientation towards final consumption. Recent evidence by Gacek (2025) confirms the mixed nature of the Polish economy, where mechanical engineering and metalworking function alongside a strong trade and transport block.

Slovakia represents a development model shaped by small-country openness, geographical position and integration into Central European production networks. Kubala et al. (2015) show that after 2004 the automotive cluster became a key driver of the Slovak economy, forming a dense network of backward linkages with component suppliers and developing a strong export orientation. Analyses of small open economies, including Guarda and Rouabah's (2015) study of Luxembourg and related evidence for Czechia and Hungary, reveal a common pattern: specialization in selected production niches, substantial dependence on imported resources, and the importance of strategic component suppliers within European networks.

Beyond country-specific input-output studies, the literature on global value chains (GVCs) and trade in value added provides a broader context for interpreting national linkage patterns. Baldwin (2016) describes how the international unbundling of production has reorganized manufacturing into cross-border networks, while Timmer et al. (2014) document the rising foreign value-added content of output and show, for example, how German automotive value chains rely on suppliers across Central Europe. Koopman et al. (2014) demonstrate that gross trade flows and total backward linkages can overstate domestically generated value added because they include imported intermediates. This caveat is directly relevant to import-dependent assembly economies. For the EU, Stöllinger (2016) identifies a Central European manufacturing core encompassing the Czechia, Hungary, Poland and Slovakia, in which deep GVC integration reinforces manufacturing specialization. This literature suggests that high measured backward linkages in smaller open economies may reflect their role as assembly nodes within regional production networks rather than only the depth of their domestic supplier base.

Despite this body of research, several gaps remain. First, comparative studies based on a unified methodology and harmonized data for economies of different scales are still fragmented. Second, medium-sized post-transition economies, including Poland, are not always examined in detail from the perspective of intersectoral architecture. Third, many existing studies rely on earlier data and therefore do not fully capture recent changes in European production networks, including digitalization and supply-chain reconfiguration.

The present study addresses these gaps by conducting a comparative analysis of intersectoral linkages in Germany, Poland and Slovakia. The use of an identical Rasmussen-based classification and harmonized OECD input-output data makes it possible to provide empirical evidence on how economy size, development stage and value-chain position are associated with the architecture of national production systems.

METHODOLOGY

This study uses OECD input-output tables for 2020 for Germany, Poland and Slovakia. These symmetric tables provide a detailed representation of intersectoral flows of goods

and services, showing how the output of each sector is used as intermediate input by other sectors or as final demand.

The choice of 2020 as the base year is motivated by the use of harmonized OECD input-output tables for Germany, Poland and Slovakia within a common statistical framework. A single comparable cross-section allows the same sectoral classification and the same Rasmussen procedure to be applied to all three economies. The linkage indices calculated in this study are based on total requirements and therefore capture intermediate demand regardless of whether it is satisfied by domestic suppliers or by imports. This feature is considered when interpreting the results for open economies integrated into cross-border production networks.

The Rasmussen method (Rasmussen, 1956) is a classical approach to classifying sectors by the strength of their backward and forward linkages. It is based on the Leontief inverse matrix (L), which shows the total direct and indirect requirements for each sector's output needed to satisfy a unit of final demand. The mathematical apparatus for the study is based on calculating two fundamental indicators: the backward linkage index and the forward linkage index.

1. Backward Linkage Index (BL_j) indicates the extent to which sector j stimulates production in other industries through demand for their intermediate products. The indicator is defined as the ratio of the average column sum of the total requirements matrix to the overall average value of the matrix elements:

where:

$$BL_j = \frac{\frac{1}{n} \sum_{i=1}^n l_{ij}}{\frac{1}{n^2} \sum_{j=1}^n \sum_{i=1}^n l_{ij}} = \frac{n \sum_{i=1}^n l_{ij}}{\sum_{j=1}^n \sum_{i=1}^n l_{ij}} \quad (1)$$

l_{ij} – elements of the Leontief total requirements matrix $L = (I-A)^{-1}$;

n – number of economic sectors;

$\sum_{i=1}^n l_{ij}$ – sum of elements in the j-th column of matrix L, reflecting the total economic response to a unit change in final demand in sector j.

2. Forward Linkage Index (FL_i) measures the extent to which other sectors depend on intermediate supplies from sector i. It is calculated as the ratio of the average row sum of matrix L to the overall average level:

$$FL_i = \frac{\frac{1}{n} \sum_{j=1}^n l_{ij}}{\frac{1}{n^2} \sum_{i=1}^n \sum_{j=1}^n l_{ij}} = \frac{n \sum_{j=1}^n l_{ij}}{\sum_{i=1}^n \sum_{j=1}^n l_{ij}} \quad (2)$$

where – the sum of elements in the i-th row of matrix L, characterizing the volume of sector i output required to support a unit increase in production across all sectors.

Based on these two indices, sectors can be classified into four categories:

1. Key sectors (BL > 1 and FL > 1): sectors with both high backward and high forward linkages, which have the greatest potential to transmit production effects through the economy.

2. Backward linkage sectors ($BL > 1$ and $FL \leq 1$): sectors with high backward linkages and low forward linkages, which stimulate production in other sectors through their demand for inputs.
3. Forward linkage sectors ($BL \leq 1$ and $FL > 1$): sectors with low backward linkages and high forward linkages, which support production in other sectors through their supply of inputs.
4. Weak linkage sectors ($BL \leq 1$ and $FL \leq 1$): sectors with low backward and forward linkages, which have limited direct potential to stimulate production through intersectoral linkages.

This classification provides a clear and intuitive framework for comparing the structural role of sectors in terms of their intersectoral linkages.

RESEARCH RESULTS

the analysis of intersectoral interactions based on OECD input-output tables for 2020 reveals substantial structural differences across the three economies. The classification of 45 sectors according to Rasmussen's methodology shows that, in the comparison between Germany, Poland and Slovakia, the share of key sectors and weakly linked sectors is higher in the smaller and more open economies, while the proportion of sectors with high backward linkages is highest in Germany (Table 1).

Table 1. Structure of sector distribution by type of intersectoral linkage

Type of intersectoral linkages	Germany		Poland		Slovakia	
	Number	%	Number	%	Number	%
Key sector	7	15.6	12	26.7	14	31.1
Sector with high backward linkages	19	42.2	11	24.4	9	20.0
Sector with high forward linkages	8	17.8	8	17.8	8	17.8
Sector with weak linkages	11	24.4	14	31.1	14	31.1
Total	45	100.0	45	100	45	100.0

Source: authors based on OECD.Stat (2023)

The German economy, as the largest and most diversified among the three countries, is characterized by the dominance of sectors with high backward linkages (42.2%). This indicates the depth and multi-level structure of domestic production chains, in which manufacturing industries are important consumers of intermediate products from related activities. In Poland (26.7%) and especially in Slovakia (31.1%), the share of key sectors is higher. This pattern can be interpreted in the context of these countries' integration into global value chains (GVCs). In smaller open economies, sectors may acquire key-sector status not only because of domestic intersectoral integration but also because they function as assembly, manufacturing or logistics nodes within European production networks. This may limit the depth of autonomous national production cycles.

The comparison also shows that the combined share of key sectors and sectors with high backward linkages is highest in Germany (57.8%), indicating a stronger capacity to generate domestic intersectoral demand. At the same time, the share of sectors with high forward linkages is identical in all three countries (17.8%). This similarity points to the common role of service and infrastructure activities in modern European

economies, where they support the functioning of the industrial core regardless of national specificity or the degree of integration into global supply networks.

The structure of the German economy is distinguished by several system-forming industries that simultaneously act as key suppliers of intermediate products and depend strongly on final demand. These include energy, extractive industries, transport and logistics, and core manufacturing industries such as chemicals, metallurgy and metalworking (Table 2). Together, they form the basis of production chains and support the high level of vertical integration characteristic of the German industrial model.

In addition, the German economy contains a broad group of sectors with high backward linkages whose production relies intensively on resources from other industries. These sectors include agriculture, food and textile industries, woodworking, pharmaceuticals, and machinery and equipment manufacturing. Mechanical engineering, despite its economic importance, is not classified as a key sector because a significant share of its output is exported.

A separate group consists mainly of service sectors with high forward linkages, including construction, trade, finance, IT and professional services. These sectors consume relatively few material resources, but their output is important for the functioning of other sectors and forms part of the production infrastructure of the economy.

Social services and cultural industries, by contrast, display weak intersectoral linkages. This reflects their budget-based financing and orientation towards final consumption, which limits their direct integration into production chains.

The Polish economy has a post-transition structural profile. Its key sectors include not only metallurgy and chemicals, as in Germany, but also agriculture, food, paper, rubber and plastic products, and construction. This indicates a combination of traditional industrial activities, sectors oriented towards intermediate demand, and service-related functions characteristic of an economy that has undergone deep restructuring after systemic transformation.

The group of sectors with high backward linkages in Poland is smaller than in Germany, reflecting a lower depth of production chains. At the same time, mechanical engineering industries remain important, confirming their integration into European production networks.

Another important feature of the Polish economy is the larger share of sectors with weak linkages. Their proportion exceeds 31%, which is higher than in Germany. This points to less extensive intermediate-sector integration and to the significant role of industries oriented towards final consumption, particularly social services, culture and information industries.

The Slovak economy, as a small open system, has the widest group of key sectors: 14 in total. In addition to traditional industrial sectors, it includes rubber products, metallurgy and almost all mechanical engineering sectors. This reflects the specificity of small open economies, where many sectors are simultaneously integrated into international production chains and serve the domestic market.

The number of sectors with high backward linkages in Slovakia is the smallest among the three countries, at only nine. This result is consistent with the limited depth of domestic production chains. At the same time, mechanical engineering and the automotive industry remain key drivers of integration into European production networks.

The structure of sectors with weak linkages in Slovakia is similar to that observed in Poland, indicating a degree of structural similarity between the two economies. Social

Table 2. Identification of economic activities in Germany, Poland and Slovakia by type of linkage

Type of economic activity (TEA)	Code TEA	Germany			Poland			Slovakia		
		Backward	Forward	I	Backward	Forward	I	Backward	Forward	I
Agriculture, hunting, forestry	A01-A02	1.00	0.74	B	1.07	1.04	K	1.01	1.08	K
Fishing and aquaculture	A03	1.09	0.52	B	1.00	0.50	B	0.96	0.45	W
Mining of energy producing products	B05-B06	1.15	1.23	K	0.85	1.34	F	0.75	1.17	F
Mining of non-energy producing products	B07-B08	1.04	0.56	B	0.92	1.02	F	1.06	0.62	B
Mining support service activities	B09	0.99	0.50	W	0.68	0.55	W	0.51	0.60	W
Food products, beverages, tobacco	C10-12	1.19	0.83	B	1.26	1.13	K	1.13	0.66	B
Textiles, wearing apparel, leather	C13-15	1.10	0.60	B	1.13	0.66	B	0.96	0.54	W
Wood and products of wood and cork	C16	1.10	0.67	B	1.13	0.77	B	1.02	0.74	B
Paper products and printing	C17-C18	1.09	0.84	B	1.16	1.04	K	1.17	0.71	B
Coke and refined petroleum products	C19	1.43	0.87	B	1.18	1.01	K	1.17	1.00	K
Chemicals and chemical products	C20	1.08	1.31	K	1.17	1.34	K	1.10	1.20	K
Pharmaceuticals, medicinal chemicals	C21	1.05	0.61	B	0.97	0.54	W	1.08	0.53	B
Rubber and plastic products	C22	1.06	0.79	B	1.13	1.16	K	1.14	1.01	K
Other non-metallic mineral products	C23	1.05	0.70	B	1.09	0.84	B	1.12	0.95	B
Basic metals	C24	1.39	1.40	K	1.32	1.32	K	1.34	1.66	K
Fabricated metal products	C25	1.06	1.05	K	1.12	1.28	K	1.12	1.37	K
Computer, electronic, optical products	C26	0.98	0.84	W	1.34	0.89	B	1.63	1.45	K
Electrical equipment	C27	1.05	0.79	B	1.30	0.98	B	1.30	1.26	K
Machinery and equipment n.e.c.	C28	1.08	0.97	B	1.12	0.88	B	1.29	1.00	K

Type of economic activity (TEA)	Code TEA	Germany				Poland				Slovakia			
		Forward		Backward		Forward		Backward		Forward			
		Backward	I	Forward	I	Backward	I	Forward	Backward	Forward	I		
Motor vehicles, trailers, semi-trailers	C29	1.14	B	0.91	B	1.31	B	0.95	B	1.54	B	1.43	K
Other transport equipment	C30	1.22	B	0.72	B	1.28	B	0.69	B	1.29	B	0.53	B
Manufacturing n.e.c.; repair of machinery	C31-C33	1.02	B	0.83	B	1.08	B	1.07	K	1.07	K	1.17	K
Electricity, gas, steam, air conditioning	D	1.01	K	1.35	K	0.85	F	1.26	F	1.18	F	1.99	K
Water supply; sewerage, waste	E	0.96	F	1.08	F	0.94	F	0.85	W	0.90	W	0.58	W
Construction	F	0.99	F	1.28	F	1.13	K	1.88	K	1.06	K	1.64	K
Wholesale, retail trade; repair of vehicles	G	0.86	F	2.86	F	0.86	F	3.50	F	0.90	F	3.34	F
Land transport and transport via pipelines	H49	1.00	K	1.21	K	1.02	K	2.01	K	0.92	K	1.40	F
Water transport	H50	1.29	B	0.65	B	1.13	B	0.50	B	1.12	B	0.49	B
Air transport	H51	1.17	B	0.52	B	1.17	B	0.52	B	1.31	B	0.51	B
Warehousing and support activities	H52	1.08	K	1.85	K	1.02	K	1.35	K	1.03	K	1.32	K
Postal and courier activities	H53	1.06	B	0.85	B	0.94	B	0.52	W	1.00	W	0.75	F
Accommodation and food service activities	I	0.99	W	0.57	W	0.99	W	0.53	W	0.86	W	0.47	W
Publishing, audiovisual, broadcasting	J58-J60	0.96	W	0.74	W	0.97	W	0.68	W	0.88	W	0.56	W
Telecommunications	J61	0.99	W	0.93	W	0.94	W	0.64	W	0.83	W	0.59	W
IT and other information services	J62-J63	0.82	F	1.86	F	0.83	F	1.47	F	0.83	F	1.27	F
Financial and insurance activities	K	0.95	F	1.58	F	0.78	F	1.14	F	0.84	F	0.93	W
Real estate activities	L	0.69	F	1.40	F	0.81	W	0.89	W	0.63	W	1.28	F

Type of economic activity (TEA)	Code TEA	Germany			Poland			Slovakia		
		Backward	Forward	I	Backward	Forward	I	Backward	Forward	I
Professional, scientific, technical activities	M	0.86	2.38	F	0.82	1.85	F	0.86	2.11	F
Administrative and support services	N	0.79	1.97	F	0.83	1.31	F	0.90	1.46	F
Public administration, defense, social security	O	0.80	0.89	W	0.68	0.52	W	0.70	0.58	W
Education	P	0.65	0.59	W	0.61	0.50	W	0.62	0.50	W
Human health and social work	Q	0.76	0.50	W	0.82	0.54	W	0.76	0.50	W
Arts, entertainment, recreation	R	0.79	0.60	W	0.91	0.53	W	0.86	0.62	W
Other service activities	S	0.72	0.62	W	0.92	0.55	W	0.83	0.56	W
Activities of households as employers	T	0.00	0.00	W	0.00	0.00	W	0.00	0.00	W

I – identification of economic activity by comparative assessment of linkages

K – key sector

B – sector with high backward linkage

F – sector with high forward linkage

W – sector with weak linkages

Source: authors based on OECD.Stat (2023)

services and final-consumption-oriented industries have limited production linkages and remain predominantly oriented towards domestic demand.

Overall, the three countries display different models of intersectoral linkages. Germany is a highly integrated and diversified economy with strong industrial sectors. Poland occupies an intermediate post-transition position, combining industrial sectors with an expanding service block and gradually approaching Western European structural patterns. Slovakia is a small open economy with concentrated production linkages, in which mechanical engineering and the automotive industry play a central role.

The results of the Rasmussen-based analysis point to substantial structural commonalities among the economies of Germany, Poland and Slovakia. As shown in Table 3, this similarity is based on four common key sectors: chemicals (C20), basic metals (C24), fabricated metal products (C25) and warehousing and support activities (H52). The high intensity of both forward and backward linkages in these industries indicates their role as important nodes within production chains. While the industrial sectors (C20–C25) act as basic suppliers of raw materials and semi-finished products, warehousing and logistics (H52) performs an integrative function by channeling resources between related industries and supporting the continuity of intermediate flows.

Table 3. Patterns of intersectoral linkages characteristic of economic activities in Germany, Poland and Slovakia

Type of economic activity (TEA)	Code TEA	Type of Linkage
Chemicals and chemical products	C20	Key sector
Basic metals	C24	
Fabricated metal products	C25	
Warehousing and support activities	H52	
Wood and products of wood and cork	C16	High backward linkage
Other non-metallic mineral products	C23	
Other transport equipment	C30	
Wholesale, retail trade; repair of vehicles	G	High forward linkage
IT and other information services	J62-J63	
Professional, scientific, technical activities	M	
Administrative and support services	N	
Public administration, defence, social security	O	Weak linkage
Education	P	
Human health and social work	Q	
Arts, entertainment, recreation	R	
Other service activities	S	
Accommodation and food service activities	I	
Publishing, audiovisual, broadcasting	J58-J60	
Telecommunications	J61	
Mining support service activities	B09	

Source: authors based on OECD.Stat (2023)

Industries with a pronounced unilateral linkage orientation also play an important role in aggregate demand and service support. Stable high backward linkages were identified in all three countries in woodworking (C16), production of mineral products (C23), and transport engineering (C30), marking these activities as strong consumers

of products from other sectors. In parallel, the infrastructure framework of the economies is formed through high forward linkages in trade (G), IT services (J62–J63), professional, scientific and technical activities (M), and administrative activities (N). This configuration indicates a common model of business-service support, in which these sectors provide organizational, informational and service inputs to national production systems.

Alongside these common patterns, the study identifies sectors whose indicators are close across the three countries, such as land transport (H49) and financial activities (K). A group of nine sectors also share a common weak-linkage profile. This group consists mainly of socially oriented spheres, including public administration, education and health care, as well as specific services such as accommodation and food services, publishing and broadcasting, telecommunications and mining support activities. Despite their social significance, these sectors have a limited direct effect on intermediate consumption in the industrial sector. These multidirectional linkages emphasize the complex structure of the Central European economic model, in which a common industrial core coexists with national growth drivers.

DISCUSSION

The structural differences identified between Germany, Poland and Slovakia are broadly consistent with the Petty-Clark law and Kuznets' account of structural change in the course of economic growth (Clark, 1940; Kuznets, 1966). These approaches emphasize the gradual shift in the relative weight of economic activity from primary production towards manufacturing and, subsequently, services as income rises. The German economy displays features of a mature post-industrial system, in which the agricultural sector (A01-A03) functions as a technologically advanced consumer of intermediate products with high backward linkages. Poland and Slovakia, by contrast, remain in a phase of service-oriented restructuring while retaining a comparatively stronger role for construction and agriculture, which is consistent with ongoing structural adaptation within the EU. The identical share of sectors with high forward linkages across all three countries (17.8%) suggests that knowledge-intensive services, including IT, consulting and professional and scientific activities, play a stable role in supporting production regardless of national economic scale.

The findings are also consistent with the theory of production fragmentation and with the literature on cross-border production networks (Baldwin, 2016; Timmer et al., 2014). The high intensity of linkages in Slovakia's mechanical engineering and automotive industries, and in Poland's chemical and mechanical engineering industries, reflects their role as nodes within the Central European manufacturing core (Stöllinger, 2016). This supports earlier evidence on the centrality of the automotive complex in the Slovak economy (Kubala et al., 2015) and on the mixed industrial profile of Poland (Górska, 2015; Gacek, 2025). Since the Rasmussen indices are computed using total input-output tables, the high backward linkages observed for assembly-oriented sectors may reflect both domestic intersectoral demand and imported intermediate inputs. This is particularly relevant for Poland and Slovakia, where industrial sectors are strongly embedded in cross-border production networks. By contrast, German mechanical engineering (C28) exhibits high backward but moderate forward linkages. This pattern may be explained by the fact that a large share of the sector's output is directed to external markets as final demand, which lowers its measured direct forward linkages; the value

embodied in these exports is partly generated along international rather than purely domestic production chains (Koopman et al., 2014; Timmer et al., 2014). These sectors should therefore be interpreted as elements of European production networks rather than only as domestic multipliers.

The identification of sectors with strong mutual interdependence is closely connected to the multiplier and linkage effects formalized within the input-output tradition (Miller, Blair, 2009). Public investment in key sectors can generate cascading demand through backward linkages and supply resources to related industries through forward linkages. Because the sets of key sectors differ across the three countries, uniform support measures are unlikely to be equally effective. Industrial policy should therefore be tailored to the specific architecture of linkages in each economy: for large diversified economies, the priority is to preserve the depth and differentiation of domestic production chains; for smaller open economies, the central challenge is to increase the domestic value-added content of import-dependent assembly nodes rather than to rely on their gross linkage intensity alone.

The classification of education (P), health care (Q) and public administration (O) as sectors with weak linkages reflects their institutional and demand characteristics, including high labor intensity and budget financing. However, their significance extends beyond direct intersectoral flows, because they form human capital and institutional infrastructure. These indirect effects are important for long-term development and require a balanced policy approach: support for key sectors can strengthen short-term multiplier effects, while support for weak-linkage sectors contributes to the quality and sustainability of economic growth.

Taken together, the results suggest that the architecture of intersectoral linkages reflects a combination of structural maturity, sectoral specialization and position within European production networks. This interpretation avoids reducing the observed cross-national differences to economy size alone and places them within broader debates on structural change and production fragmentation.

CONCLUSIONS

The comparative analysis of intersectoral linkages in Germany, Poland and Slovakia leads to the following conclusions.

The comparison indicates a consistent cross-national pattern in the distribution of linkage types. In the large and diversified German economy, key sectors account for a relatively small proportion of all sectors (15.6%), whereas in the smaller Slovak economy their share rises to 31.1%. This indicates greater structural concentration and a stronger tendency for individual industries to perform both demand-generating and supply-providing functions within production chains. This pattern is accompanied by a lower proportion of sectors with high backward linkages in Slovakia than in Germany (20.0% compared with 42.2%) and a higher share of sectors with weak linkages (31.1% compared with 24.4%). These results support the research hypothesis, while also showing that the observed differences reflect not only economy size, but also development stage, specialization, post-transition restructuring and participation in European production networks.

A common technological core was identified, comprising four sectors (8.9% of the total number of economic activities): chemicals (C20), basic metals (C24), fabricated

metal products (C25) and warehousing and support activities (H52). These industries are consistently classified as key sectors in all three countries, indicating their shared role in supporting production-chain cohesion across the examined economies.

The three economies also share sectors with high backward linkages: woodworking (C16), production of mineral products (C23) and transport engineering (C30). This common pattern indicates the presence of similar demand-generating industries, although the wider national context of these industries differs across countries.

A block of nine common weak-linkage sectors, representing 20% of all sectors, was also identified. It consists mainly of socially oriented activities, including public administration (O), education (P) and health care (Q), as well as specific services such as telecommunications (J61), publishing and broadcasting (J58–J60), accommodation and food services (I), and mining support activities (B09).

At the same time, the comparison reveals both shared structural patterns and country-specific features. Shared patterns are visible in business-service sectors such as trade (G), IT services (J62–J63), professional activities (M) and administrative services (N). Country-specific features are reflected in the relatively important role of agriculture in Poland and the automotive industry in Slovakia.

The stable share of sectors with high forward linkages (17.8%) in all three countries indicates that knowledge-intensive services, especially IT and professional activities, have become an important infrastructural component supporting production competitiveness across economies with different levels of industrialization.

The results suggest that public support may be more effective when it takes into account sectors with strong multiplier and linkage effects. For small open economies, policy priorities should also include diversification and the development of high-tech services in order to reduce vulnerability to external disruptions in global production chains. EU integration policy should therefore account for structural differences in intersectoral linkages between economies of different sizes. A one-size-fits-all approach may be ineffective; instead, economic policy should be adapted to the specific structural characteristics of different types of economies.

Overall, the Rasmussen method is useful as a transparent tool for the comparative assessment of intersectoral linkages. It makes it possible to classify sectors consistently across countries and to reveal differences in the architecture of production systems within a common methodological framework.

The study has two analytical limitations that define the scope of interpretation. First, it is comparative and structural rather than dynamic: the harmonized 2020 cross-section captures the architecture of intersectoral linkages at one point in time and does not trace their evolution. Second, the use of total input-output requirements means that linkages are measured without separating domestic and imported components. Future research could extend the analysis to multi-period and multi-regional input-output data in order to test the stability of the identified patterns and distinguish domestic from imported components of intersectoral linkages.

The results provide an empirical basis for developing differentiated strategies of structural transformation in Central and Eastern European countries in the context of digital and green restructuring of the European economy.

References

- Baldwin, R. (2016). *The great convergence: Information technology and the new globalization*. Harvard University Press.
- Clark, C. (1940). *The conditions of economic progress*. Macmillan.
- Eurostat. (2024). National accounts and GDP. Statistics Explained. Retrieved from: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=National_accounts_and_GDP (access: 15.02.2026).
- Gacek, K. (2025). Sectoral interdependencies and waste generation in Poland (2010–2018): Insights from input-output analysis. *Economics and Environment*, 92(1), 798. doi: <https://doi.org/10.34659/eis.2025.92.1.798>
- Górska, R. (2015). Backward and forward linkages based on an input-output analysis – comparative study of Poland and selected European countries. *Applied Econometrics Papers*, 2(1), 30–50. Retrieved from: <https://ideas.repec.org/a/wse/journal/v2y2015i1p30-50.html> (access: 15.02.2026).
- Guarda, P., Rouabah, A. (2015). *Is the financial sector Luxembourg's engine of growth?* Working Paper No. 97. Banque centrale du Luxembourg. Retrieved from: <https://www.bcl.lu/en/publications/Working-papers/97/BCLWP097.pdf> (access: 15.02.2026).
- Gurgul, H., Lach, Ł. (2015). Key sectors in the post-communist CEE economies: What does the transition data say? *Communist and Post-Communist Studies*, 48(1), 15–32. doi: <https://doi.org/10.1016/j.postcomstud.2014.12.001>
- Koopman, R., Wang, Z., Wei, S.-J. (2014). Tracing value-added and double counting in gross exports. *American Economic Review*, 104(2), 459–494. doi: <https://doi.org/10.1257/aer.104.2.459>
- Kubala, J., Lábaj, M., Silanič, P. (2015). Štruktúrne väzby v slovenskej ekonomike v roku 2010: Identifikácia kľúčových odvetví [Structural linkages in the Slovak economy in 2010: Identification of key sectors]. *Ekonomický časopis [Journal of Economics]*, 63(8), 795–816. Retrieved from: https://www.sav.sk/?doc=journal-list&journal_article_no=11890&lang=sk&part=article_response_page (access: 15.02.2026).
- Kuznets, S. (1966). *Modern economic growth: Rate, structure, and spread*. Yale University Press.
- Landesmann, M., Leitner, S.M., Stehrer, R. (2015). Competitiveness of the European economy (wiiw Research Report No. 401). *The Vienna Institute for International Economic Studies*. Retrieved from: <https://wiiw.ac.at/competitiveness-of-the-european-economy-p-3629.html> (access: 15.02.2026).
- Leontief, W. (1936). Quantitative input and output relations in the economic system of the United States. *The Review of Economics and Statistics*, 18(3), 105–125. doi: <https://doi.org/10.2307/1927837>
- Menges, G., Beutel, P. (1974). Triangulation der nach 11 Sektoren gegliederten Input-Output-Tabellen der Länder der alten EWG [Triangulation of the 11-sector input-output tables of the countries of the former EEC]. *Statistische Hefte*, 15(4), 276–302. doi: <https://doi.org/10.1007/BF02922911>
- Miller, R.E., Blair, P.D. (2009). *Input-output analysis: Foundations and extensions*. 2nd ed. Cambridge: Cambridge University Press. doi: <https://doi.org/10.1017/CBO9780511626982>
- Mrówczyńska-Kamińska, A., Poczta, W. (2013). Erzeugung und Verteilung der Produkte des Agrarsektors und der Lebensmittelindustrie vor dem Hintergrund ihrer Verbindungen mit der Volkswirtschaft (vergleichende Analyse des Agrar- und Lebensmittelsektors in Polen und Deutschland) [Production and distribution of agricultural and food industry products in the context of their connections with the national economy: Comparative analysis of the agricultural and food sector in Poland and Germany]. *Berichte über Landwirtschaft*, 91(1), 5–28. doi: <https://doi.org/10.12767/buel.v91i1.11>
- OECD.Stat. (2023). *Input-output tables*. *OECD Statistics*. Retrieved from: <https://www.oecd.org/en/data/datasets/input-output-tables.html> (access: 15.02.2026).
- Olczyk, M. (2011). *Structural changes in the Polish economy – the analysis of input-output*. MPRA Paper No. 33659. Munich: University Library of Munich. Retrieved from: <https://mpra.ub.uni-muenchen.de/33659/> (access: 15.02.2026).
- Rasmussen, P.N. (1956). *Studies in inter-sectoral relations*. North-Holland.

- Stöllinger, R. (2016). Structural change and global value chains in the EU. *Empirica*, 43(4), 801–829. doi: <https://doi.org/10.1007/s10663-016-9349-z>
- Temurshoev, U., Oosterhaven, J. (2014). Analytical and empirical comparison of policy-relevant key sector measures. *Spatial Economic Analysis*, 9(3), 284–308. doi: <https://doi.org/10.1080/17421772.2014.930168>
- Timmer, M.P., Erumban, A.A., Los, B., Stehrer, R., de Vries, G.J. (2014). Slicing up global value chains. *Journal of Economic Perspectives*, 28(2), 99–118. doi: <https://doi.org/10.1257/jep.28.2.99>
- Vetter, S. (1973). Internationaler Vergleich von Wirtschaftsstrukturen auf der Basis standardisierter Input-Output-Tabellen für 8 europäische Länder [International comparison of economic structures based on standardized input-output tables for 8 European countries]. *Statistische Hefte*, 14(2), 162–180.
- World Bank. (2024). *Trade (% of GDP) – Slovak Republic. World Development Indicators*. Retrieved from: <https://data.worldbank.org/indicator/NE.TRD.GNFS.ZS?locations=SK> (access: 15.02.2026).

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