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# EXPLORING CONNECTIONS BETWEEN INDUSTRIES IN THE WESTERN BALKAN COUNTRIES: A NETWORK ANALYSIS APPROACH

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**ABSTRACT**

This study employs a network analysis framework to evaluate economic vulnerabilities within the Western Balkans (WB) value chains, focusing on Serbia, North Macedonia, Albania, Bosnia and Herzegovina, and Montenegro. The aim is to identify industries critical to the network's structural integrity and assess potential impacts from disruptions. This approach provides new insights into the connections between the WB countries and regional industries based on input/output data for each sector. Evidence from raw bilateral trade data often misses those insights and does not provide the level of interconnectivity between industries. Our findings highlight the dominant importance of Serbia's Electricity, Gas, and Water (ELE) industry and Transport (TRA). Also, several industries from North Macedonia are important within the region. The obtained results can be used to revise and adjust industrial and trade policies in the WB countries. Identified interconnectedness is significant for improving the countries' position in international frameworks and their possibilities for more active participation in value chains.

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## Introduction and Research Background

The Western Balkans (WB) countries are characterised by a high degree of economic interdependence in pursuing EU membership. Those countries share a common past and specific economic characteristics that make them an interesting area for research. In recent decades, integration into regional and international economic flows has become a key issue for their economic strengthening and progress. This paper uses a network analysis to explore the relationships and connections between different industries within the WB countries. Using this methodology, the paper offers insight into structural patterns, key sectors contributing to the region's connectivity, growth, and stability, and opportunities for improving regional cooperation and integration.

Numerous studies have analysed the economies of the Western Balkans, focusing on various topics from the economic aspect, such as European integration (Dabrowski and Myachenkova 2018), financing and sustainable development (Lukšić et al. 2022), and migration (King and Oruc 2020) to regional initiatives like the Open Balkan (Rikalović, Molnar and Josipović 2022). Research focused on trade flows (Popovic, Eric and Stanic 2020; Leka, Daku and Jusufi 2022) also tried to indicate the chances of regional cooperation through openness and trade agreements. In addition to different approaches in analyses, a gap was identified in the lack of studies showing the functioning patterns of regional cooperation through trade flows. Therefore, we aim to examine which countries and industries have the dominant participation in trade at the WB region level.

In this context, the authors choose the network analysis approach. This method allows the study of relationships between companies, industries, or economies in a broader sense. In a network, nodes represent entities (industries), while edges represent relationships between those entities, viewed through the level and intensity of trade exchange. The application of the network analysis in the study of industrial linkages, especially in regions such as the Western Balkans, allows detailed insight into linkage patterns, identification of strategic sectors, and a better understanding of the region's economic resilience. The success of applying this methodology has been identified in previous research in this area. Fagiolo, Reyes, and Schiavo (2010) came to an interesting conclusion that better-connected countries tend to trade with poorly connected ones but are also involved in highly interconnected trade clusters. The authors also found that all network properties are remarkably stable across the years and do not depend on the weighting procedure. Previous studies also suggest that utilising Gephi to carry out the network analysis will make the results of traditional analytical methods more effective and complete (Sun et al. 2020). This approach can evaluate industries as an important step in industry optimisation. Wang and Yang (2022) suggest that the government should optimise the allocation of resources and promote the transfer of resources to balance industrial development.

The paper is structured as follows: After the introduction, the authors present the position of the WB countries regarding the main economic indicators, industries, and regional links. In the third section, we explain the applied methodology, followed by results and discussion. Finally, the conclusion and implications are provided.

## Economic Position of the WB Countries

### *Economic Outlook*

According to the European Commission's Country Reports (Directorate-General for Communication 2024), all WB economies still need to reach the level of a functioning market economy capable of withstanding market forces and competitive pressure within the EU. Despite recent improvements, the region's average GDP per capita remains nearly a quarter of the 27 EU members' average and roughly 40% of the CIS EU members. Furthermore, the WB remains poorly integrated into the global and European markets despite the robust growth of exports of goods and services in previous years (30% for 2022) (Directorate-General for Communication 2024). Compared to their peers in Central and Eastern Europe (CEE), where the share of exports of goods and services in GDP averages around 70% (Statistical Office of the Republic of Serbia 2023), 63% in large economies such as Poland, and over 90% in Slovakia and Hungary, according to national statistics, the WB region lags significantly behind with a share of 59% in 2022. Besides, the growth of CEE exports to the EU in the pre-accession period was much faster.

According to the World Bank's report (World Bank 2024), businesses in the WB face significant challenges in business internationalisation and global value chains and have less developed support systems. Although trading mostly with tariff-free markets, the WB markets are burdened with significant non-tariff barriers. Exporters in the WB typically face bigger obstacles to doing business than those in CEE. Expanded regional cooperation represents a unique opportunity for the WB economies to scale up by making the most of intensified economic integration. Through resource-sharing networks and knowledge-sharing networks and with enhanced regional trade, they are more likely to increase their productivity and competitiveness. Strengthened economic integration will also result in greater resilience to external shocks.

With almost 70% of the region's exports directed towards the EU (World Bank 2024), all WB governments are working to adopt EU standards and harmonise technical regulations. They are prioritising SME efforts to increase export volume and to improve their complexity and sophistication. Since 2019, financial incentives for greening available to SMEs have been multiplied, albeit unevenly

across the region. Most SMEs took at least one action to become more resource-efficient, often minimising waste or saving energy or water. The unstable geopolitical situation has significant spillover effects for the WB, underlining the need to enhance energy and food security. Energy dependence, supply insecurity, and volatile prices for fossil fuels affected the availability of energy. Unique rules and standards would provide a stimulus for intra-regional trade and investment, increase the benefits of big infrastructure projects and make the WB more attractive as an investment destination.

### *Main Industries*

According to the volume of the GDP, the total value of all products produced in 2023 in the WB amounted to EUR 146 billion (Serbian Chamber of Commerce and Industry 2024). Despite this, if we look at the EU average, the WB is significantly behind the EU economies. The Gross Value Added (GVA) of the WB economy accounted for nearly 86% of the region's total GDP. The main drivers of the WB economy by activities are manufacturing, construction, and real estate activities. In the last few years, the trend of population decline resulted in 16.9 million people in the region, with a decrease of 4.4% compared to 2019. The GDP per capita was EUR 8.596, placing the WB in the group of middle-low-level economies. The main export products of the WB were electrical machinery and equipment, machinery, mechanical appliances, iron and steel, chemical products, mineral fuels, furniture, and plastic products. On the other hand, the main import products were mineral fuels, electrical machinery and equipment, machinery and mechanical appliances, plastic products, vehicles apart from railways or tramways, and pharmaceutical products (Serbian Chamber of Commerce and Industry 2024). The WB service sector has been developing rapidly over the past few years. Although the pandemic had slowed exports in 2020, in 2023, they reached EUR 31.1 billion. However, in the last observed year, the total value of exports surpassed its pre-pandemic level. The total FDI inflow in the WB region during 2023 amounted to EUR 8.8 billion, a significant increase compared with the pandemic year (2020).

Intra-regional trade has stagnated for many years. However, in 2023, it grew significantly (EUR 8.8 billion). The share of exports within the region remains small, at around 14%, despite the proximity and other trade promotion factors. The EU remains the dominant export market for all WB economies (EUR 34 bn in 2023). For most WB economies, exports to the EU are five times bigger than to regional markets. Main trade barriers are procedural obstacles at customs, product safety requirements, including sanitary and phytosanitary measures, and technical trade barriers. There is a possibility of resolving issues related to customs procedures, further aligning with EU norms and practices for reducing SPS/TBT

barriers, and concluding mutual agreements for conformity assessment procedures and certificates. There is the highest potential for the export of machines and equipment and chemicals and plastics (Serbian Chamber of Commerce and Industry 2024).

However, there is still room for improvement in the integration of the WB SMEs in European supply chains. The cooperation exists mostly in the final stages of the international supply chains in food, beverages, and tobacco, in addition to textiles and clothing; the intermediate stages of wood and cork, paper, printing and publishing, and other non-metallic mineral products; fabricated metal products; and the first and intermediate stages of basic metals. The highest export potential in 2023 relates to machines and equipment and chemicals and plastics. The product mix within the WB economies also explains the limited integration into European supply chains. Over 50% of the region's manufactured goods are classified as "labour and resource-intensive" or "low-skill and tech-intensive", compared to about 30% in the EU. In contrast, only 18% fall into the category "high-skill and tech-intensive goods" compared to 27% in CEE.

### *Economic Connections and Trade within the Region*

Intraregional trade within the WB region has significantly increased by the CEFTA2006 (reducing tariffs and facilitating the free movement of goods). Trade volumes among the WB economies have steadily increased because the WB economies export more to their neighbours. In 2023, intra-WB export of goods was at EUR 8.5 billion, an increase of 123% compared to EUR 3.8 billion in 2013. In the same period, total exports of those economies grew from EUR 22.8 billion to EUR 54.8 billion, an increase of 141%. In 2023, an average of 15.5% of all WB exports were made to other CEFTA markets, while 67% of all exports went to the EU. In total, 82.5% of all exports made by selected economies were exported to the EU and the CEFTA2006 (CEFTA 2024).

The Green Lanes initiative was established at the onset of the COVID-19 pandemic in April 2020. The initiative's primary goal was to ensure the uninterrupted flow of essential goods and medical supplies across the WB (and the CEFTA region). In the meantime, the initiative has evolved, ensuring priority passage to certain types of goods (perishable goods). The initiative was quickly set up to facilitate priority passage for trucks carrying essential goods (it was crucial in maintaining trade flows and supporting the fight against the pandemic). The initiative supported regional cooperation. It demonstrated strong commitment and coordination among all the stakeholders. It was initially focused on road transport and later extended to include rail crossings (it covers all WB crossing points (BCPs/CCPs) and some crossing points with the neighbouring EU member states). Electronic Data Exchange SEED+ has been instrumental in

facilitating information exchange between customs administrations and other agencies. As a result of the Green Lanes initiative, the CEFTA Secretariat began collecting data on waiting times from the beginning of 2022. The average waiting time at all crossings within the CEFTA in 2023 was 86 minutes, seven minutes less per truck than in 2022. Considering the total number of truck crossings throughout the CEFTA during 2023, that adds up to an impressive sum of almost 20 years saved for all carriers moving goods under the CEFTA.

### *Regional Initiatives*

Initiated in 2014 by Germany, the Berlin Process is a diplomatic initiative aimed at fostering regional cooperation and integration among the WB. Its broader goal is to accelerate the EU accession process. Over the last ten years, the Berlin Process has focused on strengthening regional connectivity, economic cooperation, reconciliation among these economies, and tackling key political and social challenges.

Key achievements for the period 2014-2024 are within regional economic integration, as one of the major outcomes has been a significant push for regional economic cooperation. The WB agreed to enhance economic ties, starting with the Multiannual Plan for a Regional Economic Area (MAP REA) endorsed in Trieste in 2017, followed by a more ambitious Common Regional Market Action Plan (CRM AP, introduced in 2020 at the Sofia Summit, to enable the free movement of goods, services, capital, and people within the region). The CEFTA, which was initially signed in 1992 and re-envisioned for the WB in 2006 as the CEFTA 2006, has played a central role in shaping the trade dynamics of the region and serves as a precursor to the CRM. With the CEFTA 2006 acting primarily as a trade framework, together with other regional actors engaged in the implementation of the CRM AP, the aim is to achieve a more comprehensive market approach similar to the EU's single market, including harmonising digital markets and professional qualifications and creating a labour market with more mobility.

### *Active Industrial Policies and Regional Activities*

Common WB challenges to overcome and demonstrate how industrial policy should be activated following the SDGs cover continuity of policies, collaboration with stakeholders, regional coordination, and international cooperation.

Adopted industrial strategies within the WB region are defined as horizontal and relate to all economic sectors. Besides, the implementation of industrial strategies was always poor, and none of the governments managed to introduce a substantial set of policy measures that would lead to a real structural change in

their economies (Jovanović and Vujanović 2023). Smart specialisation strategies identify and select a limited number of priority areas and use industrial, educational, and innovation policies to support them, focusing on their strengths and comparative advantages. Prospective industrial sectors in the WB include agri-food, textiles, automotive, energy, IT, and tourism. The agri-food industry has a large share in most economies of the WB (in terms of GDP and employment). It varies from 25% of BDP in Albania to slightly above 10% of GDP in Montenegro and Bosnia and Herzegovina. The agri-food industry should aim for premium goods. The share of the textile sector in GDP varies for up to 4% of value added in North Macedonia, for around 3% in Albania and Bosnia and Herzegovina, and for 2% or less in the remaining economies. The textile sector should aim for high-quality final products. The automotive sector has a relatively small share of value added in most WB. It is highest in Serbia and North Macedonia (around 1.5% of GDP) and aims for advanced technologies. The energy sector has a larger share in the WB, with value-added shares ranging between 3% and 6% of BDP in all economies. The tourism sector share in total value added is the largest in Montenegro (10% of GDP). The IT industry accounts for 3% of value added in Serbia, 2% in Bosnia and Herzegovina and North Macedonia, and 1% in Montenegro and Albania (Serbian Chamber of Commerce and Industry 2024).

Infrastructural connectivity across the WB covers fields such as transportation, energy, and digital infrastructure. It has supported numerous projects, including the construction of highways, railways, and energy grids (as the aim is to bring the region closer together physically, economically, and technologically). The Roaming Agreement aimed to gradually reduce mobile phone roaming charges across the WB until it would allow users to use their mobile phones abroad in the region at the same cost as at home. Integration of the WB into the SEPA is an ongoing process that will align the WB with the broader European payment framework, facilitating smoother and more efficient payments. Continued reforms in banking and payment systems will be necessary to integrate fully into the SEPA. The Green Agenda for the WB aims to support the region's transition to a greener economy by addressing key environmental challenges, enhancing climate resilience, and fostering sustainable development. Digital Agenda for the WB is an initiative launched by the EU to support its digital transformation. It aims to align the WB with EU digital policies, fostering regional cooperation, economic growth, and integration into the broader European digital market.

## Methodology

Data is drawn from the Multi-Regional Input-Output (MRIO) table provided by the EORA database, with the latest (free) data from 2017. This table details intermediate consumption flows between industries across the selected

countries, allowing for a network representation where nodes signify industries and edges represent the value of traded intermediate goods.

The analysis is conducted using the software Gephi to calculate centrality measures and generate a visual representation of the network. Key metrics, including weighted in-degree, weighted out-degree, betweenness centrality, hub, and authority scores, are computed to determine each industry's role and connectivity within the network (Table 1). To focus on the most impactful economic relationships, edges are filtered by descending trade value, retaining only those that collectively account for a certain percentage of the total intermediate consumption within the network. This filtering enhances clarity by simplifying the network to its core economic connections.

Table 1: Network analysis metrics used in the initial analysis (node metrics)

| Description of the metric from | Weighted In-Degree | Weighted Out-Degree | Betweenness Centrality | Hub | Authority |
|---|---|---|---|---|---|
| **Network Analysis Perspective** | The number of direct incoming edges to a node, weighted by the significance of each edge. | The number of direct outgoing edges from a node, weighted by the significance of each edge. | The frequency at which a node appears on the shortest paths between other nodes. | An iterative measure reflecting a node's compound influence on network connectivity through both direct and indirect paths. | A node's importance as a primary destination, pointed to by influential hub nodes. |
| **Economic Perspective** | Represents the level of dependency on the products and services of other industries. | The industry's role in providing products and services to other industries on a 1st- level connection. | Reflects an industry's control over the flow of goods, services, or information, indicating potential bottlenecks in the value chain. | Represents an industry's role in wider economic continuity, beyond direct output to 1st-level connections. | An industry's central role as a final processor in the production chain. Its high level of intermediate consumption drives demand for upstream industries. |

Source: Authors.

A disruption analysis is then performed to examine changes in network structure when each identified key industry is hypothetically removed, simulating a complete shutdown scenario. Graph metrics are then recalculated to assess the

consequences of removing these central industries. These key metrics are node and edge counts, graph density, average path length, average degree, and clustering coefficient (Table 2). This process provides insights into network fragility, highlighting industries essential for maintaining connectivity and economic resilience across the region.

Table 2: Network Analysis Metrics Used in the Disruption Analysis (Graph Metrics)

| Description of the metric from | Graph Density | Average Path Length | Average Degree | Average Clustering Coefficient |
|---|---|---|---|---|
| **Network Analysis Perspective** | The ratio of actual present edges to all possible edges that can be formed in a network. | The average count of steps along the shortest routes connecting all possible node pairs, a measure of network efficiency. | The average number of edges per node, a measure of network connectivity. | Measures the degree to which nodes in a network tend to cluster together. |
| **Economic Perspective** | The extent of interlinkage among industries within the economy. A higher density means the network is more resilient to disruptions due to multiple connection paths. | Reflects the average separation between industries. Shorter paths imply quicker and more efficient transfer of goods and services. | The average number of direct relationships that industries have, which reflects diversification in the economy. | The tendency for industries to form localised clusters. A lower value means the economy is less resilient to shocks. |

Source: Authors.

Finally, the results of the disruption analysis are contextualised by examining each high-impact industry's economic role in the Western Balkans. Relevant studies and industry data are referenced to explain the structural importance of these industries, including their influence on upstream and downstream sectors. This step provides a deeper understanding of regional interdependencies and the potential economic consequences of industry-specific disruptions.

## Results

Table 3 presents results for five Western Balkan countries with results according to previously identified metrics. Industry code abbreviations are provided in the Appendix.

Table 3: Network analysis results

| Country | Industry Code | W In-Degree | W Out-Degree | W Degree | Betweenness Centrality | Authority | Hub |
|---|---|---|---|---|---|---|---|
| SRB | ELE | 124,484 | - | 124,484 | - | 0.75 | - |
| SRB | TRA | 54,173 | - | 54,173 | - | 0.62 | - |
| BIH | PET | 19,584 | 19,670 | 39,254 | 73.25 | 0.04 | 0.13 |
| MKD | AGR | 10,285 | 10,253 | 20,537 | 103.25 | 0.04 | 0.12 |
| MKD | PET | 6,516 | 46,109 | 52,625 | 90.58 | 0.02 | 0.18 |
| MKD | MET | 2,541 | 34,787 | 37,328 | 141.83 | 0.03 | 0.16 |
| MKD | ELM | - | 24,302 | 24,302 | - | - | 0.16 |

Source: Authors.

The network analysis for the Western Balkans region reveals a concentrated reliance on a few high-authority and high-output industries, particularly in Serbia and North Macedonia. Serbia's Electricity, Gas, and Water (ELE) industry stands out with the highest authority score (0.75) and weighted in-degree (124,484), indicating its central role as a critical receiver of inputs within the network. Similarly, Transport (TRA) in Serbia also shows a strong authority score (0.62), suggesting that it serves as a significant destination for intermediate goods. In North Macedonia, industries like Petroleum, Chemical, and Non-Metallic Mineral Products (PET) and Metal Products (MET) are key output providers with high hub scores (0.18 and 0.16, respectively), signalling their importance as primary suppliers across the network. Additionally, Agriculture (AGR) in North Macedonia has a notable betweenness centrality (103.25), highlighting its bridging role in connecting disparate sectors. Bosnia and Herzegovina's Petroleum (PET) industry, with balanced in- and out-degrees, plays a dual role in sourcing and supplying the network.

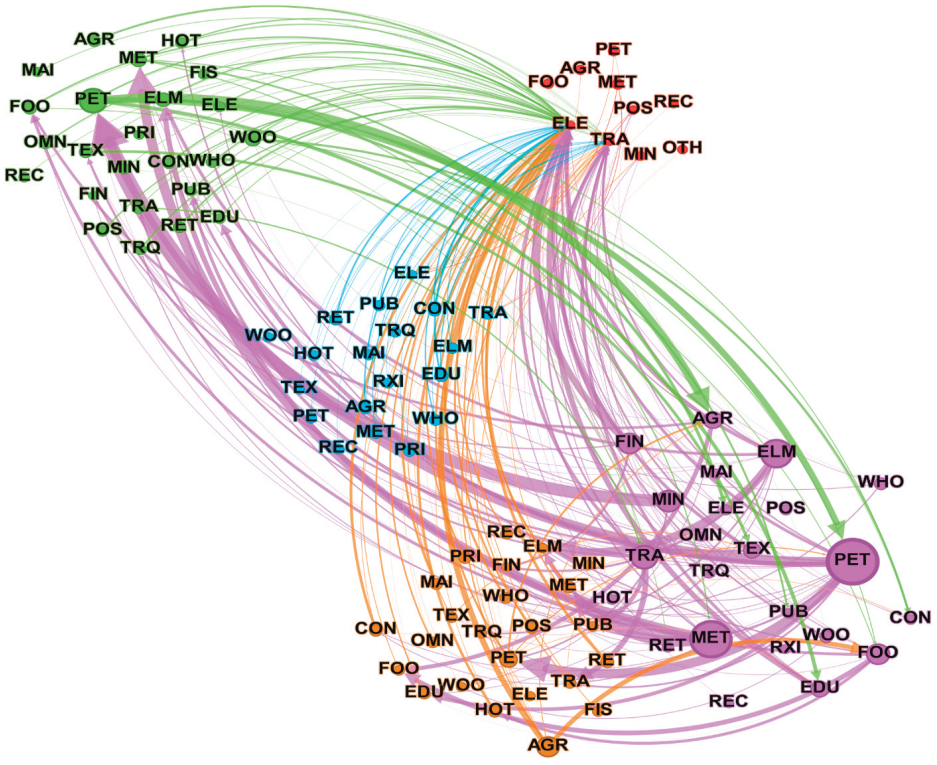
Table 4: Disruption analysis

| Network Measures | Baseline | SRB-ELE | SRB-TRA | BIH-PET | MKD-AGR | MKD-PET | MKD-MET | MKD-ELM |
|---|---|---|---|---|---|---|---|---|
| **Nodes** | 100 | 87 | 99 | 99 | 99 | 99 | 99 | 99 |
| **Edges** | 270 | 184 | 208 | 259 | 260 | 246 | 251 | 257 |
| **Graph Density** | 0.027 | 0.025 | 0.021 | 0.027 | 0.027 | 0.025 | 0.026 | 0.026 |
| **Average Path Length** | 2.121 | 2.292 | 2.241 | 2.12 | 1.81 | 2.061 | 1.734 | 2.117 |
| **Average Degree** | 2.7 | 1.859 | 2.101 | 2.616 | 2.626 | 2.485 | 2.535 | 2.596 |
| **Average Clustering Coefficient** | 0.128 | 0.103 | 0.14 | 0.124 | 0.131 | 0.134 | 0.127 | 0.129 |
| **Average % Change from Baseline** | 0% | -18.40% | -10.73% | -1.88% | 2.01% | -2.94% | 0.61% | -2.07% |

Source: Authors.

The disruption analysis reveals that Serbia's Electricity and Gas (SRB-ELE) and Transport (SRB-TRA) industries have the most severe impacts on the network structure when removed, highlighting their critical importance within the Western Balkans economic system. The removal of SRB-ELE results in an 18.4% average decrease from baseline across all network metrics, reducing the node count from 100 to 87 and edges from 270 to 184 and increasing the average path length to 2.292. That indicates significant fragmentation and reduced connectivity as fewer industries remain interconnected and economic "distances" between industries grow. Similarly, the removal of SRB-TRA leads to substantial disruptions, with a 10.73% decline from the baseline, edges dropping to 208, and average path length increasing to 2.241, demonstrating its role in maintaining efficient flow across sectors. These results highlight SRB-ELE and SRB-TRA as essential infrastructure nodes; their absence would not only hinder direct trade links but also create greater economic distance between industries due to the region's reliance on them as the main customers of many industries.

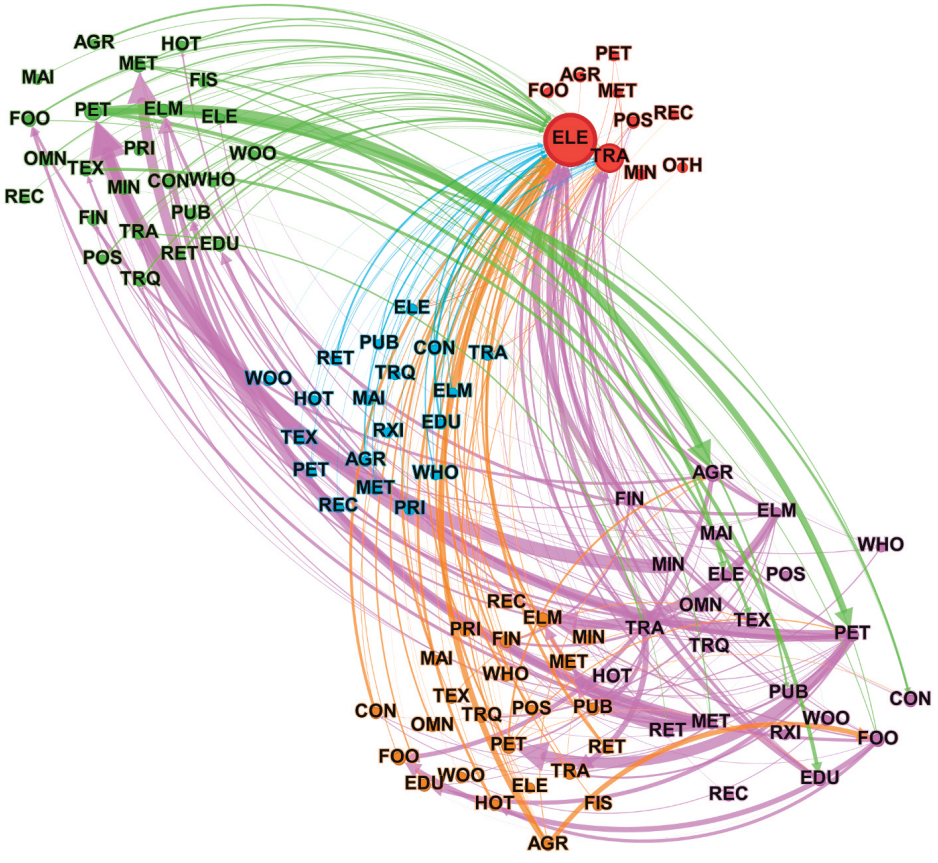
Graph 1: Weighted out degree




Source: Authors.

In this weighted out-degree graph, Petroleum, Chemical and Non-Metallic Mineral Products (PET) and Metal Products (MET) in North Macedonia (MKD) stand out due to their strong outgoing connections, indicating significant contributions to other industries within the network. This high out-degree suggests that both sectors are crucial suppliers in the region's economy, likely providing essential intermediate goods to multiple downstream industries. Additionally, Agriculture (AGR) in Albania (ALB) shows a notable presence with substantial outgoing links, emphasising its role as a key provider of primary products supporting other sectors in the regional value chain.

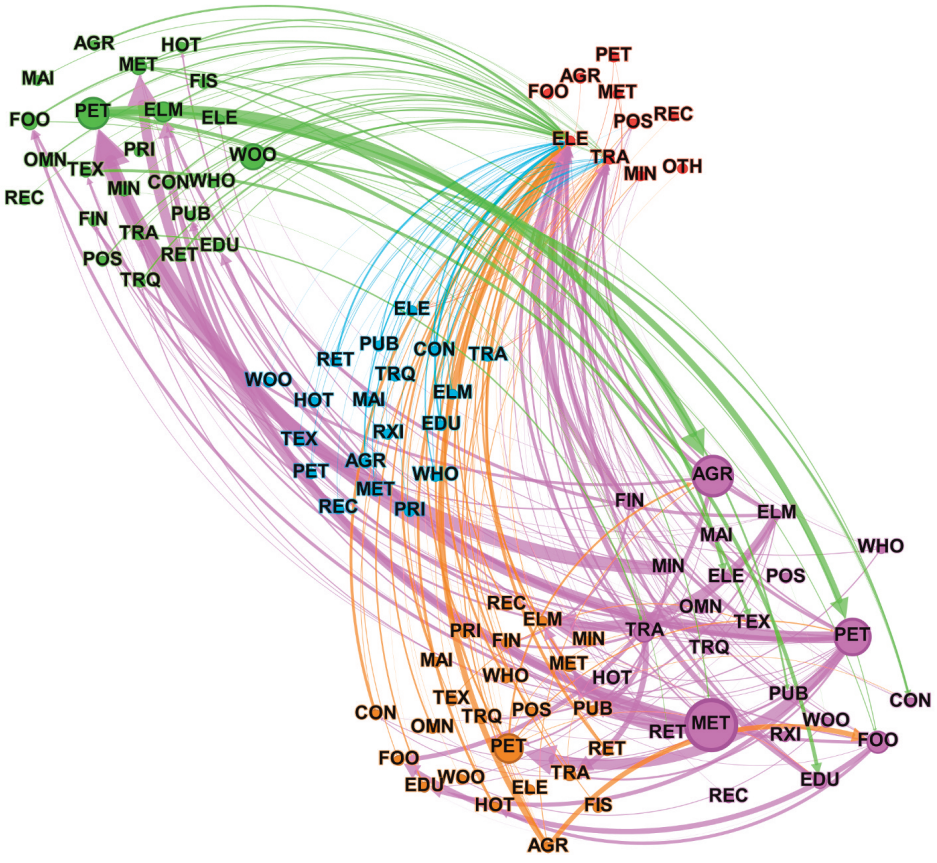
Graph 2: Weighted in degree




Source: Authors.

Electricity, Gas and Water (ELE) and Transport (TRA) in Serbia emerge as major hubs, receiving a substantial amount of inputs from multiple industries across the network. Notably, these industries absorb a significant volume of connections originating from Montenegro (MNE) and Albania (ALB), which highlights their central role in processing or utilising imports from these countries. Furthermore, Bosnia and Herzegovina (BIH) also channels a high number of connections to ELE and TRA, reinforcing their critical position within the regional supply chain.

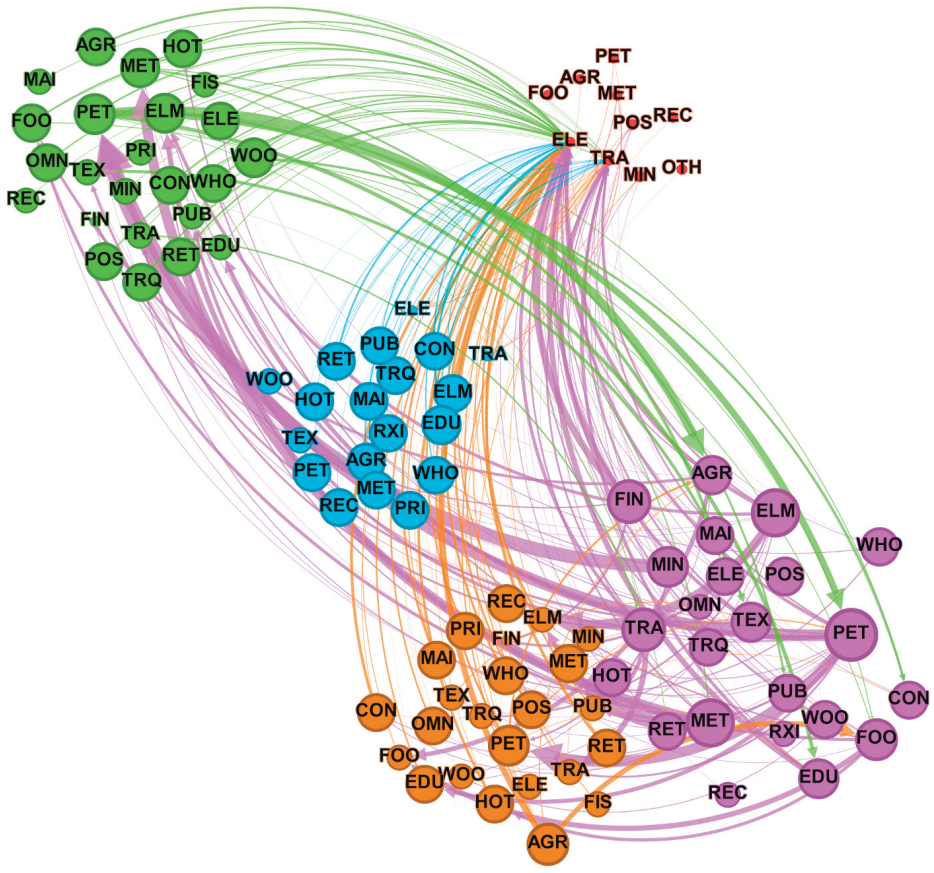
Graph 3: Betweenness centrality




Source: Authors.

In this betweenness centrality graph, Metal Products (MET) in North Macedonia (MKD) stands out as a pivotal industry, serving as a key intermediary that facilitates connections across different industries within the network. Its high betweenness centrality indicates its critical role in linking various sectors, potentially making it a bottleneck for regional value flows if disrupted. Additionally, Petroleum, Chemical, and Non-Metallic Mineral Products (PET) in Albania (ALB), North Macedonia (MKD), and Bosnia and Herzegovina (BIH) also exhibit elevated betweenness centrality. That suggests that PET in these countries holds a significant intermediary position within the network, underscoring its importance in maintaining efficient connectivity across industries in the region.

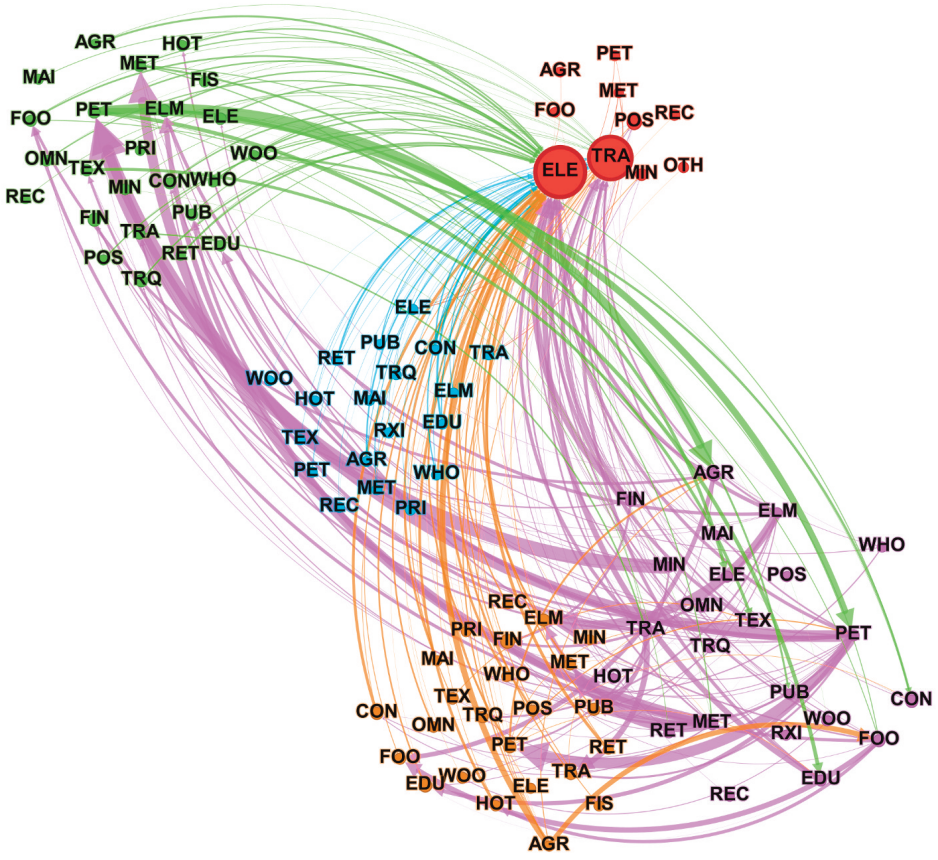
Graph 4: Hub




Source: Authors.

We observe that most countries in the network—Albania (ALB), Bosnia and Herzegovina (BIH), Montenegro (MNE), and North Macedonia (MKD)—exhibit high hub scores, represented by larger node sizes. In contrast, Serbia (SRB) shows noticeably lower hub scores, suggesting that its industries are less central in initiating connections within the regional trade network. This discrepancy indicates a different structural role for Serbian industries, reflecting more reliance on inbound connections or a lesser degree of influence in driving value chain flows outward. It is also connected with Serbian dependency on trade out of the region, especially with the EU.

Graph 5: Authority




Source: Authors.

Analysing the authority score, we see again the prominence of Serbia's Electricity (ELE) and Transport (TRA) industries. That reaffirms their critical role as central nodes attracting substantial trade and value chain dependencies from other industries across the region, positioning them as significant areas of economic activity and interconnectivity.

## Discussion and Implications

Regarding the ELE industry, all WB economies must enhance the energy sector's contribution to economic growth by improving energy efficiency, increasing energy security, and attracting investments in new capacities. That requires strengthening the internal market, restructuring public enterprises,

adjusting energy prices, advancing the decarbonisation process, and expanding the use of renewable energy sources. Additionally, these economies must align their national legislation with the EU acquis and deepen regional cooperation. MKD's economy remains highly dependent on energy imports, characterised by high energy intensity, inefficiencies in ageing energy production systems, and continued reliance on highly polluting coal. Furthermore, inefficient energy use exacerbates these challenges, underscoring the need for systemic reforms.

The energy sector in SRB accounts for about 4% of GDP, and coal-fired thermal power plants produced 66%, hydropower plants 26.1%, thermal power plants – heating plants 3.3%, wind power plants 2.7%, and other power plants 1.9% of electricity in 2022 (Serbian Chamber of Commerce and Industry 2024). For MNE's energy consumption, one of the main challenges is the insufficient level of energy efficiency and high energy intensity of its industry. MNE is facing a challenge of carbon intensity and has limited support mechanisms for the decarbonisation of the economy. In BIH's energy sector, the agriculture, industry, and transport sectors are the largest polluters and emitters of carbon dioxide (70% of total emissions related to energy, despite the share of renewable energy sources). One-third of electricity comes from hydropower potential. BiH's economy is highly energy-intensive (three times more than the EU average). ALB is a net importer of electricity. Both countries are vulnerable to hydrological conditions and insufficient to meet their energy supply needs. Dependence on energy imports accounts for 20-30% of the energy demand. For some WB economies, ensuring power supply security is the challenge, where Serbia holds the highest potential within the region.

On the other hand, transportation with warehousing and logistics is important for the WB economies concerning the increased openness to trade, FDIs, and integration in international supply chains. It has a significant impact on international trade and the economic development of the region. As all WB economies are small and open, the development of transportation and logistics quality is important for increasing trade flows domestically, regionally, and globally, as well as for improving their level of competitiveness. Efficient movement of goods and services is particularly important not only for landlocked economies (BiH, MKD, and SRB) but also for the economies with access to the sea (ALB and MNE). The average share of Transport and Warehousing in GDP in the WB is 3.5% (2021). It used to be higher in the pre-COVID-19 periods (3.7% in 2019). The total number of employees in Transport within the WB economies is 338,200 (2022). SRB has the most employees (157,600), which explains their level of importance in this sector.

The economies within the WB also heavily depend on the Petroleum, Chemical, and Non-Metallic Mineral Products (PET) and Metal Products (MET) industries in North Macedonia. They stand as key output providers and primary

suppliers across the network. Besides, the Agriculture (AGR) in North Macedonia and the Petroleum (PET) industry in Bosnia and Herzegovina play a notable role in connecting disparate sectors, according to our network analysis results. The other two countries, Montenegro and Albania, do not stand out with dominant industries in this context, primarily due to the size of these economies and the primary focus on tourism. As for the connection of individual industries, it is noticeable that the highest connection is with Serbia, as the largest economy in the region. Links from Montenegro and Albania are mostly directed exclusively towards Serbia, while among other countries, there is a significant connection of industries from Bosnia and Herzegovina and North Macedonia.

One recommendation from previous studies regarding industrial networks (Chopra and Khanna 2014) is to design new strategies. Increasing diversity, redundancy, and multifunctionality are important to ensure flexibility and to develop resilient and sustainable industrial symbiotic networks. On the other hand, Nuss, Graedel, Alonso, and Carroll (2016) conclude that the network analysis of supply chains could be combined with criticality and scenario analyses for raw materials to comprise a comprehensive picture of product platform risk. These ideas can be considered in the example of the WB industries to improve the stability of the supply chains within the region. In addition, the high density of the agricultural sector in the observed countries is in line with their level of development, which is explained by previous evidence, also based on the network analysis, which shows that when the development level increases, the role of agriculture as an exporter declines (Soyyiğit and Çırpıcı 2017). As they found, service sectors in developed countries have an important role. In developing countries, that is the food sector. Also, the results found the transportation sector to be one of the most important in terms of imports in different countries' samples.

## Conclusion

The obtained results indicate trade patterns, supply and value chains, and the dominance of certain industries within the WB region. Our analysis confirms the key role of individual industries from Serbia as the largest economy in the region. The most important implications can be drawn for Serbia's Electricity, Gas, and Water (ELE) and Transport (TRA) industries. Greater attention directed towards these sectors can bring even greater dominance in the region. These findings can have wider strategic significance and be useful as key implications in the creation of future regional policy. They also indicate the need for more active involvement of other industries at this level. On the other hand, the high level of In-Degree scores shows the high dependence of these industries on inflows from other countries in the region. That represents the level of dependency on the products and services from other industries. That may be a consequence of

Serbia's main focus on other markets, primarily the EU, while key import resources may be sought in the region.

Potential differences in the sense of dominance of certain industries concerning raw data for import and export are a consequence of the data used. We use input-output tables, showing the participation of these industries in movements exclusively within the region and the dependence of the observed sectors. The main limitation of the research is the limited availability of the required data for the WB in recent years. However, given the relatively stable patterns of trade structure within the WB region, that should not represent a significant problem in providing insights and policy recommendations. Also, the applied methodology has great potential in observing relations at the level of other countries and integrations, where significant insights and implications can be drawn and compared with current industrial and trade policies. A larger number of countries and a different focus on individual industries could be a key direction for future research.

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## APPENDIX

### Appendix 1. Industry Abbreviations

| Abbreviation | Industry |
|---|---|
| AGR | Agriculture |
| FIS | Fishing |
| MIN | Mining and Quarrying |
| FOO | Food and Beverages |
| TEX | Textiles and Wearing Apparel |
| WOO | Wood and Paper |
| PET | Petroleum, Chemical and Non-Metallic Mineral Products |
| MET | Metal Products |
| ELM | Electrical and Machinery |
| TRQ | Transport Equipment |
| OMN | Other Manufacturing |
| REC | Recycling |
| ELE | Electricity, Gas and Water |
| CON | Construction |
| MAI | Maintenance and Repair |
| WHO | Wholesale Trade |
| RET | Retail Trade |
| HOT | Hotels and Restaurants |
| TRA | Transport |
| POS | Post and Telecommunications |
| FIN | Financial Intermediation and Business Activities |
| PUB | Public Administration |
| EDU | Education, Health and Other Services |
| PRI | Private Households |
| OTH | Others |
| RXI | Re-export and Re-import |

## ISTRAŽIVANJE VEZA IZMEĐU INDUSTRIJA U ZEMLJAMA ZAPADNOG BALKANA: MREŽNA ANALIZA

**Apstrakt**: Ova studija koristi okvir mrežne analize za procenu ekonomskih ranjivosti unutar lanaca vrednosti Zapadnog Balkana (ZB), fokusirajući se na Srbiju, Severnu Makedoniju, Albaniju, Bosnu i Hercegovinu i Crnu Goru. Cilj je da se identifikuju industrije kritične za strukturni integritet mreže i procene potencijalni uticaji poremećaja. Ovaj pristup pruža nove dokaze u veze između zemalja ZB i industrija u regionu, na osnovu ulaznih/izlaznih podataka za svaki sektor. Podaci o bilateralnoj trgovini često izostavljaju te uvide i ne pružaju dokaze o nivou međupovezanosti između industrija. Naši nalazi ukazuju na dominantan značaj srpske industrije Električne energije, gasa i vode (ELE), kao i Transporta (TRA). Takođe, nekoliko industrija iz Severne Makedonije se pokazuju kao važne u regionu. Dobijeni rezultati se mogu koristiti za reviziju i prilagođavanje industrijske i trgovinske politike u zemljama ZB. Identifikovana međusobna povezanost je značajna za poboljšanje položaja zemalja u međunarodnim okvirima i njihovih mogućnosti za aktivnije učešće u lancima vrednosti.

**Ključne reči**: pristup mrežne analize; Zapadni Balkan; industrija; trgovina; lanci vrednosti.