# Canada's Production Network and Shock Transmission*

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**Abstract**

Canada's economy is made up of industries that depend on one another to produce goods and services. How these industries are connected determines how shocks, such as trade disruptions or supply shortages, spread across the economy. This paper presents the first comprehensive analysis of the Canadian production system that looks at both the structure of these connections and how disturbances move through them. We find that a small group of service sectors—Wholesale and Retail Trade, Finance and Insurance, and Professional Services—play a central role in the economy. Finance and Insurance acts as a critical hub, concentrating and amplifying shocks, while Wholesale and Retail Trade quickly spreads disturbances to other industries. Other sectors, such as construction, natural resources, and smaller manufacturing industries, have limited influence, meaning shocks originating there tend to stay localized. These results show that Canada's service-oriented economy, while efficient and highly integrated with the United States, contains concentrated points of vulnerability. Understanding which industries amplify or spread shocks provides important guidance for policymakers aiming to strengthen economic resilience and prepare for trade or policy disruptions.

*Keywords*: Canadian economy, Input–Output network, Economic shocks, Systemic risk Service sectors, Trade integration, Economic resilience

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# 1 Introduction

Modern production economies are best understood as networks: dense, weighted systems of interdependent industries linked through flows of intermediate goods, services, finance, and information. In such systems, aggregate outcomes are shaped not only by sectoral fundamentals but by the architecture of interconnections that governs how shocks propagate, where bottlenecks arise, and whether disturbances are absorbed or amplified into systemic events. A large and influential literature has shown that production networks fundamentally alter macroeconomic dynamics, overturning the classical presumption that idiosyncratic sectoral shocks diversify away in sufficiently large economies (Acemoglu et al., 2012; Carvalho, 2014; Jones, 2011). Instead, aggregate volatility, persistence, and fragility depend critically on the structure of inter-industry linkages and the concentration of flows through key sectors (Gabaix, 2011; Baqaee and Farhi, 2019). Yet despite these advances, we still lack a comprehensive, contemporary, economy-wide network analysis for Canada. This omission is striking given Canada's high degree of openness, its deep integration into global value chains, and its pronounced dependence on the United States. This paper fills that gap by providing the first integrated structural and dynamic mapping of the Canadian production network using modern network tools applied to detailed Input–Output data.

The Canadian case is economically consequential. Canada is a mid-sized, highly open economy whose production system has been shaped for decades by tight integration with the United States. From the Auto Pact of the 1960s, through NAFTA and its successor agreements, Canadian industries have evolved in close symbiosis with U.S. demand, logistics, and financial intermediation (Trefler, 2004; Baldwin, 2016). This integration has delivered scale and efficiency, but it has also created structural exposure. Recent episodes of trade conflict—most notably the imposition and threat of U.S. tariffs on Canadian steel, aluminum, and manufactured inputs during the Trump administration—made clear how rapidly policy shocks originating abroad can reverberate through domestic production chains. These events underscore a fundamental but unresolved question for Canada: which sectors transmit external shocks most forcefully, and which sectors dampen or localize them? Answering this question requires understanding not just bilateral trade flows, but the full domestic network through which disturbances propagate.

Network economics provides a natural framework for addressing these issues. Seminal work by Acemoglu et al. (2012) demonstrated that idiosyncratic shocks hitting highly connected or strategically located industries can generate large aggregate fluctuations. Carvalho (2014) formalized these propagation mechanisms, showing that the magnitude and persistence of aggregate effects depend on the structure of inter-industry linkages and the presence of dominant suppliers. Subsequent research has emphasized that shock transmission is governed not only by connectivity, but also by structural asymmetries, substitution elasticities, and bottleneck sectors that concentrate flows and amplify disturbances (Baqaee and Farhi, 2019; Oberfield, 2018). Empirical studies confirm the relevance of these mechanisms across countries and contexts, highlighting the macroeconomic importance of granular production structures and key intermediary sectors (Foerster et al., 2011; di Giovanni et al., 2014; Barrot and Sauvagnat, 2016a). However, this literature remains heavily

skewed toward large economies, with little systematic evidence for countries like Canada.

This paper contributes by bringing these insights to the Canadian context and by explicitly linking structure to function. We ask two closely related questions. First, how is the Canadian production system organized when inter-industry relationships are viewed as a weighted network rather than as isolated bilateral transactions? Second, which sectors function as bottlenecks, accelerators, or stabilizers of economic flows, and what does this imply for Canada's vulnerability to external shocks, particularly those originating in the United States? These questions are not merely descriptive. They speak directly to industrial resilience, trade exposure, and the design of policies aimed at mitigating systemic risk in an environment of persistent trade and geopolitical uncertainty.

Methodologically, we combine traditional network measures with dynamic propagation metrics to distinguish between static importance and functional influence. Using symmetric Canadian Input–Output tables, we construct a weighted, directed production network and compute standard structural indicators—degree, strength, eigenvector centrality, and betweenness—to characterize the network's architecture. We then introduce dynamic measures derived from a sectoral random-walk framework: Random Walk Centrality (RWC), which captures the speed with which shocks diffuse through the network, and Counting Betweenness Edge Transmission (CBET), which measures the concentration of flows through sectors acting as conduits. Random-walk methods are particularly well suited to Input–Output systems because they account for the full set of possible propagation paths rather than focusing on shortest routes alone (Newman, 2005a; Schweitzer et al., 2009a; Cerina et al., 2015a). This integrated approach allows us to move beyond identifying "large" or "central" sectors and instead uncover the mechanisms through which shocks spread.

Our findings reveal a sharply asymmetric core–periphery structure in the Canadian production network. Although the network is topologically dense, transaction intensities are highly concentrated. A small cluster of service sectors—Wholesale & Retail Trade, Finance & Insurance, and Professional Services—forms the core of the system, mediating a disproportionate share of domestic economic flows. Dynamic analysis shows that these sectors occupy distinct functional roles. Finance & Insurance emerges as the primary bottleneck, concentrating flows and amplifying disturbances, while Wholesale & Retail Trade acts as a distribution accelerator, enabling shocks to diffuse rapidly across the economy. Professional Services complements these roles by coordinating knowledge- and business-intensive inputs across sectors. This configuration implies that the same service-based architecture that underpins Canada's efficiency and integration with U.S. markets also constitutes a source of systemic vulnerability when shocks strike the core.

By documenting these patterns, the paper makes two main contributions. First, it provides the most comprehensive and up-to-date network-based characterization of the Canadian production system, filling a longstanding empirical gap in the literature on production networks. Second, it offers a functional classification of sectors based on their dynamic roles in shock transmission, yielding a mechanism-rich perspective on systemic risk. These insights are directly relevant for trade, industrial, and resilience policy in Canada, particularly in a context of ongoing uncertainty in Canada–U.S. economic relations.

**Related Literature.** The study of production networks has fundamentally reshaped our understanding of macroeconomic volatility and systemic risk. Early work emphasized that the architecture of inter-industry linkages matters for aggregate outcomes: shocks hitting highly connected or strategically positioned sectors can generate substantial economy-wide fluctuations, contrary to classical assumptions of diversification in large economies (Acemoglu et al., 2012; Carvalho, 2014). These insights established network structure as a first-order determinant of macroeconomic resilience, highlighting the importance of understanding not just the presence of connections but their configuration and intensity.

Building on this foundation, subsequent research examined the mechanisms through which shocks propagate. Baqaee and Farhi (2019) and Oberfield (2018) demonstrate that the impact of a sectoral disturbance depends not only on connectivity but also on structural asymmetries, substitution elasticities, and the presence of bottleneck suppliers. Dominant sectors can concentrate flows, amplifying the effects of local shocks across the economy. Similarly, studies by Gabaix (2011) and Jones (2011) underscore that aggregate volatility is often driven by a small set of granular sectors whose propagation effects dominate, suggesting that systemic risk is deeply embedded in network topology rather than in aggregate diversification alone. These works collectively motivate the focus on both structural and functional characteristics of sectors when analyzing resilience.

Parallel to these theoretical advances, methodological research has progressively moved from static to dynamic analyses of networks. Traditional centrality measures, including degree, betweenness, and eigenvector centrality, provide useful information on a sector's positional importance (Freeman, 1978; Bonacich, 1987), but they are inherently static and cannot fully capture how shocks unfold over time. Scholars have emphasized that structural prominence does not always translate into functional influence (Borgatti and Everett, 2006). Random-walk approaches and stochastic network models have emerged as powerful alternatives, tracing the diffusion of shocks through all feasible paths in a network rather than only shortest routes. Newman (2005b), Schweitzer et al. (2009b), and Cerina et al. (2015b) show that such dynamic metrics are particularly well suited to input-output networks, capturing both cumulative and indirect effects of disturbances.

Dynamic approaches also enable a functional classification of sectors. By measuring how shocks traverse networks probabilistically, researchers can identify which sectors act as bottlenecks, accelerators, or stabilizers of economic flows. This perspective moves beyond ranking sectors by size or connectivity, revealing the mechanisms through which disturbances propagate and accumulate—a critical distinction for understanding systemic risk and resilience.

Despite these advances, empirical work on Canadian production networks is limited and fragmented. Existing studies often focus on specific sectors or regions rather than the economy as a whole. Rutherford and Holmes (2008) analyze intersectoral linkages in the automotive industry, while Matthews et al. (2007) examine energy use and greenhouse gas emissions across Canadian and U.S. manufacturing and resource sectors, highlighting sectoral heterogeneity. Leung and Secrieru (2011) extend the input-output framework by incorporating financial and income flows, showing that financial intermediation amplifies the impact of final-demand shocks. While informative, these contributions remain static and do not capture dynamic propagation patterns or the economy-wide

network architecture that is central to systemic risk.

Taken together, this literature establishes a clear gap. There is no comprehensive, contemporary, economy-wide analysis of the Canadian production network that integrates both structural and dynamic perspectives. This gap is particularly salient given Canada's status as a mid-sized, open economy with a service-intensive production structure and deep integration with the United States. Without such an analysis, it remains unclear which sectors are central to the propagation of shocks, and which can buffer or stabilize the system under trade and policy disturbances.

This paper addresses this gap by providing a unified structural and dynamic mapping of the Canadian production network. Using detailed Input–Output data, we combine traditional network measures—strength, degree, betweenness, and eigenvector centrality—with dynamic random-walk metrics, including Random Walk Centrality (RWC) and Counting Betweenness Edge Transmission (CBET). This approach allows us to distinguish between static structural importance and functional influence in shock propagation. Our analysis uncovers a sharply asymmetric core–periphery architecture, in which a small cluster of service sectors—Wholesale and Retail Trade, Finance and Insurance, and Professional Services—mediate, accelerate, and amplify flows, shaping the economy's systemic risk profile. By linking structural position to functional roles, we offer a mechanism-rich understanding of resilience in the contemporary Canadian economy.

**Outline.** The remainder of the paper proceeds as follows. Section 2 describes the Canadian Input–Output data, network construction, and empirical methodology. Section 3 presents the structural and dynamic findings, highlighting the core–periphery organization and functional roles of key sectors. Section 4 concludes and draws policy implications, emphasizing strategies for mitigating vulnerabilities arising from Canada's deep integration with U.S. markets.

## 2 Data and Methodology

Understanding the Canadian production network requires both detailed sectoral data and a careful methodological framework. This section describes the data sources, the transformations applied to construct the network, and the analytical techniques used to uncover structural and dynamic properties of the economy.

### 2.1 Data

Our analysis relies on the OECD Inter-Country Input-Output (ICIO) Tables, a harmonized and comprehensive database designed for cross-country economic research. These tables provide a detailed mapping of goods and services flows between industries and countries, making it possible to capture interdependencies across sectors. For Canada, the ICIO database covers fifty sectors classified according to ISIC Rev.4, encompassing primary industries, manufacturing, utilities, services, and government activities, thereby offering a complete view of the national production system.

The ICIO database records annual input-output relationships among industries and countries, expressed in monetary terms. Each matrix entry indicates the value of inputs purchased by one sector from another, either domestically or internationally. In Canada, each of the fifty sectors is identified by a standardized code (for example, Canada_C20 for chemical manufacturing), and the dataset provides both transaction values and the derived technical coefficients that measure the intensity of inter-sectoral linkages.

The technical coefficient matrix is central to our analysis. It is computed by normalizing each column of the transaction matrix by the total output of the corresponding sector. In this formulation, each element $a_{ij}$ represents the proportion of inputs in sector $i$'s output originating from sector $j$. These coefficients encode inter-industry dependencies and form the quantitative basis for constructing a weighted network representation of the Canadian economy.

To prepare the data for network analysis, we performed several transformations. First, we excluded the sector Canada_T, representing household activities as employers and undifferentiated production for own use, since it consistently reports zero values across the matrix and contributes no measurable inter-industry flows.

Next, we extracted the domestic technical coefficient matrix for Canada, focusing exclusively on inter-industry transactions. In the resulting network, each node represents a sector, each directed edge represents the flow of inputs from one sector to another, and each edge weight corresponds to the technical coefficient, quantifying the share of inputs relative to the receiving sector's output.

These transformations produce a directed, weighted network suitable for analysis. This network enables the application of structural and dynamic measures, including centrality, clustering, and community detection, providing insights into the organization and functional roles of Canadian sectors.

### 2.2 Network Metrics

To investigate the structure and systemic importance of sectors within the Canadian economy, we employ a network analysis approach grounded in Input-Output data. This framework allows us to quantify inter-industry dependencies and identify sectors that play critical roles in shaping the flow of economic activity.

The production system is represented as a directed, weighted network $G = (V, E)$. Nodes $V$ correspond to the economic sectors of the Canadian IO table, while directed edges $E$ capture the flow of intermediate goods and services from one sector to another. Edge weights $w_{ij}$ are given by the technical coefficients, which quantify the intensity of sectoral linkages. This formulation provides a rigorous foundation for applying graph-theoretic metrics to assess sectoral importance and influence.

Network metrics allow us to characterize the role of each sector within the production network and interpret its potential impact on systemic stability. We consider both standard connectivity measures and derived indicators that capture propagative effects.

**Connectivity: Degree and Strength.** Connectivity is measured through unweighted degree metrics and weighted strength measures. The in-degree $k_{in}$ counts the number of upstream suppliers, reflecting the diversity of a sector's input sources, while the out-degree $k_{out}$ counts downstream users, indicating the breadth of its supply base. In practice, the IO network's near-complete topology renders degree values nearly uniform, limiting discrimination.

Weighted variants—In-Strength $s_{in}$ and Out-Strength $s_{out}$—provide a more informative perspective. The in-strength measures the total incoming flows, capturing backward linkages and total intermediate input consumption:

$$s_{in} = \sum_{j} w_{ji} \tag{1}$$

Out-strength captures total outgoing flows, reflecting forward linkages and the provision of intermediate outputs:

$$s_{out} = \sum_{j} w_{ij} \tag{2}$$

The total strength $S_{total} = s_{in} + s_{out}$ indicates a sector's overall economic weight within the network:

$$S_{total} = s_{in} + s_{out} \tag{3}$$

**Derived Propagative Power.** To assess a sector's role in shock propagation, we define the Sectoral Influence Index (SII) as the ratio of out-strength to in-strength:

$$\text{SII} = \frac{s_{out}}{s_{in}} \tag{4}$$

An SII greater than one identifies net intermediate suppliers, while values below one indicate net consumers. This measure captures a sector's ability to transmit or absorb shocks, offering insight into the functional role of each industry in the network.

**Centrality Metrics.** Centrality measures identify sectors that occupy structurally important positions. Betweenness centrality $C_B$ quantifies the extent to which a sector lies on shortest paths connecting other sectors:

$$C_B(i) = \sum_{s \neq i \neq t} \frac{\sigma_{st}(i)}{\sigma_{st}} \tag{5}$$

Here, $\sigma_{st}$ is the total number of shortest paths from $s$ to $t$, and $\sigma_{st}(i)$ counts those paths passing through $i$. Using the inverse of edge weights ($1/w_{ij}$) as distances ensures stronger economic linkages correspond to shorter effective paths, highlighting bridging sectors or bottlenecks.

Closeness centrality $C_C$ measures how quickly a sector can access or influence others:

$$C_C(i) = \frac{n-1}{\sum_{j \neq i} d(i,j)} \tag{6}$$

where $d(i,j)$ is the shortest-path distance, and $n$ is the total number of sectors. High closeness identifies sectors capable of rapid response or transmission of shocks.

Eigenvector centrality $C_E$ captures recursive influence, assigning higher scores to sectors connected to other influential sectors:

$$C_E(i) = \frac{1}{\lambda} \sum_j w_{ij} C_E(j) \tag{7}$$

Hub and Authority scores $C_H$ and $C_A$, derived from the HITS algorithm, describe bidirectional dependencies:

$$C_H(i) = \sum_j w_{ij} C_A(j), \quad C_A(i) = \sum_j w_{ji} C_H(j) \tag{8}$$

Hubs are key suppliers serving important consumers, while authorities rely heavily on influential suppliers. Local clustering coefficients provide a measure of local cohesion, reflecting the likelihood that neighboring sectors are interconnected, which corresponds to redundancy in supply chains.

**Limitations of Traditional Network Metrics in IO Analysis.** Despite their utility, traditional metrics face limitations in dense IO networks. High density diminishes the discriminatory power of degree and path-based measures. Weighted measures may overemphasize single "shortest" paths, neglecting alternative routes. Intra-sectoral transactions ($w_{ii}$) introduce recursive loops that standard algorithms often ignore, limiting the realism of structural interpretations.

### 2.3 Random Walk Framework for IO Networks

To overcome these limitations, we implement random walk-based centrality measures that incorporate both the magnitude of flows and the dynamic propagation of shocks. The framework treats a "walker," representing a unit of demand or a shock, moving stochastically across sectors according to transition probabilities derived from the technical coefficients:

$$P_{ij} = \frac{w_{ij}}{\sum_k w_{ik}} \tag{9}$$

This transition matrix encodes both the network's structure and the intensity of intersectoral linkages.

**Random Walk-Based Centrality Measures.** Two indicators are computed. Random Walk Centrality (RWC), the inverse of the mean first passage time to a node, reflects immediate shock effects and

sectoral responsiveness. Counting Betweenness (CBET) measures how frequently a sector is visited on first-passage random walks, capturing its mediative role in propagating economic influence.

**Advantages of Random Walk Metrics.** Random walk-based measures capture all possible paths rather than only shortest paths, providing a more realistic depiction of systemic influence. They offer a dynamic view of sectoral interactions: RWC highlights sectors most immediately affected by shocks, while CBET identifies sectors that serve as persistent conduits. Importantly, the framework incorporates intra-sectoral feedback ($w_{ii}$), reflecting loops within production processes that traditional metrics neglect.

# 3 Results

This section presents the main findings on how industries in Canada are connected through production and trade. We show how some sectors play a central role in moving goods, services, and payments across the economy, while others remain more isolated. The results clarify which industries matter most for spreading economic shocks and why.

## 3.1 Network Analysis of Sectoral Linkages

The Canadian input–output (IO) system comprising 49 sectors forms, from a purely topological perspective, a fully connected network in which every sector is linked as both a supplier and a consumer of intermediate inputs. Such complete connectivity, however, is largely uninformative about the economic structure of the system. Meaningful differentiation emerges only once linkages are weighted by the intensity of monetary transactions. These weighted interactions reveal a sharply defined core–periphery organization, consistent with production network theories emphasizing the role of heterogeneous link strengths in shaping aggregate dynamics (Acemoglu et al., 2012; Carvalho, 2014).

Weighted connectivity captures the total magnitude of intersectoral transactions and provides a natural way to identify the most active suppliers and consumers in the economy. Figure 1 situates each sector according to its in-strength and out-strength, with bubble size reflecting total strength and color indicating the Influence Index. This representation highlights a pronounced asymmetry in the distribution of connectivity across sectors.

On the supply side, Wholesale and Retail Trade emerges as the dominant provider of domestic intermediate inputs, with an out-strength far exceeding that of all other sectors. It is followed, at a considerable distance, by Finance and Insurance, Professional Services, Warehousing and Support Services, and Land Transport. Together, these activities form the backbone of the domestic supply network, channeling goods, coordination services, financial intermediation, and logistics across virtually all production stages. Their prominence aligns with evidence showing that disruptions in key intermediate service providers generate disproportionately large aggregate effects (Barrot and Sauvagnat, 2016b; Baqaee and Farhi, 2019).

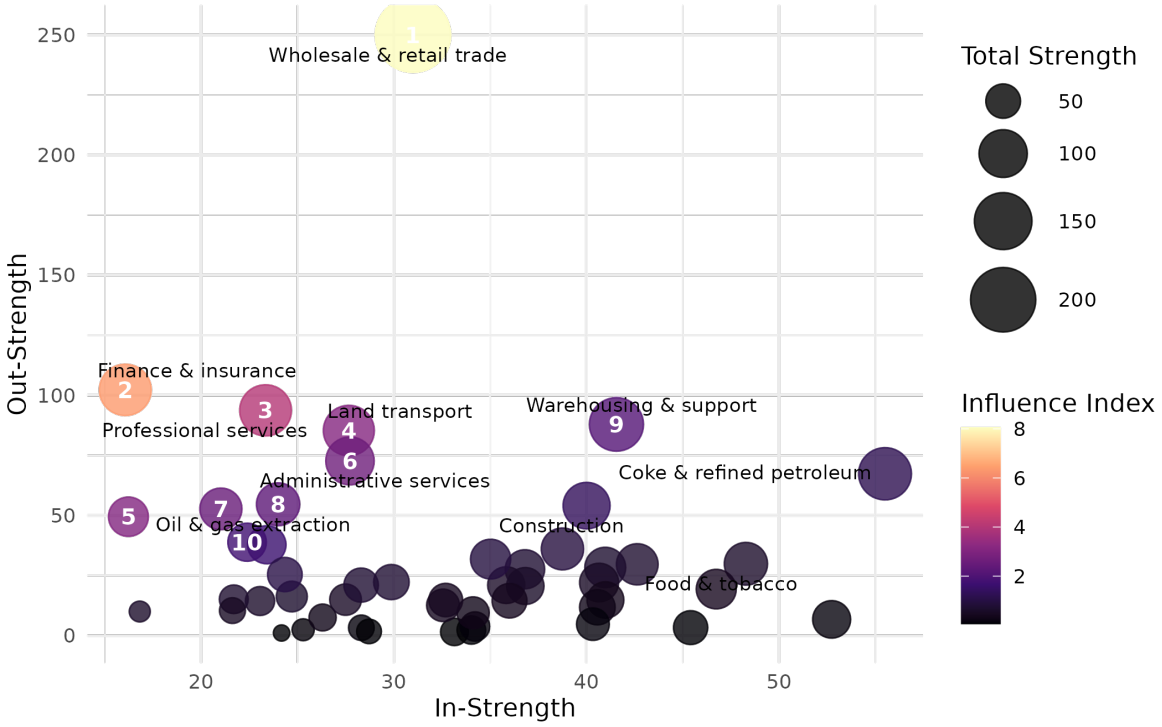


Figure 1: Strength metrics analysis: sector positioning by connectivity patterns

**Note:** This figure displays sectors according to their connectivity strengths. The horizontal axis reports in-strength, the vertical axis reports out-strength, bubble size represents total strength, and color corresponds to the Influence Index. Sector names are displayed for the ten sectors with the highest total strength, and numbers inside the bubbles indicate their ranking by influence.

On the demand side, Coke and Refined Petroleum, Air Transport, Accommodation and Food Services, Water Transport, and Basic Non-Ferrous Metals exhibit the highest in-strength values. Because the analysis relies on the domestic IO matrix, these patterns reflect sectors that rely most heavily on domestically supplied intermediate goods and services, making them particularly exposed to internal supply shocks.

Combining inflows and outflows into a single measure of total strength further sharpens the picture of network centrality. Wholesale and Retail Trade overwhelmingly dominates this ranking, followed by a second tier composed of Warehousing and Support Services, Coke and Refined Petroleum, Finance and Insurance, Professional Services, and Land Transport. Construction and Administrative Services also exhibit strong two-sided integration. Overall, the evidence confirms a production network in which distribution, logistics, finance, and business services constitute the central organizing forces of economic activity.

The Influence Index provides a complementary perspective by integrating upstream and downstream dependencies to assess a sector's potential to propagate shocks throughout the economy. Wholesale and Retail Trade again ranks as the most influential sector, followed by Finance and Insurance and Professional Services. Land Transport and Energy Supply also display

high influence values, reflecting their pivotal role in sustaining flows of goods, energy, and logistics across production chains. These sectors are structurally positioned to transmit disturbances widely due to their dense embedding on both the supply and demand sides of the network.

A second group of sectors—including Administrative Services, Real Estate, Oil and Gas Extraction, IT Services, and Metal Ore Mining—exhibits moderate influence. These activities anchor key segments of manufacturing, resource extraction, and advanced business services, acting as important intermediaries without dominating system-wide transmission. At the lower end of the distribution, Fishing, Pharmaceuticals, Shipbuilding, Textiles, and Water Transport display minimal influence, indicating limited propagation capacity beyond their immediate value chains.

Taken together, these findings underscore the primacy of service-oriented and distributional activities in shaping economic transmission channels in Canada. Influence is concentrated not in final-demand sectors, but in those that coordinate, finance, transport, and intermediate production across the economy.

The weighted network structure reveals a clear core–periphery configuration shaped jointly by transaction intensity and influence. At the core of the system lie Wholesale and Retail Trade, Finance and Insurance, Professional Services, Administrative Services, Land Transport, and Warehousing and Support Services. These sectors combine high total strength with high influence, positioning them as the primary coordination and transmission centers of the Canadian production network. Their role extends beyond scale, encompassing the facilitation of goods movement, capital allocation, information flows, and logistical coordination.

Surrounding this core is a semi-core composed of Energy Supply, Real Estate, Construction, Oil and Gas Extraction, and IT Services. These activities provide essential infrastructure, energy, property services, and advanced business inputs. Their intermediate influence reflects a bridging role, linking the central service hub to manufacturing and resource-based sectors.

The peripheral layer consists of Fishing, Textiles and Apparel, Shipbuilding, Education, Arts and Entertainment, and Health and Social Work. These sectors exhibit low levels of both strength and influence, reflecting more specialized or locally contained production processes with limited economy-wide propagation potential.

This structural interpretation is reinforced by the graphical representation of the network shown in Figure 2, constructed using the Fruchterman–Reingold algorithm (Fruchterman and Reingold, 1991). Each sector is represented by a node whose size reflects total strength and whose color captures influence, while directed edges represent intersectoral transactions weighted by technical coefficients.

The algorithm treats nodes as repelling particles while transaction links act as attractive forces, such that sectors with stronger and more numerous linkages are drawn closer together. As a result, highly interconnected service sectors cluster tightly at the center of the network, while more weakly connected activities are positioned toward the periphery. This spatial organization provides a visually intuitive confirmation of the core–periphery structure identified in the quantitative metrics.

Overall, the network visualization reinforces the conclusion that a relatively small set of intermediation sectors underpins systemic resilience and macroeconomic dynamics in the Canadian

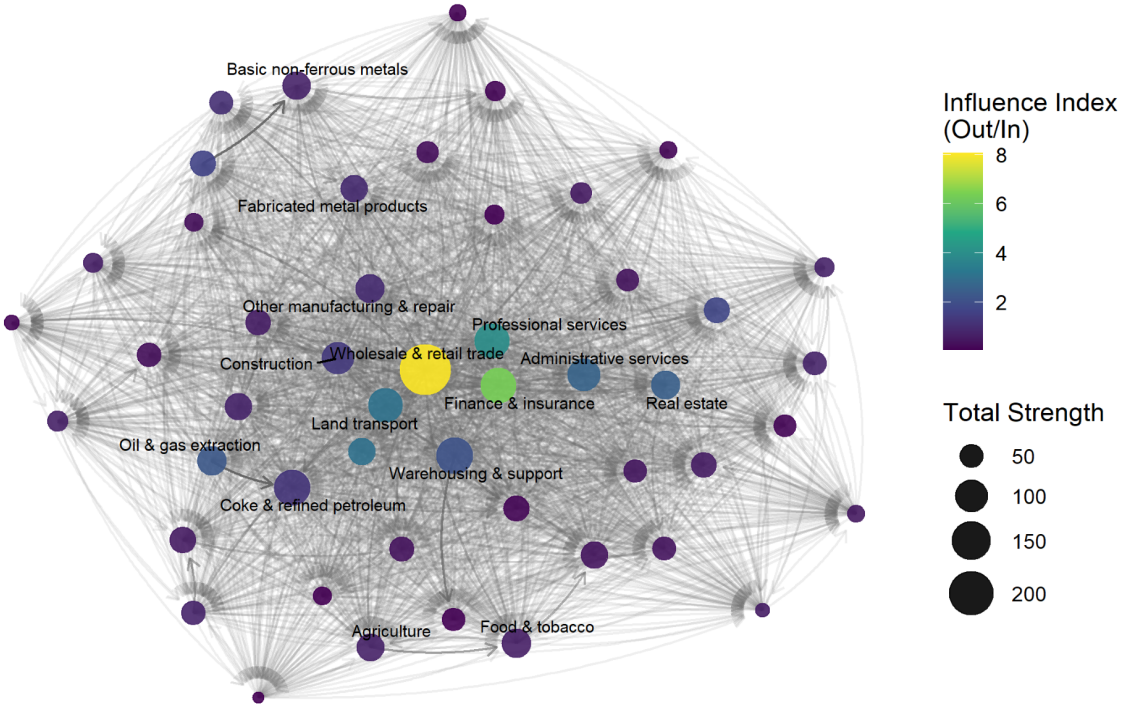


Figure 2: Canadian input–output network structure

**Note:** Nodes represent sectors, with size proportional to total strength and color indicating the Influence Index. Directed edges represent transactions between sectors, with thickness and shading (light to dark grey) proportional to the technical coefficient measuring the importance of the transaction for the destination sector.

economy, consistent with evidence from national production network studies (Acemoglu et al., 2012; Inoue and Todo, 2019).

The results demonstrate that structural asymmetries in the Canadian economy are driven primarily by differences in transaction intensity rather than by network topology. Even within a fully connected production network, heterogeneity in link weights generates a small cluster of systemically dominant sectors—notably Wholesale and Retail Trade, Finance and Insurance, and Professional Services—that anchor the entire production system. These sectors concentrate both upstream and downstream dependencies, giving rise to a hierarchical structure despite the absence of topological sparsity.

As a consequence, shocks originating in these central sectors are likely to generate disproportionately large macroeconomic effects. Their dense embedding within the production network allows disturbances to propagate rapidly through multiple layers of intermediate linkages, amplifying their aggregate impact (Carvalho, 2014). In contrast, shocks affecting peripheral industries tend to remain largely localized, producing limited spillovers beyond their immediate value chains.

Overall, the Canadian input–output network exhibits dense interconnectivity, yet its functioning is governed by a clear economic hierarchy. Trade, finance, logistics, and business services jointly

anchor the production system, shaping the circulation of goods, capital, and information across virtually all sectors.

### 3.2 Random Walk Centrality Analysis

**Dynamic Propagation Pathways.** Building on the weighted connectivity and structural analyses, we next employ random walk centrality measures to capture the dynamic propagation of economic shocks through the network. While static measures such as strength and influence identify transaction volumes and structural positioning, random walk–based metrics characterize the actual pathways and speed through which disturbances diffuse across sectors. This approach provides a dynamic perspective on how shocks originating in one sector may cascade throughout the economy (Newman, 2005b; Blöchl et al., 2011; De Paolis et al., 2022).

**Random Walk Centrality (RWC): The Velocity of Shock Transmission.** Random Walk Centrality measures the expected speed and efficiency with which a sector can reach all others through the network's transaction pathways. Sectors with higher RWC values act as rapid conduits for economic disturbances, enabling shocks to diffuse quickly across the production system.

| Sector | RWC Score | Rank |
|---|---|---|
| Wholesale & Retail Trade | 0.1017 | 1 |
| Finance & Insurance | 0.0828 | 2 |
| Professional Services | 0.0737 | 3 |
| Administrative Services | 0.0646 | 4 |
| Real Estate | 0.0506 | 5 |

The dominance of Wholesale and Retail Trade in RWC reinforces its role as the structural core of the network, while revealing an additional dynamic dimension: this sector functions as the primary accelerator of economic shocks. The consistent presence of service-oriented activities among the highest RWC values mirrors their dominance in strength metrics, confirming that the same sectors responsible for handling the largest transaction volumes also possess the fastest transmission capabilities.

**Counting Betweenness (CBET): The Concentration of Economic Flows.** Counting Betweenness captures the extent to which random walks pass through a given sector, identifying activities that function as critical bottlenecks within the network. Sectors with high CBET values concentrate economic flows and therefore have the potential to amplify disturbances.

| Sector | CBET Score | Rank |
|---|---|---|
| Finance & Insurance | 69.95 | 1 |
| Professional Services | 35.00 | 2 |

| Sector | CBET Score | Rank |
|---|---|---|
| Wholesale & Retail Trade | 34.79 | 3 |
| Administrative Services | 29.47 | 4 |
| IT Services | 26.27 | 5 |

Finance and Insurance emerges as the dominant flow concentrator, with a CBET value nearly twice that of the next-ranked sector. This finding reveals an amplification mechanism that is not fully apparent in static measures: while Wholesale and Retail Trade processes the largest volume of transactions, Finance and Insurance serves as the primary channel through which economy-wide flows are mediated and concentrated (Newman, 2005b).

Figure 3 synthesizes these dynamic dimensions by positioning sectors according to their shock transmission velocity and flow concentration.

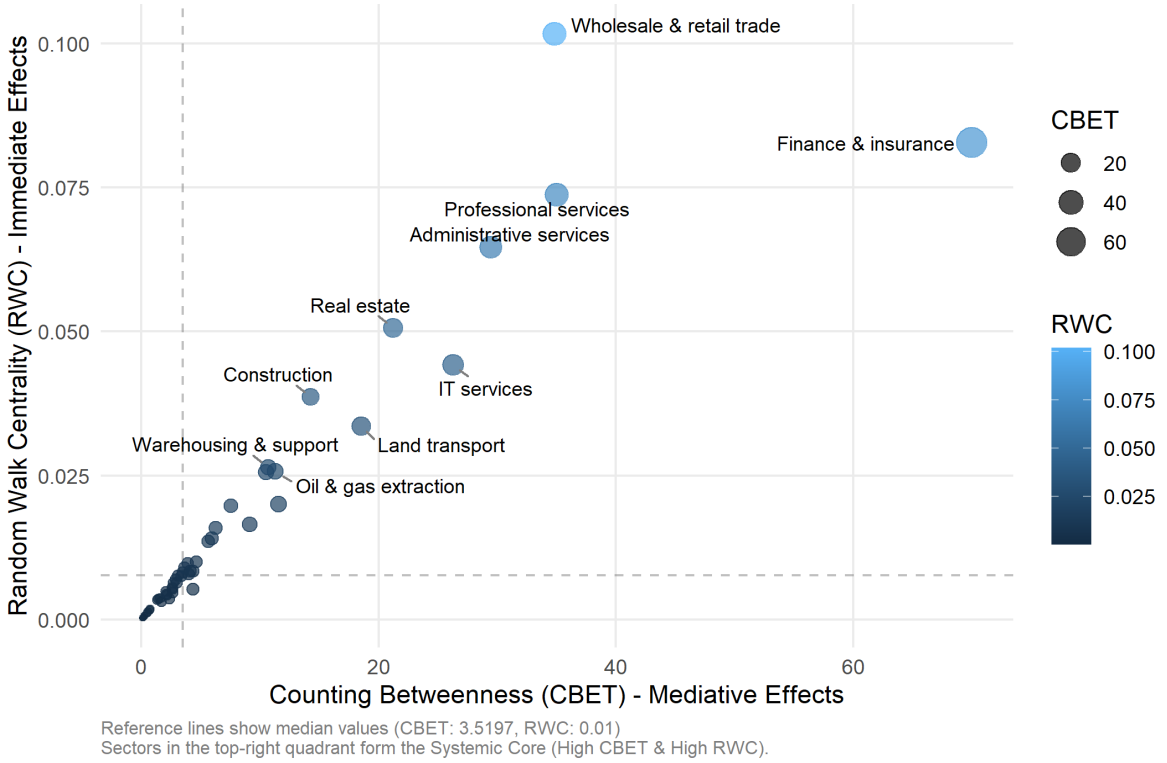


Figure 3: Dynamic Network Influence: Shock Transmission Velocity (RWC) versus Flow Concentration (CBET)

**Note:** This figure illustrates sectors according to random walk–based centrality measures. Bubble size reflects Random Walk Centrality (RWC), while color intensity corresponds to Counting Betweenness (CBET). Sector labels are shown for the ten sectors with the highest RWC values or the ten sectors with the highest CBET values.

The scatter plot reinforces the core–periphery structure identified earlier. The same service sectors—Wholesale and Retail Trade, Finance and Insurance, and Professional Services—cluster in the region characterized by both high transmission velocity and high flow concentration. Finance

and Insurance occupies an exceptional position along the CBET dimension, highlighting its unique role as both a transaction hub and the principal amplifier of economic flows. By contrast, sectors such as Construction and Real Estate, despite their strong integration in static strength metrics, occupy more moderate positions in the dynamic space, indicating that they function primarily as stable network anchors rather than rapid propagation channels.

**Dynamic Structural Interpretation.** Integrating Random Walk Centrality and Counting Betweenness with earlier structural measures reveals a coherent and internally consistent hierarchy within the Canadian production network. Together, these metrics identify not only which sectors are central, but also how shocks propagate and where economic flows are concentrated.

The dynamic core of the network consists of Finance and Insurance, Wholesale and Retail Trade, and Professional Services. Each occupies a distinct position within the dynamic spectrum, yet all combine rapid transmission capability with substantial flow-concentration effects. Finance and Insurance functions as a financial amplifier: its exceptionally high CBET indicates that a large share of economy-wide flows passes through its intermediation structure, while its elevated RWC underscores its ability to transmit shocks at high velocity. Wholesale and Retail Trade acts as a distribution accelerator, exhibiting the highest RWC in the network and enabling disturbances to diffuse quickly across sectors. Professional Services completes the dynamic core as a knowledge and coordination channel, displaying balanced strength across both dimensions.

Surrounding this core is a dynamic semi-core composed of sectors that provide more specialized propagation functions. IT Services operates as a digital conduit, with substantial betweenness positioning it as a bottleneck for information-intensive flows despite a moderate transmission speed. Administrative Services functions as an operational integrator, complementing core coordination with stable but less pronounced dynamic influence. Land Transportation and Warehousing and Support Services serve as physical distribution channels, mediating goods flows across regions and sectors with moderate velocity and substantial intermediation capacity.

Construction and Real Estate also occupy important positions within the semi-core. Although they do not match the transmission velocity or flow concentration of the dynamic core, their moderate-to-high CBET values and non-negligible RWC place them firmly within the upper-middle tier of the dynamic hierarchy. Construction operates as a material coordination node linking upstream resource sectors to downstream investment activity, while Real Estate functions as an asset-based connector between financial intermediation and production.

Resource-based sectors such as Coke and Refined Petroleum Products and Oil and Gas Extraction exhibit a different form of dynamic relevance. Their moderate RWC and CBET values indicate limited capacity for rapid shock diffusion, yet their role as suppliers of essential upstream inputs renders them structurally consequential. Their influence is therefore foundational rather than accelerative.

At the periphery of the dynamic structure lie sectors such as Fishing, Textiles, and Shipbuilding. These activities consistently display very low RWC and CBET values, indicating minimal involvement in both shock transmission and flow intermediation. Their weak dynamic profiles reinforce

their classification as peripheral contributors to the broader propagation architecture.

**Synthesis and Policy Implications.** The dynamic analysis complements and strengthens the static findings by confirming that the same service-oriented sectors dominate both transaction volumes and shock propagation mechanisms. The random walk results validate the core–periphery organization identified earlier, with service sectors governing not only the structure but also the dynamics of the network (Carvalho, 2014). While Wholesale and Retail Trade dominates transaction volumes and transmission speed, Finance and Insurance plays a uniquely critical role as the economy's primary flow concentrator and amplifier (Battiston et al., 2012).

This configuration creates a fundamental velocity–stability tradeoff. The service core's capacity for rapid transmission and flow concentration enhances efficiency but also increases vulnerability, as disturbances originating in these sectors can propagate with exceptional speed and magnitude (Acemoglu et al., 2012). At the same time, sectors such as Construction and Real Estate contribute stability by anchoring flows without acting as primary accelerators.

Taken together, the Canadian production network exhibits a coherent architecture in which coordination, transmission velocity, and amplification are concentrated within a small set of service-oriented activities. Systemic stability is therefore intrinsically linked to the coordinated functioning of this core, highlighting the importance of targeted monitoring, protection, and resilience policies focused on the financial and business-service nexus.

## 4 Conclusion

This paper provides the first comprehensive, economy-wide analysis of the Canadian production network that integrates both structural and dynamic perspectives. By representing interindustry linkages as a weighted network and combining traditional centrality measures with random-walk–based metrics, we distinguish between static structural importance and functional influence in shock propagation. Our results reveal a sharply asymmetric core–periphery architecture, dominated by a small cluster of service sectors—Wholesale and Retail Trade, Finance and Insurance, and Professional Services—that mediate, accelerate, and amplify economic flows across the entire economy.

The dynamic analysis demonstrates that these core sectors perform complementary functions: Finance and Insurance operates as a critical bottleneck, concentrating and amplifying shocks, while Wholesale and Retail Trade serves as a primary accelerator, rapidly diffusing disturbances throughout the network. Peripheral sectors, by contrast, have minimal systemic influence, indicating that shocks originating outside the core remain largely localized. These findings underscore a fundamental trade-off inherent in Canada's production system: the same service-based architecture that supports efficiency, integration with U.S. markets, and coordination of domestic flows also generates points of systemic vulnerability when external or domestic shocks strike the core.

Our study contributes to the literature in three ways. First, it provides a detailed, contemporary mapping of the Canadian production network, moving beyond sectoral or environmental case

studies to capture economy-wide interdependencies. Second, it integrates static and dynamic metrics to uncover functional roles of sectors in shock propagation, offering a mechanism-rich perspective on systemic risk. Third, by connecting network position to functional influence, the analysis delivers actionable insights for resilience-oriented policy design, including targeted monitoring of financial and trade hubs, protection of service-core functions, and reinforcement of stability anchors in construction, transportation, and real estate.

These results have clear policy implications. Canada's deep integration with the U.S., combined with the hierarchical service-oriented structure of its production network, implies that trade or policy shocks originating abroad can propagate rapidly and disproportionately through the domestic economy. Policymakers seeking to enhance resilience should prioritize interventions that reinforce the stability of core sectors, manage exposure to concentrated flows, and enhance the absorptive capacity of peripheral sectors. More broadly, the framework developed here can serve as a blueprint for monitoring systemic risk in mid-sized, open, and service-intensive economies, providing a quantitative basis for anticipating vulnerabilities before they manifest in aggregate macroeconomic volatility.

Future research could extend this analysis in several directions. First, incorporating interprovincial flows and regional heterogeneity would provide a finer-grained view of domestic transmission channels. Second, integrating international input-output linkages could quantify Canada's exposure to shocks in global value chains, particularly from the United States and other major trading partners. Finally, applying scenario-based simulations of policy or trade shocks could further elucidate the dynamics of resilience, guiding both public and private-sector decisions in an increasingly interconnected economic landscape.

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# 5 Appendix

## 5.1 Sector Table

Table 3: Sector, Acronym and Definitions

| Sector | Acronym | Full Name |
|---|---|---|
| Canada_A01 | Agriculture | Crop and animal production, hunting and related service activities |
| Canada_A02 | Forestry | Forestry and logging |
| Canada_A03 | Fishing | Fishing and aquaculture |
| Canada_B05 | Coal mining | Mining of coal and lignite |
| Canada_B06 | Oil & gas extraction | Extraction of crude petroleum and natural gas |
| Canada_B07 | Metal ore mining | Mining of metal ores |
| Canada_B08 | Other mining | Other mining and quarrying |
| Canada_B09 | Mining support services | Mining support service activities |
| Canada_C10T12 | Food & tobacco | Manufacture of food products, beverages and tobacco products |
| Canada_C13T15 | Textiles & apparel | Manufacture of textiles, wearing apparel and leather products |
| Canada_C16 | Wood products | Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials |
| Canada_C17_18 | Paper & printing | Manufacture of paper and paper products; Printing and reproduction of recorded media |
| Canada_C19 | Coke & refined petroleum | Manufacture of coke and refined petroleum products |
| Canada_C20 | Chemicals | Manufacture of chemicals and chemical products |
| Canada_C21 | Pharmaceuticals | Manufacture of basic pharmaceutical products and pharmaceutical preparations |
| Canada_C22 | Rubber & plastics | Manufacture of rubber and plastic products |
| Canada_C23 | Non-metallic minerals | Manufacture of other non-metallic mineral products |
| Canada_C24A | Basic ferrous metals | Manufacture of basic metals (Ferrous Metals) |
| Canada_C24B | Basic non-ferrous metals | Manufacture of basic metals (Non-Ferrous Metals) |
| Canada_C25 | Fabricated metal products | Manufacture of fabricated metal products, except machinery and equipment |
| Canada_C26 | Computer & electronics | Manufacture of computer, electronic and optical products |

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| Sector | Acronym | Full Name |
|---|---|---|
| Canada_C27 | Electrical equipment | Manufacture of electrical equipment |
| Canada_C28 | Machinery & equipment | Manufacture of machinery and equipment n.e.c. |
| Canada_C29 | Motor vehicles | Manufacture of motor vehicles, trailers and semi-trailers |
| Canada_C301 | Shipbuilding | Building of ships and boats |
| Canada_C302T309 | Other transport equipment | Manufacture of other transport equipment |
| Canada_C31T33 | Other manufacturing & repair | Other manufacturing; Repair and installation of machinery and equipment |
| Canada_D | Energy supply | Electricity, gas, steam and air conditioning supply |
| Canada_E | Water & waste management | Water supply; sewerage, waste management and remediation activities |
| Canada_F | Construction | Construction |
| Canada_G | Wholesale & retail trade | Wholesale and retail trade; repair of motor vehicles and motorcycles |
| Canada_H49 | Land transport | Land transport and transport via pipelines |
| Canada_H50 | Water transport | Water transport |
| Canada_H51 | Air transport | Air transport |
| Canada_H52 | Warehousing & support | Warehousing and support activities for transportation |
| Canada_H53 | Postal & courier | Postal and courier activities |
| Canada_I | Accommodation & food services | Accommodation and food service activities |
| Canada_J58T60 | Publishing & broadcasting | Publishing, audiovisual and broadcasting activities |
| Canada_J61 | Telecommunications | Telecommunications |
| Canada_J62_63 | IT services | IT and other information services |
| Canada_K | Finance & insurance | Financial and insurance activities |
| Canada_L | Real estate | Real estate activities |
| Canada_M | Professional services | Professional, scientific and technical activities |
| Canada_N | Administrative services | Administrative and support service activities |
| Canada_O | Public administration | Public administration and defence; compulsory social security |
| Canada_P | Education | Education |
| Canada_Q | Health & social work | Human health and social work activities |
| Canada_R | Arts & entertainment | Arts, entertainment and recreation |
| Canada_S | Other services | Other service activities |

## 5.2 Sector Influence and Strength Metrics

Table 4: Network Connectivity and Influence Metrics by Sector

| Acronym | InStrength | OutStrength | InfluenceIndex | TotalStrength |
|---|---|---|---|---|
| Agriculture | 40.98 | 28.36 | 0.69 | 69.34 |
| Forestry | 29.88 | 22.29 | 0.75 | 52.17 |
| Fishing | 24.18 | 1.10 | 0.05 | 25.28 |
| Coal mining | 25.30 | 2.45 | 0.10 | 27.75 |
| Oil & gas extraction | 24.00 | 54.65 | 2.28 | 78.65 |
| Metal ore mining | 23.41 | 37.82 | 1.62 | 61.23 |
| Other mining | 24.71 | 16.27 | 0.66 | 40.98 |
| Mining support services | 23.06 | 14.40 | 0.62 | 37.46 |
| Food & tobacco | 48.28 | 29.90 | 0.62 | 78.18 |
| Textiles & apparel | 34.03 | 2.34 | 0.07 | 36.37 |
| Wood products | 40.66 | 22.10 | 0.54 | 62.76 |
| Paper & printing | 40.99 | 14.84 | 0.36 | 55.83 |
| Coke & refined petroleum | 55.50 | 67.35 | 1.21 | 122.85 |
| Chemicals | 36.81 | 27.63 | 0.75 | 64.44 |
| Pharmaceuticals | 33.15 | 1.55 | 0.05 | 34.70 |
| Rubber & plastics | 35.84 | 21.02 | 0.59 | 56.86 |
| Non-metallic minerals | 40.57 | 11.81 | 0.29 | 52.38 |
| Basic ferrous metals | 24.35 | 25.42 | 1.04 | 49.77 |
| Basic non-ferrous metals | 42.64 | 29.68 | 0.70 | 72.32 |
| Fabricated metal products | 35.03 | 31.84 | 0.91 | 66.87 |
| Computer & electronics | 28.32 | 3.29 | 0.12 | 31.61 |
| Electrical equipment | 34.22 | 3.81 | 0.11 | 38.03 |
| Machinery & equipment | 34.12 | 9.52 | 0.28 | 43.64 |
| Motor vehicles | 26.31 | 7.55 | 0.29 | 33.86 |
| Shipbuilding | 28.72 | 1.75 | 0.06 | 30.47 |
| Other transport equipment | 27.50 | 14.98 | 0.54 | 42.48 |
| Other manufacturing & repair | 38.76 | 36.08 | 0.93 | 74.84 |
| Energy supply | 16.23 | 49.47 | 3.05 | 65.70 |
| Water & waste management | 32.56 | 12.61 | 0.39 | 45.17 |
| Construction | 40.01 | 54.09 | 1.35 | 94.10 |
| Wholesale & retail trade | 31.00 | 249.86 | 8.06 | 280.86 |
| Land transport | 27.67 | 85.33 | 3.08 | 113.00 |
| Water transport | 45.41 | 3.34 | 0.07 | 48.75 |
| Air transport | 52.73 | 6.77 | 0.13 | 59.50 |
| Warehousing & support | 41.56 | 87.88 | 2.11 | 129.44 |

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| Acronym | InStrength | OutStrength | InfluenceIndex | TotalStrength |
|---|---|---|---|---|
| Postal & courier | 32.70 | 14.81 | 0.45 | 47.51 |
| Accommodation & food services | 46.74 | 19.36 | 0.41 | 66.10 |
| Publishing & broadcasting | 28.31 | 21.03 | 0.74 | 49.34 |
| Telecommunications | 21.70 | 15.14 | 0.70 | 36.84 |
| IT services | 22.39 | 38.87 | 1.74 | 61.26 |
| Finance & insurance | 16.07 | 102.25 | 6.36 | 118.32 |
| Real estate | 21.03 | 52.74 | 2.51 | 73.77 |
| Professional services | 23.35 | 93.73 | 4.01 | 117.08 |
| Administrative services | 27.73 | 72.69 | 2.62 | 100.42 |
| Public administration | 36.83 | 20.65 | 0.56 | 57.48 |
| Education | 16.82 | 10.03 | 0.60 | 26.85 |
| Health & social work | 21.63 | 10.42 | 0.48 | 32.05 |
| Arts & entertainment | 40.34 | 4.77 | 0.12 | 45.11 |
| Other services | 36.01 | 14.52 | 0.40 | 50.53 |

### 5.3 Sector Centrality Metrics

Table 5: Centrality Metrics by Sector

| Acronym | Betweenness | Closeness | Eigenvector | HubScore | AuthorityScore |
|---|---|---|---|---|---|
| Agriculture | 0.08 | 1.29 | 0.75 | 0.15 | 0.64 |
| Forestry | 0.03 | 1.44 | 0.53 | 0.09 | 0.46 |
| Fishing | 0.00 | 0.49 | 0.46 | 0.01 | 0.35 |
| Coal mining | 0.00 | 0.56 | 0.45 | 0.01 | 0.27 |
| Oil & gas extr | 0.02 | 1.61 | 0.32 | 0.33 | 0.27 |
| Metal ore min | 0.01 | 1.11 | 0.34 | 0.11 | 0.24 |
| Other mining | 0.00 | 1.16 | 0.35 | 0.07 | 0.26 |
| Mining supp | 0.02 | 1.40 | 0.35 | 0.04 | 0.29 |
| Food & tobac | 0.05 | 1.14 | 0.92 | 0.13 | 0.73 |
| Textiles & app | 0.00 | 1.23 | 0.54 | 0.01 | 0.53 |
| Wood product | 0.13 | 1.56 | 0.71 | 0.09 | 0.51 |
| Paper & print | 0.00 | 0.65 | 0.69 | 0.05 | 0.54 |
| Coke & refine | 0.05 | 1.63 | 0.70 | 0.25 | 0.58 |
| Chemicals | 0.01 | 0.96 | 0.59 | 0.11 | 0.58 |
| Pharmaceutic | 0.00 | 0.22 | 0.50 | 0.01 | 0.56 |

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| Acronym | Betweenness | Closeness | Eigenvector | HubScore | AuthorityScore |
|---|---|---|---|---|---|
| Rubber & pla | 0.00 | 0.89 | 0.58 | 0.08 | 0.55 |
| Non-metallic | 0.02 | 1.28 | 0.61 | 0.54 | 0.54 |
| Basic ferrous | 0.03 | 1.22 | 0.37 | 0.09 | 0.49 |
| Basic non-fer | 0.03 | 1.12 | 0.54 | 0.11 | 0.35 |
| Fabricated met | 0.08 | 1.35 | 0.53 | 0.11 | 0.44 |
| Computer & el | 0.00 | 0.27 | 0.41 | 0.01 | 0.43 |
| Electrical equ | 0.00 | 0.36 | 0.56 | 0.02 | 0.42 |
| Machinery & eq | 0.00 | 0.45 | 0.51 | 0.03 | 0.47 |
| Motor vehicle | 0.00 | 0.65 | 0.39 | 0.03 | 0.63 |
| Shipbuilding | 0.00 | 0.41 | 0.45 | 0.01 | 0.36 |
| Other transpor | 0.02 | 0.71 | 0.42 | 0.06 | 0.43 |
| Other manufac | 0.04 | 1.09 | 0.64 | 0.14 | 0.44 |
| Energy supply | 0.01 | 1.22 | 0.24 | 0.18 | 0.20 |
| Water & waste | 0.00 | 0.50 | 0.49 | 0.04 | 0.53 |
| Construction | 0.32 | 1.99 | 0.65 | 0.15 | 0.46 |
| Wholesale & r | 0.33 | 3.98 | 0.42 | 1.00 | 0.28 |
| Land transpor | 0.07 | 1.78 | 0.48 | 0.35 | 0.40 |
| Water transpo | 0.00 | 0.38 | 0.90 | 0.01 | 0.62 |
| Air transport | 0.00 | 0.55 | 1.00 | 0.02 | 0.69 |
| Warehousing | 0.00 | 1.59 | 0.65 | 0.38 | 0.46 |
| Postal & cour | 0.02 | 0.97 | 0.52 | 0.05 | 0.45 |
| Accommodat | 0.00 | 0.88 | 0.89 | 0.06 | 0.58 |
| Publishing & m | 0.03 | 0.88 | 0.39 | 0.05 | 0.30 |
| Telecommuni | 0.02 | 0.79 | 0.28 | 0.05 | 0.21 |
| IT services | 0.10 | 1.63 | 0.29 | 0.11 | 0.23 |
| Finance & ins | 0.07 | 2.62 | 0.21 | 0.34 | 0.13 |
| Real estate | 0.21 | 2.28 | 0.32 | 0.16 | 0.21 |
| Professional s | 0.12 | 2.76 | 0.33 | 0.29 | 0.23 |
| Administrativ | 0.02 | 2.11 | 0.40 | 0.22 | 0.36 |
| Public admin | 0.04 | 0.55 | 0.49 | 0.07 | 0.31 |
| Education | 0.00 | 0.70 | 0.26 | 0.03 | 0.18 |
| Health & soci | 0.00 | 0.53 | 0.33 | 0.03 | 0.26 |
| Arts & entert | 0.00 | 0.52 | 0.59 | 0.01 | 0.45 |
| Other service | 0.00 | 0.53 | 0.51 | 0.05 | 0.41 |

### 5.4 Sector Random Walk Metrics

Table 6: Random Walk Metrics by Sector

| Acronym | RWC | CBET |
|---|---|---|
| Agriculture | 0.0053 | 2.6914 |
| Forestry | 0.0046 | 2.6618 |
| Fishing | 0.0002 | 0.1178 |
| Coal mining | 0.0011 | 0.4653 |
| Oil & gas extraction | 0.0257 | 11.3056 |
| Metal ore mining | 0.0077 | 3.1110 |
| Other mining | 0.0036 | 1.4778 |
| Mining support services | 0.0082 | 3.5197 |
| Food & tobacco | 0.0078 | 4.0332 |
| Textiles & apparel | 0.0006 | 0.3071 |
| Wood products | 0.0084 | 4.3512 |
| Paper & printing | 0.0085 | 4.1352 |
| Coke & refined petroleum | 0.0256 | 10.5289 |
| Chemicals | 0.0064 | 2.9820 |
| Pharmaceuticals | 0.0004 | 0.2046 |
| Rubber & plastics | 0.0064 | 2.7319 |
| Non-metallic minerals | 0.0054 | 2.6245 |
| Basic ferrous metals | 0.0053 | 4.3573 |
| Basic non-ferrous metals | 0.0043 | 2.1621 |
| Fabricated metal products | 0.0100 | 4.6239 |
| Computer & electronics | 0.0014 | 0.5955 |
| Electrical equipment | 0.0018 | 0.7810 |
| Machinery & equipment | 0.0037 | 1.6036 |
| Motor vehicles | 0.0031 | 1.7174 |
| Shipbuilding | 0.0003 | 0.1703 |
| Other transport equipment | 0.0036 | 2.4090 |
| Other manufacturing & repair | 0.0070 | 2.8965 |
| Energy supply | 0.0198 | 7.5896 |
| Water & waste management | 0.0076 | 3.3685 |
| Construction | 0.0386 | 14.3024 |
| Wholesale & retail trade | 0.1017 | 34.7851 |
| Land transport | 0.0336 | 18.5134 |
| Water transport | 0.0016 | 0.7085 |
| Air transport | 0.0034 | 1.3724 |
| Warehousing & support | 0.0264 | 10.7043 |

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| **Acronym** | **RWC** | **CBET** |
|---|---|---|
| Postal & courier | 0.0141 | 5.9360 |
| Accommodation & food services | 0.0159 | 6.2609 |
| Publishing & broadcasting | 0.0200 | 11.5987 |
| Telecommunications | 0.0165 | 9.1424 |
| IT services | 0.0442 | 26.2711 |
| Finance & insurance | 0.0828 | 69.9528 |
| Real estate | 0.0506 | 21.2362 |
| Professional services | 0.0737 | 34.9961 |
| Administrative services | 0.0646 | 29.4654 |
| Public administration | 0.0136 | 5.6735 |
| Education | 0.0090 | 3.6399 |
| Health & social work | 0.0044 | 2.0979 |
| Arts & entertainment | 0.0049 | 2.0833 |
| Other services | 0.0098 | 3.9149 |


Figure 4: Hub and Authority Centrality vs Eigenvector Centrality

**Note:**his graphic illustrates sectors according to their centrality measures: Hub Centrality (red) relative to Eigenvector Centrality, and Authority Centrality (blue) relative to Eigenvector Centrality. The industry name is displayed for the ten sectors with the highest Hub values or the ten sectors with the highest Authority values.


Figure 5: Betweeness and Closeness metrics

**Note:**This graphic illustrates sectors according to their centrality measures: Betweenness Centrality (bubble size) relative to Closeness Centrality (bubble color). The industry name is shown for the ten sectors with the highest Betweenness values or the ten sectors with the highest Closeness values. Median values are indicated with reference lines (Betweenness = 0.02; Closeness = 0.97).