Economic Resilience and Structural Shocks: A Leontief Input-Output Analysis of Hungary (2008–2009)

Content

Executive Summary

This research presents a comprehensive structural analysis of the Hungarian economy during the pivotal transition years of the Global Financial Crisis (2008–2009). Utilizing the Leontief Input-Output framework, this study quantifies inter-industry dependencies and sectoral output multipliers across more than 40 industrial nodes.

By constructing and solving for the Leontief Inverse Matrix, the analysis identifies the total (direct and indirect) requirements generated by changes in final demand. The findings reveal a significant systemic contraction, where aggregate output multipliers declined in nearly all sectors as credit tightened and global demand plummeted. Notably, while the Manufacturing (Secondary) sector maintained the highest backward linkages - serving as the economy's primary "pull" engine—the Services (Tertiary) sector demonstrated lower inter-industry integration, highlighting a higher vulnerability to shifts in final consumption. This report provides a quantitative roadmap of how macroeconomic shocks propagate through a small open economy's industrial supply chain.

Hungary's Input–Output Analysis (2008 - 2009)

1. Introduction to Input–Output Analysis and its Significance

Input–Output (I–O) analysis is one of the frequently used frameworks in economics for understanding the interconnection of different industries within an economy. Wassily Leontief pioneered the idea, for which he later received the Nobel Prize in Economics. His research was to show that the economy could be represented through a set of interlinked tables, where the output of one sector becomes the input of another. This way, we can track how goods and services flow between industries and how final demand (consumption, investment, government expenditure, exports) influences production. In other words, Rows represent how much a sector produces and where its output goes, while columns represent how much a sector needs to purchase from others to produce its output.

The importance of I–O analysis is: First, it helps to measure the shape of the Economy. For instance, when we calculate Gross Domestic Product (GDP), we need to distinguish between intermediate inputs like steel used to make a car and final goods, which is the Car. So, I–O tables allow us to do exactly that by separating what is used up in production from what is consumed by final consumers. Second, it allows us to study interdependencies: if demand in

one sector changes, we can trace the ripple effects across the entire economy. This is where the Leontief inverse is used, which shows the direct and indirect requirements of output when final demand increases.

In today's world, the significance of I–O analysis has increased. Governments and central banks depend a lot on such functions for policy decisions. For example, the Reserve Bank of India (RBI) and the government use sectoral GDP and demand data to decide on monetary and fiscal policies. When the RBI reduced the repo rate twice in 2025, the intention was to lower borrowing costs, increase investment and consumption, and so increase final demand. Using I–O analysis, policymakers can predict sectors that will benefit most from such a policy and how much indirect impact it will create in supplier industries. Similarly, fiscal policies like infrastructure spending can be constructed through I–O tables to estimate multiplier effects. If the government builds extra highways, how much additional demand will be created in cement, steel, construction services, and transport?

Another application is in analytics and forecasting. Economists and data scientists use I–O models to predict future outcomes, for example, during the COVID-19 pandemic, I–O frameworks were used globally to estimate how lockdowns in some sectors, like retail and transport, would drag down others.

Input–Output analysis is not just a set of tables but a lens to view the economy as a web of interdependent industries. It plays a central role in GDP measurement, policy planning, crisis management, and long-term economic forecasting. For Hungary in 2008 and 2009, years marked by the global financial crisis, the I–O framework provides a powerful way to analyse which sectors were most vulnerable and how the economic downturn spread across industries.

Structure of the Input-Output Dataset-

The Input-Output dataset is organized in a tabular format, with rows and columns representing industries, products, and key economic flows.

1) **Rows:** Each row of industries (supplies) shows the output or supply of a specific product or industry. It details how that output is distributed across various sectors and types of final demand, Intermediate demand. The quantity of that industry's output is used as an input by other industries. Final demand is the amount consumed by households, government, exports, and investments.

2) **Columns:** Each column inputs to industries (requirements) shows the inputs or requirements of a specific industry to produce its output, including intermediate inputs: goods and services purchased from other industries, and primary inputs: factors like labour and capital.

3) **Economic Flows:**
   i) **Intermediate Consumption:** Shows how goods and services produced by one industry are used as inputs by others.
   ii) **Value Added:** Includes wages, profits, and taxes, representing the contribution of industries to GDP.
   iii) **Final Demand:** Captures the end use of goods and services, such as exports or domestic consumption.

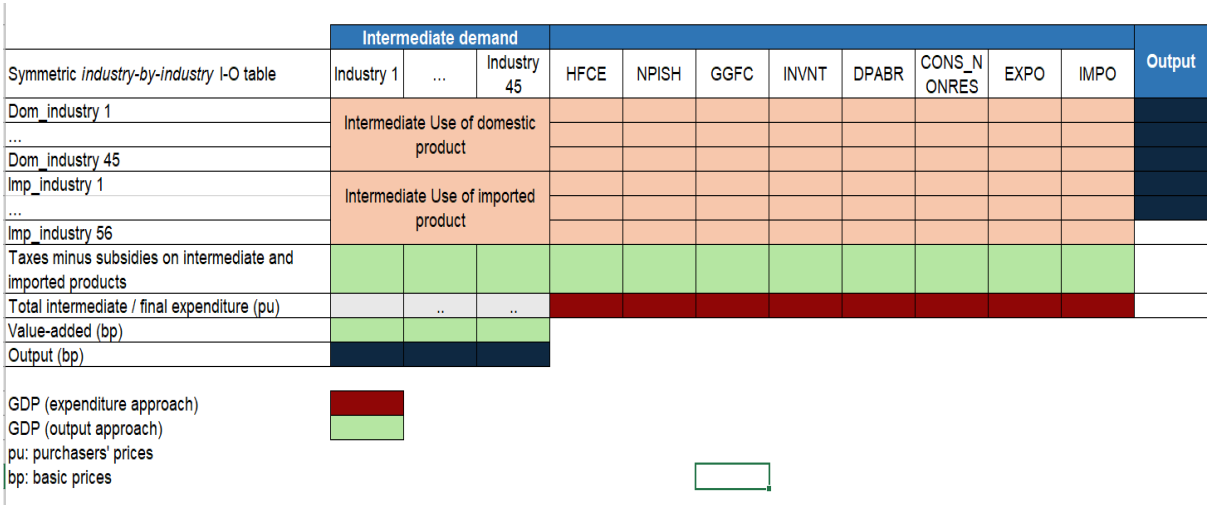

Figure 1: Structure of the input-output table

2. Constructing an Input–Output Table (3×3 Matrix)

For this project, we created a 3×3 Input–Output (I–O) matrix of Hungary's economy for 2008 and 2009. We distributed industries into three sectors:

1. Primary Sector – agriculture, forestry, fishing, and mining.
2. Secondary Sector – manufacturing, construction, and energy.
3. Tertiary Sector – trade, transport, finance, real estate, and other services.

This distribution helps simplify the analysis while still reflecting the economy's structure. By grouping, we can more easily identify patterns and compare sectoral changes across the two years, especially given the global financial crisis of 2009.

Structure of the 3×3 I–O Table

Layout of the table:

From / To	Primary	Secondary	Tertiary
Primary			
Secondary			
Tertiary			

- Rows represent the supply of output: how much one sector provides to itself and to the other two sectors.
- Columns represent the inputs: how much each sector uses from itself and the others to produce output.

Significance of Constructing the Table

The reason we constructed this 3×3 I–O table was:

- To highlight inter-sectoral linkages in a simple, easy-to-read format.
- To make a clear comparison between 2008 (pre-crisis) and 2009 (crisis year).
- For deeper analysis, such as sectoral performance, top/bottom industries, and Leontief inverse calculations.

By merging Hungary's Input–Output data into three major categories, we created a model that strikes a balance between simplicity and insight. It avoids the complexity of taking individual industries, while still showing how the economy changed during the crisis.

Table 1: FOR 2008

Industries	**Primary**	**Secondary**	**Tertiary**
Primary	3020.7	8931	1370.3
Secondary	3162.5	68087.9	19205.5
Tertiary	2250.5	31579.7	45667.5

Table 2: FOR 2009

Industries	Primary	Secondary	Tertiary
Primary	2378.4	6836.3	1145
Secondary	2445	49410.9	15275.9
Tertiary	1865.6	25007.3	39571.5

3. Sectoral Analysis of the Hungarian Economy (2008–2009)

The sectoral analysis of Hungary's Total Output (in millions of currency units) shows a sharp contraction in the economy between 2008 and 2009, with a distinct shift in the relative importance of the sectors.

Table 3:

Sector	2008 output	2009 output	Growth%	2008 share %	2009 share %	% point difference
Primary	13322	10359.7	-22.24%	7.27%	7.20%	-0.07%
Secondary	90455.9	67131.8	-25.79%	49.36%	46.64%	-2.72%
Tertiary	79497.7	66444.4	-16.42%	43.38%	46.16%	2.79%
Total	183275.6	143935.9				

Interpretation of Results

1. The Secondary sector, e.g., Manufacturing, Construction, Energy, etc. Experienced a rapid decline, contracting by −25.79% in Total Output. This confirms that the crisis in Hungary was primarily an industrial and export-driven shock, hitting manufacturing and related activities the hardest.
2. The Tertiary sector (Services) contracted by −16.42%, which was the mild decline among the three sectors. This relative resilience, often due to stable domestic services (like health, public administration, and utilities), allowed the Tertiary sector to significantly increase its share of the total economy from 43.38% to 46.16%.
3. The data clearly shows a structural shift away from the Secondary sector (a loss of 2.72 percentage points in share) and towards the Tertiary sector during the crisis year of 2009. The Primary sector remained a marginal contributor, with a contraction nearly as severe as the Secondary sector.

4. Top 5 and Bottom 5 Industries

Table 4: Top 5 Industries (Based on 2008 Total Output)

Rank (2008)	Sector Name	Total Output (2008)	Sector Group	Description (NACE Codes)	Output Change (2008→2009)
1	G	32,713.20	Tertiary	Wholesale and Retail Trade	−23%
2	C29	24,001.90	Secondary	Manufacture of Motor Vehicles, Trailers and Semi-trailers	−36%
3	C26	22,717.00	Secondary	Manufacture of Computer, Electronic, and Optical Products	−16%
4	F	17,397.50	Secondary	Construction	−17%
5	L	17,025.40	Tertiary	Real Estate Activities	−11%

Table 5: Bottom 5 Industries (Based on 2008 Total Output)

Rank (2008)	Sector Name	Total Output (2008)	Sector Group	Description (NACE Codes)	Output Change (2008 → 2009)
41	H50	257.50	Tertiary	Water transport	−32%
42	B05_06	254.30	Primary	Mining of coal and lignite	−58%
43	B09	185.50	Primary	Mining support service activities	+38%
44	A03	60.80	Primary	Fishing and aquaculture	−22%
45	T	18.10	Tertiary	Activities of households as employers	−37%

Discussion of Changes

- **Vulnerability of Top Industries:** The high concentration of economic activity in export-oriented manufacturing (C29 - Motor Vehicles; C26 - Electronics) made Hungary extremely vulnerable to the global crisis. C29 (Motor Vehicles) saw the most catastrophic output collapse in the top 5, falling by 36%. The decline in G (Trade) and F (Construction) also reflects the sharp drop in both domestic and international demand.
- **Relative Resilience in the Top:** L (Real Estate) and C26 (Electronics) showed comparatively milder contractions within the top 5 but still contributed significantly to the overall economic decline.
- **The Anomaly of B09:** The B09 (Mining support services) sector, though tiny, experienced significant positive growth (+38%) in output. While its impact on the macro-economy is negligible, this growth in a small sector is notable.
- **Bottom Industries:** The bottom five are consistently marginal sectors. Their decline or growth has no significant impact on the nation's economy. The massive fall in B05_06 (Coal/Lignite Mining) reflects Hungary's energy transition away from coal.

5. Leontief Inverse Matrix and Sectoral Interdependencies

The final step is to compute and interpret the Leontief inverse for both years. Steps taken -

1. **Formation of Technology Matrix (A):** Divided each intermediate input by the total output of the receiving sector.
    - Example: Agriculture → Industry flow (3,000) ÷ Industry output (130,000).
2. **Identity Matrix (I):** Created a 45X45 identity matrix.
3. **Subtract (I – A):** Subtracted the technology matrix from the identity matrix.
4. **Inverse:** Used the R programming SOLVE function to compute the inverse matrix of I-A
5. **Interpret Columns:** Each column shows the total (direct + indirect) output needed in all sectors if final demand for that sector increases by 1 unit.

    The Leontief Inverse Matrix:

$$(I-A)^{-1}$$

Provides the Output Multipliers (the sum of each column), indicating the total economic output required from all sectors to satisfy a unit increase in final demand for a specific sector's output.

Table 6: Change in Sectoral Interdependencies

Rank (2008)	Sector Name	Multiplier 2008	Multiplier 2009	Change (2009-2008)	Sector Group
1	C26	3.590	3.659	+0.069	Secondary
2	C29	3.083	2.982	−0.101	Secondary
3	C24	2.898	2.982	+0.085	Secondary
4	C10T12	2.855	2.746	−0.109	Secondary
5	C22	2.806	2.688	−0.119	Secondary

Interpretation

1. Weakening Interdependencies (Crisis Effect)

- The majority of the highest-linked sectors, like C29, C10T12, and C22, saw a reduction in their Output Multipliers between 2008 and 2009 (indicated by the negative change).
- **Economic Meaning:** A reduction in a multiplier means that for every dollar of new final demand, the resulting total ripple effect through the economy is smaller. This is a classic sign of a recession, where firms:
    1. Cut back on production and intermediate purchases, e.g., reducing inventory.
    2. Shift to less input-intensive production methods.
    3. Depends more on external/imported inputs relative to their domestic inputs, though this requires further analysis.
- The overall finding is that the Hungarian economy became less interconnected in terms of domestic intermediate flows, indicating a general weakening of the backward linkages that drive growth.

2. Manufacturing as the Engine

- Despite the weakening, the top 5 multipliers in both years are exclusively Secondary sector (Manufacturing) industries. This confirms that manufacturing remains the most

powerful economic engine in Hungary; an increase in final demand for any of these sectors has the largest "pull" effect on the rest of the economy.

- The Anomaly of C26 and C24: C26 (Electronics) and C24 (Basic Metals), two major manufacturing sectors, saw a slight increase in their multipliers. This suggests that despite the massive fall in output volume, these sectors either became slightly more reliant on domestic intermediate inputs per unit of output or had a more resilient technical structure than other manufacturing sectors.

3. Low Linkages in Services

- The lowest 5 multipliers are predominantly found in the Tertiary sector (e.g., Real Estate L, Public Administration O, Education P).
- Economic Meaning: Services generally have lower multipliers because their production process is less reliant on intermediate material inputs and more on value added (labour). This lack of strong backward linkages is why the Tertiary sector, while growing its relative share, is not the ideal engine for overall economic recovery in terms of generating widespread ripple effects. The lowest multiplier is exactly 1.000 for T (Activities of households as employers), meaning a unit of final demand here generates virtually no additional intermediate demand.

6. Rationale for Hungary (2008–2009) Analysis

We chose Hungary's Input-Output (I-O) tables from 2008 to 2009 because this period gives us an unmatched, stark contrast to study a major economic disaster. This wasn't a slow drift; it was a sudden, violent collision with the Global Financial Crisis (GFC).

1. The Shock and the Snapshot

The main draw is the "before-and-after" picture it offers. 2008 was the cliff edge, and 2009 was the deep plunge. This time frame allows the I-O model to do what it does best: trace how a massive, sudden cut in Final Demand (like the collapse of global exports) physically rippled through the domestic economy. Hungary, with its major reliance on external loans and foreign-owned export manufacturing (think car parts and electronics), was a prime target for this external shock.

2. Exposing the Economy's Engine

Our analysis wasn't just about total GDP falling; it was about who fell the hardest. The I-O model clearly showed that the Secondary sector - Hungary's industrial engine - took the biggest hit, contracting by over 24%. By comparing the Leontief Inverse Multipliers year-over-year, we could literally measure how the recession weakened the connections between businesses. Those valuable ripple effects that turn one dollar into three were suddenly much smaller, revealing that the gears of the domestic economy were grinding to a halt.

3. The Great Structural Shift

Finally, the data highlighted a lasting structural change. Because the service sector (Tertiary) was slightly more resilient, it gained a relative share of the economy as manufacturing suffered. Studying this moment of involuntary transformation is key to understanding how resilient - or fragile - modern economies are when the next major global shock inevitably arrives.

7.Conclusion & Policy Implications

The longitudinal analysis of Hungary's 2008 and 2009 Input-Output tables illustrates the profound fragility of industrial linkages during a global liquidity crisis. The calculation of output multipliers confirms that the recession was not merely a drop in production, but a structural weakening of the "inter-locked" nature of the Hungarian economy.

Key Analytical Findings:

- **Manufacturing Resilience:** Despite a drop in total output, the Secondary sector consistently exhibited the strongest backward linkages. Industries such as *Manufacture of Motor Vehicles (C29)* and *Computer & Electronics (C26)* remained critical hubs, where every unit of output triggered significant demand for domestic intermediate inputs.
- **Services Vulnerability:** The Tertiary sector showed the lowest multipliers, indicating a reliance on final demand rather than intermediate industrial trade, which limited its ability to stimulate wider economic recovery.

Policy Implications: Based on the identified multiplier effects, this research suggests that economic recovery strategies for small open economies should prioritize fiscal stimulus in **High-Multiplier Manufacturing sectors**. Such targeted investment maximizes the "multiplier effect," effectively pulling connected upstream industries out of stagnation. Conversely, a failure to support these "hub" industries during a crisis can lead to a disproportionate collapse

in the broader industrial ecosystem due to the high degree of sectoral interdependency revealed in the Leontief Inverse.