Linkages and Structural Changes in the Chinese Financial Sector, 1996–2018: A Network and Input–Output Approach

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Outline

Transformations in the Chinese Financial Sector

Scope:

- The Chinese financial sector has undergone profound transformations in recent decades, playing a pivotal role in the nation's extraordinary economic growth and industrial development.
- These shifts were propelled by a confluence of domestic policy reforms, evolving market dynamics, and significant technological advancements. system.

Transformations in the Chinese Financial Sector

Key Reforms:

- Initiation of substantial financial reforms aimed at modernization and liberalization, commencing from the 1992 framework.
- Implementation of a ”dual-track” financial system, allowing state-owned banks to operate alongside market-oriented commercial banks.
- The 1994 Budget Law and subsequent establishment of policy banks (e.g., China Development Bank, Export-Import Bank of China, Agricultural Development Bank of China) were instrumental in separating policy finance from commercial banking and restructuring the financial system.

Transformations in the Chinese Financial Sector

Key Reforms:

- These policy banks made significant contributions to financing critical infrastructure, energy, transportation, and other projects, enhancing the financial sector's capacity to drive sustained economic growth.
- The financial sector exhibits a considerable multiplier effect due to extensive linkages with both upstream and downstream sectors (e.g., real estate, construction, manufacturing). It acts as a critical intermediary between various economic sectors.

Motivation for the Study

Motivation for the Study:

- The transition to an investment-driven economy and financial reforms, coupled with technological advancements and shifting consumer demands, have likely altered the Chinese financial sector's intersectoral linkages.
- The 2007-08 Global Financial Crisis (GFC) brought widespread recognition that the financial sector's indirect (cascading) effects can cause significant risk propagation across sectors, potentially leading to aggregate fluctuations.

Motivation for the Study

Motivation for the Study:

- Therefore, assessing structural changes in the financial sector's intersectoral linkages, sectoral interdependencies, (a)symmetries, and the overall economic structure is crucial .
- Such an assessment can provide policymakers with insights into the changing role of China's financial sector, assist in identifying risks and opportunities, and guide policy decisions for long-term resilient and balanced sectoral growth .

Research Objectives

This study pursues three main objectives:

1. To evaluate the intersectoral linkages (both push and pull effects) of the Chinese financial sector, along with the evolution of its industrial structure. This involves identifying which sectors are most influenced by the financial sector's demand and supply.
2. To examine the changes in the intersectoral structural feedback relationship between the Chinese financial sector and other economic sectors . This aims to understand how the mutual influence between finance and other sectors has evolved.

Research Objectives

This study pursues three main objectives:(Continued)

3. To investigate how closely the Chinese financial sector is clustered with other sectors, the degree of mutual dependence (or interdependence) it has with these sectors, and its vulnerability to external shocks . This assesses the sector's integration and risk profile within the economic network.

Significance and Contributions

This study makes several contributions to the literature :

- **Novel Application of Network Analysis**: To the authors' knowledge, this is the first study to apply network analysis to an Input-Output (IO) framework to analyze the structural dynamics of the Chinese financial sector in a macroeconomic network system from 1996 to 2018 . It provides comprehensive estimates of downstream and upstream closeness, and betweenness measures not previously reported .
- **Causative Matrix for Structural Change**: It presents the first empirical evidence using the Causative matrix approach on the intersectoral portion of system-wide structural changes in the Chinese financial sector and its relationship with other sectors .

Significance and Contributions

This study makes several contributions to the literature :(Continued)

- **Risk Assessment with Fagiolo & Symmetry Coefficients**: It offers the first application of Fagiolo clustering and symmetry coefficients to assess the level of risk in the financial sector, its clustering degree, and mutual dependence with other sectors .
- **Methodological Refinement**: It identifies and addresses shortcomings in existing network methods within the IO framework by using both allocation (direct output) and technical (direct input) coefficients to measure push and pull effects via Strongest Paths (SPs), correcting potential biases in previous studies .

Core Methodological Approaches

- **Input-Output (IO) Analysis**: Proposed by Leontief (1936), IO analysis is a widely used method for measuring the flow of goods and services between sectors of an economy . It is valuable for evaluating supply- and demand-side effects and analyzing indirect impacts of sectoral changes .
- **Network Analysis**: Based on graph theory, network analysis provides tools to evaluate structural aspects (connectedness, clustering) and dynamics of resource flows within a network . It complements IO analysis by offering a more comprehensive view of intersectoral linkages and complex interdependencies in modern economies .

Core Methodological Approaches

- **Rationale for Combination**: While IO analysis is powerful, it has limitations in capturing the full complexity of interconnected modern economies as a complete system . Network analysis helps overcome these limitations .
- **Data Source**: OECD Inter-Country Input-Output (ICIO) Tables for China, spanning 1996–2018 . Chosen for comprehensive and consistent coverage compared to other datasets like National Bureau of Statistics tables, which have limitations in temporal and sectoral consistency .

Strongest Path (SP) Analysis: Foundation

The analysis starts with a national IO table with n sectors (nodes) and a matrix of intermediate deliveries Z, where element z_{ij} is the delivery from sector i to sector j (links) .

- **Technical (Direct Input) Coefficient (a_{ij})**: Represents the amount of intermediate input from sector i used in the production of one unit of output of sector j.

$$a_{ij} = \frac{z_{ij}}{x_j}$$

where x_j is the total output of sector j . Matrix $A = [a_{ij}]$.

- **Allocation (Direct Output) Coefficient (b_{ij})**: Describes the distribution of sector i's output to sector j as a share of sector i's total output.

$$b_{ij} = \frac{z_{ij}}{x_i}$$

where x_i is the total output of sector i . Matrix $B = [b_{ij}]$.

- This study innovatively uses both A and B to analyze demand-pull and supply-push effects, respectively .

Strongest Path (SP) Analysis: Calculation

The "strength" of an SP from sector i to sector j via a sequence of intermediate sectors $k_1, \ldots, k_m$ is maximized. To use Dijkstra's algorithm (which finds shortest paths), the problem is transformed by taking negative logarithms of coefficients.

- **Strength based on Technical Coefficients (Demand-Pull)**: The path that maximizes $\prod a_{ik_1} \cdot a_{k_1k_2} \cdot \ldots \cdot a_{k_mj}$ is found by minimizing:

$$P_{ij}^{path} = -\ln(a_{ik_1}) - \ln(a_{k_1k_2}) - \ldots - \ln(a_{k_mj})$$

The SP value is $P_{ij} = \min(\text{all } P_{ij}^{path})$. (Original Eq. 1 and 3)

Strongest Path (SP) Analysis: Calculation

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- **Strength based on Allocation Coefficients (Supply-Push)**: The path that maximizes $\prod b_{ik_1} \cdot b_{k_1k_2} \cdot \ldots \cdot b_{k_mj}$ is found by minimizing:

$$R_{ij}^{path} = -\ln(b_{ik_1}) - \ln(b_{k_1k_2}) - \ldots - \ln(b_{k_mj})$$

The SP value is $R_{ij} = \min(\text{all } R_{ij}^{path})$. (Original Eq. 2 and 4)

Strongest Path (SP) Analysis: Calculation

The "strength" of an SP from sector i to sector j via a sequence of intermediate sectors $k_1, \ldots, k_m$ is maximized. To use Dijkstra's algorithm (which finds shortest paths), the problem is transformed by taking negative logarithms of coefficients.

- Dijkstra's algorithm solves for these minimum sum paths .
- SP matrices SP^A (from P_{ij}) and SP^B (from R_{ij}) summarize these strongest paths .
- Strongest pull matrix Q and push matrix R are obtained by weighting with actual output values, emphasizing actual quantity effects . (Details in paper: SP^A and Q, SP^B and R)

Strongest Path (SP) Analysis: Calculation

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Network Centrality: SP Closeness

Closeness centrality measures how centrally located a sector is based on shortest paths .

- **Upstream Closeness (Cl_i^{up})**: Measures the SPs from sector i to all other sectors (flows originating from i) . High values mean sector i heavily relies on inputs from other sectors (important consumer) .

$$Cl_i^{up} = \frac{\sum_{j \neq i}(q_{ji}/X_j)}{N_i^{up}}$$

where q_{ji} is the intermediate output of sector j pulled by sector i through SP, X_j is total output of j, and N_i^{up} is the number of adjacent sectors via SPs starting from i . (Uses pull matrix Q_S in paper, referring to q_{ji} derived from P_S and actual values).

Network Centrality: SP Closeness

Closeness centrality measures how centrally located a sector is based on shortest paths .

- **Downstream Closeness (Cl_i^{down})**: Measures the SPs from all other sectors to sector i (flows ending at i) . High values mean sector i's outputs are widely used as intermediate inputs (important supplier) .

$$Cl_i^{down} = \frac{\sum_{j \neq i}(r_{ij}/X_i)}{N_i^{down}}$$

where r_{ij} is the intermediate output of sector i pushed to sector j through SP, X_i is total output of i, and N_i^{down} is the number of adjacent sectors via SPs ending at i . (Uses push matrix R_S in paper, referring to r_{ij} derived from R_S and actual values).

Network Centrality: SP Closeness

Closeness centrality measures how centrally located a sector is based on shortest paths .

- Measured using strongest pull matrices (P_S, Q_S) for upstream and push matrices (R_S, M_S) for downstream linkages . (Note: Paper uses Q and M for quantity-based effects, P_S and R_S for proportional. Eq. 5 & 6 use q_{ji}/Q_j and r_{ij}/R_i, let's clarify Q_j is total output of j, R_i is total output of i from context, not the matrices Q, R). The paper refers to X_j and X_i for total output in later betweenness discussion, which is clearer. The division by X_j (or X_i) normalizes the flow.

Network Centrality: SP Betweenness

Betweenness quantifies how well a node (sector) acts as a crucial link or intermediary in the network .

- A sector with high betweenness plays a significant role in connecting different sectors and facilitating the flow of goods and services between them .
- Computed using SP matrices SP^A (from P_{ij}) and SP^B (from R_{ij}) .
- **Betweenness for sector k (Pull-perspective, based on $\mathbf{SP}^A$):**

$$B_k^P = \sum_{i \neq j \neq k} \frac{\sigma_{ij}^P(k)}{\sigma_{ij}^P} X_j (Eq.7)$$

Network Centrality: SP Betweenness

Betweenness quantifies how well a node (sector) acts as a crucial link or intermediary in the network .

- **Betweenness for sector k (Push-perspective, based on SP^B):**

$$B_k^R = \sum_{i \neq j \neq k} \frac{\sigma_{ij}^R(k)}{\sigma_{ij}^R} X_j (Eq.8)$$

where:

- $\sigma_{ij}(k)$ is the number of SPs from sector i to sector j that pass through sector k.
- σ_{ij} is the total number of SPs from sector i to sector j.
- X_j is the total output of sector j (used as a weight) .

Structural Change: Causative Matrix Model

The Causative Matrix model assesses the financial sector's linkage structure and the extent of financialization . Developed by Lipstein (1968) and refined by others .

- Model for two time periods (t_0 and t_1):

$$C = L_1 L_0^{-1} (Eq.9)$$

  where L_0 and L_1 are the Leontief inverse matrices $(I - A)^{-1}$ for periods t_0 and t_1 respectively. A is the matrix of technical coefficients.
- The element c_{ij} of C is given by $c_{ij} = \sum_k l_{ik}^{(1)} m_{kj}^{(0)}$, where $l_{ik}^{(1)}$ are elements of L_1 and $m_{kj}^{(0)}$ are elements of L_0^{-1} . (Paper simplifies this to c_{ij} represents impact of sector j on sector i's ability to influence other sectors' output multipliers).

Structural Change: Causative Matrix Model

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- **Interpretation (following Jackson et al., 1990):**
  - **Diagonal element (c_{ii}) :**
    - $c_{ii} > 1$: Sector i's final demand has a significant impact on its *own* output relative to the base period; sector is becoming more internalized (endogenized).
    - $c_{ii} < 1$: Sector i's final demand has a significant impact on *other sectors'* output relative to its own; sector is becoming more externalized.

Structural Change: Causative Matrix Model

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- **Sum of Off-Diagonal Row Elements ($\sum_{j \neq i} c_{ij}$ denoted as Sum of ODE)** :
  - Sum of ODE > 0: Increased contribution of other sectors' final demand to sector i's output.
  - Sum of ODE < 0: Decreased contribution of other sectors' final demand to sector i's output.
- **Row Sum ($\sum_j c_{ij}$)** : If > 1 (< 1), changes in final demand of other sectors have a stronger (weaker) overall impact on sector i's output.

Causative Matrix Interpretation Typology (Table 1 from paper)

Table 1: Classification based on C_{ii} and Sum of ODE

		Sum of ODE < 0 *Decreased output impacts caused by the final demand of other sectors*	**Sum of ODE** > 0 *Increased output impacts caused by the final demand of other sectors*
$C_{ii} > 1$	**Type IV**	Sectors are becoming increasingly endogenized, and receiving less feedback from other sectors	**Type I** Sectors are becoming increasingly endogenized, with more feedback from other sectors
$C_{ii} < 1$	**Type III**	Sectors are becoming more externalized, with less feedback from other sectors	**Type II** Sectors are becoming more externalized, with more feedback from other sectors

Causative Matrix Interpretation Typology (Table 1 from paper)

- **Type I**: $C_{ii} > 1$, Sum of ODE > 0. Sectors are becoming increasingly endogenized, with more feedback from other sectors .
- **Type II**: $C_{ii} < 1$, Sum of ODE > 0. Sectors are becoming more externalized, with more feedback from other sectors .
- **Type III**: $C_{ii} < 1$, Sum of ODE < 0. Sectors are becoming more externalized, with less feedback from other sectors .
- **Type IV**: $C_{ii} > 1$, Sum of ODE < 0. Sectors are becoming increasingly endogenized, and receiving less feedback from other sectors .

Network Topology: Fagiolo Clustering Coefficient

Proposed by Fagiolo (2007), it measures the degree to which nodes (sectors) in a network cluster together in densely interconnected groups . It can identify clusters of interrelated economic sectors .

- Intermediate use matrix Z is normalized to $\tilde{Z}$ where $\tilde{z}_{ij} = z_{ij} / \sum_k z_{ik}$ (this normalization appears to be row-normalization, making it similar to an allocation coefficient).
- The method generates a weighted adjacency matrix $\tilde{Z}$ and considers four types of weighted triangles centered on vertex i: *cyc*, *mid*, *in*, *out* . Each triangle is weighted by the product of its edge weights (geometric mean in paper's figure caption for weights).

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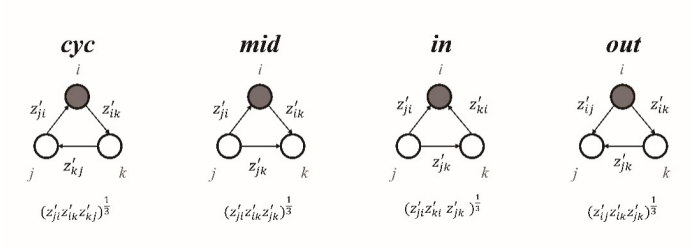

Figure 1: Triangle Motifs for Clustering Coefficient

- First point about the clustering coefficient
- Second point about its applications

Network Topology: Fagiolo Clustering Coefficient

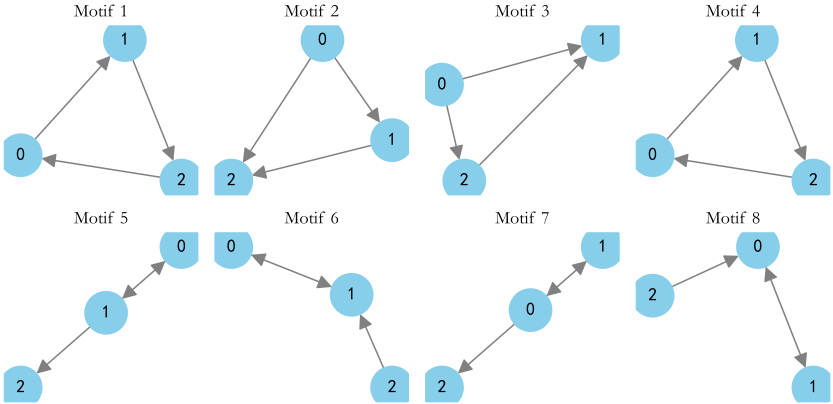

Figure 2: Triangle Motifs for Clustering Coefficient

Network Topology: Fagiolo Clustering Coefficient

Proposed by Fagiolo (2007), it measures the degree to which nodes (sectors) in a network cluster together in densely interconnected groups . It can identify clusters of interrelated economic sectors .

- T_i^* is the weighted sum of all triangles of type $*$ centered on i (Eq. 12-15, e.g., $T_i^{cyc} = \sum_{j,k \neq i} (\tilde{z}_{ij} \tilde{z}_{jk} \tilde{z}_{ki})^{1/3}$) .
- $T_{i,max}^*$ is the maximum possible weight (Eq. 16-19, involving in/out-degrees d_i^{in}, d_i^{out}) .
- Local clustering for type $*$: $C_i^* = T_i^* / T_{i,max}^*$ (Eq. 20).
- Total local clustering for vertex i: $C_i^{total} = \frac{\sum_* T_i^*}{\sum_* T_{i,max}^*}$ (Eq. 21).
- Global clustering coefficient: $C^{global} = \frac{1}{N} \sum_i C_i^{total}$ (Eq. 22).

Network Topology: Industry Symmetry

Symmetry refers to the extent of mutual exchange in inter-industry transactions and is crucial for evaluating paired directed relations .

- Two industries i and j are symmetric if sector i buys inputs from j, AND sector j buys inputs from i .
- Asymmetric relationships (unequal supply levels) can generate economic imbalances and destabilize the system; economic fluctuations can be induced by asymmetry .

Network Topology: Industry Symmetry

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- Symmetry coefficient S_i for sector i (Han et al., 2021) :

$$S_i = \frac{1}{k_i^{adj}} \sum_{j \in N(i), w_{ij}>0, w_{ji}>0} \frac{\min(w_{ij}, w_{ji})}{\max(w_{ij}, w_{ji})} (Eq.23)$$

where:

- k_i^{adj} is the number of sectors j for which a mutual connection ($w_{ij} > 0$ and $w_{ji} > 0$) exists with sector i. (Paper states k_i^{adj} as "number of sectors adjacent to sector i", but summation is only over mutual connections from w_{ij}, w_{ji} context) .
- $N(i)$ is the set of neighbors of i.

Network Topology: Industry Symmetry

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$$S_i = \frac{1}{k_i^{adj}} \sum_{j \in N(i), w_{ij}>0, w_{ji}>0} \frac{\min(w_{ij}, w_{ji})}{\max(w_{ij}, w_{ji})} (Eq.23)$$

  where:
  - w_{ij} and w_{ji} are the transaction flows (from normalized intermediate use matrix $\tilde{Z}$ as per Han et al. 2021 context, though not explicitly stated here if $\tilde{Z}$ or Z is used). The paper uses w_{ij} and w_{ji} generally for weaker/stronger transaction flows in a mutual connection .
- $S_i \in [0, 1]$. Higher $S_i \Rightarrow$ higher symmetry, more balanced economic network .

Pulling Effects of Financial Sector (1996 & 2001)

1996

Rank	Sector	Code	Value
1	Real Estate	S37	0.0386
2	IT Services	S35	0.0335
3	Utilities	S23	0.0225
4	IT Services	S35	0.0145
5	Printing	S9	0.0124
6	Trade & Repair	S26	0.0089
7	Motor Vehicles	S20	0.0071
8	Construction	S25	0.0066
9	Telecom	S34	0.0053
10	Admin Support	S39	0.0048

2001

Rank	Sector(short name)	Code	Value
1	IT Services	S35	0.0605
2	Real Estate	S37	0.0370
3	Electronics	S17	0.0155
4	Accommodation	S32	0.0143
5	Printing	S9	0.0118
6	Admin Support	S39	0.0112
7	Construction	S25	0.0106
8	Prof. Services	S38	0.0100
9	Land Transport	S27	0.0085
10	Air Transport	S29	0.0065

Table 2. Pulling effects of financial sector

Pulling Effects of Financial Sector (2006 & 2008)

2006

Rank	Sector(short name)	Code	Value
1	IT Services	S35	0.0367
2	Admin Support	S39	0.0316
3	Accommodation	S32	0.0287
4	Real Estate	S37	0.0272
5	Prof. Services	S38	0.0243
6	Telecom	S34	0.0210
7	Printing	S9	0.0162
8	Construction	S25	0.0121
9	Electronics	S17	0.0116
10	Utilities	S23	0.0085

2008

Rank	Sector	Code	Value
1	Admin Support	S39	0.0308
2	Prof. Services	S38	0.0234
3	Real Estate	S37	0.0213
4	IT Services	S35	0.0192
5	Accommodation	S32	0.0183
6	Telecom	S34	0.0099
7	Printing	S9	0.0097
8	Postal Services	S31	0.0058
9	Food & Beverage	S6	0.0049
10	Utilities	S23	0.0045

Table 2. Pulling effects of financial sector

Pulling Effects of Financial Sector (2013 & 2018)

2013

Rank	Sector	Code	Value
1	Admin Support	S39	0.0352
2	Real Estate	S37	0.0335
3	Prof. Services	S38	0.0263
4	Accommodation	S32	0.0252
5	Printing	S9	0.0136
6	Telecom	S34	0.0103
7	IT Services	S35	0.0096
8	Postal Services	S31	0.0088
9	Food & Beverage	S6	0.0075
10	Construction	S25	0.0048

2018

Rank	Sector	Code	Value
1	Admin Support	S39	0.0241
2	Real Estate	S37	0.0215
3	Accommodation	S32	0.0147
4	Prof. Services	S38	0.0142
5	Printing	S9	0.0066
6	IT Services	S35	0.0061
7	Telecom	S34	0.0046
8	Food & Beverage	S6	0.0038
9	Machinery	S22	0.0037
10	Textiles	S7	0.0034

Table 2. Pulling effects of financial sector

Intersectoral Linkages: Pull Effects (Financial Sector's Demand) - Part 1

Measured using the column vector of SP matrix Q (quantity-based pull effects) . **Key Upstream Sectors Pulled by the Financial Sector (selected findings from Table 2):**

- **Real Estate Activities (S37)**: Strong pull, ranked 1st in 1996 (coeff: 0.0386) , 2nd in 2001, 2013, 2018 . Attributed to property management, development services, and appraisals for financial institutions .
- **IT and Other Information Services (S35)**: Significant pull, ranked 2nd in 1996, 1st in 2001 (coeff: 0.0605) and 2006 . Driven by technology adoption for efficiency and cost reduction in finance . Coefficient value declined post-2001 peak .

Intersectoral Linkages: Pull Effects (Financial Sector's Demand) - Part 2

Key Upstream Sectors Pulled by the Financial Sector (continued from Table 2):

- **Administrative and Support Services (S39)**: Strong backward linkage, rising from 10th in 1996 to 1st in 2008 (coeff: 0.0308), 2013, and 2018 (coeff: 0.0241) . Demand fueled by financial sector growth requiring specialized legal, accounting, and tech support .
- **Professional, Scientific, and Technical Activities (S38)**: Important input, ranked 2nd in 2008 . Provides specialized consulting, risk management, and investment advisory services .

Intersectoral Linkages: Pull Effects (Financial Sector's Demand) - Part 3

Key Upstream Sectors Pulled by the Financial Sector (continued from Table 2):

- Dynamic nature: Some sectors like Wholesale/Retail Trade (S26) lost prominence, while Postal and Courier (S31), Food Products (S6) emerged later .

The analysis reveals evolving input dependencies of the financial sector.

Pushing Effects of Financial Sector (1996 & 2001)

1996

Rank	Sector	Code	Value
1	IT Services	S35	0.061
2	Real Estate	S37	0.045
3	Postal Services	S31	0.041
4	Utilities	S23	0.020
5	Air Transport	S29	0.019
6	Telecom	S34	0.017
7	Printing	S9	0.017
8	Water & Waste	S24	0.014
9	Electronics	S17	0.009
10	Machinery	S22	0.008

2001

Rank	Sector	Code	Value
1	IT Services	S35	0.097
2	Air Transport	S29	0.042
3	Real Estate	S37	0.038
4	Postal Services	S31	0.037
5	Accommodation	S32	0.019
6	Telecom	S34	0.018
7	Printing	S9	0.016
8	Admin Support	S39	0.016
9	Prof. Services	S38	0.015
10	Land Transport	S27	0.008

Table 3. Pushing effects of financial sector

Pushing Effects of Financial Sector (2006 & 2008)

2006

Rank	Sector	Code	Value
1	Postal Services	S31	0.080
2	IT Services	S35	0.076
3	Telecom	S34	0.056
4	Admin Support	S39	0.047
5	Accommodation	S32	0.040
6	Prof. Services	S38	0.035
7	Air Transport	S29	0.035
8	Real Estate	S37	0.032
9	Printing	S9	0.028
10	Arts & Recreation	S43	0.016

2008

Rank	Sector	Code	Value
1	Postal Services	S31	0.0596
2	Admin Support	S39	0.0446
3	IT Services	S35	0.0375
4	Prof. Services	S38	0.0337
5	Accommodation	S32	0.0276
6	Telecom	S34	0.0275
7	Real Estate	S37	0.0226
8	Printing	S9	0.0193
9	Air Transport	S29	0.0187
10	Arts & Recreation	S43	0.0105

Table 3. Pushing effects of financial sector

Pushing Effects of Financial Sector (2013 & 2018)

2013

Rank	Sector	Code	Value
1	Postal Services	S31	0.1023
2	Admin Support	S39	0.0651
3	Accommodation	S32	0.0551
4	Prof. Services	S38	0.0427
5	Real Estate	S37	0.0381
6	Telecom	S34	0.0374
7	Printing	S9	0.0323
8	Arts & Recreation	S43	0.0262
9	Air Transport	S29	0.0247
10	IT Services	S35	0.0238

2018

Rank	Sector	Code	Value
1	Admin Support	S39	0.0299
2	Accommodation	S32	0.0270
3	Postal Services	S31	0.0240
4	Prof. Services	S38	0.0238
5	Real Estate	S37	0.0225
6	Arts & Recreation	S43	0.0225
7	Telecom	S34	0.0200
8	IT Services	S35	0.0182
9	Printing	S9	0.0162
10	Machinery	S22	0.0113

Table 3. Pushing effects of financial sector

Intersectoral Linkages: Push Effects (Financial Sector's Supply) - Part 1

Measured using the row vector of SP matrix R (quantity-based push effects) .
Key Downstream Sectors Pushed by the Financial Sector (selected findings from Table 3):

- **IT and Other Information Services (S35)**: Ranked 1st in 1996 (coeff: 0.061) and 2001 (coeff: 0.097) . High financing needs for tech innovation and R&D in its early growth phase . Impact declined from 2008 .
- **Real Estate Activities (S37)**: Significant reliance, 2nd in 1996, 3rd in 2001 . Driven by capital-intensive nature, housing reforms, urbanization, and increased bank lending to the sector . U-shaped pattern in output coefficients, later ranking 5th in 2013/2018 .

Intersectoral Linkages: Push Effects (Financial Sector's Supply) - Part 2

Key Downstream Sectors Pushed by the Financial Sector (continued from Table 3):

- **Postal and Courier Activities (S31)**: Rose from 4th in 2001 to 1st in 2006, 2008, 2013 (peak coeff: 0.1023 in 2013) . Financial sector expansion boosted consumer spending and e-commerce, increasing demand for these services .
- **Administrative and Support Services (S39)**: Ranking significantly improved, 2nd from 2008-2013, 1st in 2018 (coeff: 0.0299) . Increased financing needs due to economic expansion and demand for specialized services .

Intersectoral Linkages: Push Effects (Financial Sector's Supply) - Part 3

Key Downstream Sectors Pushed by the Financial Sector (continued from Table 3):

- **Overall Observation**: The impact of the financial sector on service sectors is generally more pronounced than on manufacturing sectors . This may be due to higher demand for financial services by service firms for investments in technology, R&D, and marketing .

Upstream and Downstream Closeness of the Financial Sector - Table 4

Upstream Closeness			Downstream Closeness		
Year	Closeness	Rank	Year	Closeness	Rank
1996	244.964	29	1996	828.435	11
1997	215.732	30	1997	831.342	14
2001	443.668	30	2001	1247.661	12
2002	414.952	30	2002	1274.199	12
2006	1367.730	23	2006	2779.085	14
2008	1413.823	29	2008	5242.659	11
2009	917.213	36	2009	5726.918	11
2010	908.853	37	2010	6521.356	11
2013	4293.425	24	2013	14619.487	6
2016	2925.076	29	2016	16940.506	6
2018	3433.677	30	2018	18776.767	7

Table 4. Values and Rankings of Upstream and Downstream Closeness of Financial sector

Upstream and Downstream Closeness of the Financial Sector - Part 1

Key Findings (Table 4 & Figure 1):

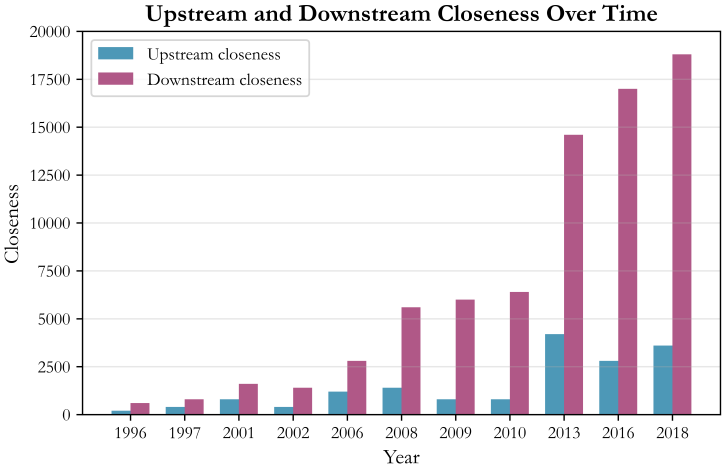
- **Upstream Closeness** (demand-side pull, financial sector as consumer):
  - Showed volatility; rankings often in the lower half (e.g., 30th out of 44 in 2001) , implying relatively weaker interdependence with its suppliers compared to other sectors .
  - Some periods showed increased influence (e.g., 23rd in 2006, 24th in 2013) .

Upstream and Downstream Closeness of the Financial Sector - Part 2

Key Findings (continued from Table 4 & Figure 1):

- **Downstream Closeness** (supply-side push, financial sector as supplier):
  - Consistently higher than upstream closeness .
  - Showed a rising trend in ranking (e.g., 11th in 1996 to 6th in 2013 and 2016, 7th in 2018) .
  - This suggests the financial sector's role in driving demand and activity in its downstream sectors has steadily increased, having significant supply-side effects .

Upstream and Downstream Closeness of the Financial Sector



Upstream and Downstream Closeness of the Financial Sector - Part 3

Key Findings (continued from Table 4 & Figure 1):

- **Implication**: The financial sector is more influential as a supplier of crucial inputs/services to the economy than as a demander of inputs from it, becoming increasingly important in driving growth in downstream sectors . It appears less reliant on specific upstream sectors for its operations .

Financial Sector Betweenness (1996–2008)

Year	Betweenness (Method 1)	Betweenness (Method 2)	No. of SPs	Ranking
1996	105.65	96.07	3	19
1997	163.08	23.27	4	17
2001	712.52	693.34	9	14
2002	861.95	629.73	13	10
2005	1394.70	1105.33	17	8
2006	875.05	888.97	9	11
2007	852.80	627.45	6	18
2008	1209.10	840.96	6	17
2009	257.11	139.80	2	25
2013	3582.58	5803.63	12	15
2016	1872.69	3324.73	4	24
2017	4233.05	6029.00	6	24
2018	4019.05	6367.84	5	26

Table 5. Financial sector Betweenness, number of SPs and rankings

Industry Betweenness of the Financial Sector - Part 1

Betweenness quantifies the financial sector's role as an intermediary or bridge in the economic network .

Key Findings (Table 5):

- **Fluctuating Role**: Betweenness values, number of SPs passing through the sector, and rankings displayed considerable fluctuation over the study period .
- **Pre-GFC Trend (1996-2005)**: An increasing trend in betweenness values and SPs was observed (e.g., SPs from 3 to 17; rank improved from 19th to 8th) . This may reflect the growing importance of the financial sector in intermediating between different sectors, possibly linked to events like China's WTO accession and increased international trade .

Industry Betweenness of the Financial Sector - Part 2

Key Findings (continued from Table 5):

- **GFC Impact (2007-2009)**: A subsequent decline in betweenness values and SPs (e.g., SPs dropped to 2 in 2009; rank to 25th) . This is likely attributable to the global financial crisis .
- **Post-GFC Recovery and Volatility**: A sharp rise in betweenness post-GFC (e.g., 2013 SPs at 12, rank 15th), followed by fluctuations . This suggests a recovery but also ongoing adjustments in its intermediary role.

Industry Betweenness of the Financial Sector - Part 3

Key Findings (continued from Table 5):

- **Overall Implication**: The financial sector generally serves as an important network intermediary, facilitating transactions and interactions among various economic sectors, with its significance evolving with major economic events .

Result of the Causative Matrix: Financial Sector

Period	**Row Sum of Financial Sector**	**Diagonal Element $C_{36,36}$**
1996–2001	1.041	0.95
2001–2006	1.039	0.87
2008–2013	1.340	1.09
2013–2018	0.807	1.18

Table 6. Result of the causative matrix

Structural Change via Causative Matrix Analysis - Part 1

Analyzed for periods: 1996-2001, 2001–2006, 2008–2013, 2013–2018 .

Key Findings from Causative Matrix (Table 6):

- **Row Sum** (Impact of other sectors' final demand on financial sector output):
  - > 1 for 1996-2001 (1.041), 2001-2006 (1.039), and 2008-2013 (1.340) . This indicates the financial sector's output was heavily influenced by final demand from other sectors, especially during 2008-2013 .
  - < 1 for 2013-2018 (0.807) . Suggests a weaker output effect from other sectors' demand in this later period .

Structural Change via Causative Matrix Analysis - Part 2

Key Findings from Causative Matrix (continued from Table 6):

- **Diagonal Element ($C_{FS,FS}$)** (Financial Sector's internal vs. external impact):
  - < 1 for 1996-2001 (0.95) and 2001-2006 (0.87) . Indicates the financial sector's final demand was relatively more externalized, increasing other sectors' output more than its own .
  - > 1 for 2008-2013 (1.09) and 2013-2018 (1.18) . Suggests the sector became more internalized; its own final demand had a larger impact on its own output .

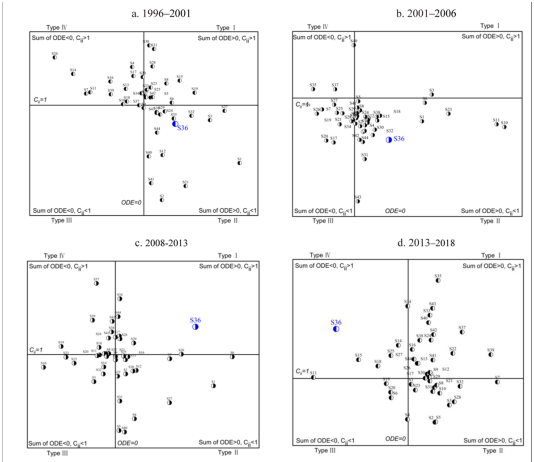


Fig. 3. A typology of structural change.
Source. Calculated by the authors.

Figure 3: A typology of structural change

Typology of Structural Change in the Financial Sector - Part 1

Based on Causative Matrix results (Figure 2):

- **1996–2001 & 2001–2006 (Classified as Type II)** :
  - The financial sector was more **externalized** ($C_{\text{FS,FS}} < 1$) .
  - Its output was increasingly influenced by (received significant feedback from) the final demand of other sectors (Sum of ODE > 0) .

Typology of Structural Change in the Financial Sector - Part 2

Based on Causative Matrix results (Figure 2):

- **2008-2013 (Classified as Type IV)** :
  - The financial sector became more **internalized** ($C_{FS,FS} > 1$) .
  - Other sectors had a smaller output impact on it (Sum of ODE < 0, meaning less feedback) .

Typology of Structural Change in the Financial Sector - Part 3

Based on Causative Matrix results (Figure 2):

- **2013-2018 (Classified as Type I)** :
  - The financial sector remained **internalized** ($C_{FS,FS} > 1$) .
  - However, it received significant feedback effects from other sectors (Sum of ODE > 0), a reversal from the 2008-2013 period regarding feedback levels .

Typology of Structural Change in the Financial Sector - Part 4

Overall Trajectory: A shift in financialization from externalization to internalization, while largely maintaining strong (though evolving) feedback linkages with other sectors . This indicates increasing importance in the overall economy, potentially with a greater role in driving growth .

Financial Sector: Clustering and Symmetry Coefficients

Fagiolo Clustering Coefficient

Year	Coefficient	Rank
1996	0.073	32
1997	0.066	35
2001	0.058	32
2002	0.058	29
2006	0.036	35
2007	0.030	38
2008	0.027	37
2009	0.027	35
2010	0.025	36
2013	0.017	38
2014	0.016	37
2015	0.015	36
2017	0.016	36
2018	0.015	36

Industry Symmetry Coefficient

Year	Coefficient	Rank
1996	0.298	32
1997	0.195	39
2001	0.276	25
2002	0.266	28
2006	0.295	23
2007	0.223	35
2008	0.224	36
2009	0.164	41
2010	0.145	41
2013	0.217	32
2014	0.222	30
2015	0.180	38
2017	0.191	38
2018	0.204	35

Fagiolo Clustering and Industry Symmetry Coefficients - Part 1

Assessing interconnectedness, mutual dependence, and vulnerability (Table 7).

- **Fagiolo Clustering Coefficient (C^F)**:
  - Shows a **decreasing trend** over time (e.g., from 0.073 in 1996 to 0.015 in 2018) . Rankings are generally in the middle to bottom range among 44 sectors .
  - Suggests the financial sector is becoming **less densely interconnected** within tight clusters of sectors in the network .
  - This could imply diminishing direct influence over some sectors and, potentially, **reduced vulnerability** to certain types of shocks propagating through these dense clusters . This is consistent with Han et al. (2021) for the Chinese real estate sector .

Fagiolo Clustering and Industry Symmetry Coefficients - Part 2

Assessing interconnectedness, mutual dependence, and vulnerability (Table 7).

- **Industry Symmetry Coefficient (S)**:
  - **Fluctuates** across years without a clear unidirectional trend (e.g., 0.298 in 1996, 0.164 in 2009, 0.204 in 2018) . Rankings (23rd to 41st) suggest a relatively lower level of mutual dependence and reciprocity compared to some other sectors .

Fagiolo Clustering and Industry Symmetry Coefficients - Part 3

Industry Symmetry Coefficient (S) (Continued):

- **Interpretation of Fluctuations** :
  - *Rising* S: More even distribution of financial sector's resource consumption and production. Potentially beneficial for efficiency/diversification, but could increase vulnerability if interdependence tightens broadly .
  - *Falling* S: Less even distribution, possibly more specialization. Could decrease efficiency if it leads to bottlenecks, or reduce systemic risks if it means diversification away from tight coupling with the whole economy .

Recapitulation of Core Findings - Part 1

1. **Dominant Supply-Side Influence**: The Chinese financial sector consistently exhibits greater downstream closeness than upstream, underscoring its pivotal role in propelling growth in downstream sectors through significant supply-side effects . It is comparatively less reliant on upstream sectors for its operational inputs .
2. **Critical Network Intermediary**: The financial sector functions as a key network intermediary, as evidenced by its betweenness values. It facilitates transactions and interactions among diverse economic sectors, with its importance fluctuating but showing an upward trend, especially around the GFC .

Recapitulation of Core Findings - Part 2

3. **Dynamic Structural Evolution**: The sector has undergone significant structural transformations in its intersectoral relationships. An initially more "externalized" financial system (pre-GFC, strongly influenced by other sectors' final demand) transitioned to a more "internalized" state post-GFC, with evolving feedback dynamics .
4. **Interconnectedness and Risk Profile**: The financial sector is becoming less tightly clustered with other sectors (declining Fagiolo clustering coefficient), potentially reducing its vulnerability to certain shocks . Fluctuating industry symmetry coefficients suggest a dynamic and heterogeneous pattern of resource consumption and production distribution, with varying implications for systemic risk exposure .

Recapitulation of Core Findings - Part 3

Key interacting sectors consistently include Administrative and support services, Real estate activities, IT and other information services, Accommodation and food service activities, and Professional, scientific and technical activities .

Policy Implications and Recommendations - Part 1

The comprehensive analysis offers crucial insights for policymakers :

- **Acknowledge Supply-Side Impact & Manage Risk**: Given the financial sector's substantial supply-side effects, policymakers must prioritize robust risk management frameworks and ensure financial stability to safeguard overall economic health .
- **Integrate Intersectoral Linkages into Industrial Policy**: When formulating industrial policies, it is essential to consider the intricate intersectoral linkages. This allows for effective utilization of the positive supply-side effects generated by the financial sector to promote balanced and widespread economic growth .

Policy Implications and Recommendations - Part 2

The comprehensive analysis offers crucial insights for policymakers (Continued):

- **Enhance Regulatory Frameworks for Resilience**: Continuous development and implementation of effective regulatory frameworks and proactive risk mitigation strategies are necessary. This will improve the financial sector's resilience to shocks, maintain its stability, and prevent the accumulation of systemic risks that could destabilize the broader economy .

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Questions & Discussion Thank You!

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