

一种主导产业结构的可视化方法及其应用研究

A Method to Visualize the Skeleton Industrial Structure and Its Application

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Outline

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- Research Aim
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- Verification of DFM
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Introduction

- The modern history of economic development shows that the process of economic development of a region, is not only for the growth of the total economy, but also is accompanied by the evolution of the industrial structure.
- Especially in the middle stage of industrialization, the accelerated transformation of industrial structure is the important characteristic of economic growth.
- Find the rules of industrial structure change will be helpful to make economic growth.

Literatures Review

- Since the 1960s, there are many theories of industrial structure change.
- From Hoffman's law (1931), Petty-Clark Law(1940) to study of changes in the trend of Kuznets(1946), then to input-output analysis of Leontief (1953), Chenery's 'standard configuration'(1960) and 'flying geese form' provided by Kiyoshi Kojima (2000), Zheng (2017) and so on.
- They have demonstrated that the development and evolution of the industrial structure had its own laws on the whole.



The Existed Findings

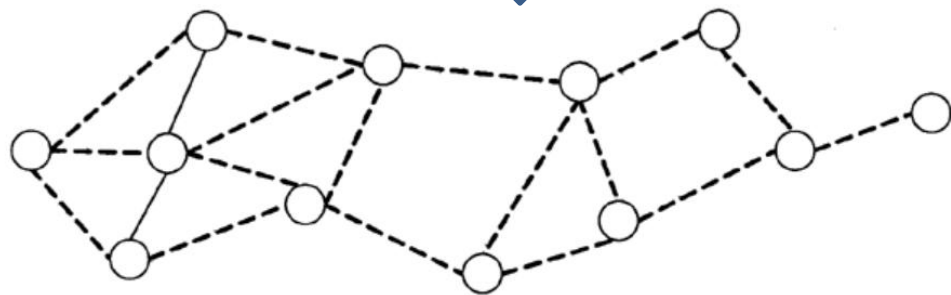
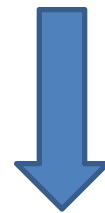
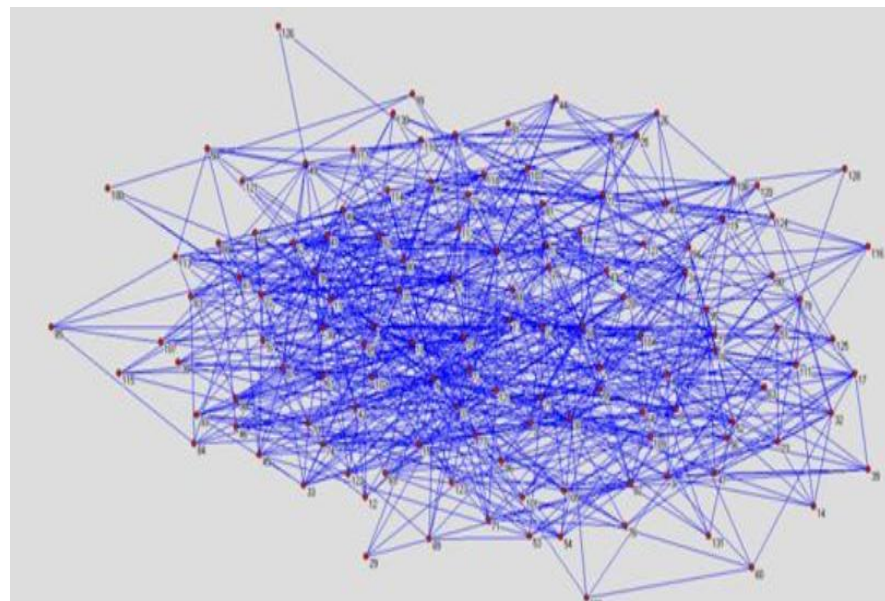
- In general, from the respect of the conversion of the three industries, they presence of ‘One, two, three’ to ‘three, two, one’ change trend.
- From the perspective of leading industries: the leading industry in order replacement for agriculture, textile industry, heavy industry, low processing and assembly industries, highly processing and assembly industries, the tertiary industry, the information industry.

Further Thought

- There are complex supply and demand conjunctions among all industries. This determines that the development of a particular industry would inevitably have impacts on the development of many other associated industries.
- To examine the industrial structure changes cannot be confined among the three industries and leading sectors. It should also be inspected from the industrial system, and examine the conjunctions among all the industries.

Question

- There are complex supply and demand connections among all industries. While the existing researches **are seldom from the view of industrial connections** (Feldman *et. al.*, 1987).





One pioneering research is from Schnabl (2001) who provided **Minimum Flow Analysis(MFA)** method to describe the law of the industrial structure changes during 1980-1990 in Germany, USA and Japan.

- **Disadvantages of the MFA :**
- There has no criterion to decide the filter value.
- Boolean algebra method was applied to determine the values of the incidence matrix, which could not reflect the strength of industrial linkages reasonably.

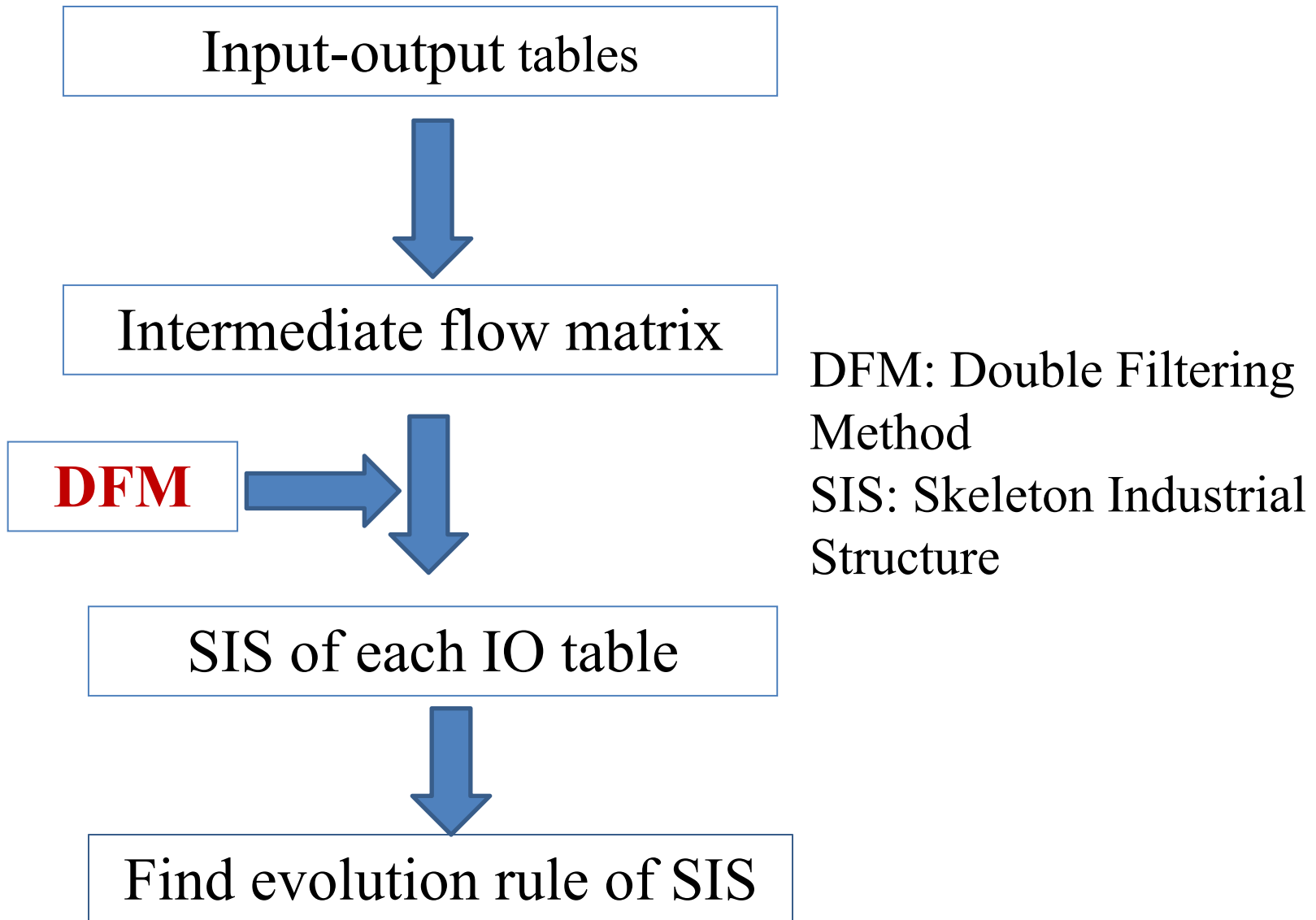




Research Aim

- To provide a method to visualize the skeleton industrial structure from the view of industrial linkages.

Main Thoughts



Double Filtering Method

Step1. From IO table, one can get $T = A < X >$ (1)

Where, T represents the intermediate flow matrix, A means direct input coefficient matrix, $< X >$ means the diagonal matrix of X , while

$$X = (I - A)^{-1}Y = (I + A + A^2 + A^3 + \dots)Y \quad (2)$$

Input (2) to (1):

$$T = A < (I + A + A^2 + A^3 + \dots)Y > = A < Y > + A < AY > + A < A^2Y > + \dots \quad (3)$$

Where $< Y >$ means the diagonal matrix of final demand Y , $< AY >$ means the diagonal matrix of $AY \dots$

$$\text{Set } L^0 = A < Y >, L^1 = A < AY >, L^2 = A < A^2Y >, L^3 = A < A^3Y > \dots$$

$$\text{Get } LD^s = L^s - \text{diag}(L^s) \quad (s = 0, 1 \dots K)$$

For any element of A is smaller than 1, there will exist a number $K, LD^K \rightarrow 0$.



Steps of DFM

Step2. Set the first threshold $F1 = \frac{1}{K+1} \cdot \sum_{s=0}^K \frac{1}{n^2} \sum_{i=1}^n \sum_{j=1}^n l_{ij}^s$ (4)

Step3. Get the incidence matrix $W^0, W^1, W^2, W^3 \dots W^K$ of $LD^0, LD^1, LD^2, LD^3 \dots$ with

$$w_{ij}^s = \begin{cases} 1 & l d_{ij}^s \geq F1 \\ 0 & \text{the other} \end{cases}, \quad l d_{ij}^s \text{ is the element of matrix } LD_s.$$

Step4. Calculate $D = (d_{ij})$, $D = W^0 + W^1 + W^2 + W^3 + \dots + W^K$ (5)

Step5. Calculate $E = (e_{ij})$,

$$e_{ij} = d_{ij} / (K+1) \quad (6)$$

Step6. Set the second threshold $F2 = \frac{1}{n^2} \sum_{i=1}^n \sum_{j=1}^n e_{ij} = \frac{1}{K+1} \cdot \frac{1}{n^2} \sum_{i=1}^n \sum_{j=1}^n d_{ij}$ (7)

Step7. Set the incidence matrix $F = (f_{ij})$ of E , $f_{ij} = \begin{cases} 1 & e_{ij} \geq F2 \\ 0 & \text{the other} \end{cases}$,



Double Filtering Method

Step8. Calculate $G=(g_{ij})_{n \times n}$

$$g_{ij} = f_{ij} + f_{ji} \quad (8)$$

F matrix is a 0-1 matrix, the elements of G only have three possible value 0, 1 or 2. If $g_{ij}=0$, means the conjunction between $\underline{i}$ and j is weak. If $g_{ij}=1$, then $f_{ij} = 1$ (or $f_{ji} = 1$). This means that if the total output of all sectors increased one unit, the intermediate input of sector j to sector $\underline{i}$ (or the intermediate use of sector j from sector $\underline{i}$) will have an increase greater than the average level. If $g_{ij}=2$, This means that if the total output of all sectors increased one unit, not only the intermediate input of sector j to sector $\underline{i}$ but also the intermediate use of sector j from sector $\underline{i}$ will have an increase greater than the average level.

Step9. If $g_{ij}=2$, sector $\underline{i}$ and sector j were called as leading sectors. The network combined by the conjunction among all the leading sectors was called as the skeleton industrial structure(SIS).



Comparison with MFA

- With 9 steps of DFM, the two disadvantages of MFA were overcome.
- Two filtering threshold $F1$ and $F2$ are set in the DFM.
- D matrix in (5) is obtained by numerical summation, the linkage strength among all sectors is fully reflected.



Theorem 1. The leading sector selected by DFM must be key sector selected by Hirschman-Rasmussen Method.

Prove: From the steps of DFM method, if j_0 is a leading sector,

$$a_{ij_0} > \frac{1}{n^2} \sum_{i=1}^n \sum_{j=1}^n a_{ij} \quad (9)$$

$$b_{ik} a_{kj_0} > \frac{1}{n^2} \sum_{i=1}^n \sum_{j=1}^n b_{ik} a_{kj} \quad (10)$$

While $b_{ij_0} = a_{ij_0} + \sum_{k=1}^n b_{ik} a_{kj_0}$, from equations(9) and (10),

$$\begin{aligned} b_{ij_0} &> \frac{1}{n^2} \sum_{i=1}^n \sum_{j=1}^n a_{ij} + \sum_{k=1}^n b_{ik} a_{kj_0} \Rightarrow \sum_{i=1}^n b_{ij_0} > \frac{1}{n} \sum_{i=1}^n \sum_{j=1}^n a_{ij} + \sum_{i=1}^n \sum_{k=1}^n b_{ik} a_{kj_0} \\ &\Rightarrow \frac{1}{n} \sum_{i=1}^n b_{ij_0} > \frac{1}{n^2} \sum_{i=1}^n \sum_{j=1}^n a_{ij} + \frac{1}{n} \sum_{i=1}^n \sum_{k=1}^n b_{ik} a_{kj_0} \\ &> \frac{1}{n^2} \sum_{i=1}^n \sum_{j=1}^n a_{ij} + \frac{1}{n} \sum_{i=1}^n \sum_{k=1}^n \left(\frac{1}{n^2} \sum_{i=1}^n \sum_{j=1}^n b_{ik} a_{kj} \right) \text{ (from equation(10))} \\ &= \frac{1}{n^2} \sum_{i=1}^n \sum_{j=1}^n a_{ij} + \frac{1}{n^2} \sum_{i=1}^n \sum_{j=1}^n \sum_{k=1}^n b_{ik} a_{kj} = \frac{1}{n^2} \sum_{i=1}^n \sum_{j=1}^n (a_{ij} + \sum_{k=1}^n b_{ik} a_{kj}) = \frac{1}{n^2} \sum_{i=1}^n \sum_{j=1}^n b_{ij} \end{aligned} \quad (11)$$

In accordance with the definition of key sectors by Hirschman (1958),

If j_0 is a key sector, then $\frac{1}{n} \sum_{i=1}^n b_{ij_0} > \frac{1}{n^2} \sum_{i=1}^n \sum_{j=1}^n b_{ij}$, from equation (11) one knows

that j_0 is a key sector.



Application: Data Source

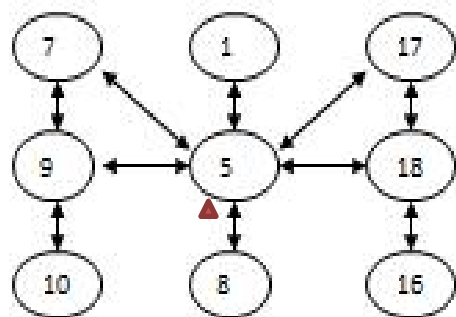
- China input-output tables in 1981 with 26 sectors, in 1987 with 35 sectors, in 1992, 1995 with 33 sectors, in 1997, 1999 with 40 sectors which were published by [China Statistics](#).
- The USA input-output tables in 1972, 1977, 1982, 1985 and 1990 with 36 sectors and in 1998 with 85 sectors (OECD).
- Japan input-output tables in 1970, 1975, 1980, 1985, 1990, 1995 with 36 sectors and in 2000 with 50 sectors (OECD).

Application

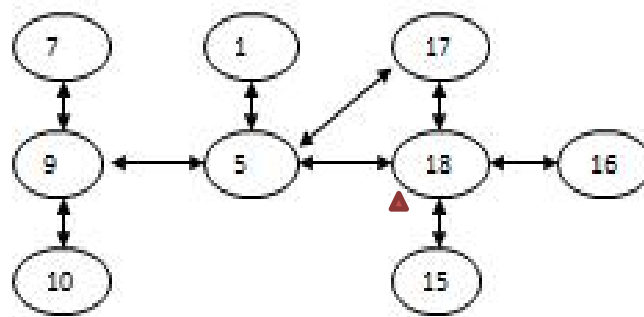
Table 1. China, Japan and the United States Input-Output Tables Sector Definitions

Code	Description	Code	Description
①	Agriculture	10	Machinery Industry
2	Coal Mining	11	Transportation Equipment Manufacturing
3	Oil and Gas Exploration	12	Electronics and Electrical Equipment Manufacturing
4	Other Mining industry	13	Instrumentation Office Machinery and other
⑤	Food, Textile, Paper-making and Furniture	14	Electricity, Gas, Water Production and Supply
6	Petroleum Processing and Coking industry	15	Construction
7	Chemical Industry	16	Transportation, Post and Storage
8	Construction Materials, etc	17	Commercial and Catering industry
9	Metal Smelting and Fabricated Metal products	⑮	The Other Services

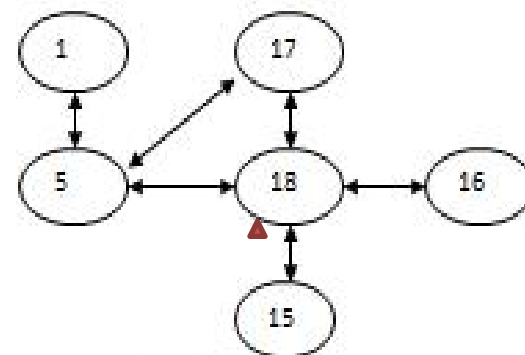
Results-USA



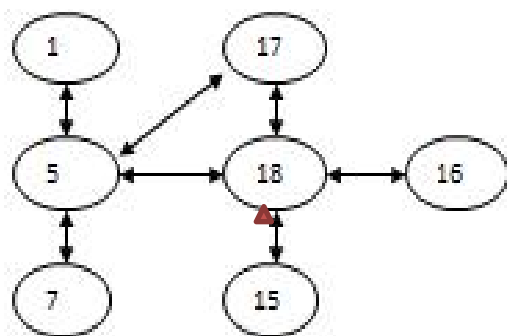
USA 1972



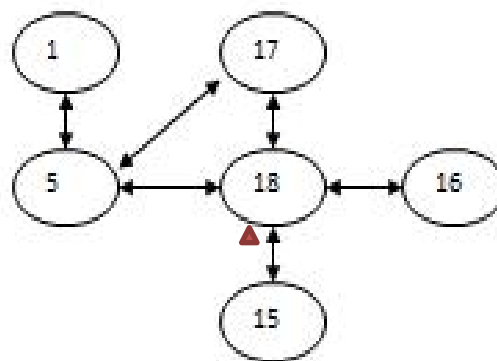
USA 1977



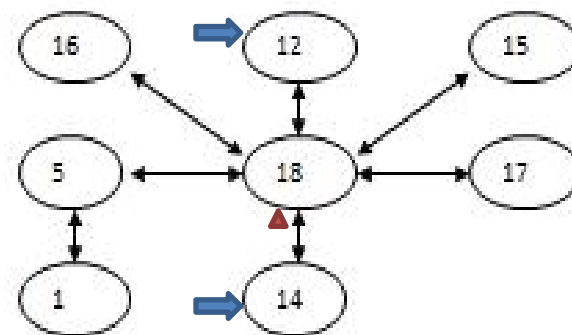
USA 1982



USA 1985



USA 1990



USA 1998

Figure 1. SIS of the United States from 1972 to 1998



The main features of the USA's SIS evolution during 1972-1998

- With the impact of the new technological revolution, **the core of the national economy of USA was shifted from the secondary industry to the tertiary industry.**
- **The gravity of the manufacturing sector is gradually transferred to the High Technological Industries.**
- **The tertiary industry is becoming more and more important in the economic structure of USA.** It has been out of the labor-intensive, low-skilled or unskilled traditional areas, and gradually joined the rank of the advanced technology.

Bubble Economy

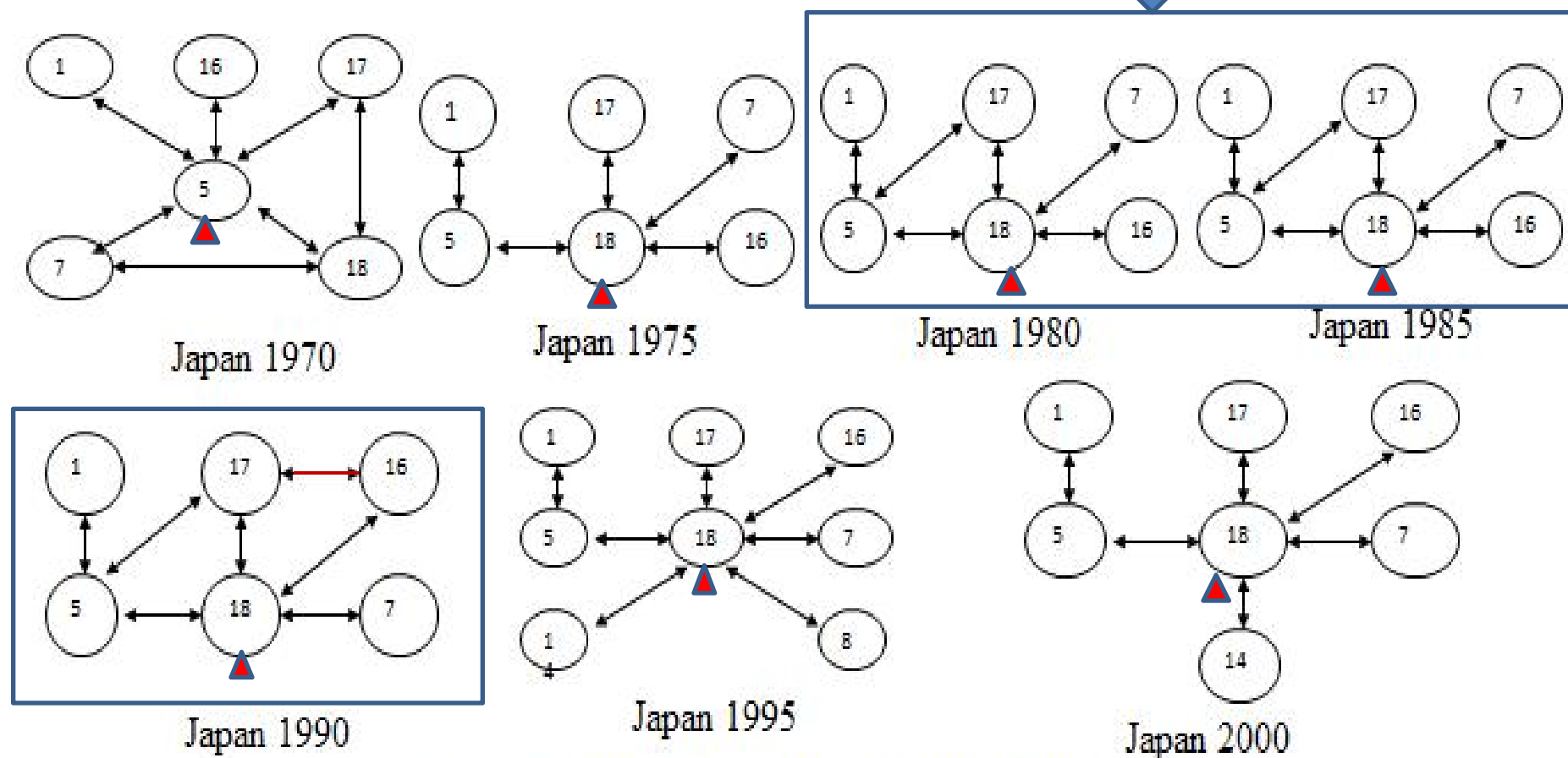


Figure 2. SIS of Japan from 1970 to 2000



The main features of Japan's SIS evolution during 1970-2000

- The core of the SIS transferred from the second industry to the tertiary industry. The core of the tertiary industry became more and more prominent.
- **Japan's SIS had little change from 1980 to 1990.** In the late 1980s, on the heels of a three-decade long 'Economic Miracle', **Japan experienced its 'bubble economy'**.
- The delay change of SIS during 1980-1990 was one of the main factors that made Japan fall into the worst postwar recession.

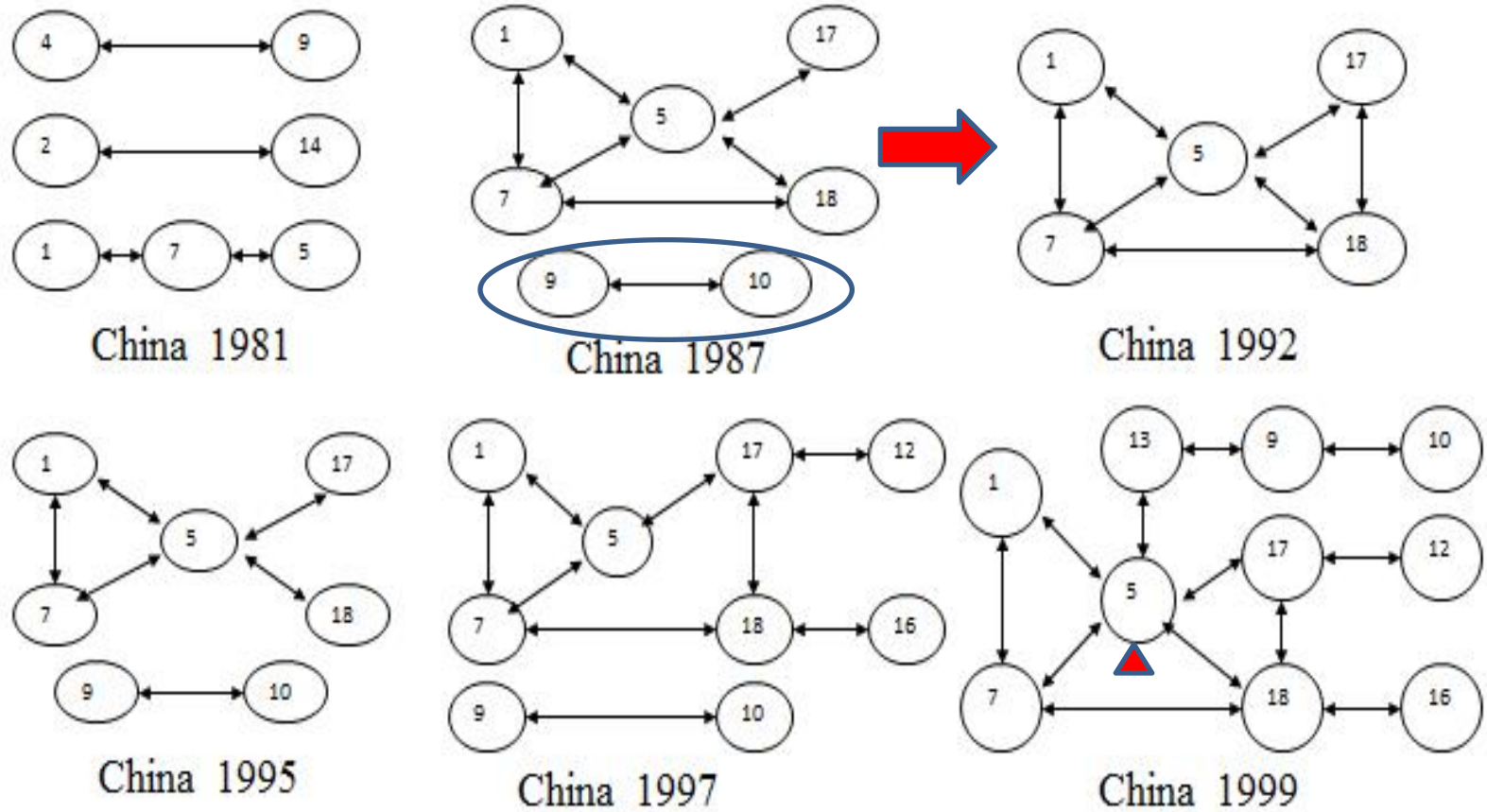


Figure 3. SIS of China from 1981 to 1999



The main features of China's SIS evolution during 1981-1999

- The SIS was evolved from the split industry chain to the complex industry conjunction networks.
- From 1987, the core of the SIS was always sector 5.
- The role and the impacts of The Other Services became more and more prominent. There was a trend that it would become the core of the SIS.
- The SIS of 1992 is much more simply than that of 1987. At the same time, in 1990, the economic growth of China was 3.8%, it's the bottom during 1987-1992.



Findings

- The evolutions of the SIS of Japan and USA are similar. **They obey the general rule of industrial structure change from the existing researches.**
- The core of its SIS was almost always Food Textile and Paper making Furniture industry. **From this point of view, China's industrialization process behind Japan and USA 20-30 years.**



Findings

- The bilateral linkages between Sector 1 and Sector 5, between Sector 5 and Sector 18 were in each SIS of USA and Japan.
- **These showed that in any stage of industrialization, the development of Agriculture and the relevant industries should not be ignored.**

Complexity Analysis

Complexity Index (CI_t) of SIS are defined with equation (10). ↗

$$CI_t = (\ln_t * 2 + s_t) / 100 \quad (10) \quad \leftarrow$$

where $\ln_t$ is the number of lines in the SIS in year t , s_t is the number of sectors in the SIS in year t . ↗

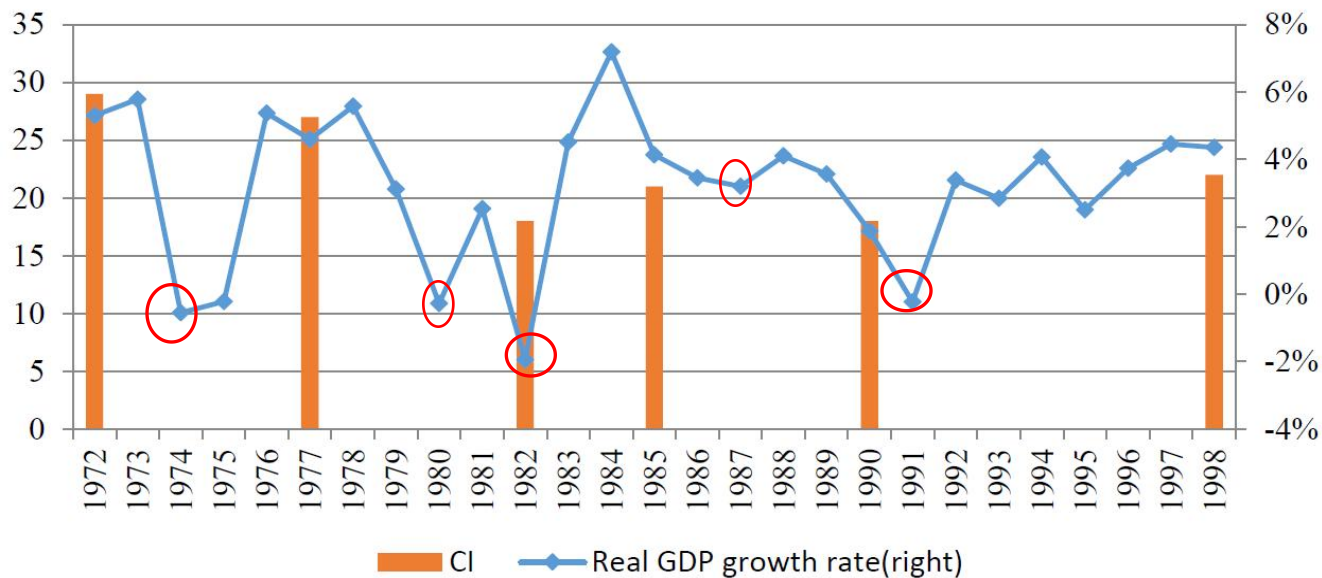


Figure 4. Real GDP growth rate and CI of USA

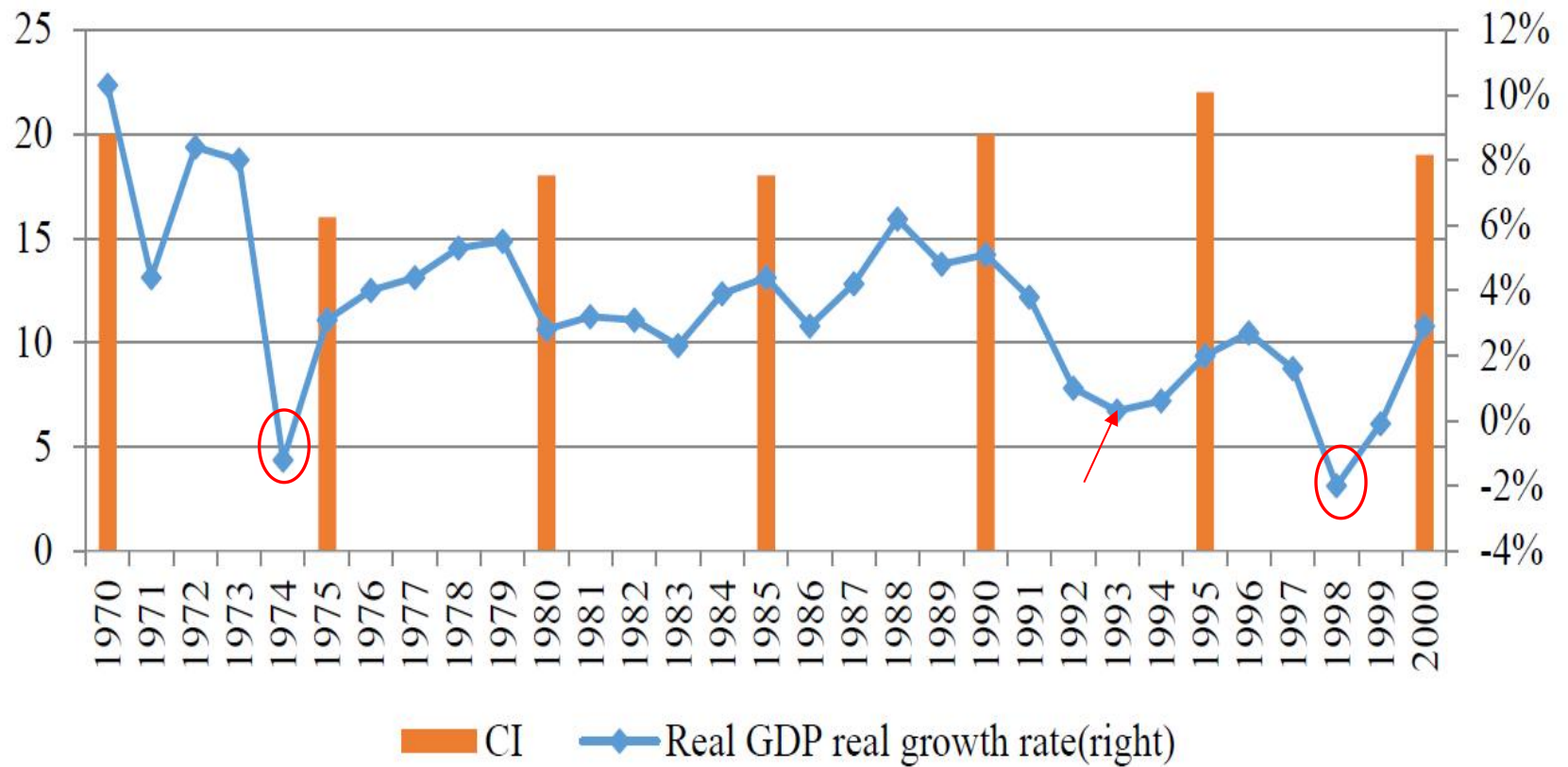


Figure 5. Real GDP growth rate and CI of Japan

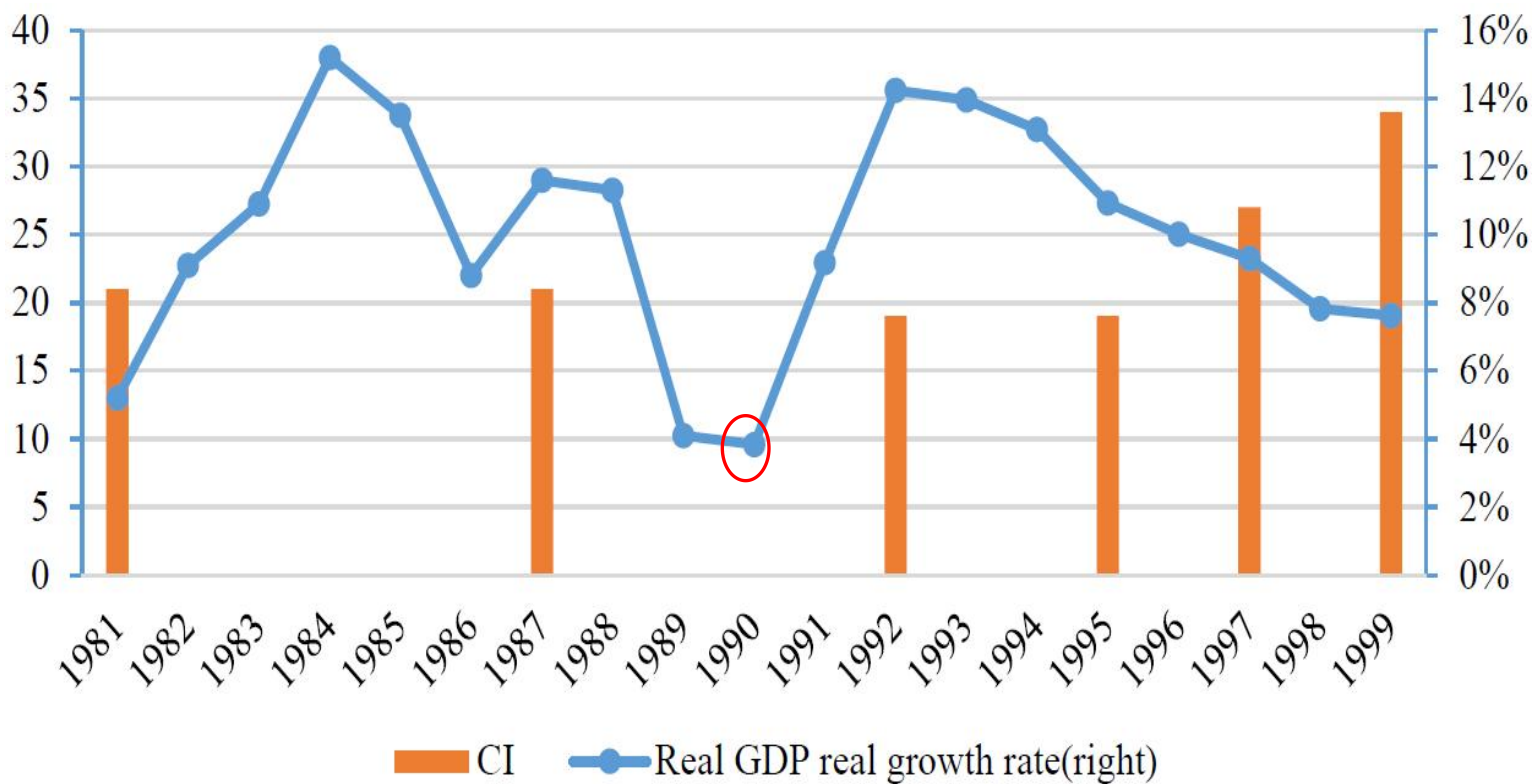


Figure 6. Real GDP growth rate and CI of China



Finding from Complexity Analysis

When CI decrease, there is probably a turn point of GDP growth.

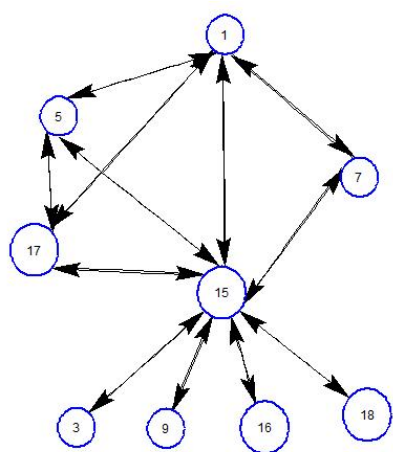
This finding implies that changes in CI and changes in growth rate seem to have high correlation.

Results Comparison between MFA and DFM

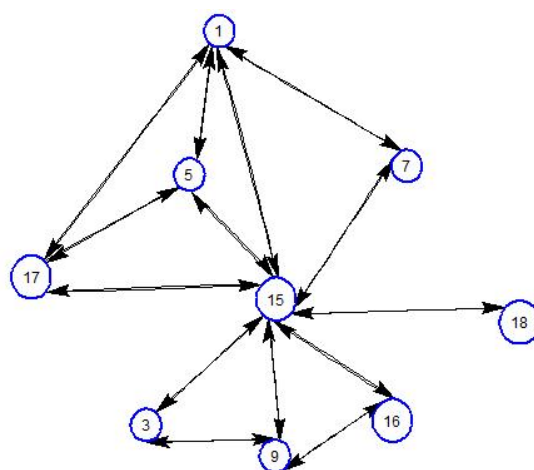
With no aid of this criterion, nearly all the sectors were selected as leading sectors for USA and Japan in each year, which revealed that **SIS selected by MFA was very sensitive to the filter value.**

Even with the given criterion as that in DFM, leading sectors and SIS of USA and Japan with MFA were very different with those selected by DFM.

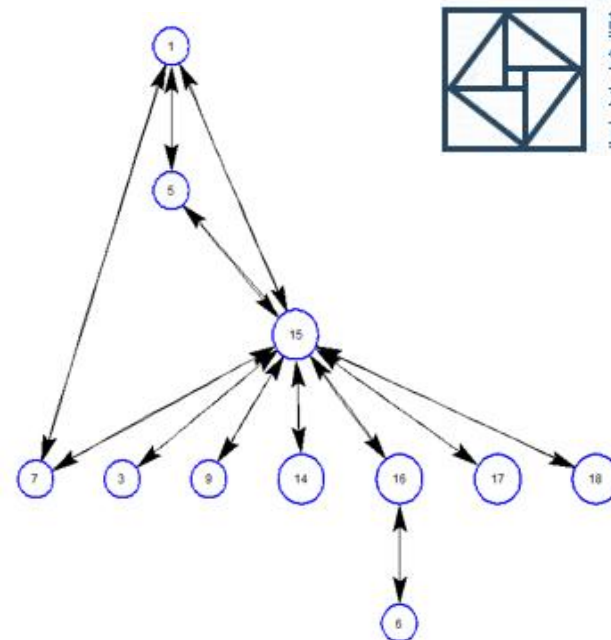
These SIS of USA and Japan selected by MFA disobeyed the general evolution rule of the industry structure, which suggests that DFM performs much better than MFA in finding SIS.



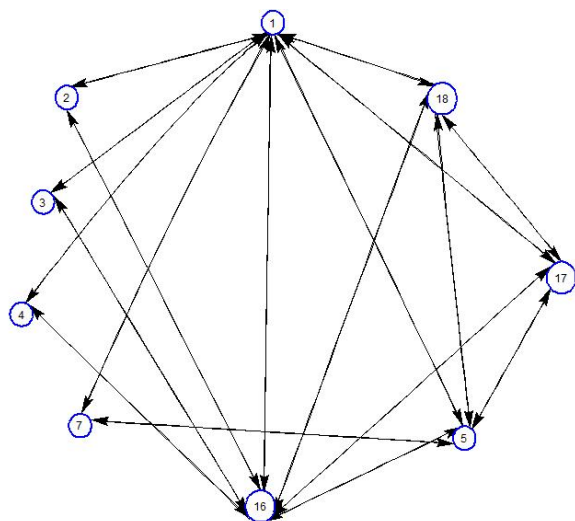
Appendix 1. SIS of
USA in 1972 with
MFA



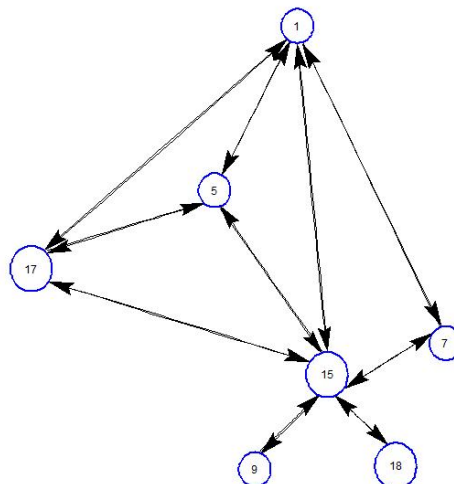
Appendix 2. SIS of
USA in 1977 with
MFA



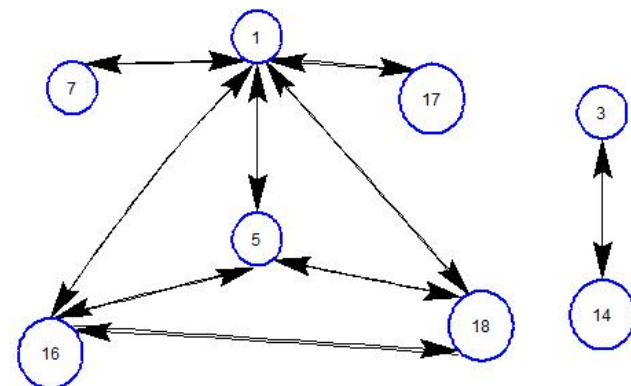
Appendix 3. SIS of USA in
1982 with MFA



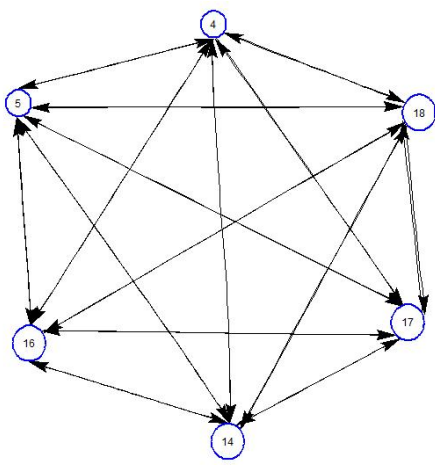
Appendix 4. SIS of USA in 1985
with MFA



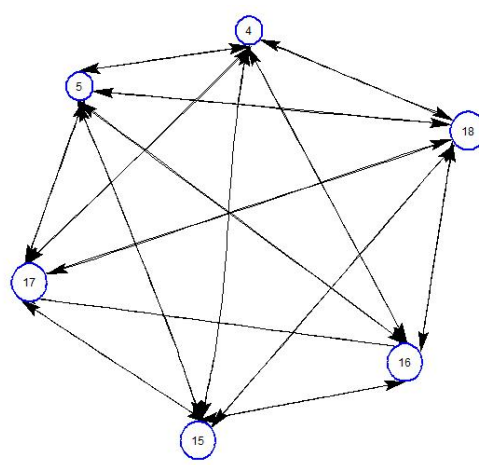
Appendix 5. SIS
of USA in 1990
with MFA



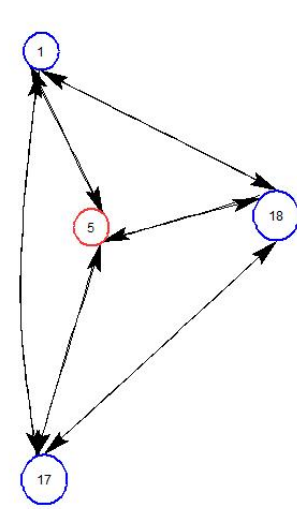
Appendix 6. SIS of USA in
1998 with MFA



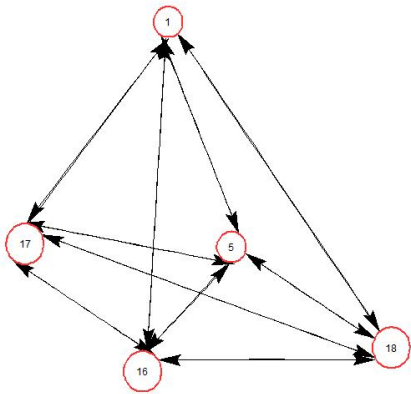
Appendix 7. SIS of Japan in 1975 with MFA



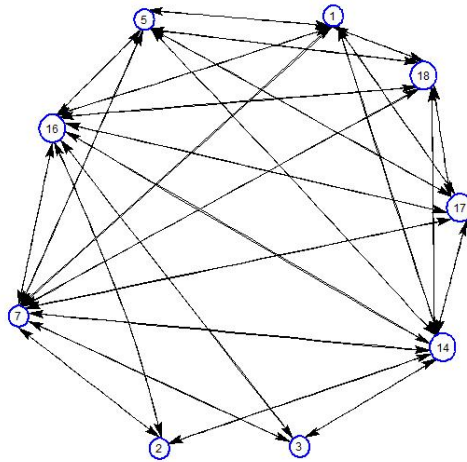
Appendix 8. SIS of Japan in 1980 with MFA



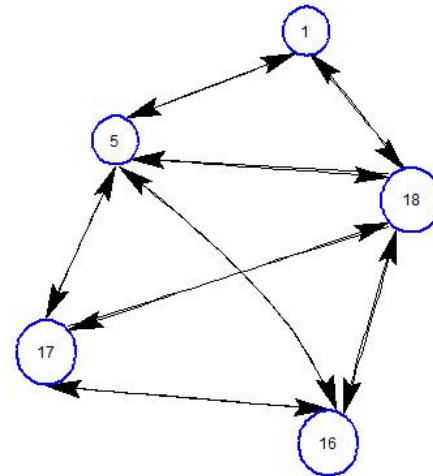
Appendix 9. SIS of Japan in 1985 with MFA



Appendix 10. SIS of Japan in 1990 with MFA



Appendix 11. SIS of Japan in 1995 with MFA



Appendix 12. SIS of Japan in 2000 with MFA



Conclusion

DFM could visualize the SIS of one economy, seize the evolution rules and reflect characteristics of the industrial structure change from the view of industrial linkages.



Further Research

- Data from more countries will be needed
- to further verify if changes in CI and changes in GDP growth rate have high correlation
- to forecast SIS, especially for developing countries.

A Method to Visualize the Skeleton Industrial Structure with Input-Output Analysis and Its Application in China, Japan and USA*

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Abstract The paper established a double filtering method (DFM) to visualize the skeleton industrial structure (SIS) of one economy and find its evolution rule. Different with the previous researches, this method is from a new view of industrial conjunctions combined by leading sectors to depict the industrial structure. It was proved that the leading sector selected by DFM must be key sector selected by Hirschman-Rasmussen method. Applied DFM to input-output tables of China, Japan and USA and MFA to Japan and USA, the results analysis showed that DFM could overtake the two main shortcomings of minimum flow analysis (MFA), scratch SIS of each economy with its own characteristics, visualize the general evolution rules of the industrial structure with crisscrossed conjunctions among leading sectors.

Keywords Double filtering method, economic growth, evolution rule, input-output analysis, skeleton industrial structure.

Extended papers

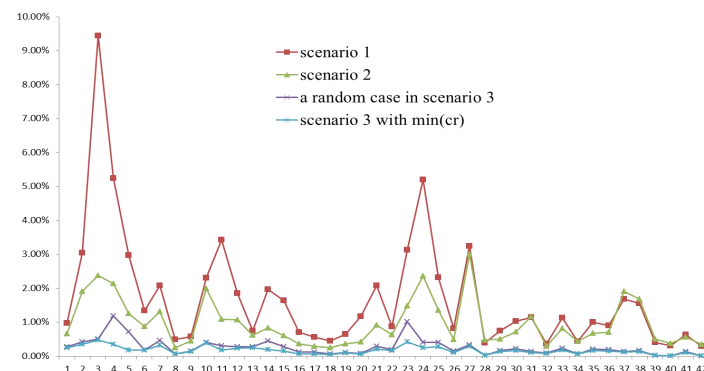


Fig.7 Price change rates in 3 scenarios compared with their basic prices that equal to 1.



Fig.8 SI and OI for 42 sectors

Evaluating the impacts of waste treatment management modes on each sector's price in a macro economic system

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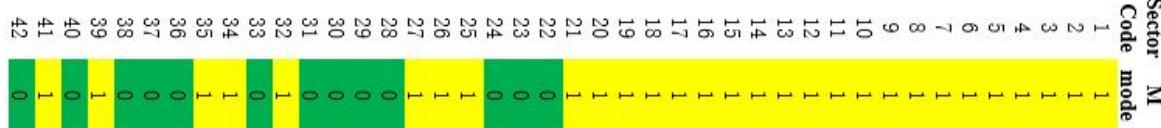
Price change

Input-occupancy-output analysis

ABSTRACT

This paper created an Input-Occupancy-Output (IOO) table that was integrated with several alternative waste treatment management modes. Based on this table, a Ghosh price model was developed to evaluate the price changes in each sector compared with their traditional prices for the direct and indirect impacts of the costs of waste treatment management modes. The model was applied to the waste water treatment case in China. The data were sourced from the China Statistical Bureau and a survey made by Tan et al. (2015). In each waste treatment management mode, the price change of each sector was evaluated. The results revealed that different waste treatment management modes generated different ranks for the price changes by sector. There are 22 sectors whose prices increase are mainly caused by other sectors' added waste water treatment costs. An optimal combination of two waste treatment management modes for 42 sectors generates the minimum price increase for all industries. To limit the waste water discharged in China, one possible intervention would be to increase the fine imposed for unit waste water discharged, setting it at a higher level than the unit waste water discharge fee and its treatment cost. Furthermore, it is suggested that the waste water treatment cost needs to be reasonably incorporated in the products' prices. The model proposed in this paper will be particularly appropriate to evaluate these price increases and their impacts.

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1-集中处理 0-分散处理

本研究构建了环境Ghosh Price一般模型,用于测算不同废弃物处理管理模式下增加的成本对各个部门产品价格变化的直接和间接影响。应用于我国污水处理管理,找到了一种对42个部门总价格增幅影响最小(0.72%)的污水集中与分散处理的最优组合模式。³⁷



Identification of changes in the economic interactions among sectors from 1995 to 2010 for Chicago economy using hierarchical feedback loop analysis

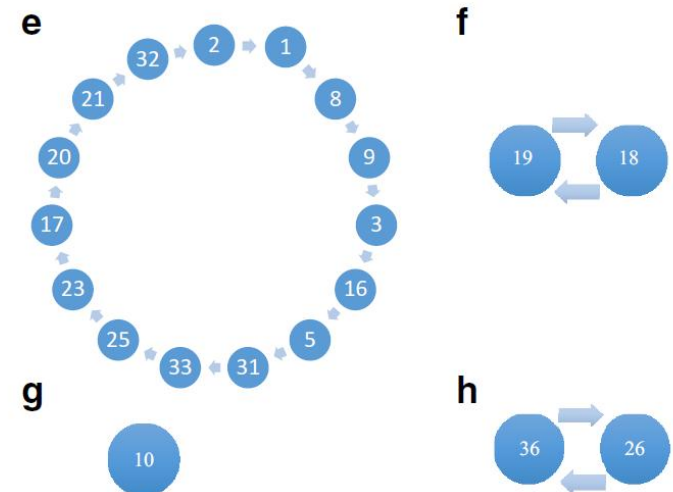
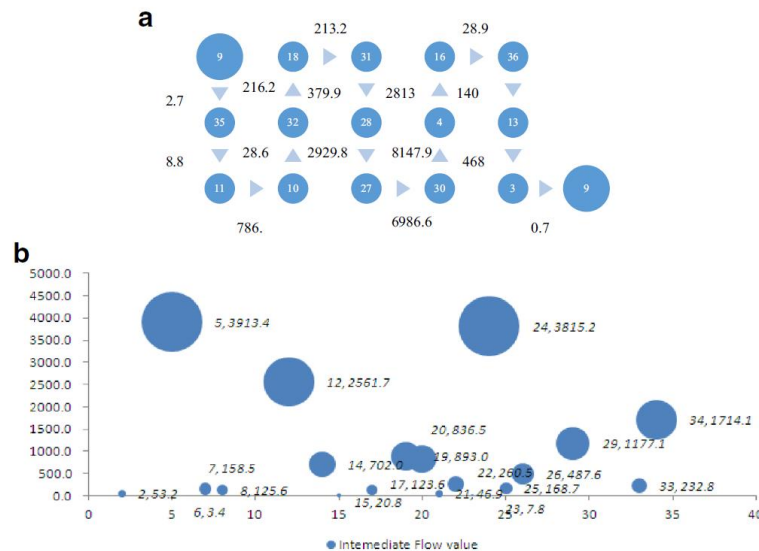
Xiuli Liu^{1,2,3} · Geoffrey J. D. Hewings⁴

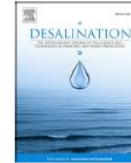
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Abstract

In this paper, hierarchical feedback loop analysis is employed to identify changes in the economic interactions among sectors during the process of structural transformation of the Chicago economy. The application in our paper differs from previous

本文从时间维度基于反馈路径分析方法研究了1995-2010期间芝加哥36个产业部门之间在经济转型时期交互影响的变化规律。





Research on the economic and environmental impacts of China's seawater desalination industry with different technologies in the macroeconomic system

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HIGHLIGHTS

- This paper compiled China's input-occupancy-output tables, with RO and MED industries specially separated.
- RO and MED industries had similar pulling effects on China's economy. Either one was greater than the average level of all 50 industries.
- MED industry had stronger CO₂ emission intensity than RO industry.

The framework of input-occupancy-output (IOO) model

	Intermediate demand	Final demand			Total output
		1, 2, ..., n	Consumption	Capital formation	Net exports
Intermediate input	1	Z _{ij}		Y _i	X _i
	2				
	...				
	n				
Value-added	Employees' compensation	V _j			
	Net taxes on production				
	Fixed assets depreciation				
	Operating surplus				
Total input	X _j				
Energy consumption	E _j				

The water supply sector was separated especially, and we separated RO and MED industries from the water supply sector.

本研究编制了区分
RO,MED两种技术的
2002, 2007, 2012年我
国投入占用产出表。

Data source: Zheng S. The Study on China's Household Consumption and Structure Prediction and Its Impacts on Resources Consumption[D]. University of Chinese Academy of Sciences, 2020.

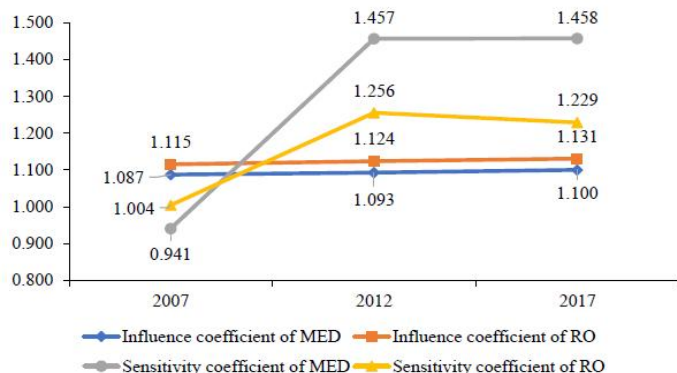


Fig.9 The influence coefficients and sensitive coefficients of RO and MED industries

2002-2017年，RO、MED两个产业发展对经济系统的拉动和推动作用几乎全部超过48个部门的平均水平，且作用随时间逐渐增强。

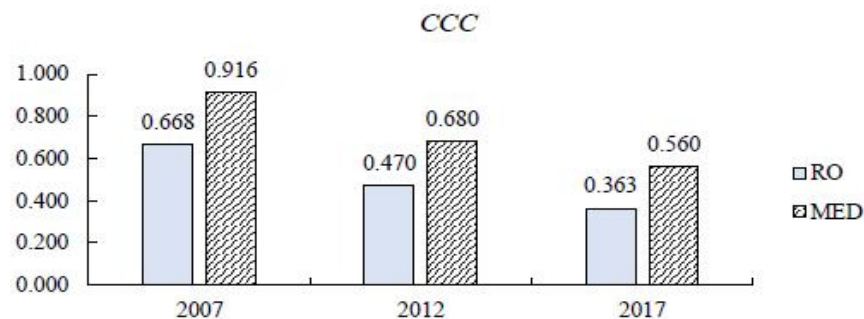
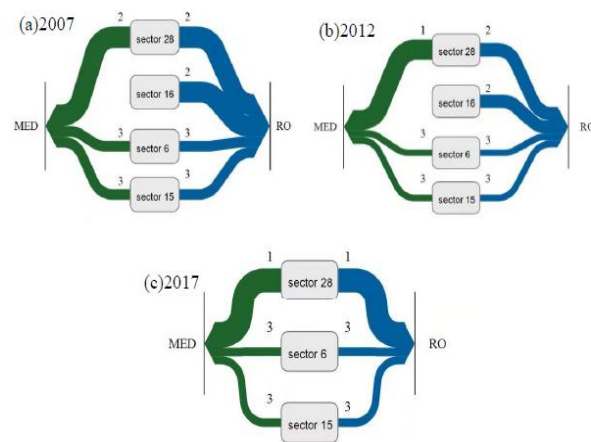


Fig.10 The CO2 emission coefficients of RO and MED industries

它们的完全碳排放系数在48个部门中总是排前5，MED的排放系数更高。



辨识出3个上游的能源部门与RO, MED产业的碳排放密切相关。

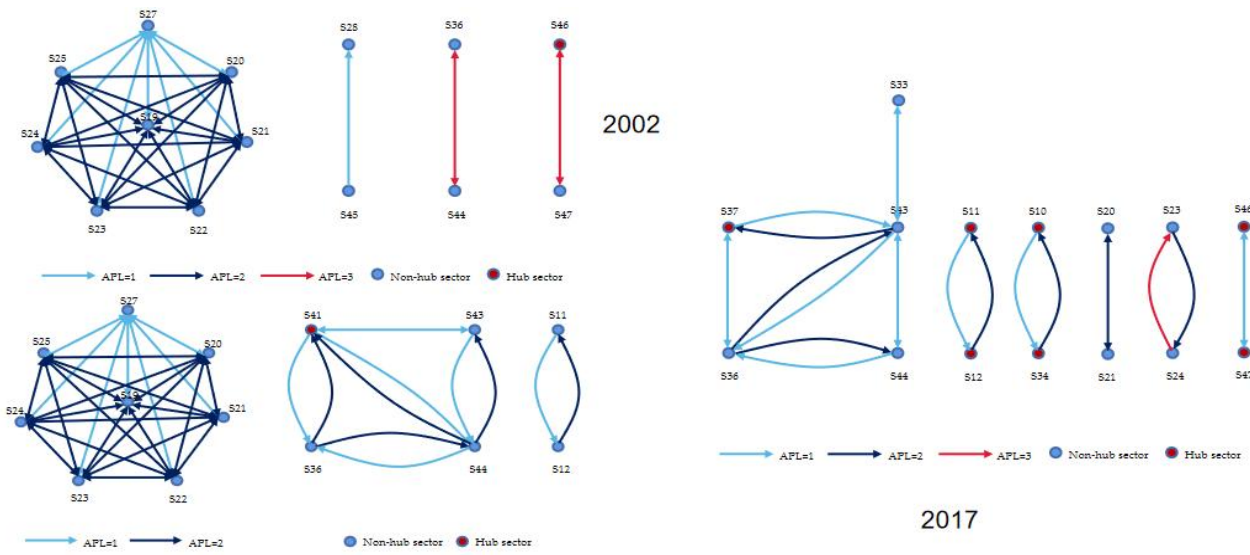
Fig.11 The upstream sectors and their CO2 emission APL distance with RO and MED

Article
Identifying Hub Wastewater Propagation Chains in China's National Economic System: A Model Coupled Input-Output Analysis with Graphical Theory

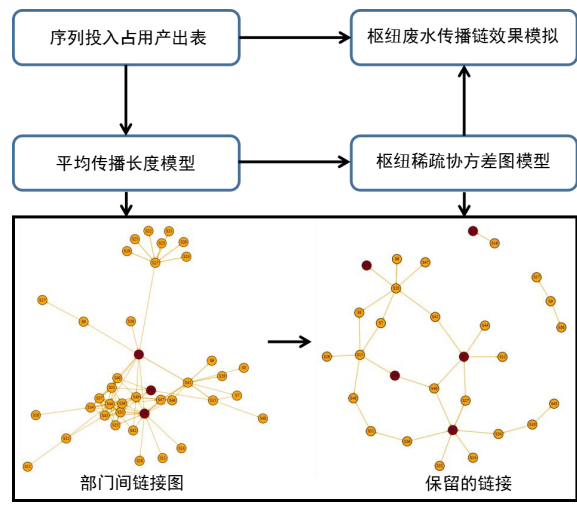
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Abstract: Wastewater propagation chains (WPCs) measure inter-sector average propagation lengths (APL) of wastewater discharge. To achieve sustainable wastewater management, one needs to understand the propagation mechanisms by identifying WPCs at a national level over time. However, the traditional model of identifying WPCs is prone to retaining APLs with lower values but larger wastewater discharge intensities, ignoring many linkages whereby intensities are less than a preset threshold. Nevertheless, these overlooked linkages are valuable in understanding wastewater propagation mechanisms. This study proposed a new model coupled input-output analysis with the graphical theory, called the average propagation lengths-hub covariance graph (APL-HCG). This



本文提出一种在宏观经济系统中识别枢纽废水传播链的平均传播距离-协方差图耦合模型，考虑了部门关联紧密程度变化方向及大小，通过枢纽废水传播链比传统方法平均提升了53.8%的减排效果。



Thanks for your attention!

Your Comments and Questions Please.

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