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COMPARATIVE ANALYSIS OF CHINA'S ECONOMIC
STRUCTURES BETWEEN 1987 AND 1997: AN
INPUT-OUTPUT PROSPECTIVE

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Comparative analysis of China's economic structures between 1987 and 1997: an input-output prospective¹

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Abstract

China experienced a rapid economic growth since 1979 when it opened up. The fast transformation affected the country in many ways including economic structure. This paper tries to identify the changes of economic structure influenced by economic growth from input-output prospective. The methodology is rooted in key sector analysis and complemented by presentation of the multiplier product matrix (MPM), which presents an interpretation of structure based on the products of the row and column of Leontief inverse, and provides a macro-economic visualization (economic landscape) of economic structure to make a better understanding of economic structure change of one economy in different times. The analyses results show that heavy industries sectors maintain dominant roles in the Chinese economy from 1987 to 1997, but with different emphases. Labor-intensive industries like textiles are giving way to high-technology industry due to an active policy that intends to develop high-technology. Some non-manufacturing sectors changed their roles in the national economy and started to influence the economy in a positive way, but the services sector has not been a key sector in national economy. Therefore China's developing character as a developing country has not changed.

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1. Introduction

China experienced rapid economic growth after the country was opened up in 1979. How has this transformation affected the economic structure of the country? This paper describes some comparative analyses of the economic structure of China focusing on interrelationships between sectors over the period 1987-1997. The analysis draws on published input-output tables and a several methods are used to explore changes in structure.

The methodology is rooted in key sector analysis, which was directed to the identification of sectors whose backward and forward linkages create more than average impacts on the other sectors of the whole economy. However, this is complemented by presentation of the multiplier product matrix or MPM (Sonis *et al.*, 1997a), which presents an interpretation of structure based on the products of the row and column multipliers of the Leontief inverse. It has some related properties with backward and forward linkage, and what is more, it can provide a macro-economic visualization (economic landscape) of economic structure, making it possible to compare one economy in different time periods and to provide a better understanding of the effects of economic structure changes on economic growth and the way economic growth has affected structure.

2. Methodology

2.1 Key sectors analysis to establish rank-size hierarchies of backward and forward linkages

Let $A=[a_{ij}]$ be a matrix of direct inputs in the usual input-output system, $B=(I-A)^{-1}=[b_{ij}]$ be the associated Leontief inverse matrix and let $B_{.j}$ and B_i be the column and row multipliers of this Leontief inverse. These are defined as:

$$B_{.j} = \sum_{i=1}^n b_{ij}, \quad B_i = \sum_{j=1}^n b_{ij} \quad (1)$$

Let V be the global intensity of the Leontief inverse matrix:

$$V = \sum_{i=1}^n \sum_{j=1}^n b_{ij} \quad (2)$$

Rasmussen (1956) has proposed two types of indices drawing on entries in the Leontief inverse.

First, the power of dispersion for the backward linkages BL_j is defined as follows:

$$BL_j = \frac{\frac{1}{n} \sum_{i=1}^n b_{ij}}{\frac{1}{n^2} \sum_{i,j=1}^n b_{ij}} = \frac{\frac{1}{n} B_{\cdot j}}{\frac{1}{n^2} V} = \frac{B_{\cdot j}}{\frac{1}{n} V} \quad (3)$$

Secondly, the indices of the sensitivity of dispersion for forward linkages FL_i are defined as:

$$FL_i = \frac{\frac{1}{n} \sum_{j=1}^n b_{ij}}{\frac{1}{n^2} \sum_{i,j=1}^n b_{ij}} = \frac{\frac{1}{n} B_{i \cdot}}{\frac{1}{n^2} V} = \frac{B_{i \cdot}}{\frac{1}{n} V} \quad (4)$$

The usual interpretation is to propose that if $BL_j > 1$ a unit change in final demand in sector j will generate an above-average increase in activity in the economy; similarly, for $FL_i > 1$, it is asserted that a unit change in all sectors' final demand would create an above average increase in sector i . A key sector, K , is usually defined as one in which both indices are greater than 1.

2.2 The multiplier product matrix and the visualization of economic structure

The input-output multiplier product matrix (MPM) is a visualization technique to provide an overview of industrial structure change. It is defined as (see Sonis *et al.*, 1997a):

$$M = \frac{1}{V} [B_i B_{\cdot j}] = \frac{1}{V} \begin{pmatrix} B_{1 \cdot} \\ B_{2 \cdot} \\ \vdots \\ B_{n \cdot} \end{pmatrix} (B_{\cdot 1} \quad B_{\cdot 2} \quad \cdots \quad B_{\cdot n}) = [m_{ij}] \quad (5)$$

It is important to underline that the column and row multipliers from MPM are the same as those from the Leontief inverse matrix:

$$\sum_{j=1}^n m_{ij} = \frac{1}{V} \sum_{j=1}^n B_i \cdot B_j = B_i \quad (6)$$

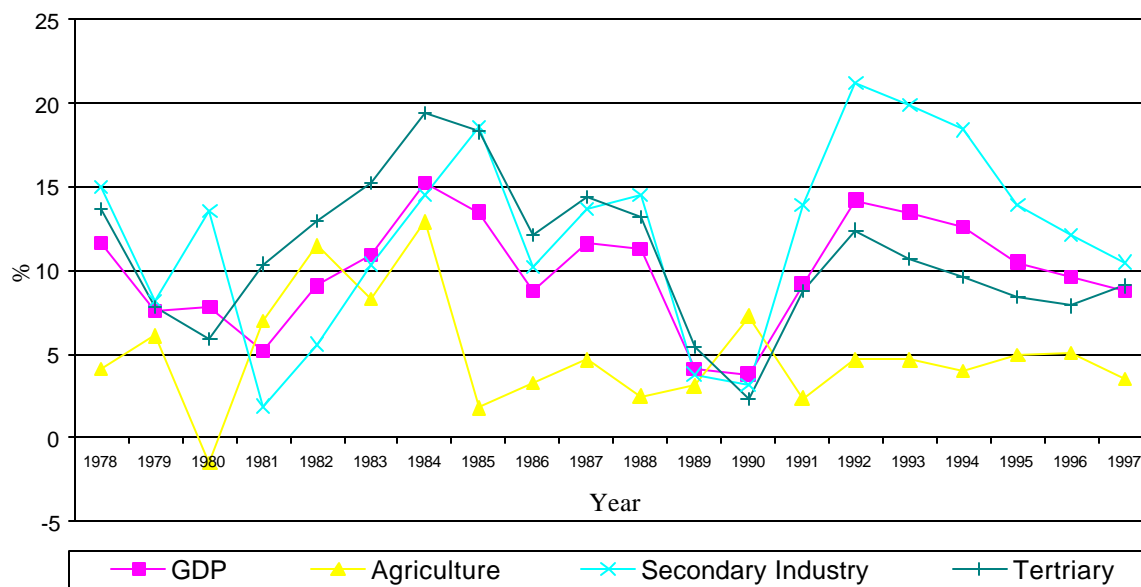
$$\sum_{i=1}^n m_{ij} = \frac{1}{V} \sum_{i=1}^n B_i \cdot B_j = B_j \quad (7)$$

Thus, the MPM structure is essentially connected with the properties of sector backward and forward linkages. The rows and columns of matrix M can be rearranged along the magnitude of the value of backward and forward from the largest to the smallest to provide the hierarchy of backward (for columns) and forward (for rows) linkages, so that it is possible to construct *regional economic landscapes* to provide a summary view of economic structure. Further, if the ordering of rows and columns is “frozen” at one point in time, it will be possible to compare the landscapes at subsequent time periods to gain a sense of the degree to which the structure has remained stable or has changed. Detailed sector-by-sector analysis can thus focus on the area or areas in which the dominating changes have been observed.

3. Changes in the China's economy

Since 1979, China has been engaged in an effort to reform its economy, trying to combine central planning with market-oriented reforms to increase productivity, living standards and technological quality without exacerbating inflation, unemployment and budget deficits. The government has emphasized raising personal income and consumption and introducing new management systems to help increase productivity. The reforms started in agriculture by introducing the household responsibility system that provided peasants greater decision-making in agricultural activities. With the successful experience in agriculture reform, China extended the reform to non-agriculture activities, such as village enterprises in rural areas, and promoted more self-management for state-owned enterprises to increase competition in the marketplace and facilitate direct contact between Chinese and foreign trading enterprises. Also, the reform was extended to fiscal, financial, banking, price setting, and labor systems. The government has also focused on foreign trade as a major vehicle for economic growth.

Figure 1 GDP and industries growth rate in China from 1978 to 1997



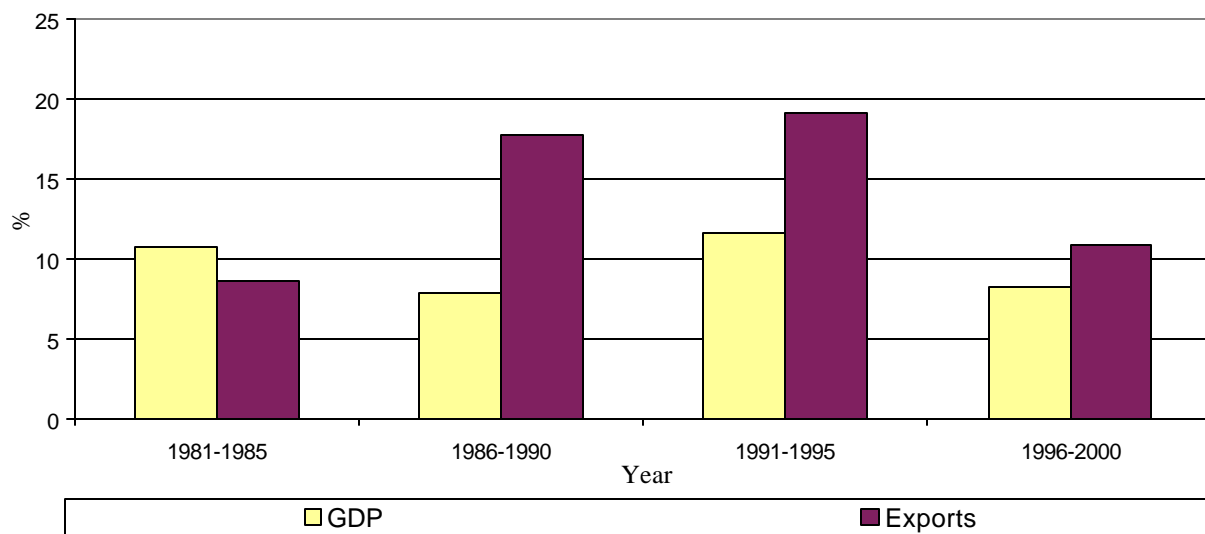
The reforms to date have yielded impressive dividends, with the result that China is the fastest growing country in the world. The average annual growth rate from 1978 to 1997 was 9.7%, while the world average annual growth rate was no more than 3.2 % (during the 1980 to 1990 period and 2.5% during the 1990 to 1998 period). Figure 1 shows the GDP and industries' growth rate from 1979 to 1997. From figure 1, we can see that since 1985, secondary industry (manufacturing and constructions) is the main driving strength of China's national economy, since the growth rate for this component of the economy is much faster than that for GDP as a whole. On the other hand, tertiary industry (services), which used to grow faster than GDP in the first five years of 1980's, has slowed in the 1990's. Primary industry (agriculture) has kept a relatively more stable growth rate since 1985 compared to rates observed before 1985. Productivity has been increased together with personal income. Hence, GDP per capita is increasing rapidly. Table 1 shows the GDP per capita from 1979 to 1997 in China.

Table 1 GDP per capita comparisons in China from 1979 to 1997

Year	GDP per capita
1979	417
1987	1104
1992	2287
1997	6053

Foreign trade is the major vehicle for economic growth. If we compare the exports growth and economic growth rate at same period, it is easy to learn that 5-year-average-growth rate of exports is much higher than that of economic growth since 1986, even though GDP growth rate is higher at the beginning period of open up from 1981 to 1985. Figure 2 shows the average exports growth rate and GDP growth rate from 1980 to 2000 with five years interval. Note that exports growth rate is higher than economic growth rate after 1985.

Figure 2 GDP and exports growth rates



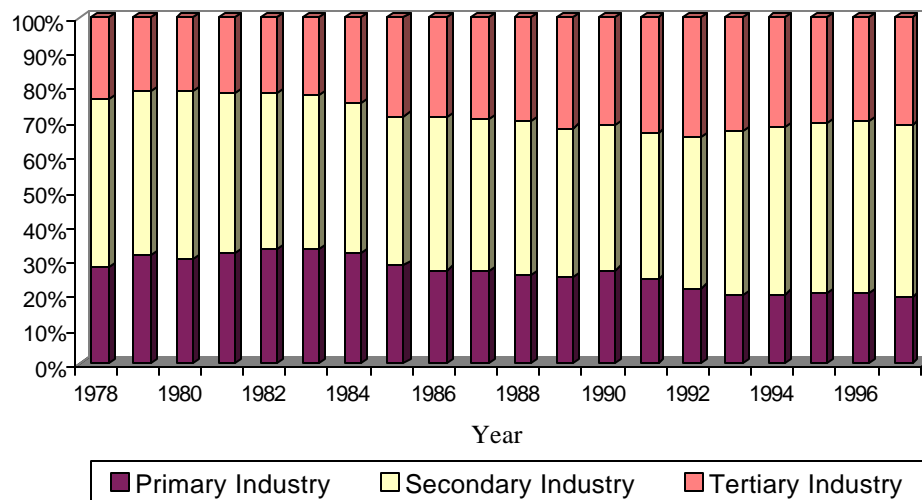
Has the rapid economic growth rate been reflected in changes to China's economic structure? From the changes of composition of GDP, we can compare the share of different industries from 1978 to 1997 in the economy. Figure 3 shows the composition of GDP in China from 1978 to 1997. It is not difficult to find that the share of primary industry (agriculture) is decreasing, but that of secondary industry (manufacturing and construction) is increasing. Tertiary industry experienced an increase in the first ten years since reform and a decrease since then (in relative terms). For example, the share of primary industry declined from 26.8% in 1987 to 21.8% in 1992, and to 19.1% in 1997. In contrast, the secondary industry's composition increased, from 43.9% (1987) to 50.0% (1997) (Figure 3). This process is not unusual in a developing economy; what is unusual is the speed of this adjustment. The significant case is South Korea's development model. Being a typical developing, largely agrarian, country before 1960's, South Korea started with the export-oriented industrialization since then. It only took the country three

and a half decades to transform from a largely agrarian into modern industrialized country. Table 2 shows that after more than 30 years' reform, South Korea's main characteristics as a typical industrialized economy, which primary industry holds a smaller share in the whole economy, while manufacturing and service sectors holds larger ones. Comparing to South Korea, China may take more time to reach the level of industrialization. The main reason is even though the secondary industry (or manufacturing) holds a largest share in the economy after reforms were put into practice for 20 years, primary industry (agriculture) still holds relatively a larger share (18.4%) and tertiary industry (service) a smaller share (32.9%) of the whole economy.

Table 2 Composition of South Korea's GDP from 1970 to 1993 (%)

	1970	1980	1993
Primary industry	25.4	14.5	7.1
Secondary industry	28.7	40.4	43.4
Tertiary industry	45.9	45.1	49.5

Figure 3 Composition of China's GDP from 1978 to 1997



4. 1987 to 1997 China's economy: MPM applications

4.1 Data Source

Comparison of economic structure was undertaken using data derived from input-output tables for China for 1987, 1992 and 1997. From 1987, China began to assemble national input-output tables every five years on survey data according to the SNA framework. By now, three national input-output tables have been completed⁴. There are 18 sectors classified for the structural analysis as shown in table 3.

Table 3 Industrial Classification and Codes of Chinese Input-Output Table

Manufacturing Sector		Non-Manufacturing Sector	
Code	Description	Code	Description
1.	Food	11.	Agriculture
2.	Textiles	12.	Mining
3.	Furniture	13.	Construction
4.	Paper, printing and related products	14.	Transportation and communication
5.	Energy	15.	Commerce and restaurants
6.	Chemical industries	16.	Public utilities and household services
7.	Building Materials	17.	Finance and insurance
8.	Metal manufacturing	18.	Public services
9.	Machinery, equipment and electronics		
10.	Industries not elsewhere classified		

4.2 Key sectors analysis

As noted earlier, key sectors are the sectors whose both backward and forward linkages multiplier are greater than 1. That means that changes in key sectors should have a greater than average influence on the whole economy. Key sectors in the period of 1987 to 1997 in China are identified in table 3 and figure 4. It is easy to note that during this period, even though the forward and backward linkages changed, the key sectors remain sector 2 (textiles), 6 (chemical), 8 (metal manufacturing) and 9 (machinery, equipment and electronics). For the last ten years, all the key sectors interact with these four sectors, which can be said that the most important sectors

⁴ For more information on these tables and their constructions, refer to National Accounts Department, National Bureau of Statistics of China.

(or the core) of China's national economy. This stability in structure reflects China's long-run policy to keep the manufacturing industries as a driving strength in national economy.

Table 4 Sector Classifications for the 1987,1992 and 1997 in China

Code	Sectors	Year		
		1987	1992	1997
1	Food	B	O	B
2	Textiles	K	K	K
3	Furniture	B	B	B
4	Paper, printing and related products	B	B	B
5	Energy	F	F	F
6	Chemical industries	K	K	K
7	Building Materials	B	B	B
8	Metal manufacturing	K	K	K
9	Machinery, equipment and electronics	K	K	K
10	Industries not elsewhere classified	B	B	O
11	Agriculture	F	F	F
12	Mining	F	F	F
13	Construction	B	B	B
14	Transportation and communication	O	O	O
15	Commerce and restaurants	F	F	F
16	Public utilities and services to household	O	O	O
17	Finance and insurance	O	O	O
18	Public services	O	O	O

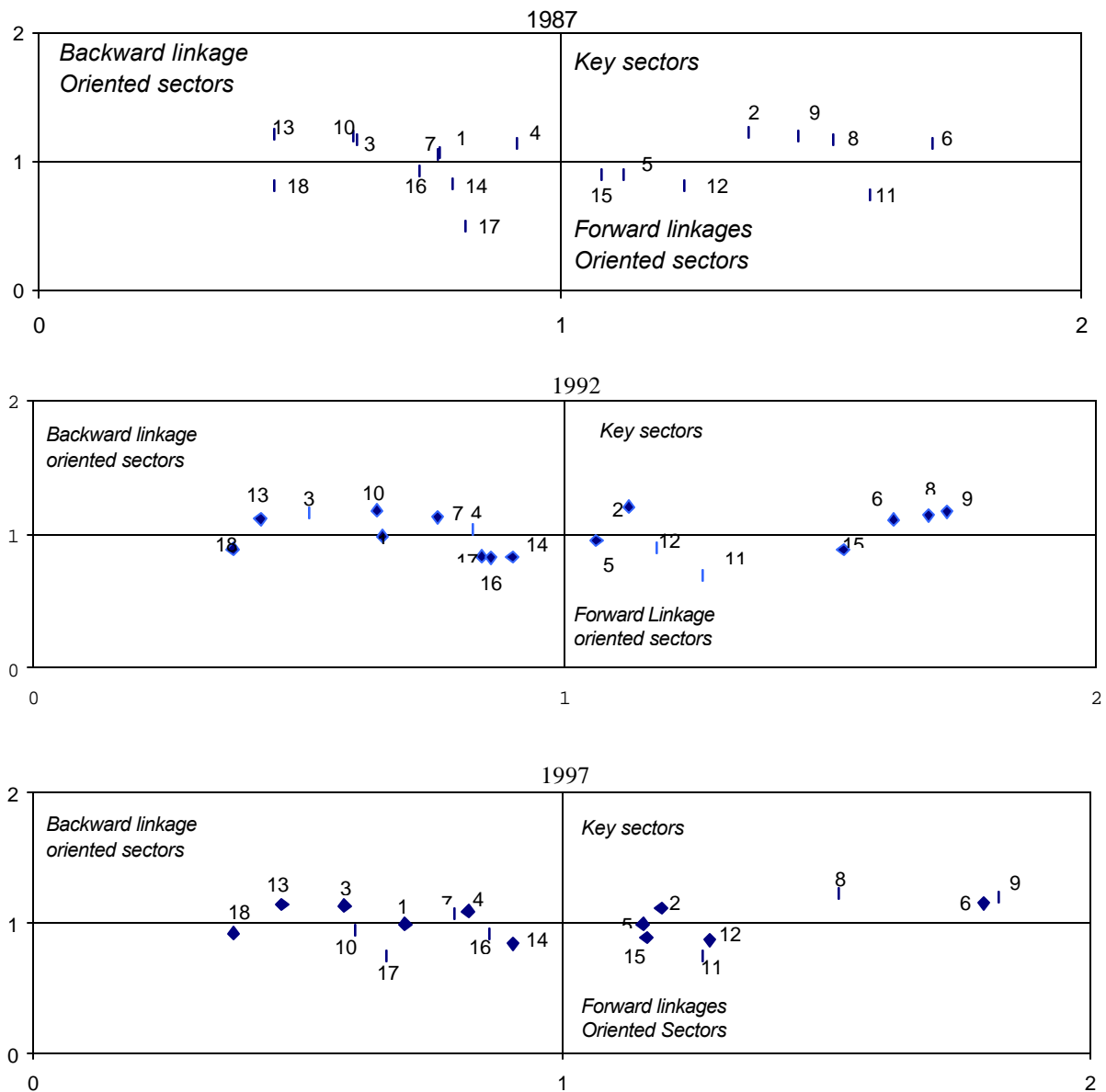
Note: K—Key sectors B—Backward linkage oriented sectors

F—Forward linkages oriented sectors O—other sectors

In terms of the value of both forward and backward linkage, we can see that those for sector 9 (machinery, equipment and electronics) are increasing through the whole period, and this sector has the highest forward and backward linkage since 1992. As a result, the position of sector 9 as a basic industry seems to be increasing. Sector 6's (chemicals) forward and backward linkages decreased from 1987 to 1992, while, at the same time, those for sector 8 (metal manufacturing) increased. However, from 1992, sector 6 surpassed sector 8 in both aspects to indicate its role in the economy. In contrast to the heavy industry's role as a key sector from 1987 to 1997, sector 2 (textiles) is the only light industry that remains in this position. The main reason is that China has implemented an exports-oriented development policy focusing attention on labor-intensive industries such as textiles. Even though its declining forward and backward linkage reflect its

reduced position in national economy, cheaper labor costs still continue to attract inward international investment in factories in China, sustaining the growth of textiles and its position as a key sector.

Figure 4 China's backward and forward linkage between 1987 and 1997



While a non-key sector in terms of the definition (both backward and forward linkage multiplier are less than 1), sector 5 (energy) deserves our attention because of its importance in national economy. In fact, its forward and backward linkages are increasing through the period indication that its importance in economy is growing. The forward linkage is always greater than 1 reflecting that it is very involved with other sectors of the economy. By 1997, its backward linkage multiplier approached 1 (0.998), and we can say that has really become one of the most important sectors in China's economy. In many ways, this sector's evolution may be traced to a very pro-active development strategy.

Figure 5 China backward linkage hierarchies

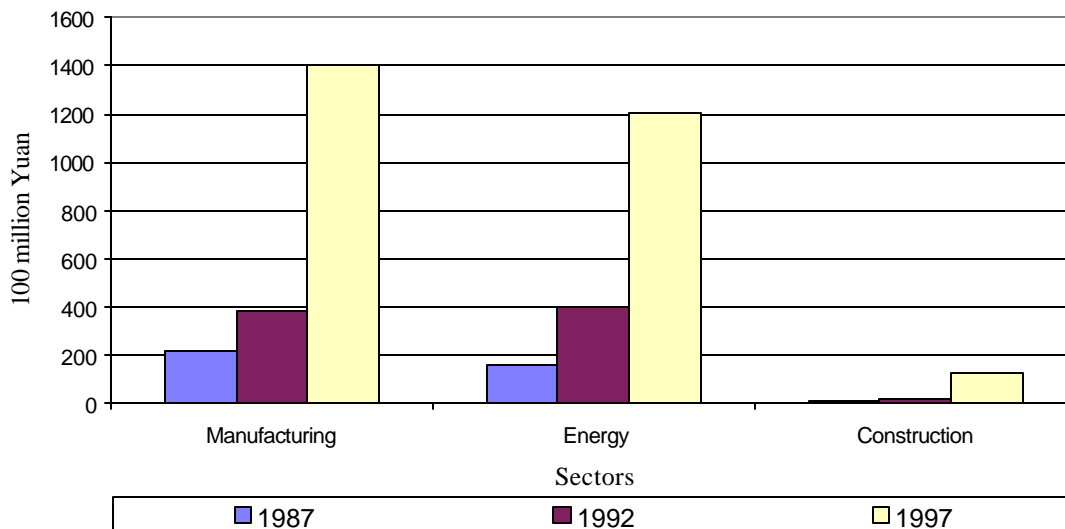
Rank	1987	1992	1997
1	02	10	08
2	13	09	09
3	09	03	06
4	03	08	13
5	08	04	03
6	10	02	02
7	04	13	04
8	06	06	07
9	01	07	05
10	07	01	01
11	18	05	10
12	05	12	18
13	15	18	16
14	14	15	15
15	12	17	12
16	16	14	14
17	11	16	11
18	17	11	17

4.3 Backward and forward linkage hierarchy

Figure 5 shows that the changing rankings of each sector based on backward linkages. It is common that high ranked sectors should be manufacturing sectors, which have higher intermediate input ratio while low-ranked sectors should be primary industries and service sectors. No sector remains on the top of the list, but there are some sectors such as 9 (machinery, equipment and electronics), 8 (metal manufacturing), 7 (building materials), 6 (chemicals) and 5

(energy) have moved upward consistently during the period. It can be explained that heavy industries have always been the driving strength of the economy; domestic replacement from previously imported inputs have contributed to its ascendancy in the backward input linkage ranks. The fast growth of construction and real estate is the main reason for sector 7 (building materials) moving up consistently through the whole period and sector 13 (constructions) moving up quickly from 1992 to 1997. Figure 6 shows the increased fixed assets in different sectors. Note that fixed assets in all of the three sectors in 1997 have increased significantly through capital construction. This indicates that investment put into these sectors is exhibiting an increasing trend. This is possibly one of the reasons why these three sectors have an increasing rank of backward linkage, but also note that although the level of fixed assets in construction sector is relatively smaller, it has a relatively higher growth rate.

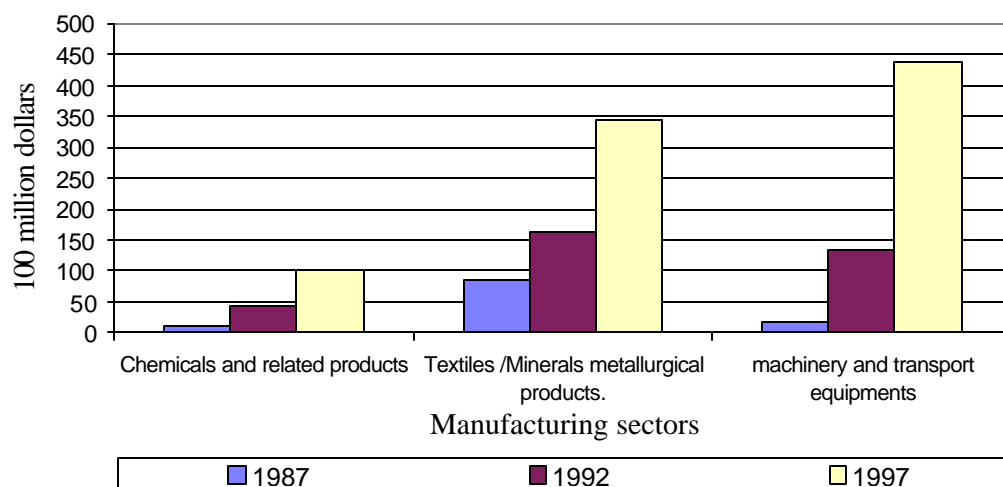
Figure 6 Newly increased fixed assets through capital construction by sectors



On the other hand, sector 2 (textiles), 15 (commerce and restaurants) and 14 (transportation and communications) have dropped. Since the labor costs increased rapidly, the share of added value increased accordantly. It is common that salaries in these sectors are higher than those in other sectors in China. As a result, a lower share of intermediate input ratio would be obtained in these sectors. On the other hand, it reflects that infrastructure such as transportation and communications, are not well developed because the inputs are not sufficient, and have even decreased.

Figure 8 shows that the changing rankings of each sector based on forward linkages. And provides a different picture from that of the backward linkages. Generally, manufacturing sectors producing intermediate or semi-finished products have shown higher ranks in the forward linkages. Sector 6, 8 and 9 are atop the list through the period with sector 9 (machinery, equipment and electronics) maintaining the first rank since 1992. This is related to the rapid growth of heavy industry from the 1990s. The intermediate products of heavy industries such as chemical, electronics and metal manufacturing have been distributed into intermediate demand sectors at an increasing rate. On the other hand, the fast export growth of sector 9 has also contributed to this phenomenon. Figure 7 shows the exports of three manufacturing sectors: chemical and related products, textiles and rubber minerals and metallurgical products and machinery and transport equipment. Note that from 1987 to 1997, machinery and equipment maintains a fast growth rate (from 1987 to 1992, its exports increases by a factor of 6.6, and from 1992 to 1997 by a factor of 2.3), while chemicals exports increase rapidly too, but not as fast as machinery; during the same time period, its exports increase 2.5 and 1.4 times respectively.

Figure 7 Exports of three manufacturing sectors in China from 1987 to 1997



Sector 16 (public utilities and services to households) moved up very quickly from 1987 to 1992 and remained stable from 1992 to 1997. The expansion of the service sector indicates that China's economy is reconstructing towards a new level from 1987 to 1992. However, the rank-size of sector 17 (finance and insurance services) decreases from 1987 to 1997. The service of

finance and insurance is highly related to manufacturing, so the late development of the service industries adds to the difficulties for China's transformation from traditional to modern industries. Sector 2 (textiles) and 5 (energy)'s forward hierarchy decreased. Part of the reason is that increasing energy products fulfill the need of other products and have led to the decreasing demand for intermediate products from the energy sector in the domestic market especially in the period of 1987 to 1992. On the other hand, final demand from outside decreased. Figure 7 shows that textiles exports have the slowest growth rate, only an increase of 88% and 113% comparing to the other two industries.

In terms of both the backward and forward linkage hierarchies, only sector 9 (machinery, equipment and electronics) keep moving up; on the other hand, sector 2 (textiles) moves down. This indicates that policy makers in China keep technology-intensive heavy industry as a driver of economic development rather than light industry with labor-intensive characteristics.

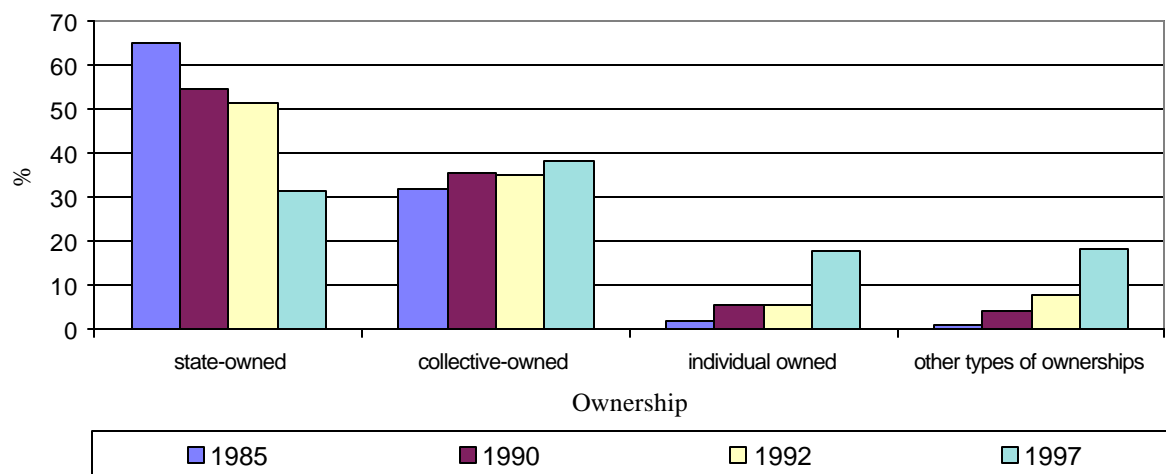
Figure 8 China forward linkage hierarchies

Rank	1987		1992		1997
1	06		09	_____	09
2	11	_____	08	_____	06
3	08	_____	06	_____	08
4	09	_____	15	_____	12
5	02	_____	11	_____	11
6	12	_____	12	_____	02
7	05	_____	02	_____	15
8	15	_____	05	_____	05
9	04	_____	14	_____	14
10	17	_____	16	_____	16
11	07	_____	17	_____	04
12	14	_____	07	_____	07
13	01	_____	04	_____	01
14	18	_____	01	_____	17
15	03	_____	10	_____	10
16	10	_____	03	_____	03
17	16	_____	13	_____	13
18	13	_____	18	_____	18

If we try to find what the three largest sectors' values in one another's key sector's backward linkage and forward linkage respectively, we can construct the industrial complex of national economy. Figure 11 shows the industrial complex for the key sectors for each of the three years.

Note that the industrial complex in 1987 is the most complicated and the one in 1997 is the most simplified if we view the whole figure directly. Agriculture and construction are the two non-key-sectors in 1987 industrial complex; in 1992 only industry not else classified is in it, but in 1997 no non-key sectors appear. In 1987, agriculture input to all key sectors and construction obtain inputs from all key sectors. The backward linkage rank size of agriculture and construction reveals the same story: agriculture ranks 2 and construction ranks the last. The reason is that in the early development phase after China opened up, the industrial economy was not fully developed and the agricultural economy remained dominant; on the other hand, infrastructure needed to be improved quickly to meet the goals set for rapid economic development.

Figure 9 Shares of gross industrial output value by ownerships



In 1992, things changed: key sectors mainly obtain their inputs from their own circle or from themselves, agriculture is no longer a major player, but industries not else classified became the sector that gets inputs from key sectors: it ranked the first in 1992 in the backward linkage hierarchy. Village enterprises in rural areas used to be encouraged when reforms were carried out. From then on, non-state-own enterprises have a greater and greater share of industry output. Also they have respectable growth rates and grow much faster than state-owned enterprises. (Figure 9 and 10). The policy to encourage a competitive environment for the whole industry has proven successful with the result of increased rural income. However, in the meantime,

there some problems have arisen. Most of the enterprises have limited technology and poor efficiency. Further, they are competing with raw materials needed by modern industry and thus may influence the role played by key industries. In fact, China set as one of its policies the targeting of electronics, as a symbol of national industrial development. So China made its mind to clear, stop and merge village enterprises to provide a way of developing modern industries no matter the ownership. It has worked; even though state-owned industry output growth rate keeps on decreasing, non-state-owned industries have assumed an important role in every aspect, including the key sectors. We can see that sector 10 (industries not else classified) rank size of backward linkage decreased in 1997. From the industrial complex in 1997, note that all the key sectors obtain input from and provide input to each other or themselves. Note that all the key sectors are manufacturing sectors, so that by 1997, manufacturing sectors have been developed enough to form an integrated system to provide input and outputs to each other.

Figure 10 Industry output growth rate (last year=100)

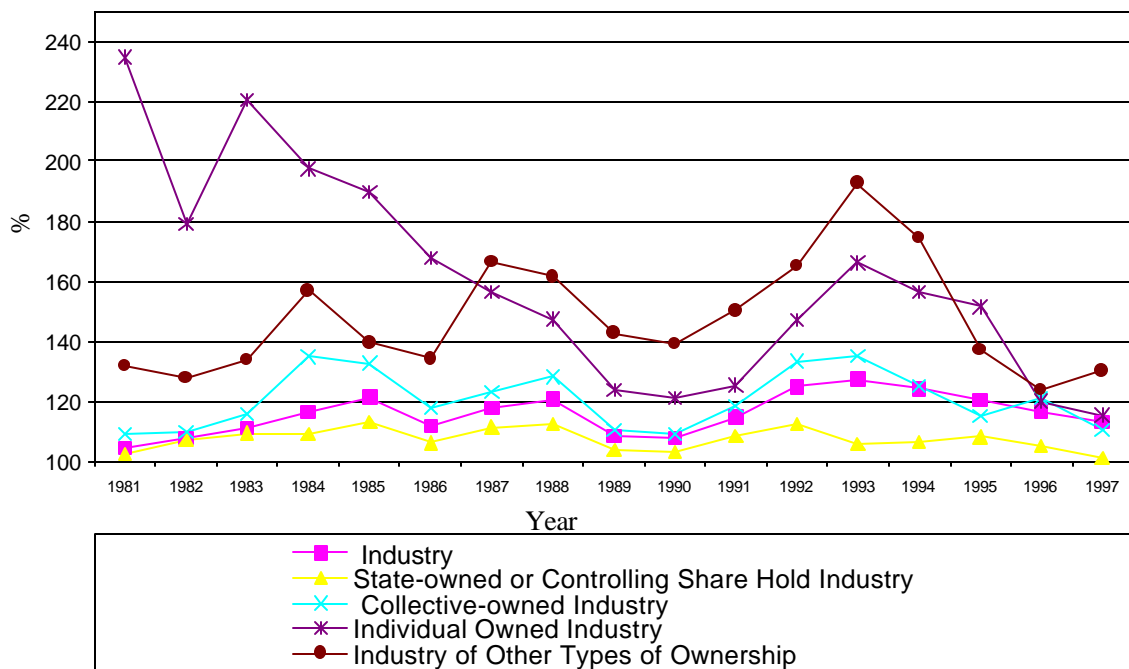
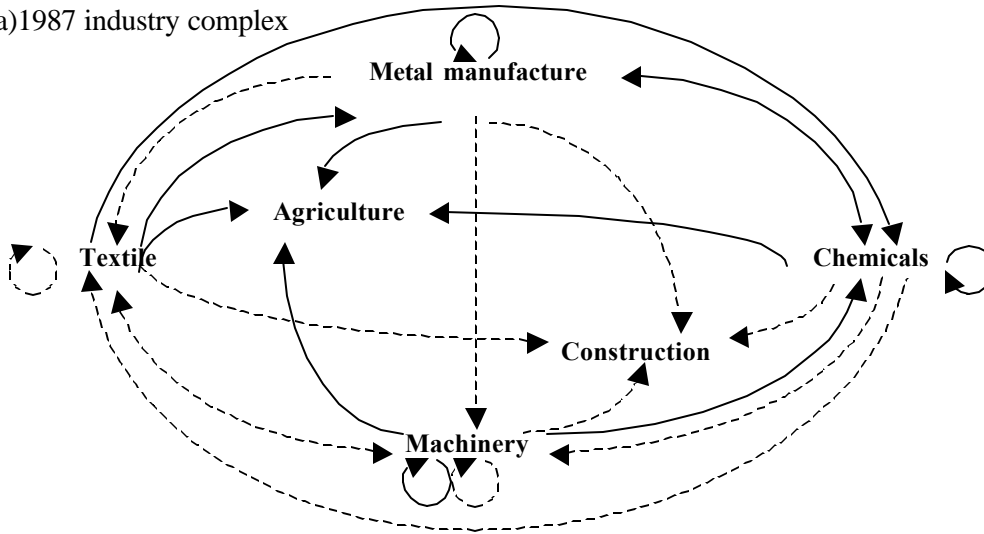
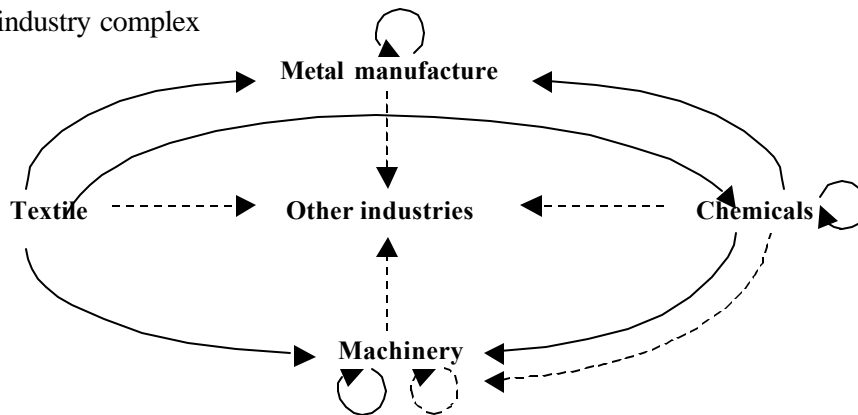


Figure 11 1987-1997 key sectors' industry complex

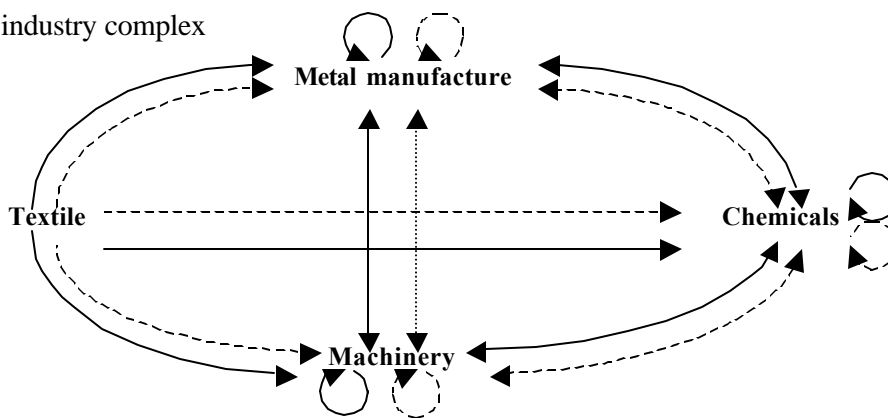
(a) 1987 industry complex



(b) 1992 industry complex



(c) 1997 industry complex



—— Backward linkage Forward linkage

4.4 The Visualization of Economic Structure

Finally, in this section, a generalization of the changes in economic structure is provided. Figure 12 shows the changing economic landscape of China between 1987 and 1997 using the MPM method described earlier. The 18 sectors are classified in table 1. The rows represent the hierarchy of forward linkages while the columns provide the similar details for the backward linkages. The nature of the hierarchy is such that the northwest quadrant provides the highest elevation and the landscape slopes away to the east and south. Note that the ordering of the row hierarchy of forward linkages and the column hierarchy of backward linkages is the same as the hierarchy of forward linkages and the column hierarchy of backward linkages in the key sector analysis. In order to facilitate comparison over time, the sector order for 1987 was adopted as the *numeraire*.

The overall trend reveals that the average of individual values (shown as the height of the column) in 1992 and 1997 increased compared to those in 1987. In terms of forward linkages, sector 6 (chemical industry), 8 (metal manufacturing), 9 (machinery, equipment and electronics), 15 (commerce and restaurants), 14 (transportation and communications) and 16 (public utilities and service to household) increased shown by the height of intersection columns of these sectors with all sectors in the economy. This confirms the earlier commentary about the growth rates of these heavy industries; in parallel fashion, the development of a market system encourages the prosperity of commerce. At the same time, the increase of people's living standard creates a need for broad public services, resulting in the fast growth of the public services and communications. Sector 2 (textiles), on the other hand, shows a declining growth trend from the intersection with other sectors. In 1997, sector 8 (metal manufacturing) and 9 (machinery, equipment and electronics) maintained a high intersection with other sectors as before while sector 5 (energy) shows an increasing relationship with other sectors. All this means that heavy industries assume a more important position in national economy, and the more related sector of energy accordingly is being pushed in the same way as a dominant sector.

In terms of backward linkages, sector 2 (textiles) is declining from 1992 to 1997. On the contrary, sector 8 (building materials) and 14 (transportation and communications) are increasing. Transforming the economy from labor-intensive industry to high-technology industry results in a

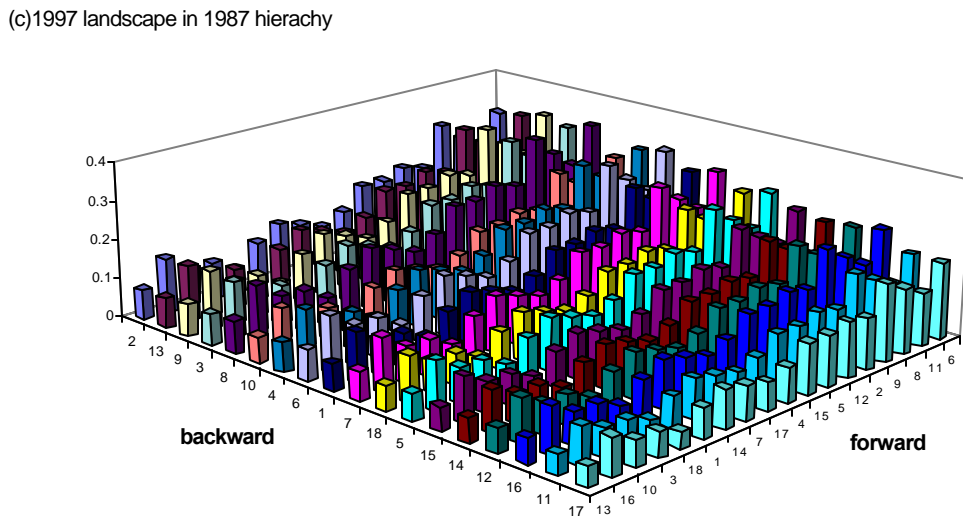
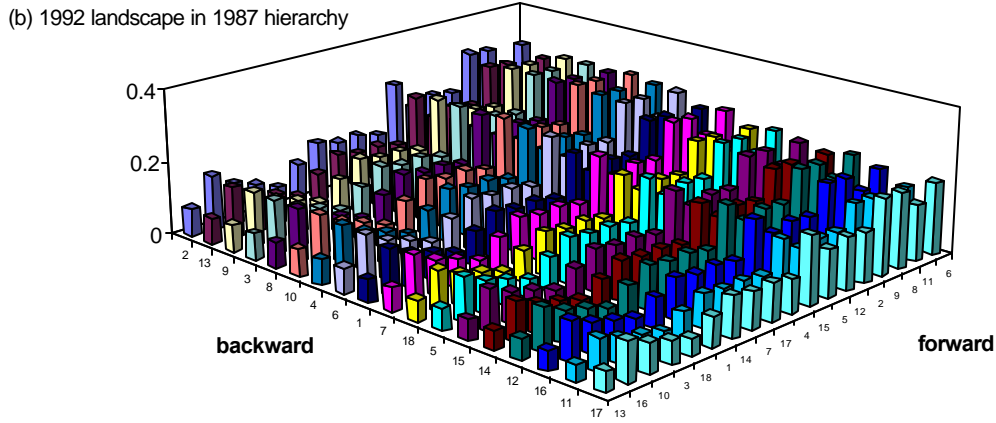
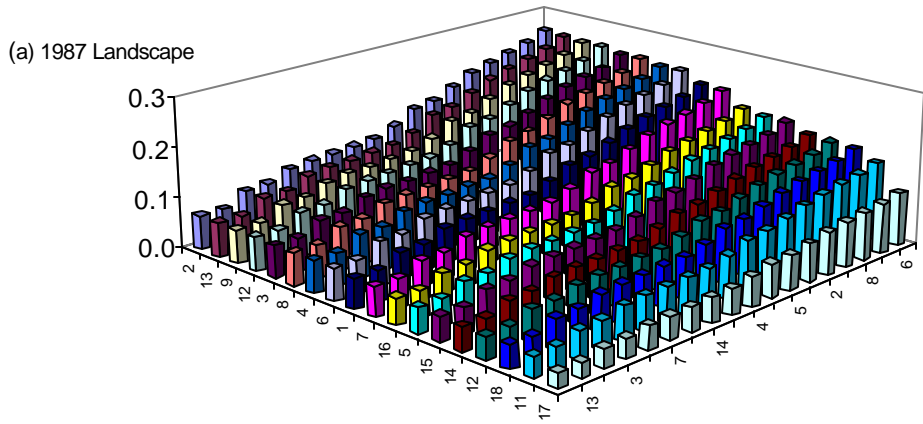
decrease in the input of textiles. On the other hand, the rapid growth of real estate promotes more input to building materials. The inadequate conditions of infrastructure and the associated need of communications generate growth in these sectors, which result in an increase of input.

Finally, the apex of the hierarchy has shifted from the intersection of sector 6 (chemical industries) and sector 2 (textiles) in 1987 to that of sector of 9 and 8 in 1997. It reflects that the economic structure in China has changed from a relatively lower level of light industry to an economy in which heavy industries play a more active role.

5. Conclusion

In the last twenty years, China's position as one of the fastest economic growing countries in the world has generated forces that have changed its economic structure. With the rank-size analysis and the method to visualize economic structure, we have provided a brief overview of these changes. Heavy industries sectors maintain dominant roles in the Chinese economy from 1987 to 1997, but with different emphases----the first ten years on chemicals, and the second ten years transferring to machinery and electronics. Labor-intensive industries like textiles are declining due to an active policy that intends to develop high-technology industry. Some non-manufacturing sectors changed their roles in the national economy and started to influence the economy in a positive way, but the services sector has not been a key sector in national economy, so China's developing character as a developing country has not changed.

Figure 12 Economic landscapes for China from 1987 to 1997



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