Trends and Characteristics in China's Industrial Sectors —Analysis Based on the Gm (1, 1) Model with the Seventh Weakness Operator

WANG Tianying[1,*]; WANG Siqi[2]

[1]School of Economy, Nanjing Audit University , P.R.China.
[2]School of Business, Curtin University , Australia.
*Corresponding author.
Email: wtyingfy@yahoo.com.cn

Abstract

This paper measured the influence and induction coefficients of the main industrial sectors of China in 1987, 1992, 1997 and 2002, based on the input-output tables of the four years, using the input-output methods, and discovered those sectors that have the strongest pulling or supporting effects in favor of national economic growth. The GM (1, 1) model with the seventh weakness operator was then applied to analyze the trends and characteristics in those sectors that predictably have the strongest pulling or supporting effects for economic growth in 2007, 2012, 2017 and 2022. In particular, the current study shows that, as those sectors of the strongest supporting effects are typically the greatest waste producers and environmental threats, China must establish the industrial chains with such sectors, which may serve as an avenue to circular economy.

Key words: Influence coefficient; Induction coefficient; Pulling effect; Supporting effect; GM (1, 1) model

INTRODUCTION

As a responsible and the greatest developing country, China has given the solemn promise for dealing with the serious climate problem at the 2009' United Nations Climate Change Conference: that emission level of CO_2 in 2020 will be decreased by 40 to 45 percent based on the emission level in 2005. Meanwhile, some western countries still bicker endlessly about whether or not decreasing the emission level of CO_2 by 20 percent in 2020 based on the emission level in 1990. Thus it can be seen that China has shown the firm determination and actively undertaking courage.

In fact, while studying the factors which have influenced the earth climate change since the western industrial revolutionary, it is easy to discover that when we are enjoying the modern industrial civilization, the climate and environment what our human relies on for living has been continuously deteriorating. But which countries will give up or slow down the process of modern industrialization under the background of global economy integration?

Accordingly, China has to change the economic development modes and develop the circular economy tremendously to achieve determined goals as a result of facing double pressures of accelerating the process of industrialization and decreasing the emission level of CO_2. So it is very important for us to study the sectors which have great pulling or supporting force for China economic growth and establish the circular economy industrial chains based on the these industries.

As a matter of fact, if we want to study the trends of some industries which have stronger pulling or supporting force in the economic growth, we have to research the economic and technological relationships among the industrial sectors in China, measuring and evaluating these relationships through some indexes and use some models to forecast the trends, so as to provide the evidences for establishing the industrial chains of circular economy and stipulate out the scientific and reasonable industrial policies.

1. DATA RESOURCE AND ADJUSTMENT

To examine the links between the economy and technology among different sectors within a country or region, or to research the changing law of the sectors which have stronger pulling effect or supporting effect on the economic grown in a country or region, we may study a number of its input-output table in a period and calculate the influence coefficient or induction coefficient of some sectors. But till 2010, the National Bureau of Statistics only published the input-output tables of 1987,1990,1995,1997 and 2002, and it is required to have the equal time interval in the original data series when we construct the GM(1,1) model. Therefore, we select only the input-output tables of 1987,1992, 1997 and 2002 as the original data.

On the other hand, in order to meet the requirement of transforming the planned economy into the market economy in China, some statistical range and statistical names have been changed. Thus there are some differences in some statistical ranges and statistical names in the same sectors in different years.

(i) In 2002, "Transport and Storage", "Postal Service" and "Information Transmission, Computer Services and Software" merged into "Cargo of Posts and Telecommunications". That is consistent with statistical standards in 1987 and 1992.

(ii) In 1997, "Transport and Storage of Goods" and "Postal Service" merged into "Cargo of Posts and Telecommunications". That is consistent with statistical standards in 1987 and 1992.

 (iii) In 2002, "Oil Processing, Coking and Nuclear Fuel" and "Gas Production and Supply " merged into "Oil processing, Coking, Gas and Coal Products".

(iv) In 1997, "Oil Processing and Coking" and "Gas Production and Supply" merged into "Oil Processing, Coking, Gas and Coal Products".

(v) In 1987 and 1992, "Oil Processing" and "Coking, Gas and Coal Products" merged into "Oil Processing, Coking, Gas and Coal Products".

(vi) In 2002,"Machinery"has been transferred into "Manufacture of General and Special Purpose Machinery", "Trade" changed into "Wholesale and Retail Trades", "Catering Services" changed into "Hotels and Catering Services", "Electric Power, Steam and Hot Water Production and Supply" changed into "Production and Supply of Electric Power and Heat Power", so these items also have been changed similarly in 1987, 1992 and 1997. Meanwhile, " Mining and Washing of Coal" changed into " Coal Mining and Processing", so that they are consistent with statistical standards in 1987,1992 and 1997.

2. ATA PROCESSING

2.1 Calculating the Complete Consumption Coefficient, Complete Distribution Coefficient,

Influence Coefficient and Induction Coefficient

By utilizing the statistical software SPSS and these data which have been adjusted with the statistical standards and names in 1987, 1992, 1997 and 2002 in China, we can calculate the complete consumption coefficient, complete distribution coefficient, influence coefficient and induction coefficient in main product production sectors in 1987, 1992, 1997 and 2002, which have shown in the Table 1,2,3 respectively.

3.2 Constructing the Forecast Models of GM(1,1) with the Induction Coefficient and Influence Coefficient Respectively

3.2.1 Based on the Time Series of Induction Coefficient and Influence Coefficient in China's Main Product Production Sectors in 1987, 1992, 1997 and 2002, and by Calculating Again and Again, We Utilize the Method of the Seventh- Mean Weakness Buffer Operator and Abide by the Steps of Constructing the Model of Gm(1,1),and have Constructed the Following Forecast Model Of Gm(1,1) .

Forecast Models of Gm(1,1) of Induction Coefficient in China's Main

Code of sector procdut	production sectors based on the senventh-mean weakness operator
1.	$\hat{x}^{(1)}(k) = 4867.715346e^{0.0001230k} - 4867.116847, k=1,2,\cdots$
2.	$\hat{x}^{(1)}(k) = -1087.939423e^{-0.0012263k} + 1089.274139, k=1,2,\cdots$
3.	$\hat{x}^{(1)}(k) = 3673.722300e^{0.0006553k} - 3671.315676, k=1,2,\cdots$
4.	$\hat{x}^{(1)}(k) = 11520.859512e^{0.0002189k} - 11518.337487, k=1,2,\cdots$
5.	$\hat{x}^{(1)}(k) = -2009.170311e^{-0.0005788k} + 2010.333485, k=1,2,\cdots$
6.	$\hat{x}^{(1)}(k) = 476.617572e^{0.0008796k} - 476.198475, k=1,2,\cdots$
7.	$\hat{x}^{(1)}(k) = -225.48426e^{-0.0031606k} + 226.197759, k=1,2,\cdots$
8.	$\hat{x}^{(1)}(k) = 252.412978e^{0.0010138k} - 252.157226, k=1,2,\cdots$
9.	$\hat{x}^{(1)}(k) = 1440.996116e^{0.0004683k} - 1440.321271, k=1,2,\cdots$
10.	$\hat{x}^{(1)}(k) = -1762.748249e^{-0.0004698k} + 1763.576396, k=1,2,\cdots$
11.	$\hat{x}^{(1)}(k) = 3124.906722e^{0.0004474k} - 3123.509032, k=1,2,\cdots$
12.	$\hat{x}^{(1)}(k) = 5423.01553e^{0.0002547k} - 5421.634396, k=1,2,\cdots$
13.	$\hat{x}^{(1)}(k) = 1057.172658e^{0.0007852k} - 1056.342720, k=1,2,\cdots$
14.	$\hat{x}^{(1)}(k) = -3483.599304e^{0.0004426k} + 3485.141609, k=1,2,\cdots$
15.	$\hat{x}^{(1)}(k) = 1537.665208e^{0.0006228k} - 1536.707765, k=1,2,\cdots$
16.	$\hat{x}^{(1)}(k) = -2322.694884e^{-0.0003620k} + 2323.535745, k=1,2,\cdots$
17.	$\hat{x}^{(1)}(k) = 552.127886e^{0.0013994k} - 551.355578, k=1,2,\cdots$
18.	$\hat{x}^{(1)}(k) = 797.377797e^{0.0011276k} - 796.479040, k=1,2,\cdots$
19.	$\hat{x}^{(1)}(k) = 860.688990e^{0.0010623k} - 859.775194, k=1,2,\cdots$
20.	$\hat{x}^{(1)}(k) = 1805.181216e^{0.0005143k} - 1804.252724, k=1,2,\cdots$
21.	$\hat{x}^{(1)}(k) = -157.536130e^{-0.0034469k} + 158.080335, k=1,2,\cdots$
22.	$\hat{x}^{(1)}(k) = -2582.704946e^{-0.0004991k} + 2583.994286, k=1,2,\cdots$
23.	$\hat{x}^{(1)}(k) = 82.227529e^{0.0003637k} - 82.197633, k=1,2,\cdots$
24.	$\hat{x}^{(1)}(k) = -635.364568e^{-0.0013296k} + 636.209882, k=1,2,\cdots$
25.	$\hat{x}^{(1)}(k) = -2155.068002e^{-0.0003518k} + 2155.826372, k=1,2,\cdots$

Forecast Models of Gm(1,1) of Influence Coefficient in China's Main

Code of sector	procdut production sectors based on the senventh-mean weakness operator
1.	$\hat{x}^{(1)}(k) = 1612.058047e^{0.0003705k} - 1611.460989, k = 1,2,\cdots$
2.	$\hat{x}^{(1)}(k) = -503.112325e^{-0.0012908k} + 503.762126, k = 1,2,\cdots$
3.	$\hat{x}^{(1)}(k) = -4398.10180e^{-0.0000944k} + 4398.516977, k = 1,2,\cdots$
4.	$\hat{x}^{(1)}(k) = -660.924331e^{-0.0013354k} + 661.807293, k = 1,2,\cdots$
5.	$\hat{x}^{(1)}(k) = 10925.0161e^{0.0000760k} - 10924.185478, k = 1,2,\cdots$
6.	$\hat{x}^{(1)}(k) = -4363.791284e^{-0.0002198k} + 4364.750722, k = 1,2,\cdots$
7.	$\hat{x}^{(1)}(k) = 3136.169555e^{0.0004071k} - 3134.892980, k = 1,2,\cdots$
8.	$\hat{x}^{(1)}(k) = 2583.232933e^{0.0004964k} - 2581.950767, k = 1,2,\cdots$
9.	$\hat{x}^{(1)}(k) = -8037.659550e^{-0.0001474k} + 8038.844442, k = 1,2,\cdots$
10.	$\hat{x}^{(1)}(k) = -2901.858665e^{-0.0003708k} + 2902.934784, k = 1,2,\cdots$
11.	$\hat{x}^{(1)}(k) = 2199.334467e^{0.0004637k} - 2198.314915, k = 1,2,\cdots$
12.	$\hat{x}^{(1)}(k) = -251158.818316e^{-0.0012908k} + 251160.034454, k = 1,2,\cdots$
13.	$\hat{x}^{(1)}(k) = -1845.046602e^{-0.0005550k} + 1846.070837, k = 1,2,\cdots$
14.	$\hat{x}^{(1)}(k) = -2638.658639e^{-0.0004725k} + 2639.905516, k = 1,2,\cdots$
15.	$\hat{x}^{(1)}(k) = 10324.502889e^{0.0001304k} - 10323.156438, k = 1,2,\cdots$
16.	$\hat{x}^{(1)}(k) = 2150.263157e^{0.0005930k} - 2148.988305, k = 1,2,\cdots$
17.	$\hat{x}^{(1)}(k) = -15707.105478e^{-0.0000867k} + 15708.467987, k = 1,2,\cdots$
18.	$\hat{x}^{(1)}(k) = -4504.529843e^{-0.0003014k} + 4505.887358, k = 1,2,\cdots$
19.	$\hat{x}^{(1)}(k) = 2463.589278e^{0.0006367k} - 2462.021250, k = 1,2,\cdots$
20.	$\hat{x}^{(1)}(k) = 1711.626716e^{0.0008147k} - 1710.23284, k = 1,2,\cdots$
21.	$\hat{x}^{(1)}(k) = 3285.968120e^{0.0003613k} - 3284.781100, k = 1,2,\cdots$
22.	$\hat{x}^{(1)}(k) = -581.589205e^{-0.0012234k} + 582.301019, k = 1,2,\cdots$
23.	$\hat{x}^{(1)}(k) = 3114.653713e^{0.0004045k} - 3113.394176, k = 1,2,\cdots$
24.	$\hat{x}^{(1)}(k) = 506.296987e^{0.0014993k} - 505.538326, k = 1,2,\cdots$
25.	$\hat{x}^{(1)}(k) = -506.125109e^{-0.0011105k} + 506.687396, k = 1,2,\cdots$

Where, 1-Agriculure; 2-Coal Mining and Processing; 3- Extraction of Petroleum and Natural Gas; 4-Mining and Processing of Metal Ores; 5-Mining and Processing of Nonmetal Ores; 6-Manufacture of Foods and Tobacco; 7-Manufacture of Textile; 8- Manufacture of Wearing Apparel, Leather, Fur, Feather and Related Products; 9-Processing of Wood and Manufacture of Furniture; 10- Manufacture of Paper and Paper Products; 11-Oil Processing, Coking, Gas and Coal Products; 12-Manufacture of Chemistry; 13-Manufacture of Nonmetallic Mineral Products;14-Smelting and Pressing of Metals;15-Manufacture of Metal Products; 16-Manufacture of General and Special Purpose Machinery; 17-Manufacture of Transport Equipment; 18-Manufacture of Electrical Machinery and Equipment; 19-Manufacture of Communication Equipment, Computer and Other Electrical Equipment; 20-Manufacture of Measuring Instruments and Machinery for Culture Activity and Office Work; 21-Other Manufacture; 22-Production and Supply of Electric Power, Heat Power; 23-Construction; 24-Cargo of Posts and Telecommunications; 25-Wholesale and Retail Sale Trades.

3.2.2 In the above models, let , then we can obtain

$\hat{x}_i^{(1)}(3), x_i^{(1)}(4), x_i^{(1)}(5), x_i^{(1)}(6), x_i^{(1)}(7)$ of different sectors in 2002, 2007, 2012, 2017 and 2022 respectively. If we again do subtraction as follows:

$\hat{x}_i^{(0)}(4) = x_i^{(1)}(4) - x_i^{(1)}(3), x_i^{(0)}(5) = x_i^{(1)}(5) - x_i^{(1)}(4), x_i^{(0)}(6) = x_i^{(1)}(6) - x_i^{(1)}(5),$ $and \hat{x}_i^{(0)}(7) = x_i^{(1)}(7) - x_i^{(1)}(6), i = 1,2,\cdots,25$, then we could obtain the induction coefficient of different sectors. For example, in "Extraction of Petroleum and Natural Gas", when $i=3$, let

k=1, 2, 3, 4, 5, 6, 7 in the model of

$\hat{x}^{(1)}(k) = 3673.722300e^{0.0006553k} - 3671.315676$

respectively, $\hat{x}_3^{(1)}(3), x_3^{(1)}(4), x_3^{(1)}(5), x_3^{(1)}(6), x_3^{(1)}(7)$ is respectively 9.636203, 12.049224, 14.463826, 16.880011 and 19.297780. Hence, the induction coefficients of "Extraction of Petroleum and Natural Gas" in 2007, 2012, 2017 and 2022 are obtained as follows:

$\hat{x}_3^{(0)}(4) = x_3^{(1)}(4) - x_3^{(1)}(3) = 12.049224 - 9.636203 = 2.413020$

$\hat{x}_3^{(0)}(5) = x_3^{(1)}(5) - x_3^{(1)}(4) = 14.463826 - 12.049224 = 2.414602$

$\hat{x}_3^{(0)}(6) = x_3^{(1)}(6) - x_3^{(1)}(5) = 16.880011 - 14.463826 = 2.416185$

$\hat{x}_3^{(0)}(7) = x_3^{(1)}(7) - x_3^{(1)}(6) = 19.297780 - 16.880011 = 2.417769$

Other relevant data and the indexes of testing models have shown in Table 1,2.

3.2.3 Except from the two models of "Extraction of Petroleum and Natural Gas" and "Chemistry Industry" based on the Table 1, 2, which standard deviation ratio is 0.465992 and 0.945363 respectively and does not reach the level of first-exactitude, the other models of GM(1,1) which constructed with the induction coefficient and influence coefficient in China's main product production sectors all attain the level of first-exactitude. Therefore, we can use these models to forecast the relevant induction coefficients and influence coefficients in these sectors in 2007, 2012, 2017 and 2022, and the results have been shown in Table 1, 2.

4. ANALYZING ON THE TREND OF CHINA'S INDUSTRIAL PLATES FROM 1987 TO 2022

Since China has launched reform and opening-up from1978, the economic system has changed from planned economy to planned commodity economy and to socialist market economy. During the period, China's industrial structure is also changing along with the changes of economic system. Hence, this period from 1987 to 2022 can be divided three stages: the first stage is that China's market economy system had been preliminarily established from 1987 to 2002, the second stage is that China's market economic system has been perfected preliminarily from 2002 to 2012, the third is that China's market economic system will be further perfected and is developing rapidly, so as to research the changes of industrial plates which have stronger pulling or supporting effects for economic growth in China.

Table 1
Forecast Values of Induction Coefficient and Test Values of Models of Gm(1,1) in China's Main Industries from 1997 to 2022

Code of sector	Year						Mean relative error	Index Inter-relationship	Standard deviation ratio
	1997	2002	2007	2012	2017	2022			
1	0.58993	0.59873	0.598805	0.598879	0.598953	0.599026	0.000003	0.999999	0.038147
2	1.54988	1.33003	1.328428	1.326800	1.325174	1.32355	0.000021	0.999850	0.030210
3	2.21292	2.41143	2.413020	2.414602	2.416185	2.417769	0.000004	0.999995	0.010569
4	2.44157	2.52347	2.523993	2.524546	2.525099	2.525651	0.000012	0.999986	0.091088
5	1.25053	1.16123	1.160566	1.159895	1.159224	1.158553	0.000007	0.999996	0.021736
6	0.37122	0.42017	0.420535	0.420905	0.421276	0.421647	0.000010	0.999998	0.020324
7	1.00526	0.70703	0.704829	0.702605	0.700387	0.698177	0.000043	0.999983	0.023568
8	0.22486	0.25655	0.256814	0.257075	0.257336	0.257597	0.000016	0.999998	0.027536
9	0.63044	0.67569	0.675994	0.676311	0.676628	0.676945	0.000018	0.999994	0.067644
10	0.88513	0.82713	0.826763	0.826375	0.825987	0.825599	0.000026	0.999989	0.095254
11	1.31850	1.39954	1.400164	1.40079	1.401417	1.402044	0.000002	0.999999	0.006607
12	1.33742	1.38217	1.382523	1.382875	1.383227	1.38358	0.000001	1.000000	0.003933
13	0.74164	0.83176	0.832396	0.83305	0.833705	0.834359	0.000021	0.999992	0.045280
14	1.62478	1.54022	1.539531	1.53885	1.538169	1.537488	0.000005	0.999996	0.017990
15	0.88124	0.9592	0.959794	0.960392	0.96099	0.961589	0.000004	0.999998	0.011444
16	0.88112	0.84	0.839702	0.839398	0.839094	0.83879	0.000007	0.999997	0.321494
17	0.62862	0.7754	0.776465	0.777552	0.778641	0.779732	0.000027	0.999990	0.033234
18	0.76592	0.90169	0.902692	0.903711	0.90473	0.905751	0.000017	0.999993	0.025317
19	0.79431	0.91674	0.91772	0.918695	0.919672	0.920649	0.000006	0.999997	0.010010
20	0.85362	0.92964	0.93008	0.930558	0.931037	0.931516	0.000042	0.999981	0.138746
21	0.76430	0.53839	0.536506	0.534659	0.53282	0.530986	0.000058	0.999985	0.029091
22	1.37070	1.28743	1.286790	1.286148	1.285506	1.284865	0.000002	0.999999	0.007024
23	0.02853	0.02993	0.029941	0.029952	0.029963	0.029974	0.000001	1.000000	0.002928
24	0.98648	0.842	0.840884	0.839767	0.838651	0.837536	0.000003	0.999998	0.004347
25	0.78732	0.75748	0.757202	0.756936	0.75667	0.756404	0.000015	0.999994	0.072130

Notes: (i)The code of sector is as the above. (ii)"Agriculture", "Cargo of Posts and Telecommunications" and "Wholesale and Retail Sale Trades" is viewed as reference departments. (iii)Except from the mini-error probability of "Manufacture of Measuring Instruments and Machinery for Culture Activity and Office Work" is less than0.95, the other are more than 0.95.

4.1 Changes of Industrial Plates which have Stronger Pulling Effect for China's Economic Growth from 1987 to 2012

On according to the relevant analysis above, we may obtain the trend of alteration of industrial plates which have stronger pulling effect for economic growth by studying the influence coefficient changes of relevant sectors. In fact, when the influence coefficient is more than 1, it means this industry will have stronger "pulling" or "leading" effect, and the more the influence, the more the "pulling" or "leading" effect. Therefore, to accelerate economic growth in a country or a region, these industries must be emphasized firstly. Especially, we can draw the following conclusions from Table 2 and 3.

(i)During the period of China's market economic system constructed preliminarily from 1987 to 2002, the former five sectors which have the largest influence coefficients and their influence coefficient and their ranks in 1987,1992,1997 and 2002 are as follows: Manufacture of communication equipment, computer and other electrical equipment, their influence coefficients are 1.43508, 1.22579, 1.44588 and 1.57106, their ranks of "pulling" effect are the first, the fifth, the first and the first respectively; Manufacture of transport equipment, their influence coefficients 1.34146,1.22192,1.38268 and 1.36225, their ranks the second, the sixth, the third and the third; Manufacture of electrical machinery and equipment, 1.30837,1.20377,1.41678 and 1.35644, the fourth, the eighth, the second and fourth; Manufacture of measuring instruments and machinery for culture activity and office work, 1.03722,1.03214,1.25402 and 1.39732,the fourteenth, the fourteenth, the sixth and the second; Manufacture of metal products, 1.24285,1.24816,1.32620 and 1.34701, the seventh, the third, the fifth and the fifth.

Table 2
Forecast Values of Influence Coefficient and Test Values of Models of Gm(1,1) in China's Main Industries from 1997 to 2022

Code of sector	Year						Mean relative error	Index Inter-relationship	Standard deviation ratio
	1997	2002	2007	2012	2017	2022			
1	0.57147	0.59776	0.597987	0.598208	0.59843	0.598652	0.000009	0.999997	0.041750
2	0.75505	0.64732	0.646487	0.645653	0.64482	0.643988	0.000003	0.999999	0.003823
3	0.41554	0.41510	0.415049	0.41501	0.414971	0.414931	0.000029	0.999994	0.465992
4	1.03909	0.87962	0.878469	0.877297	0.876126	0.874957	0.000027	0.999988	0.034527
5	0.82179	0.83072	0.830781	0.830844	0.830907	0.83097	0.000003	0.999999	0.060359
6	0.98781	0.95884	0.958634	0.958424	0.958213	0.958002	0.000005	0.999997	0.042413
7	1.20741	1.27805	1.27856	1.27908	1.279601	1.280122	0.000008	0.999995	0.035162
8	1.19662	1.28396	1.284582	1.28522	1.285858	1.286497	0.000012	0.999993	0.040877
9	1.20725	1.18436	1.184187	1.184012	1.183838	1.183663	0.000001	0.999999	0.013996
10	1.12667	1.07494	1.074543	1.074145	1.073747	1.073349	0.000002	0.999999	0.007969
11	0.95843	1.02094	1.021408	1.021882	1.022356	1.02283	0.000005	0.999998	0.018423
12	1.22073	1.21619	1.216194	1.216188	1.216182	1.216176	0.000008	0.999995	0.945363
13	1.10075	1.02264	1.022087	1.02152	1.020953	1.020386	0.000014	0.999993	0.043119
14	1.33059	1.2453	1.244738	1.24415	1.243562	1.242974	0.000021	0.999987	0.076024
15	1.32620	1.34701	1.34719	1.347366	1.347542	1.347717	0.000003	0.999998	0.043002
16	1.17788	1.27707	1.277822	1.27858	1.279338	1.280097	0.000005	0.999997	0.013585
17	1.38268	1.36225	1.362146	1.362027	1.361909	1.361791	0.000010	0.999993	0.198368
18	1.41678	1.35644	1.356052	1.355644	1.355235	1.354827	0.000015	0.99999	0.087982
19	1.44588	1.57106	1.572068	1.573069	1.574071	1.575074	0.000005	0.999996	0.012715
20	1.25402	1.39732	1.398465	1.399605	1.400745	1.401887	0.000004	0.999997	0.009353
21	1.12840	1.18821	1.188627	1.189056	1.189486	1.189916	0.000011	0.999994	0.051178
22	0.82628	0.70933	0.708478	0.707612	0.706746	0.705882	0.000021	0.999992	0.030092
23	1.19508	1.26104	1.261548	1.262059	1.262569	1.26308	0.000001	0.999999	0.006084
24	0.61021	0.76197	0.763098	0.764243	0.76539	0.766539	0.000019	0.999993	0.022307
25	0.64319	0.56049	0.559876	0.559254	0.558634	0.558013	0.000014	0.999996	0.021585

Notes: (i) The code of sector is as the above. (ii)"Agriculture", "Cargo of Posts and Telecommunications" and "Wholesale and Retail Sale Trades" is viewed as reference sectors.

In addition, as a traditional country of Manufacture of textile, its influence coefficient that had reached 1.31453,1.27586,1.20741 and 1.27805 in China, their ranks are the third, the second, the eighth and the seventh in 1987, 1992, 1997 and 2002 respectively. And Manufacture of wearing apparel, leather, fur, feather and related products, their influence coefficient were 1.29881,1.30742,1.19662 and 1.28396, their ranks the sixth, the first, the tenth and sixth in 1987, 1992, 1997 and 2002 respectively.

Obviously, with the construction of socialist market economic system in China, the industries which have stronger pulling effect for economic growth are also in the processes of consistently adjusting during the period. For instance, during the time of planned economy and the commodity economy, the Manufacture of textile and Manufacture of wearing apparel, leather, fur, feather and related products have very stronger pulling effect for China's economic growth, but their pulling effects are reducing with the industrial structural adjustment and the technological progress. This pulling effect of Manufacture of Textile had decreased from the second in 1992 to the seventh in 2002, and the ratio of its added values to all added values of industrial sectors accounted independently also decreased from 8.38% in 1995 to 6.99% in 2007. The pulling effect of Manufacture of Wearing Apparel, Leather, Fur, Feather and Related Products had decreased even from the first in 1992 to the sixth in 2002. However, the pulling effect of Manufacture of Measuring Instruments and Machinery for Culture Activity and Office Work had increased from the fourteenth in 1992 to the second in 2002, and the pulling effect of Manufacture of Metal Products also had increased from the seventh in 1987 to the fifth in 2002. These show not only the changes of product market demand, but also the selection of modernistic industry development: the product production sector with higher technology will supersede gradually the product production sector with lower technology and become the main sectors which pull the modern economic growth.

Table 3
Influence Coefficient and Induction Coefficient of Main Industry in China in 1987 and 1992

Code of Sector	Influence Coefficient		Induction Coefficient	
	1987	1992	1987	1992
2	0.67903	0.84091	1.53480	1.40018
3	0.43081	0.57235	1.70622	1.89021
4	0.80056	0.89413	2.58844	2.74265
5	0.60596	0.84180	1.12512	1.22991
6	1.02818	0.94907	0.37154	0.37985
7	1.31453	1.27586	0.96434	0.91858
8	1.29881	1.30742	0.29006	0.13952
9	1.19804	1.21168	0.89958	0.74798
10	1.15429	1.15465	0.86913	0.66169
11	0.80539	0.96245	1.33815	1.26940
12	1.15284	1.09589	1.38469	1.28238
23	0.9898	0.99385	0.92267	0.87673
14	1.19887	1.07643	1.66938	1.80297
15	1.24285	1.24816	0.86163	0.85586
16	1.19104	1.15758	0.73692	0.84756
17	1.34146	1.22192	0.65806	0.75813
18	1.30837	1.20377	0.74378	0.82751
19	1.43508	1.22579	0.71387	0.60036
20	1.03722	1.03214	1.18880	1.28532
21	1.22646	1.23552	1.47169	1.4148
22	0.65114	0.74738	1.50692	1.42046
23	1.30281	1.15307	0.00000	0.02738

Note: The code of sector referes the above.

(ii)The years between 2002 and 2012 are the preliminary improvement stage of the socialist market economic system, but it is the time that the country's economy increases rapidly. For example, China's gross domestic product has increased from ¥1205.86 billion in 1987 to ¥39798.3 billion in 2010, and has in turn exceed Italy, France, England, Germany and Japan in GDP and become the second stronger country in the world. Meanwhile, during the period, China's industrial economic structure has become more reasonable and the industrial plates with stronger pulling effect for economic growth have been determined and gradually stabled. But its rapid economic growth also results in serious problems in resources and environment protection in the period. Hence, the changes of China's industrial plates, especially, their formation which have stronger pulling effect for economic growth will be related to improve the ecology and environment in the future.

From the results of the forecast models of GM(1,1) in Table 3, we can find out that the following five sectors with the most strongest pulling effects for China's economic growth are Manufacture of Communication Equipment, Computer and Other Electrical Equipment, Manufacture of Measuring Instruments and Machinery for Culture Activity and Office Work, Manufacture of Transport Equipment, Manufacture of Electrical Machinery and Equipment, Manufacture of Metal Products from 2002 to 2012. Especially, the pulling effects for economic growth become stronger gradually year by year in the two sectors of Manufacture of Communication Equipment, Computer and Other Electrical Equipment,

Manufacture of Measuring Equipment and Machinery for Culture Activity and Office Work.

In fact, the output of computer has increased from 1.46351million in 2002 to 245.845 million in 2010, and the output of auto also from 3.251 million in 2002 to 18.2699 million in 2010, and their average accrual rate reached 42.28% and 24.10% respectively. The rates of the two sectors had greatly surpassed the rate of GDP in the time. This means that the two sectors have very strong pulling effect for China's economic growth.

Nevertheless, the ratios of the volume of waste water discharged, waste gas emission and solid wastes generated in Manufacture of communication equipment, computer and other electrical equipments to the total volume of all industries discharged (emission and generated) are 0.868%, 0.576%, 0.079% in 2005 and 1.603%, 0.777%, 0.091% in 2009, Manufacture of transport equipment 1.141%, 0.726%, 0.271% in 2005 and 1.312%, 0.841%, 0.265% in 2009 (and other relevant sectors shown in Table 4). These data represents that the sectors with the strongest pulling effect for economic growth also produce less negative influence upon the environment. Hence, these sectors with the stronger pulling effect for economic growth are consistent with China's policy of environment protection, and represent the direction of economic structure adjustment and modern industries development. It may meet the needs of maintaining rapid economic growth and protecting the environment to largely develop these sectors with the stronger pulling effect.

4.2 Changes of Industrial Plates which have Stronger Supporting Effect for China's Economic Growth from 1987 to 2012

Based on the above analysis, we could draw the conclusion that the sectors with stronger supporting effect for China's economic growth are those with larger induction coefficient. If the induction coefficient of a sector is more than 1, it will play some supporting or restricting role basically for economic growth. And the more the induction coefficient, the stronger the supporting or restricting effect there will be. Namely, when those sectors develop better, the supporting role to other sectors will be more salient; however, when those sectors develop worse, the restricting role to other sectors will become even serious. Therefore, these sectors with bigger induction coefficients must be given priority to develop to maintain the rapid economic growth. Otherwise, the development of some sectors will be restricted. The following results can be obtained from the Table 1, 3:

(i)In the period of China's market economic system constructed preliminarily from 1987 to 2002, the former seven sectors which have the largest induction coefficients and their induction coefficient and their ranks in 1987,1992,1997 and 2002 are as follows: Mining and processing of metal ores, their induction coefficients are 2.58844, 2.74265, 2.44157 and 2.52347 in 1987, 1992,

1997,and 2002 respectively, their ranks of supporting effects are all in the first; Extraction of petroleum and natural gas, their induction coefficients1.70622, 1.89021, 2.21292 and 2.41143, and their ranks are all in the second in 1987, 1992, 1997 and 2002; Smelting and pressing of metals, 1.66938, 1.80297, 1.62478 and 1.54022, and all in the third; Coal mining and processing, 1.53480, 1.40018, 1.54988 and 1.33003, their ranks the fourth, the sixth, the fourth and sixth; Production and supply of electrical power, heat power, their induction coefficients 1.50692, 1.42046, 1.37070 and 1.28730, its rank the fifth, the fourth, the fifth and seventh; Oil processing, coking, gas and coal products, their induction coefficients 1.33815, 1.26940, 1.31850 and 1.39954, their rank the eighth, the ninth, the seventh and the fourth; Manufacture of chemistry, their induction coefficients are 1.38469, 1.28238, 1.33742 and 1.38217, their ranks the seventh, the eighth, the sixth and fifth respectively.

Table 4
Ratios of Wastes Produced in Main Industrial Sectors in China in 2004, 2005 and 2009   unit: %

Code of sector	2004			2005			2009		
	Waste water discharged	Waste Gas Emission	Solid Wastes Generated	Waste water discharged	Waste Gas Emission	Solid Wastes Generated	Waste water discharged	Waste Gas Emission	Solid Wastes Generated
2	2.526	0.770	13.917	2.160	0.722	14.678	3.838	0.535	12.518
3	0.524	0.334	0.125	0.521	0.359	0.120	0.488	0.250	0.092
4	2.129	0.683	23.640	2.101	0.575	23.359	2.528	0.424	25.850
A	0.724	0.385	13.774	0.659	0.352	10.238	0.744	0.341	12.294
B	1.405	0.299	9.865	1.442	0.223	13.121	1.785	0.082	13.556
11	3.105	4.154	1.621	3.154	3.406	1.481	3.177	3.624	1.570
12	16.338	6.018	7.757	15.698	5.927	7.427	14.211	5.314	6.606
5	2.417	19.665	2.960	2.234	18.601	2.604	1.568	18.088	2.286
14	11.244	24.136	21.130	9.430	25.880	22.751	7.413	28.216	21.493
C	9.447	19.275	17.185	7.868	20.962	18.907	6.027	23.754	17.776
17	2.032	0.925	0.305	1.141	0.726	0.271	1.312	0.841	0.265
18	0.403	0.272	0.046	0.375	0.232	0.034	0.446	0.253	0.037
19	0.718	0.386	0.086	0.868	0.576	0.079	1.603	0.777	0.091
20	0.501	0.350	0.062	0.335	0.196	0.045	0.277	0.124	0.014
22	12.716	33.622	21.012	11.628	32.959	20.622	7.129	32.937	23.669
合计	54.654	91.314	92.661	49.647	90.159	93.469	43.911	91.383	94.491

Note: The number of code refers to the above, but A- Mining and Processing of Ferrous Metal Ores, B-Mining and Processing of Non-ferrous Metal Ores, C- Smelting and Pressing of Ferrous Metals.

Obviously, the industries with stronger supporting effect for China's economic growth mainly focus on these sectors relate to producing steel, iron, energy and electricity. In fact, the process of industrialization of a country or region must be based on the rapid increases of steel, iron, energy and electricity. These sectors with bigger induction coefficient not only could play stronger supporting role for other sectors, but also restrain other sectors development and become the inhibitory sectors once they are not in healthy orbit of development. Such as the phenomena of "shortage of electricity", "shortage of coal" and "shortage of construction materials" in the 1990s, these had to a certain extent inhibited the economic and social development in China.

(ii) In the period of preliminary improvement stage of the socialist market economic system from 2002 to 2012, the industries with the most strongest supporting effect for China's economy are Mining and processing of metal ores, Extraction of petroleum and natural gas, Smelting and pressing of metals, Oil processing, coking, gas and coal products, Manufacture of chemistry and Mining and processing of coal. The comparison of sectors with stronger supporting effect from 2002 to 212 with the one from 1987 to 2002, they are still the same sectors, but their ranks of supporting effect have quietly changed, such

as the ranks of Manufacture of chemistry have risen from the seventh in 1987, the eighth in 1992 and the sixth in 1997 to the fifth in 2002, 2007 and 2012; Oil processing, coking, gas and coal products from the eighth in 1987, the ninth in 1992, the seventh in 1997 to the fourth in 2002, 2007 and 2012; however, the ranks of Mining and processing of coal and Production and supply of electrical power, heat power have decreased from 2002 to 2012.

In China, coal is the most important energy for economic development, such as the ratios of output of coal to total outputs of energies produced have still surpassed 70% since 1987, especially reached 76% in 2004, and the production of electricity also depends on the thermal power, which proportions of thermal power in the electric power produced was 81.9% in 2005 and 80.8% in 2008, so there is a great demand for coal in China's economic development. On the one hand, the pressure of demand for energy was solved partly by launching a lot of small coal workplaces and small thermal power plants, on the other hand, this way also seriously damaged to the environment. For instance, the ratios of volume of waste water discharged, waste gas emission and solid wastes generated in Mining and processing of coal sector and Production and supply of electric power, heat power sector to the one of all industries are 13.788%, 33.681%,

35.300% in 2005 and 10.967%, 33.472%, 36.187 in 2009 (shown in Table 4).

Moreover, we could find out that the sectors with very stronger supporting effect for economic growth in China are also the sectors with the more wastes produced in product production and seriously damaged to the environment from table 4. For example, except from Mining and processing of coal sector and Production and supply of electric power, heat power sector, Manufacture of chemistry sector and Smelting and pressing of Metals sector also produced more waste water discharged in their product production, the ratio of volume of waste water discharged to the one of all industries are 16.338% and 11.244% in 2004 respectively, 14.211% and 7.413% in 2009; the ratios of volume of waste gas emission and solid wastes generated in Smelting and processing of Metals to the one of all industries are 24.136% and 21.130% in 2004, 23.754% and 17.776% in 2009, where the ratios of volume of waste gas emission and solid wastes generated in Smelting and pressing of ferrous metals sector to the one of Smelting and pressing of metals are more than 80%. And the ratio of volume of solid wastes generated in Mining and processing of metal ores sector which has the most supporting effect with China's economic growth to the one of all industries are 23.640% in 2004 and 25.850% in 2009 respectively.

Therefore, to solve the conflicts of maintaining rapid economic development and protecting the environment, on the one hand, we must strengthen the sectors with very stronger supporting effect for economic growth, such as Mining and processing of metal ores, Extraction of petroleum and natural gas, Smelting and pressing of metals, Oil processing, coking, gas and coal products, Manufacture of chemistry and Mining and processing of coal, so as to meet the demand for steel, energy, electricity and construction materials in modern economic growth and industrialization. On the other hand, we must give priority to increase the investments on technology in these sectors, strengthen the policy support on the technological inport and technological creation, actively construct and develop the industrial chain with cyclical economy which must focus on these sectors, so as to reduce the wastes produced in production processes of these sectors.

In addition, the sectors with very larger induction coefficient have the basic support or restriction roles, so these sectors easily become the bottleneck sectors during the period of rapid economic development. However, once some sectors become the restriction sectors in rapid economic development, we often also neglect or slack in monitor and prevent from damaging the environment for those sectors' economic activities, so that when the restriction problem is solved, the problem of environment also become serious, and strengthen the management on the sectors which had seriously damaged to the environment by some administrative measures, such as ordering to "closing, stopping, merging, transferring"

them. For instance, during the period of "the tenth-five year plan", to solve the "shortage of coal", "shortage of electricity" and "shortage of construction materials", there risen many small coal workplaces, small thermal power plants in short time all over the country. This indeed improved the situation of economic development, but also resulted in very serious problem of environment. Hence, during the period of "eleventh-five year plan", the government firstly put forward an aim that the volume of wastes produced in 2010 must been reduce by 20% based on the volume of wastes produced in 2005, so there were many small coal workplaces and small thermal power plants those had been closed or stopped or merged or transferred from 2006 to 2009, but the result was not ideal, such as the volume of wastes produced in 2009 only reduced by 14.38% based on the one in 2005.

Therefore, the government had decided to largely clean out the backward capacities of production, close 10 million KW of small thermal power plants, clean out 25 million tons of smelting iron, 6 million tons of crude steel, 50 million tons of cement, 0.33 million tons of electrolyzed aluminum, 6 million weight cases of plain glass, 0.53 million tons of machine-made paper and paperboard. These show that the sectors with stronger supporting effect for economic growth are also those that may produce many wastes and damage to the environment. Especially, during the rapid economic growth in a country or region, the development of sectors with stronger supporting effect for economic growth must be consistent with the environment protection, never to only attach attention to the supporting effect of some sectors for economic growth, and neglect their negative influence on environment.

4.3 Prospects for the Changes of China's Industrial Plates from 2012 to 2022

Based on the above, we can find out that China's industrial structures have undergone a process of continuous adjustment and improvement from 1987 to 2012. These sectors with stronger pulling effect for economic growth have not only gradually formed some relevant stable industrial plates, but also brought a few of negative influence on the environment, and the development of these sectors indicates the direction of China's modern industrial development under current level of science and technology. In fact, it is demonstrated by the forecasts of the pulling effects of China's main industries based on the model of GM(1,1) with seventh-weakness operator (reference to Figure 1).
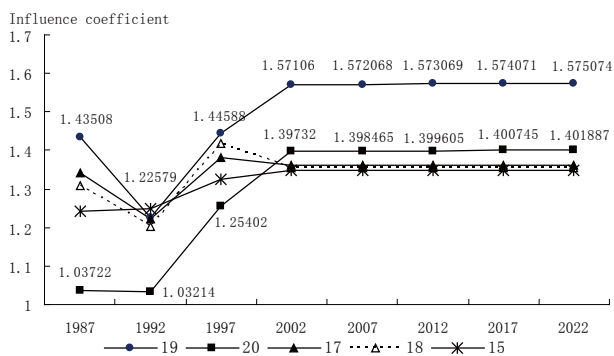
Figure 1
Trends of the Five Sectors with the Most Pulling Effect for China's Economic Growth from 1987 to 2022
 Note: The number of the key is the code of sector as the above.

Similarly, we can find out that sectors with stronger supporting effect for economic growth have also gradually formed some relevant stable industrial plates, but those plates have also brought a lot of negative influence on the environment since 1987, and have become the key sectors that China is engaged in improving environment and saving energy and reducing the wastes produced. In fact, it is demonstrated by the forecasts of the supporting effects of China's main industries based on the model of GM(1,1) with seventh-weakness operator (reference to Figure 2)

Moreover, if we divide the period of from 1987 to 2022 into two stages that 20 years of the fomer from 1987 to 2007 and 15 years of the later from 2007 to 2022, we can find out from Table 5:

(i)The following sectors with supporting effects being stronger from 2007 to 2022 than from 1987 to 2007 are Manufacture of communication equipment, computer and other electical equipment, Manufacture of electrical machinery and equipment, Manufacture of metals, Manufacture of transport equipment, Oil processing, coking, gas and coal products and Manufacture of general and special equipment. It means some industry sectors not only continue to undertake the tasks of pulling economic growth, but also gradually undertake the tasks of supporting economic growth in the future, such as Manufacture of communication equipment, computer and other electrical equipment sector and Manufacture of electrical machinery and equipment sector. But the supporting effects or restrictions for China's economic growth of some sectors, such as Oil processing, coking, gas and coal products sector, may become very obvious in the future.

 (ii)The following sectors with supporting effects being weaker from 2007 to 2022 than from 1987 to 2007 are Other manufactures, Manufacture of textile, Mining and processing of coal and Production and supply of electrical power, heat power. In fact, other manufacture sectors, such as Machinery equipment repairing, could not continue to have stronger supporting effect for China's economic

growth from 2007 to 2020 than in 1990s. Likely, though the status of China, as a Textile empire, will not be changed from 2007 to 2022, the supporting effect of Manufacture of textile will gradually give way to the new modern elementary industries. However, the decreases of the supporting effect for China's economic growth, such as Mining and processing of coal and Production and supply of electrical power, heat power, mean that the supply of energy will gradually transfer to depend on the clean energies, such as, nuclear energy, wind energy, solar energy and water energy, and also demonstrates that there will be huge adjustment in the structures of energy production and energy consumption in China.
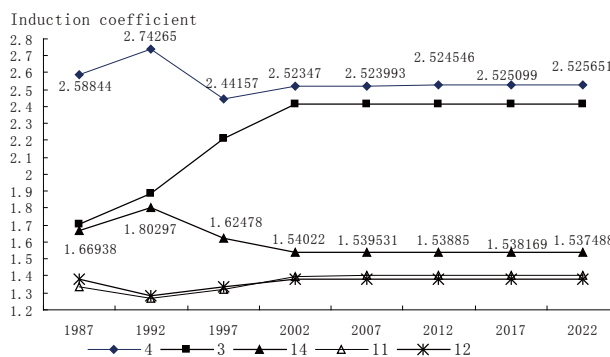

Figure 2
Trends of the Five Sectors with the Most Supporting Effect for China's Economc Growth from 1987 to 2022
 Note: the number of the key is the code of sector as the above.

(iii)There are the following sectors with pulling effects being stronger from 2007 to 2022 than from 1987 to 2007 those: Manufacture of measuring instruments and machinery for culture activity and office work, Manufacture of chemistry and Oil processing, coking, gas and coal products and so on. And the following sectors with pulling effects be weaker from 2007 to 2022 than from 1987 to 2007 are Construction, Processing of wood and manufacture of furniture, Smelting and pressing of metals and so on.

Obviously, with the improvement of Chinese living standard, the demands for culture and education, health equipment and security will become more and more, this could certainly raise the status of Manufacture of measuring instrument and machinery for culture activity and office work in national economy, and enhance its pulling effect for economic growth. Moreover, we can find out that Manufacture of chemistry has not only stronger pulling effect but also stronger supporting effect for China's economic growth, and their pulling effect and supporting effect will be strengthened for China's economic growth as an elementary industry and a leading industry in the future. Meanwhile, the pulling effect for economic growth of Oil processing, coking, gas and coal products also has become more and more stronger, which

shows that the demand for oil, coke, gas and coal products will continuously increase in China in the future and those demands will certainly promote the rapid development of the sector.

Table 5
Ranks and Changes of Pulling and Supporting of Main Industries in China from 1987 to 2022

Code of sector	1987-2007		2007-2022		Stronger (+)	Weaker (-)
	Pulling	Supporting	Pulling	Supporting	Pulling	Supporting
2	21	4	22	6	-1	-2
3	25	2	25	2	0	0
4	18	1	18	1	0	0
5	19	8	19	8	0	0
6	16	23	17	23	-1	0
7	6	13	7	19	-1	-6
8	5	24	6	24	-1	0
9	10	20	13	20	-3	0
10	14	17	14	16	0	1
11	17	7	15	4	2	3
12	13	6	11	5	2	1
13	15	15	16	15	-1	0
14	8	3	10	3	-2	0
15	4	14	5	9	-1	5
16	9	16	8	13	1	3
17	2	21	3	17	-1	4
18	3	18	4	12	-1	6
19	1	19	1	11	0	8
20	12	9	2	10	10	-1
21	11	10	12	22	-1	-12
22	20	5	21	7	-1	-2
23	7	25	9	25	-2	0

Notes: (1) The code of sector as the above. (2) The ranks based on the simple arithmetic average of influence coefficients and induction coefficients respectively.

In fact, to meet the requirement for improving resident's housing conditions and infrastructure in urban and rural in China during the first decade of the 21st century, its construction sector has received rapid development and been pulling China's rapid economic growth. But with the continuous improvement of residents' housing conditions and infrastructure in urban and rural, especially, the government starts to manage and control the estate market by very strict and normal polices, its pulling effect for economic growth will become weak from 2007 to 2022, like the forecast on its influence coefficient based the model of GM(1,1). Whereas, there are two main reasons that will result in falling of pulling effect for economic growth of Processing of wood and manufacture of furniture. The first is because the government has strengthened to protect the forest and vegetations, and this will result in increasing the production costs of Processing of wood and manufacture of furniture sector and directly restrict its development in the future. The second is that the furniture is durable goods, once a family has bought some furniture's, they will be used a few of decades. On the one hand, Manufacture of furniture sector had the stronger puling effect for economic growth from 1987 to 2007, on the other hand, there are full of various furniture in Chinese families. Hence, the demand for furniture in Chinese families will relatively reduce from 2007 to 2022.

CONCLUSIONS

With the gradual construction and improvement of Chinese socialist market economic system, China's industrial structures have gone through a process of continuous readjustment and evolution. Though the two big industrial plates that have the stronger pulling effect and supporting effect for China's economic growth will maintain the basic stability, the non-basic changes among the different industries in the two industrial plates still happen during the period of next 15 years. Especially, when the government stipulates the mid-term or long-term plans of national economy, the sectors with stronger puling effect for economic growth must be not only focused on, but also largely support the sectors with stronger supporting effect for economic growth by finance, taxation and technology creation and technology imports, so at to not only maintain the healthy development of these sectors, but also further reduce the wastes produced in their production and decrease the content of damage on environments as result of their productions.

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