An Empirical Study on the Correlation and Coordination Degree of Linkage Development between Manufacturing and Logistics

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***Abstract*—Manufacturing is a major driving force and an important pillar for national economic development .It is an important source to create national income. Currently the low level of logistics industry development significantly restricted prosperity and development of manufacturing, and affected the overall competitiveness of the supply chain. The paper firstly explains the relevant research about industrial linkage and coordination degree, and creatively forms development paths of industry linkage between manufacturing and logistics. Then, the paper takes the development situation of the manufacturing and the logistics industry during the period of 2000 to 2008 in China. It builds an evaluation model about coordination of manufacturing and logistics industry linkage and analyzes the changes of coordination degree between manufacturing and logistics. The research results show that manufacturing is positively related to logistics industry. But their coordination degree is in the critical state of coordination and disharmony. In the economic restructuring, making efforts to promote linkage development has more significance for enhancing the competitiveness of industries in China.**

***Index Terms*—correlation, coordination degree, manufacturing, logistics, industry linkage**

I. Introduction

Since the 21st century, manufacturing industry in China can be considered as the rapid development stage, and the manufacturing industry has started into advanced course. These own many characteristics, such as having the knowledge, intensive in information and technology, output with high added value, low consumption of resources, environmental pollution and so on. Even though, it has many constraints. Especially in the new supply chain management, manufacturing enterprises are increasingly faced with pressures, for example, lower costs, shorted delivery time, improving product quality and serve.

The current logistics model of manufacturing and the low level of development in logistics industry significantly restricted prosperity and development of manufacturing, and affected the overall strength of the supply chain.

Logistics in manufacturing is an important part of the logistics industry. It is the key to enhancing the core competitiveness of manufacturing industries. It is also the base demand for logistics development [1]. According the survey, from raw materials to finished products, general product processing time does not exceed 10%. And 90% of the time is spent in storage, transport, handling, packaging, distribution and other logistics sectors. Promoting the linkage development of manufacturing and logistics industry is not only an important way to adjust industrial structure and transform economic growth, but also the common requirements and the urgent desire to manufacturing and logistics companies [2].

II. Literature Review

A. *Industry Linkage*

Currently, the term of industry linkage is widely used in China, but related connotations have not been defined. Rui Nie [3] proposed the linkage industries both the industry and the linkage. Industries are the set or system interacted formed by economic organization and activities with same features. Linkage refers to a number of associated things with "contact" and "interaction". When the one makes a movement or change, the others follow. Based on industry association, he defined industrial linkage as some industry collaborative activities, which are launched in the industrial chain links in order to reduce transaction costs and reduce business risk between the same or different enterprises. Lan Ling [4] considered the industry linkage as the main form of regional interaction, and economic organizations with similar characteristics integrated into the economic cooperation organization or economic group based on the institutional framework and regulatory mechanism. Its purpose is to achieve complementary and coordinated development during regional industries, optimize the regional industrial structure, upgrade the industry level, and enhance the competitiveness of regional industries.

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B. Correlation

Currently researches on the correlation between the two industry linkages mainly are reflected in the followings:

Based on related analysis on the number of large enterprises patents and profits, Baizhou Li [5] applied statistics software to make Granger tests for them. The results showed that the number of invention patents had positive impact on corporate profits .He also calculated out that profits upgraded the corresponding 0.5615% when the number of invention patents increased by 1%.

Starting from the evidence, Hongqiong Zhu [6] made a solution to this problem from tax revenue and total economic output. He did regression analysis, structure decomposition, and systematic analysis on each factor affecting the revenue growth and economic growth, in order to overcome the total lack, and arrived at quantitative and more powerful findings.

While measuring information development index of regional information development level and economic growth index of regional economic growth level, Yukai Shao, Huanchen Wang and Saixing Zeng [7] used the latest statistical data to analyze their correlation and found that China's economic growth and information development showed strong regional imbalance. The information development had a more regional imbalance. With the region's economic growth, information development showed strong correlation.

III. DEVELOPING PATHS OF INDUSTRY LINKAGE

At present, China is in transition mode of economic development, analysis of development path of linkage between logistics and manufacturing, exploring the continuous and stable development of the industry and promoting the process of new industrialization have important practical significance and practical value. Based on some studies, this section divides the development path into five stages, including cells, the division of labor, interaction, integration and linkage, and eventually receives that two industry's linkage development is the future trend of industrial development.

A. Industrial Cell

Cells are the basic unit of life activities. Most of the family business stem from early small workshop, which is like a single cell and the basis for industrial production and growth. Although smaller, it is independent that can be described as small and complete.

With the deepening impact on the industrial revolution, manufacturing has achieved an unprecedented development. Once unable to transit to adapt the new changing economic form, cell-oriented enterprises are more vulnerable to face bankruptcy.

B. The Division of Labor

Adam Smith, a British classical economics pedigree, was the first one to systematically discuss the causes of division. As early as 200 years ago, Adam Smith proposed that the division of labor aroused from the need for transactions and trading capacity, which will affect the development of the division of labor in his book. Marx pointed out that natural division of labor and the growth of social productivity led to commodity exchange, which further led to specialized commodity production and social division of labor. All of those driving force is the behind interests [8]. Jingdong Huo [9] did the induction on the industrial division of labor and pointed out that the transaction costs was the direct cause of separation in manufacturing and logistics industry. When the logistics cost was higher than the cost of acquisition, the business will implement logistics outsourcing. In this demand stimulus, the logistics industry has produced.

C. Interaction

The performance to interaction is interacting, interdependence and common development between logistics and manufacturing [10]. With the expansion of the manufacturing sector, the demand for the logistics industry increased rapidly, that will improve the productivity of the manufacturing. The other hand is also fit. Moreover, with economic development, they rely on a deeper level each other. Payne noted that in our special institutional transformation environment, logistics and manufacturing have been involved in highly relevant and additional stage [11].

D. Integration

As development and wide application of information and communication technology, services and manufacturing increasingly blurred boundaries and had emerging integration. Porter made the Convergence of the Theory in 2001, that new economy and old economy increasingly integrated, and IT companies and traditional business's boundaries trended to disappear [12].

E. Industrial Linkage

In recent years, manufacturing logistics has rapid development, but many problems to be solved, which mainly due to lack of communication and convergence between manufacturing and logistics industry. Manufacturers do not trust logistics services capabilities, and logistics companies do not understand the real needs of manufacturers. Thus, to achieve industry interaction and to enhance the exchange of the two industries is not only conducive to the development of manufacturing and logistics industry, but also to help improve the competitiveness of the industry chain.

IV. DEVELOPMENT SITUATION OF MANUFACTURING AND LOGISTICS INDUSTRY IN CHINA

Although the scope of industries is wider, the channels to grasping China's manufacturing statistical data are few. In this paper, the industrial output value is instead of manufacturing sector (MGDP). The Statistics Bureau of China has not yet regarded the logistics industry as an independent industry, so in this paper, output value of tertiary industry will take place of production value of the logistics industry (PESR).

A. Analysis of MGDP and PESR

From the two growth trends of Fig.1, obtained from the use of Eviews3.1 software, we can see that MGDP was up from 4.0034 trillion Yuan to 12.9112 trillion Yuan and the average annual growth rate researched 15.84% from 2000 to 2008. PESR increased to 12.0487 trillion Yuan from 3.8714 trillion Yuan, and the average annual growth rate researched 15.29%. Average annual growth rate of logistics industry is slightly less than that of manufacturing industry, but more similar, we can see that the logistics industry in China started relatively late has been great development.

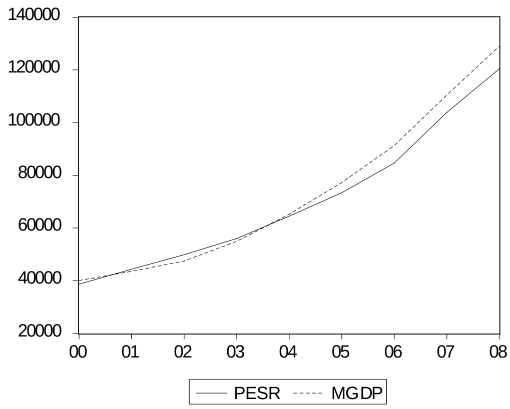


Figure.1 Growth trends of MGDP and PESR from 2000 to 2008

B. *Analysis of Growth Rate of MGDP and PESR*

As can be seen from Fig.2, there are two distinct peaks respectively in 2004 and 2007. But in 2008 there is a clear decline. The reason is that Chinese manufacturing and logistics industry have a rapid development stage with Chinese openness and market improvement. Since China joined in the WTO in 2001, China's logistics industry and manufacturing have entered a rapid development process and created a peak in 2004. In 2008 Olympics Game, Chinese economic development was strong and reached a new peak. Second half of 2008, due to U.S. subprime mortgage crisis, the world economy gone into the valley. China was also affected, so that the economic situation was worrying and manufacturing and logistics industry had a significant decline.

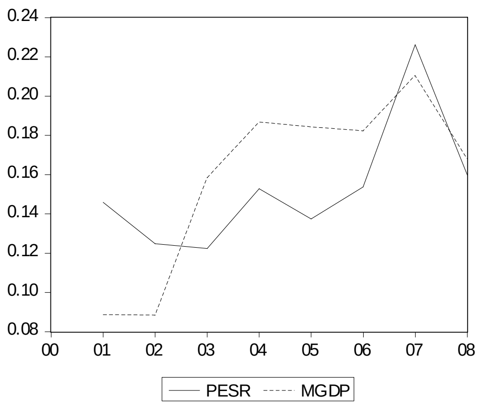


Figure. 2 Changing trends Figure of growth rate of MGDP and PESR from 2000 to 2008

Fig.2 also shows that growth trend in logistics industry and manufacturing have a strong consistency. And logistics and manufacturing have a strong positive correlation. Of course, changes in the logistics industry grow slightly lag behind the growth of manufacturing, especially in the year of 2003.

V. CASE ANALYSIS ON CORRELATION OF MANUFACTURING AND LOGISTICS INDUSTRIES

A. *Analysis of the Correlation between Variables by EVIEWS*

- *OLS Regression Analysis*

The paper selects MGDP on behalf of the level of manufacturing industry and PSER on behalf of the logistics industry development, units both are 100 million Yuan. Selected sample interval is from 2000 to 2008, and the data source is the China Statistical Yearbook published in 2009 Analysis of the data relies on application of Eviews3.1.

Since taking the natural logarithm of the data does not alter the integration relationship between variables and can linear the trend between the variables. To some extent, it can also be possible to eliminate time-series heteroscedasticity, so the paper takes the natural logarithm of $MGDP$ and $PSER$, respectively LN_{MGDP} and LN_{PSER}. Model is build as follows:

$$MGDP = a + b * PSER \quad (1)$$

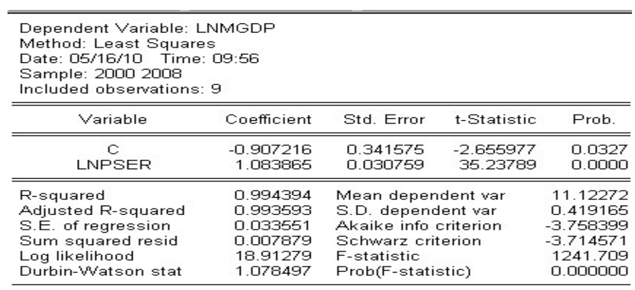
$$LN_{MGDP} = c_1 + c_2 * LN_{PSER} \quad (2)$$

One said that c_1 for constant, c_2 for LN_{PSER} 's coefficient. It uses Eviews3.1 software to carry out the ordinary least squares regression analysis for equation (1) and (2), and heteroscedasticity and autocorrelation were processed, the final results are shown in table Ⅰ.

TABLE I.

CORRELATION COEFFICIENTS BETWEEN VARIABLES

	MGDP	**PSER**		LN_{MGDP}	LN_{PSER}
MGDP	1.000000	0.996974	LN_{MGDP}	1.000000	0.994394
PSER	0.996974	1.000000	LN_{PSER}	0.994394	1.000000



Dependent Variable: LNMGDP
Method: Least Squares
Date: 05/16/10 Time: 09:56
Sample: 2000 2008
Included observations: 9

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.907216	0.341575	-2.655977	0.0327
LNPSER	1.083865	0.030759	35.23789	0.0000

R-squared	0.994394	Mean dependent var	11.12272
Adjusted R-squared	0.993593	S.D. dependent var	0.419165
S.E. of regression	0.033551	Akaike info criterion	-3.758399
Sum squared resid	0.007879	Schwarz criterion	-3.714571
Log likelihood	18.91279	F-statistic	1241.709
Durbin-Watson stat	1.078497	Prob(F-statistic)	0.000000

Figure.3 Regression results of LN_{MGDP} and LN_{PSER}

Making OLS regression on LN_{MGDP} 、 LN_{PSER} , the regression results are shown in Figure.3:

$$LN_{MGDP} = -0.907216 + 1.083865 * LN_{PSER}$$

$$s = (0.341575)(0.030759)$$

$$t = (-2.655977)(35.23789)$$

$$R_2 = 0.994394, DW = 1.078497, F = 1241.709$$

It showed that in the sample period, added value of manufacturing and logistics not only has a positive relationship, and that is significant. c_2 =1.083865 indicated that at this stage, when one percentage point increases in added value of logistics, added value of manufacturing will increase 1.083865 percent. It can be seen that during the period of 2000-2008, the role of manufacturing to the growth in the logistics industry is obvious. Similarly, manufacturing also has a positive role in stimulating and promoting the growth of the logistics industry.

- *Variable Stability Test*

Although the correlation between variables is high, a false return likely exited in the measurement results of data involved time series. Namely if there are two non-stationary time series data showing a consistent trend, even if there is no economic relationship between them, the use of their traditional methods may also show a high coefficient of determination.

To test whether a false return is exited, it is necessary to check the stationary of time series data. If the mean and variance of a random time series are constant, and any covariance of two periods only rely on their distance or the lag time, rather than relying on the calculating the actual time of covariance, we call it stable. In economic field, a lot of time series observations are the non-stationary series, and stability is in an important position in economic modeling. Therefore, it is necessary to check the stationary of time series data. The methods of Stationary test comprise the unit root test and diagram test. As there is significant growth trend in GDP's time series, this paper adopts ADF to conduct unit root test on LN_{MGDP} and LN_{PSER} .The test results is shown in Fig.4 and Fig.5.

ADF Test Statistic	-0.320604	1% Critical Value*	-5.2459
		5% Critical Value	-3.5507
		10% Critical Value	-2.9312

*MacKinnon critical values for rejection of hypothesis of a unit root.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LNMGDP)
Method: Least Squares
Date: 05/26/10 Time: 15:51
Sample(adjusted): 2003 2008
Included observations: 6 after adjusting endpoints

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNMGDP(-1)	-0.021973	0.068536	-0.320604	0.7789
D(LNMGDP(-1))	0.222128	0.466724	0.475930	0.6810
D(LNMGDP(-2))	0.133977	0.478836	0.279798	0.8059
C	0.359601	0.692047	0.519620	0.6551

R-squared	0.253693	Mean dependent var	0.166900
Adjusted R-squared	-0.865768	S.D. dependent var	0.015070
S.E. of regression	0.020584	Akaike info criterion	-4.693883
Sum squared resid	0.000847	Schwarz criterion	-4.832710
Log likelihood	18.08165	F-statistic	0.226620
Durbin-Watson stat	2.885736	Prob(F-statistic)	0.872220

Figure.4 Unit root test results of LN_{MGDP}

Seen from the test results, at three significance level, including 1%, 5% and 10%, the unit root test's critical values of LN_{PSER} were -5.2459, -3.5507, -2.9312, and t test's statistic is 2.475771, more than three different significant thresholds, indicating that the sequence is non-stationary.

Based on the above, researching on the correlation between manufacturing and logistics had false return by EVIEWS software. It has some differences from desired results, but it is normal to produce this result. At first, it was because of the small sample used in this paper. Secondly, the reason was that domestic GDP was influenced by many economic factors, in most cases, it grew sustained over time.

ADF Test Statistic	2.475771	1% Critical Value*	-5.2459
		5% Critical Value	-3.5507
		10% Critical Value	-2.9312

*MacKinnon critical values for rejection of hypothesis of a unit root.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LNPSER)
Method: Least Squares
Date: 05/26/10 Time: 15:52
Sample(adjusted): 2003 2008
Included observations: 6 after adjusting endpoints

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNPSER(-1)	0.193448	0.078137	2.475771	0.1317
D(LNPSER(-1))	-1.077860	0.637086	-1.691859	0.2327
D(LNPSER(-2))	-0.705362	0.967653	-0.728941	0.5418
C	-1.766025	0.779438	-2.265767	0.1517

R-squared	0.767572	Mean dependent var	0.146923
Adjusted R-squared	0.418931	S.D. dependent var	0.030343
S.E. of regression	0.023130	Akaike info criterion	-4.460660
Sum squared resid	0.001070	Schwarz criterion	-4.599487
Log likelihood	17.38198	F-statistic	2.201609
Durbin-Watson stat	2.102053	Prob(F-statistic)	0.327521

Figure.5 Unit root test results of LN_{PSER}

TABLE II.

CORRELATIONS

		X	Y
X	Pearson Correlation	1	.989(**)
	Sig. (2-tailed)	.	.000
	Sum of Squares and Cross-products	760144941.432	1894938830.270
	Covariance	95018117.679	236867353.784
	N	9	9
Y	Pearson Correlation	.989(**)	1
	Sig. (2-tailed)	.000	.
	Sum of Squares and Cross-products	1894938830.270	4830116200.000
	Covariance	236867353.784	603764525.000
	N	9	9

Note:Correlation is significant at the 0.01 level (2-tailed)

The results showed that: the correlation coefficient of the variable X for a total profit of the manufacturing (billion) and variable Y for cargo turnover of logistics industry (million tons / km) is 0.989, and it is significant in the 0.01 significance level. This can be learned in two ways: the first is the "**" in the right shoulder of correlation coefficient for 0.989, the other is that significance probability (Sig.) of the bilateral test in the second line is less than 0.01. And the significance level of the correlation coefficient is 0.000, less than 0.01 significantly. Thus, the total profits of manufacturing and cargo turnover of logistics industry is related.

VI. EVALUATION MODEL OF COORDINATION DEGREE

A. Index Selection

Based on the actual situation and indicators system, comprehensiveness, independence, and so on, this paper determines the index system of coordination degree, as table Ⅲ.

It is necessary to be stated that these indicators are based on China Statistical Yearbook (2009) and collected corresponding statistics between 2000 and 2008. Data on manufacturing systems mainly is aimed at industrial enterprises above the scale. At the same time, the development of logistics industry indirectly is assessed by transport-related indicators. In addition, the selection of this indicator will be corrected and improved in the future.

B. Calculation of Coordination Degree

- *Methods*

Coordination degree is a quantitative indicator to measure coordination level among the state system or elements. Studies about the degree of coordination have four main categories: coupled coordination degree model, entropy change equation, interval-valued judgments method and grey relational model [13].

Coupled coordination degree model can couple parties' properties to evaluate the harmony level in different stages among systems [14]. Entropy equation can be used to describe the law that the isolation system evolves non-equilibrium to equilibrium state [15]. Interval-valued judgments method is to establish mathematical models to determine the system whether is coordinated or not. Grey model can calculate the correlation between each indicator of one system and each indicator of another system for, and calculate a major stress factor of the impact. It is superior to other methods [16]. To this end, this paper constructed grey model to research coordination degree of manufacturing and logistics.

- *Calculation Procedure*

Firstly, in order to eliminate indicators' dimensional relationship between the original data, it makes normalized data processing before carrying out correlation analysis. In other words, it uses SPSS software's principal component analysis on data for standardization, so that data is comparable.

Only through standardization of data, that it is comparable. The general standard is adopted standardized Z , that is mean 0, variance 1.

Secondly, on the basis of standardized, calculating correlation coefficient.

$$\xi_{ij}(t) = \frac{\min_i \min_j \left| zx_i(t) - zx_j(t) \right| + \rho \max_i \max_j \left| zx_i(t) - zy_j(t) \right|}{\left| zx_i(t) - zy_j(t) \right| + \rho \max_i \max_j \left| zx_i(t) - zy_j(t) \right|}$$

(3)

Where ρ is standardized coefficient, the general value is 0.5; $zx_i(t)$ and $zy_j(t)$ for standardized value of each index for the t moment; $\xi_{ij}(t)$ is correlation coefficient for the t moment.

Thirdly, calculate the mean of correlation coefficient, according to the sample size, in order to get correlation coefficient matrix. It can reflect relationships between manufacturing and logistics industry. By comparing the size of correlation γ_{ij} , it can analyze whether the relationships between the factors in manufacturing and the factors in logistics industry is close or not. That is calculated as follows:

$$\gamma_{ij} = \frac{1}{k}\sum_{i=1}^{k} \xi_{ij}(t)$$

(4)

On the basis of the connection matrix, respectively seek their mean by rows or columns. According to the average size, the most important factors affecting manufacturing and logistics industry each other can be selected.

Fourthly, define coordination degree. In order to determine the size of coordination degree between the two systems from the overall, it can on the basis of equation (3), further define the coordination degree [17]. The equation is:

$$C(t) = \frac{1}{m \times l}\sum_{i=1}^{m}\sum_{j=1}^{l} \xi_{ij}(t)$$

(5)

VII. CASE STUDY

A. Data Standardization

According to China Statistical Yearbook (2009), it achieves the corresponding data of indicators. Then, using SPSS11.5 to standardize the above data for Z .

B. Correlation Matrix

According to the equation (3), (4) and (5), use MATLAB to build grey linkage model ,and make program to calculate gray correlation matrix for manufacturing system indicators $x_1 \sim x_6$ on the logistics system indicators $y_1 \sim y_6$.

Evaluation criteria of coordination degree is provided as follow: If $\gamma = 1$, it indicates the relevance of an indicator in logistics system and one in manufacturing system is a target maximum. If $0 < \gamma < 1$, it indicates x_i is associated with y_i , and the greater the value is, the greater the relevance is and the stronger coordination is, and vice versa. If $0 < \gamma_{ij} < 0.45$, correlation is weak, and the coordinating role is weak; If $0.45 < \gamma_{ij} < 0.65$, the correlation degree and the coordinating role is in the middle; If $0.65 < \gamma_{ij} < 0.85$, correlation and coordination role is stronger; If $0.85 < \gamma_{ij} < 1.00$, correlation and coordinating role is strong [18].

Based on evaluation standards of coordination degree, the correlation between the individual indicators can be calculated. The minimum is 0.3407 and the maximum is 1.0000. Coordination degree is mostly in three areas of middle, stronger and strong. On the basis of correlation matrix, it can calculate the correlation with the logistics industry index and manufacturing index by line and column. The association of indicators of Manufacturing and Logistics is more evenly, and the correlation coefficient is 0.6197～0.7142. The coordinating role is in the stronger situation, in which industrial output value is associated with the logistics industry in the strongest level for 0.7142.

As to the level of manufacturing indexes associated with the logistics industry, the correlation coefficient is 0.4049~0.8680, and the coordinating intensity is of inequality. The coordinating role of freight and manufacturing is the strongest for 0.8680. The specific circumstances of manufacturing associated with logistics each other is shown in Fig.5:

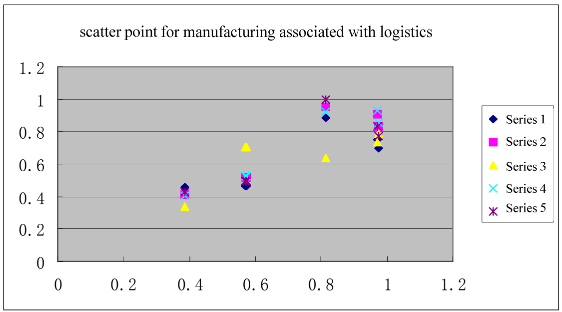


Figure.5 Scatter point for the strength of manufacturing associated with logistics

Seen from table Ⅳ and Fig.5, in general, the relationship of manufacturing and logistics industry shows the same phase and positive correlation, characterizing status quo of the relationship between manufacturing and logistics industry. Among 36 associated values of 6 indicators of manufacturing and Logistics, 9 showed strong association, 10 showed stronger association, 12 showed moderate correlation, and only five showed weak correlation. The number of occurrences of the strong, stronger, medium and weak respectively covered percentage of the total 36 was: 25.00%, 27.78%, 33.33%, 13.89%.

C. The Change of Coordination Degree between Manufacturing and Logistics

According to equation (5), the coordination degree curve of manufacturing and logistics since 2000, is shown in Fig.6.

The Fig.6 shows the changes in the coordination of two systems. In the whole, the coordination degree fluctuates between 0.6251 and 0.7542, showing the close of coordination between manufacturing and logistics. Seen from the curve, the fluctuation of coordination degree is less sensitive from 2000 to 2008 and around 0.67. During 2001 and 2005, there was a maximum of ups and downs, that from the peak 0.7542 in 2001 rapidly declining in the low to 0.6335, and to 0.728 reaching the second peak in 2004. From 2004 to 2005, it fell to 0.6251 in the valley bottom.

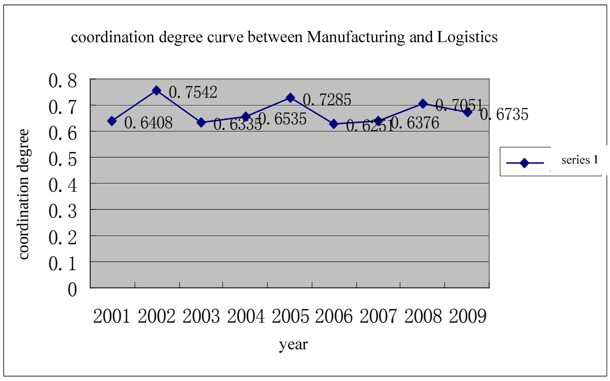


Figure.6 China's manufacturing and logistics' coordination degree curve

Overall, from Chinese manufacturing and logistics the change of degree coordination between the two system during 2000 to 2008, we can see that the coordination degree reach the highest point for 0.7542 at the stronger stage. But it is far from full coordination, namely that the coordinated development of the two industries is far from ideal.

VIII. CONCLUSIONS

OLS using EVIEWS showed that in the sample period, added value of manufacturing and logistics not only has a positive relationship, but also when one percentage point increases in added value of logistics, added value of manufacturing will increase 1.083865 percent. Similarly, manufacturing also has a positive role in stimulating and promoting the growth of the logistics industry. But, research on the correlation between manufacturing and logistics existed false return, heteroscedasticity and so on, that may influence the reliability of results.

Seen from the above, manufacturing is positively related to logistics industry, and the coordination of the two industries is more closely, but the coordination degree is at most about 0.66, in the critical state of coordination and disharmony. In the economic restructuring, making efforts to promote linkage development has far-reaching significance for enhancing the competitiveness of China's industries.

The industry linkage between manufacturing and logistics is the linkage in ideas, organization, and mode of operation, cost-effective and exchange of human resources. For manufacturing, two industries' linkage development can promote internal division of labor, focus on core business in order to reduce logistics costs, improve manufacturing competitiveness and enhance the manufacturing sector's ability to tackle the financial crisis. For the logistics industry, the linkage development can promote the optimization and integration of resources, and improve service levels. Meanwhile, deepening logistics outsourcing can increase the total market share of the logistics industry, to provide more space for the survival and development.

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REFERENCES

[1] Tuanying He, Tianshan Ma, "Thinking about linkage development On manufacturing and logistics industry", Innovation Exploration, vol. 5, pp. 28-29, 2009.

[2] Jian Zhou, "Empirical Study on Interaction between manufacturing and producer services-a case study Jiangsu Province(1990-2007)", Market Weekly(Disquisition Edition), vol. 4, pp. 38-40, 2009.

[3] Rui Nie, Tao Lv, "Industrial Linkage: Strategic Options for Sustainable Development and Utilization of Western Energy Resources", Natural Resource Economics of China, vol. 1, pp. 12-14, 2008.

[4] Lan Lin, Sen Ye, Gang Zeng, "STUDY ON REGIONAL INDUSTRY COOPERATION IN THE YANGTZE RIVER DELTA", Economic Geography, vol. 30, pp. 6-10, 2010.

[5] Baizhou Li, Yuanyuan Dong, "China's Large Enterprises' Evaluation of the Original Innovation Ability Based on AHP", Science & Technology Progress and Policy, vol. 27, pp. 125-129, 2010.

[6] Hongqiong Zhu, "A Study on Relation between Tax Increase and Economic Growth", Productivity Research, vol. 19, pp. 38-40, 2007.

[7] Yukai Shao, Huanchen Wang, Saixing Zeng, "The Relative Analyse between the Informatization Index and the Economy Growth in China", Information Science, vol. 24, pp. 172-174, 2006.

[8] Liufu Chen, "Formation and deepening of the division of labor", Frontier, vol. 12,pp. 47-49, 2002.

[9] Jingdong Huo, Jiechang Xia, "The International Comparison on R&D Competitiveness of Modern Service Industry", China Soft Science, vol. 10, pp.10-13, 2007.

[10] Xian Chen, Jianfeng Huang, "Division of Labor, Interactions and Convergence: Empirical Research on the Evolvement of the Relationship between Service and Manufacturing Industries", China Soft Science, vol. 10, pp. 65-71, 2004.

[11] Jianhui Shi, Peirong Ding, "Interaction between manufacturing and producer services in developing relations - Analysis based on the paradigm stage", North Trade, vol. 11, pp. 45-46, 2008.

[12] Shixian Zhang, "The efficiency of industrial investment and industrial structure of the Empirical Study", Management World, vol. 5, pp. 79-85, 2000.

[13] Shengbin, Bo Yu, "Research on Coupling Degree Model and Application of the Enterprise's Technology Capacity and Technology Management Capacity", Forecasting, vol. 27, pp. 12-15, 2008.

[14] Tong Yang, Nengmin Wang, "An Empirical Study on the Coupling Model of Ecological Environment and Urban Competitiveness", Ecological Economy, vol. 10, pp. 33-36, 2008.

[15] Jichu Tang, "The Entropy Variation Equation of Thermodynamic Open System", Journal of Systemic Dialectics, vol. 8, pp. 88-90, 2000.

[16] Hong Mi, Guoli Ji, "Chinese county-level regional population, resources, environment and sustainable development of the coordinated development of economic systems theory and evaluation methods", POPULATION & ECONOMICS, vol. 6,pp. 17-24, 1999.

[17] Xiaoli Han, Li Wang, "The Quantitative Analysing on Coordinated Development Between Manufacture and Logistics", Value Engineering, vol. 1, pp. 84-86, 2009.

[18] Weidong Chen, Hua Wang, "Education and Economic Development by Gray Correlation Analysis - A Case Study of Shenzhen City", Journal of Southwest University for Nationalities(Humanities and Social Science), vol. 3, pp. 195-197, 2007.

TABLE III.

THE INDEX SYSTEM OF COORDINATION DEGREE OF INDUSTRY LINKAGE

	Evaluation System	**Evaluation indicator**	**variables**
Coordination Evaluation System	Manufacturing system	industrial output value (billion)	x_1
		Enterprises (unit)	x_2
		Main Business Revenue (billion)	x_3
		Total profit (billion)	x_4
		Annual Average Number of workers (million)	x_5
		Total Assets (million)	x_6
	Logistics system	the tertiary industry output value (billion)	y_1
		Passenger volume (million)	y_2
		Total cargo throughput (tons)	y_3
		Cargo turnover (100 million tons km)	y_4
		Civilian car ownership (10000)	y_5
		The scale of port cargo throughput of coastal (tons)	y_6

TABLE IV.
GREY LINKAGE MATRIX

	y_1	y_2	y_3	y_4	y_5	y_6	**mean**
x_1	0.9702	0.3843	0.8124	0.5706	0.9763	0.5716	0.7142
x_2	0.7514	0.4551	0.8845	0.4635	0.6997	0.4642	0.6197
x_3	0.9050	0.4127	0.9507	0.5177	0.8311	0.5185	0.6893
x_4	0.7334	0.3407	0.6395	0.7043	0.7903	0.7059	0.6524
x_5	0.9335	0.4070	0.9211	0.5269	0.8551	0.5278	0.6952
x_6	0.8331	0.4296	1.0000	0.4933	0.7701	0.4941	0.6700
mean	0.8544	0.4049	0.8680	0.5461	0.8204	0.5470	

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