An Empirical Study on the Relationship between Equipment Manufacturing Industry and Economic Growth in a Certain Area

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Abstract
In this paper, the relationship between equipment manufacturing industry and economic growth is analyzed: based on actual calculation, the input-output table, and the econometric model, the direct and indirect contributions of equipment manufacturing industry to economic growth, as well as the dynamic relationship of the two are examined. We conclude that the equipment manufacturing industry makes certain contributions to economic growth, though the contribution rates are fluctuating; the influence coefficients indicate that it has a strong impact on other sectors, whereas the low sensitivity coefficients show it is less stimulated by the demands of other sectors; the dynamic relationships of the two indicate the pull effect of economic growth on equipment manufacturing industry is not obvious, but equipment manufacturing industry promotes economic growth to some extent.
Key words: EQUIPMENT MANUFACTURING INDUSTRY, ECONOMIC GROWTH, INPUT-OUTPUT METHOD, VAR MODEL.

1. Introduction

As the core and foundation of the whole industry, equipment manufacturing industry plays a crucial role to promote economic growth[1-2]. Many researchers focus their attention on this important sector that is undergoing industrial transformation and upgrading[3-6]. From the review of the literature obtained, we know that some researchers study equipment manufacturing industry using input-output method [7-8], econometric model [9-10] and dual-sector model[11-12]. In these empirical researches, the relationship between equipment manufacturing industry and economic growth is discussed, and the results show that the pull effect of equipment manufacturing industry on economic growth is significant.

However, most of the previous studies are general researches of the whole country or economically developed cities like Chongqing[13], economically backward cities like the region in this study are rarely concerned. It is these economically backward cities that need strong pillar industry to stimulate their economic growth. The studies region I this paper is one of the first fourteen open coastal cities, whose economic aggregate is continually taking new steps forward and demonstrates characteristics of the current development stage. But in recent years, gaps of economic growth has been formed between this region and the peripheral ones within the same province, as well as other open coastal cities, due to different reasons. And the slow pace of industrial restructuring is a particularly acute problem hindering overall economic development.

Therefore, based on empirical research, the contribution of equipment manufacturing industry to economic growth, and the linkage effect between equipment manufacturing industry and other sectors of the national economy are examined in this paper. And the dynamic relationship between equipment manufacturing industry and economic growth is also analyzed using econometric model, which has guiding significance in policy making for the sectors involved.

2. The Direct Contribution of Equipment Manufacturing Industry as a Whole in This Region to Economic Growth

Given the availability of data from the studied region Statistical Yearbook, the equipment manufacturing industry is divided into seven sub-sectors: metal products manufacturing; special equipment manufacturing; general machinery manufacturing; electrical machinery and equipment manufacturing; transport equipment manufacturing; telecommunication equipment, computer and other electronic equipment manufacturing; instruments, meters, cultural and office machinery manufacturing. The absolute contribution of equipment manufacturing industry and the seven sub-sectors to economic growth is determined based on the rates of their contributions to GDP and economic growth. The contribution rate of equipment manufacturing industry to GDP is measured by the proportion of its added value in GDP; and its contribution rate to economic growth is measured by the proportion of its added value in the added value of GDP. The results are shown in Figure 1.

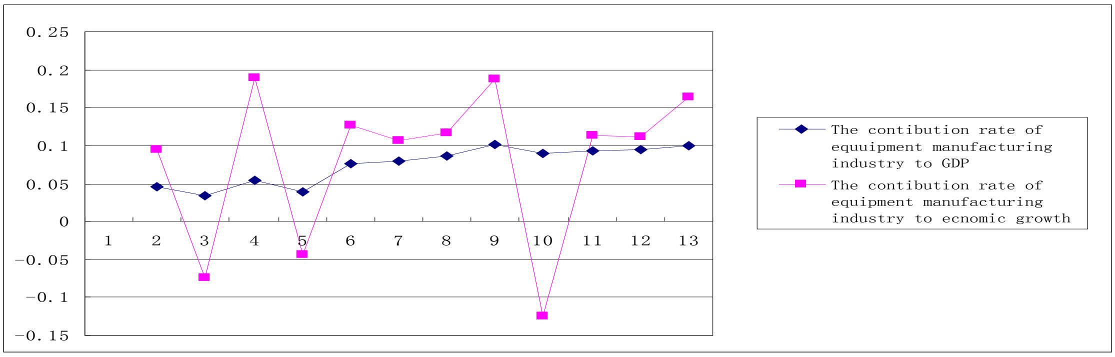

Figure 1.The direct contribution of equipment manufacturing industry to economic growth and GDP

From Fig.1, we know that the rate of equipment manufacturing industry’s contribution to GDP ranges from 3% to 10%. It takes on a waving trend from 2002 to 2006, and an uptrend from 2005 to 2009; it is in a stable state from 2010 up to now. The rate of equipment manufacturing industry’s contribution to economic growth is fluctuating wildly, and reaches around 20% in 2004 and 2009. This means equipment manufacturing industry is the pillar industry in the national economy and makes great contribution to economic growth. But, in the year 2003, 2005, and 2010, the rates are all negative and the rate in 2010 is -12.5%, which indicates the equipment manufacturing industry not only fails to promote economic growth, but also has negative effect on it. Therefore, it can be asserted that the equipment manufacturing industry in this region does no develop in a steady way, nor does it continuously boost healthy economic growth.

The contributions of the seven sub-sectors of equipment manufacturing industry to economic growth, see more detailed results in Figure 2.

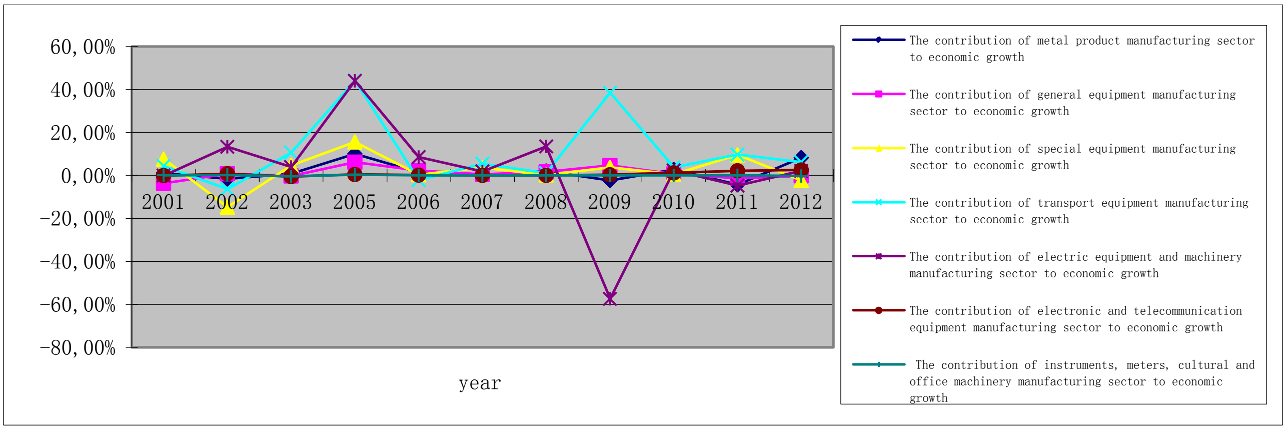

Figure 2. The contributions of sub-sectors of equipment manufacturing industry to economic growth

From Figure 2, we know that the rates of most of the seven sub-sectors' contributions to economic growth are positive: the transport equipment manufacturing sector makes a large contribution to economic growth, and the contribution rate fluctuates with large amplitude and reaches two peaks in 2005 and 2009 respectively; the rate of electrical machinery and equipment manufacturing sector's contribution to economic growth fluctuates wildly: the positive contribution is 44.2% in 2005, while the negative contribution is－57.4% in 2009, which sets back economic growth considerably; the contribution rate of instruments, meters, cultural and office machinery manufacturing sector to economic growth is relatively low. In recent years, the contribution of electronic and telecommunication equipment manufacturing sector to economic growth is on an increasing trend and reaches 2.53% in 2012. And the contribution rates of the other sectors take on a fluctuating trend, and negative ones used to occur in all of them. The contributions of the sub-sectors to economic growth shown in Fig.2 further verify the results of Fig.1.

3. The Indirect Contribution of Equipment Manufacturing Industry to Economic Growth

Beside its direction contribution to GDP and economic growth, the impact of equipment manufacturing industry on economic growth is also reflected by its correlation effect, as well as its indirect influence on other sectors of the national economy [14-15]. The correlation coefficients between equipment manufacturing industry and the primary industry, the secondary industry and the tertiary industry, are respectively calculated using the grey relational analysis model. The higher the correlation coefficient is, the more closely the two are related. The concrete calculation steps are as follow:

To measure, compare and rank the correlations degree between the equipment manufacturing industry and the thrice industrial sectors, let the added value of equipment manufacturing industry from 2000 to 2012 be reference sequence, and that of the primary industry, the secondary industry, and the tertiary industry be compare sequence, thereby set up the correlation model.

Table1. Original Data: added value of equipment manufacturing industry and the thrice industrial sectors (unit: billion Yuan, Data source: The studied region Statistical Yearbook (2001-2013))

Year	Added Value of equipment manufacturing industry	Value added of the primary industry	Value added of the secondary industry	Value added of the tertiary industry
2000	10.59	36.01	95.99	128.12
2001	12.73	38.11	99.94	144.65
2002	10.57	39.19	112.22	160.22
2003	19.4	35.48	138.02	184.74
2004	30.16	42.29	166.05	216.80
2005	34.29	48.49	180.46	224.54
2006	42.93	59.50	203.77	271.09

2007	56.19	78.07	258.75	310.89
2008	77.36	92.35	316.35	351.93
2009	71.9	102.35	311.71	390.48
2010	86.07	126.72	367.79	435.99
2011	101.71	139.94	419.48	510.66
2012	113.07	152.41	447.68	539.27

Calculating the absolute difference between each compare sequence and reference sequence, the calculation formula is:

$$\xi_i(k) = \frac{\min_i \min_k |x_0(k) - x_i(k)| + \alpha \max_i \max_k |x_0(k) - x_i(k)|}{|x_0(k) - x_i(k)| + \alpha \max_i \max_k |x_0(k) - x_i(k)|}$$

$(k = 1, 2, \cdots, n; i = 1, 2, \cdots, m)$ (1)

Of all the absolute differences, to find out the minimum with $\min_i \min_k |x_0(k) - x_i(k)|$, and the maximum with $\max_i \max_k |x_0(k) - x_i(k)|$

Calculate with the formula D= $\max \max \Delta i(k)$ =5.718,d= $\min \min \Delta i(k)$ =0.

Let α be 0.5, calculate the correlation coefficient. Plug the number into the equation above, we yield the correlation coefficient and correlation degree. The results are shown in Tab.2. The correlation coefficients between equipment manufacturing industry and the thrice industrial sectors are: 0.612, 0.649 and 0.636 respectively, which are all above 0.6. And the order of the thrice industrial sectors with correlation coefficients from high to low, is the primary industry >the tertiary industry>the secondary industry. It means the equipment manufacturing industry in this region stimulates the local economic growth to some extent. For the convenience of further analysis about the degree of interaction between equipment manufacturing industry and each sub-sector, the input-output table in 2007 is employed to calculate the influence coefficient and response coefficient of each sub-sector, which will reflect the effect of equipment manufacturing industry on economic growth.

Table 2. The value of coefficient degree between equipment manufacturing industry and the thrice industrial sectors

Grey relational degree	The primary industry	The secondary industry	The tertiary industry
value	0.612	0.649	0.636
rank	4	1	3

Table 3. The influence coefficient and response coefficient of equipment manufacturing industry in this region in 2007 (Source of the data: the input-output table in 2007)

Input-output sector	Influence coefficient	Response coefficient
Metal Products Manufacturing	1.43	1.74
General, Special Equipment Manufacturing	1.29	0.82
Transport Equipment Manufacturing	1.38	0.63
Communication Equipment, Computer and Other Electronic Equipment Manufacturing	1.17	0.67
Electric Equipment and Machinery Manufacturing	1.00	0.81
Instruments, Meters, Cultural and Office Machinery Manufacturing	1.02	0.52

The input-output table (2007) shows the influence coefficients and response coefficients of the sub-sectors of the equipment manufacturing industry (the General, Special Equipment Manufacturing as a whole). The influence coefficients of all these sub-sectors are greater than 1, which means the effect of equipment manufacturing industry in this region on other sectors of national economy is above the social average level. The high degree of influence indicates the equipment manufacturing industry has strong industrial linkage effect and plays an important role in national economy. The influence coefficient of metal product manufacturing sector is 1.43, the highest of the six, which indicates that iron-ore-mining and metal smelting enterprises play supporting roles in equipment manufacturing industries. It can be seen that industrial structure in this region is mainly characterized by low value-added industries and upstream industries with high energy consumption and high pollution.

Only the response coefficient of metal product manufacturing sector is greater than 1 and the value is 1.74, while that of other sectors are all less than 1. On the whole, the degree of equipment manufacturing industry's response to other sectors in the national economy is under the social average degree. One reason is that equipment manufacturing industry is less stimulated by the demands of other sectors[16]; the other is that the equipment manufacturing industries in this area are mainly final product sectors and the direct sales of final products is the main source of national economic income, which results in low response coefficient. It also demonstrates that the rate of intermediate demand of equipment manufacturing industry is low, and the pull effect that downstream industry has on equipment manufacturing industry is insufficient.

Further cross-over analysis shows that the response coefficient and influence coefficient of metal product manufacturing sector are all greater than 1.Therefore, it is a sector that has strong radiation and constraining force, and also the main provider of intermediate goods consumed by other sectors. With its strong radiation effect, it is regarded as a pillar industry in national economy. The general and special equipment manufacturing industry, telecommunication equipment, transport equipment, computer and other electronic equipment manufacturing sectors, have high radiation and low constraining force. All of their influence coefficients are greater than 1, and their response coefficients less than 1.The influence coefficients of electric equipment and machinery manufacturing sector and the instruments, meters, cultural and office machinery sector are 1.02 and 1.00 respectively, which are almost flat with the average; but their reaction coefficients are less than 1, which indicates the pulling effect of these sectors is relatively small.

4. Positive Analysis Based on the VAR Model

After brief introduction about the static relationship between equipment manufacturing industry and GDP, we set up the VAR model to examine the impact of equipment industry on economic growth.

4.1 Model Construction

The degree of equipment manufacturing industry's influence on economic growth are quantitively analyzed based on the vector auto-regression model (the VAR model). In the VAR model, which is not based on economic theory, simultaneous equations are set up. Within each equation, regression is performed with the lags of all the endogenous variables to estimate the dynamic relationships of endogenous variables. The mathematical expression of VAR（P）is:

$$y_t = A_1 y_{t-1} + \cdots + A_p y_{t-p} + Bx_t + \varepsilon_t ,\quad t = 1, 2, 3 \cdots t \qquad (2)$$

y_t are k -dimensional non-stationary series; and the endogenous variables are collected in d -dimensional vector x_t ; p is the lag intervals for endogenous, t is sample number. $k \times k$ -dimensional matrix $A_1, \cdots, A_p$ and $k \times d$ -dimensional matrix B are coefficient matrixes to be estimated. ε_t is k -dimensional disturbance vector.

4.2 Source of the Data

In this paper, the industrial added value of equipment manufacturing industry (EMI) are used to reflect the development status of this industry; the gross domestic product (GDP) which is the sum of added values of the tree major industries, is used to measure economic growth, and the unit is ten thousand RMB; data are collected from The studied region Statistical Yearbook (2001-2013), and the industrial added value of equipment manufacturing industry is the sum total of the added values of its seven sub-sectors. To avoid wild data swing as well as the heteroscedasticity in time series, with the original variable relationship unchanged, perform natural logarithmic transformation on the original data and the variables ultimately used are $\ln GDP$ and $\ln EMI$. Using the ADF method, the stationarity test on $\ln GDP$ and $\ln EMI$ is carried out with EViews6.0. The results show that $\ln GDP$ and $\ln EMI$ are non-stationary series, and after first-order difference calculation, $D\ln GDP$ and $D\ln EMI$ are stationary series, as shown in Tab.4. Therefore, we set up VAR model with the two stationary variables: $D\ln GDP$ and $D\ln EMI$.

Table 4. ADF unit root test

Variable	Test Type	ADF	5% Critical		Conclusion

		Value	Value	P	
$\ln GDP$	(c,t,0)	-2.533172	-3.020686	0.1230	Non-stationary
$\ln EMI$	(c,t,0)	-0.816516	-3.020686	0.7925	Non-stationary
D $\ln GDP$	(c,0,1)	-3.11373	-3.02997	0.0063	Stationary
D $\ln EMI$	(c,0,1)	-7.52988	-3.02997	0.0000	Stationary

4.3 Granger Causality Test

In the Granger Causality Test, the causal relationships between variables are analyzed, and the results are shown in Tab.5. Based on the principle of the minimum AIC value, the VAR model is most effective when lag length is 1. Now, the original assumption that D $\ln EMI$ does not Granger cause D $\ln GDP$ is accepted, while the assumption that D $\ln GDP$ does not Granger cause D $\ln EMI$ is rejected. This means that is a one-way Granger-causality between equipment manufacturing industry and GDP.

Table 5 Granger Causality between D $\ln GDP$ and D $\ln EMI$

Null Hypothesis	Lag Intervals for Endogenous	F-statistics	P	5% Conclusion
D $\ln EMI$ does not Granger cause D $\ln GDP$ D $\ln GDP$ does not Granger cause D $\ln EMI$	1 1	0.00873 5.24405	0.9267 0.0359	reject accept

4.4 Stability Test of the VAR Model

There are 2 endogenous variables in this model. Because lag 1 is chosen, there are two characteristic roots, whose moduli are all in the unit circle and less than 1. Therefore, it can be concluded that the VAR model has good stability and can be used in impulse response analysis and variance decomposition analysis.

4.5 The Impulse Response Function Analysis

The horizontal axis represents the number of the years in which the shock affects; the vertical axis represents the response of dependent variable to each variable; solid line represents the impulse response function curve, and the dotted lines on the two sides represent the positive and negative two times standard deviation.

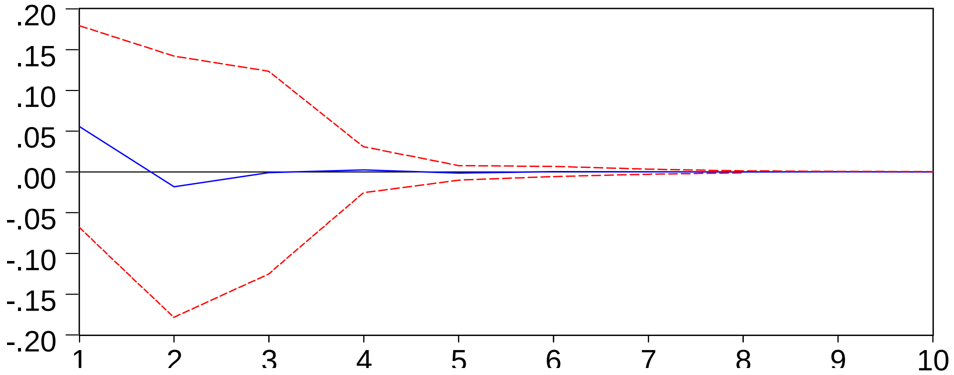

Figure 3. The responses of DlnEMI to shocks

As is shown in Figure 3, when a positive shock is given to GDP in the current period, it fluctuates over the first 3 periods: during the first period, the changes of industrial added value of equipment manufacturing industry demonstrate positive response; and then in the second period, it is negative response which will then increase and converges to zero in the third period. This indicates that, after shocks being imposed on it, the industrial added value of equipment manufacturing industry fluctuates in the first three periods, and then its changes with time is approximate to zero and the effect of shocks imposed by GDP gradually disappear. On the whole, the shocks given by GDP do not have marked impact on equipment manufacturing industry, nor demonstrates regularly changing trend. This indicates equipment manufacturing industry is less influenced by economic growth.

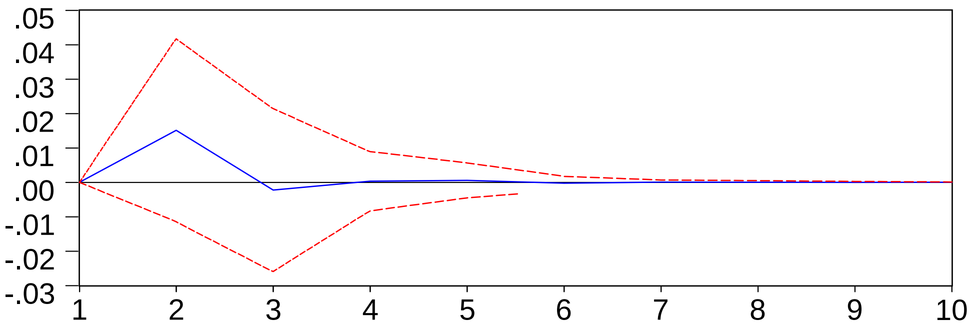

Figure 4. The response of D $\ln GDP$ to shocks

As is shown Figure 4, when a positive shock is given to the industrial added value of equipment manufacturing industry, GDP fluctuates over the first 4 periods: during the first time period, GDP does not show any response, and then it increases to the maximum positive response point, after which it decreases to a negative response point in the third time period; then it rises slowly and is tending towards stability after the fourth time period. This indicates that the industrial added value of equipment manufacturing industry is undergoing positive shocks, which will promote the rapid development of GDP in the earlier stage. It is consistent with the analysis result that equipment manufacturing industry has strong linkage effect on other sectors of national economy. But then, the positive shocks hardly exert any effect on GDP.

4.6 Variance Decomposition

In this paper, the importance of information structural shock is determine through variance decomposition-based analysis of the contributions of every structural shock to the changes of endogenous variable in the model. It is a quantitative research, in which the mutual influence between D $\ln GDP$ and D $\ln EMI$ (variables in the VAR model), is examined with variance decomposition. The results are shown in Tab.6.

Table 6. Variance Decomposition Table

	D $\ln EMI$		D $\ln GDP$	
Period	D $\ln EMI$	D $\ln GDP$	D $\ln EMI$	D $\ln GDP$
1	100.0000	0.000000	4.372772	95.62723
2	99.87954	0.120456	15.79665	84.20335
3	99.82775	0.172246	15.70627	84.29373
4	99.82634	0.173663	15.70946	84.29054
5	99.82639	0.173609	15.72073	84.27927
6	99.82625	0.173747	15.72248	84.27752
7	99.82623	0.173769	15.72261	84.27739
8	99.82623	0.173769	15.72261	84.27739
9	99.82623	0.173769	15.72262	84.27738

10	99.82623	0.173769	15.72262	84.27738

The effects of $D\ln EMI$ variance can be classified into two: the relative contribution rate of the stochastic disturbance term of EMI increase to variation of EMI increase; the stochastic disturbance term of GDP increase to variation of EMI increase. The sum of these two rate values is 1.

From Tab.6, we know that standard deviation of $D\ln EMI$ is loaded by itself from 100% to 99.8%, and its important impact lasts until the tenth period. But GDP hardly has any impact, which only reaches 0.2% in the tenth period; similarly, the standard deviation of $D\ln GDP$ is loaded 95.6% by itself in the first period, and equipment manufacturing industry is loaded 4.4%; starting from the second period, the standard deviation of $D\ln GDP$ is loaded 85% by itself, and the equipment manufacturing industry is loaded around 15.7%. This situation lasts until the tenth period, which indicates that the equipment manufacturing industry has some pull effects (though not obvious) on GDP. This is a further verification of the results derived from the impulse-response function. This is mainly due to the supererogation of industrial structure. In 2012, the ratio of the primary industry, secondary industry and tertiary industry in this region is 13.4 : 39.3 : 47.3. The proportion of tertiary industry is higher than that of the secondary industry, but the proportion of the primary industry remains unchanged. It indicates that the secondary industry is less developed, and the gross industrial output value of equipment manufacturing industry above designated size is 27.8% of the gross industrial output value of the overall manufacturing industries above designated size in this region. Therefore, it can be concluded that equipment manufacturing industry in this region does not play a decisive role in boosting GDP growth.

5. Conclusions

Based on the above positive analysis, we conclude that:

(1) In this region, the equipment manufacturing industry makes stable contribution to economic growth: the transport equipment manufacturing sector contributes a large proportion to economic growth, while high-end equipment manufacturing sectors, such as the electronic and communication equipment, instruments, meters manufacturing, contribute a small proportion. This indicates that: traditional sectors of the equipment manufacturing industry make progress, while emerging sectors do not receive due development

(2) In terms of the indirect effect between equipment manufacturing industry and economic growth, the response coefficients of the sub-sectors of equipment manufacturing industry in Qin Huangdao are all greater than 1, which means equipment manufacturing industry has strong industrial linkage with other sectors of the national economy. But the overall response coefficients are low, which means the equipment industry in this region are less stimulated by downstream industry and its intermediate demand rate is low. Among the sub-sectors of equipment manufacturing industry, metal product manufacturing sector, whose influence coefficient and response coefficient are greater than 1, has strong radiant and pull effect, and its development should be highlighted, while the other sectors with relatively weak pull effect have much room for further development.

(3) One-way Granger causality exists between the equipment manufacturing industry and GDP, which indicates the stimulating effect of equipment manufacturing industry on GDP is stronger (though not obviously) than vice versa. The analysis of impulse response function demonstrates that equipment manufacturing industry in this region is hardly stimulated by GDP, conversely, it boosts economic growth to some extent, but does not play a decisive role. Therefore, it is imperative to develop equipment manufacturing industry in this region to further promote economic growth.

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