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Analysis of industrial investment efficiency based on co-integration theory and error correction model

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ABSTRACT

Elaborating the theory of industrial investment efficiency, co-integration and error correction model, the paper analyzes the current situation of Hebei industrial investment efficiency briefly and utilizes co-integration test and error correction model to do an in-depth analysis, according to the statistical data of the GDP, the GDP of the three industries, the total fixed asset investment and the total fixed asset investment of the three industries in Hebei province between 1990 and 2011.The conclusions are that the overall industrial investment efficiency of Hebei is low in 1990-2011, the large fluctuation of the primary industrial investment efficiency and low investment efficiency and unreasonable structure of the tertiary industry are the important factors restricting economic growth of Hebei Province, and Hebei should increase the scale of investment and optimize investment structure based on the characteristics of each industry to improve the industrial investment efficiency and achieve sustained and stable economic growth in Hebei province.

Key words: Industry; investment efficiency; investment structure; Co-integration; error correction model

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INTRODUCTION

Investment is an important factor in stimulating economic growth. Its size, efficiency and quality directly affect the quality and speed of regional economic growth. In particular, as the subject of investment, the fixed asset investment plays a vital role in regional economic development. There is a problem with investment exists a long time in China that the scale of investment increases substantially but the efficiency of investment fails to obtain a corresponding increase. Therefore, to maintain a sustained and stable economic growth, it not only maintains an appropriate scale of investment, but also should pay more attention to improve investment efficiency [1].

The investment efficiency is a comparison between the effective results and the capital of engaging in an investment activity. At present, the domestic scholars study the investment efficiency of fixed assets mainly from the production, configuration and output angles. Viewing from the microscopic point, the profit rate of enterprise asset can be used to reflect the investment efficiency, while from a macro perspective, the economic growth can be used. Duo Qin and Haiyan Song defined investment efficiency as the deviation of the actual investment from the willingness investment, and used the data of 1989-2000 to estimate the investment efficiency of each province [2]. Studying the mechanism of the Chinese capital formation, investment efficiency and the efficiency of savings into investment from the financial perspective, Kunrong Shen and Wenjie Song found the low investment efficiency caused the low TFP, and then led to macroeconomic volatility of china [3]. Yongping Hu and Jiejin Zhu used VAR model to study on the mutual influence of investment and economic growth of the four provinces along the southeast coast [4]. Yongjun Zhang used ICOR to study on the investment efficiency of China and analyzes the reasons for the ICOR increasing [5]. Jian Zhou and Wei Wang used VAR model to study on the dynamic correlation among Chinese capital formation, the investment efficiency and economic growth [6]. HongxiaDuan used VEC model to do an empirical research about the relationship between economic growth and fixed asset investment [7]. Hong Zhou and other scholars used

DEA method to analyze the industrial structure of China's investment, considered that there is a big gap between the input-output efficiencies of China's secondary and tertiary industries, and thought that improving investment efficiency of the tertiary industry is a key to achieve structure optimization [8].

In conclusion, domestic scholars has done much research on the measurement and evaluation of the fixed assets investment efficiency, but these are often based on a whole range of national without systematic and in-depth research on regional industrial investment efficiency. In view of this, the paper based on the three industries and according to the 2009-2011 statistics of Hebei applies co-integration and error correction model measure the industrial investment efficiency. At the same time, it reveals the problem in three industrial investment structures and puts forward some countermeasures and suggestions.

CO-INTEGRATION AND ERROR CORRECTION MODEL

Co-integration and error correction model is one of the most important tools to analyze the quantitative relationship between non-stationary economic variables. Specifically, co-integration is mainly used to test whether it has a long-term equilibrium relationship between the non-stationary economic variables, and error correction model is an econometric model that reflects the degree of short-term fluctuation of the relationship between the variables. Specific steps of co-integration and error correction model are as follows:

1.1 Unit Root Tests

Unit root test is mainly used to test whether a variable is a stationary sequence. There are two common methods: ADF test method and DF test method. The paper selects ADF. The regression model inspecting the time sequence Y whether contains a unit root is as follows:

$$\Delta x_i = \beta_0 + \alpha_0 t + \alpha_1 x_{t-1} + \sum_{i=1}^{p} \beta_t \Delta x_{t-1} + \varepsilon_t \tag{1}$$

The testing hypotheses is $H_0 : \alpha_1 = 0$; $H_1 : \alpha_1 \neq 0$. If it accepts the null hypothesis H_0 , the alternative hypothesis H_1 is rejected. Thus, it suggests the existence of a unit root and indicates that the time sequence is non-stationary. Conversely, the time sequence is stationary [9].

1.2 Co-integration

If the sequences are the same order integration, it can make a co-integration test. There are two common methods which are Engle-Granger two-step test and Johansen maximum likelihood method for co-integration test. Engle-Granger two-step test method is generally applicable to the relationship between the two variables, while Johansen maximum likelihood method is applicable to the relationship between multiple variables. The paper selects Engle-Granger two-step test method.

Step 1.Use the least squares method to estimate the equation on the same order integration sequence. The equation as follows:

$$Y_t = \alpha_0 + \alpha_1 x_t + \mu_t \tag{2}$$

Calculate non-equilibrium error, we get:

$$\begin{aligned} \hat{Y}_t &= \hat{\alpha_0} + \alpha_1 x_t \\ \hat{e}_t &= Y_t - \hat{Y}_t \end{aligned} \tag{3}$$

This equation is called co-integration regression.

Step 2.Test weather $\hat{e}_t$ is stationary sequence. If $\hat{e}_t$ is, it thinks that there is co-integration relationship between X_t and Y_t . Conversely, it thinks that there is no [9].

1.3 Error Correction Model

Error correction model is an econometric model with a specific form. The concept was first proposed by Sargan in 1964, and .he used this model to calculate the adjusted value of the dependent variable. Then Davidson, Hendry, Srba and Yeo et al further improved the model, and Granger and others proposed and proved Granger theorem.

According to Granger theorem, if two time sequence are co-integrated, the short-term non-equilibrium relationship between them can always be expressed by the following error correction model.

$$\Delta x_t = \alpha_0 + \alpha_1(x_{t-1} - \beta y_{t-1}) + \sum_{i=1}^{k}(\alpha_i \Delta x_{i-1} - \gamma_i \Delta y_{t-1}) + e_t \quad (4)$$

In the equation, β is the long-term equilibrium parameter, $\alpha_1 < 0$ is the coefficient of adjusting the balanced bias, e_t is a random error term, k is the lag periods. Because $x_{t-1} - \beta y_{t-1}$ $l(0)$, all variables in formula (4) are stable. When $x_{t-1} > \beta y_{t-1}$, because $\alpha_1 < 0$, the net effect of $x_{t-1} - \beta y_{t-1}$ for Δx_t is negative. The actual meaning is that when x is higher than the equilibrium growth, $x_{t-1} - \beta y_{t-1}$ will make the value of Δx_t decreases, and when less, it will make the value increases. In other words, it forced x to return to the long-term coordinated and balanced track. Obviously, the error correction model reflects the short-term relationship between variables, while the error correction term reflects a long-term relationship [9, 10].

SELECT THE DATA AND ANALYZE THE STATUS OF INVESTMENT EFFICIENCY

2.1 Select the Data

Considering data availability and reliability, the paper selects the statistical data of the GDP, the GDP of the three industries, the total fixed asset investment and the total fixed asset investment of the three industries in Hebei province between 1990 and 2011. The data are from "New Hebei 60 years" (2009) and "Hebei Economic Yearbook" (1991-2012 years). In order to eliminate the effects of inflation, the paper uses the actual values of GDP and total fixed asset investment that are respectively treated by the GDP deflator (1990 = 100) and fixed asset investment price index (1990 = 100). The actual values are shown in the Table 1.

Table 1.The actual value of gross industrial product and fixed asset investment in Hebei Province during 1990-2011

(100 million yuan)

Year	Gross Industrial Product				Fixed Asset Investment			
	Total Product	Primary Industry	Secondary Industry	Tertiary Industry	Total Investment	Primary Industry	Secondary Industry	Tertiary Industry
1990	896.33	227.89	387.52	280.92	177.21	15.68	91.10	70.43
1991	994.93	219.84	426.82	348.27	225.22	16.91	97.51	110.81
1992	1150.13	231.27	515.60	403.26	243.31	12.98	134.71	95.63
1993	1353.71	241.53	678.86	433.32	313.62	10.40	170.08	133.14
1994	1555.41	321.33	748.82	485.26	374.26	17.88	188.60	167.78
1995	1771.61	392.52	822.40	556.70	463.76	31.74	232.11	199.91
1996	2010.78	408.18	969.36	633.24	564.59	35.53	280.16	248.90
1997	2262.13	435.84	1106.74	719.55	688.45	50.36	303.72	334.37
1998	2504.18	465.18	1226.39	812.61	790.69	67.16	321.46	402.07
1999	2732.06	487.79	1324.57	919.70	866.19	63.35	349.34	453.49
2000	2991.60	489.05	1491.64	1010.92	880.25	42.39	373.76	464.10
2001	3251.87	538.65	1589.54	1123.68	926.29	49.71	339.48	537.10
2002	3564.05	566.64	1724.32	1273.09	981.18	68.28	368.49	544.40
2003	3977.48	611.48	1963.98	1402.02	1178.98	76.88	490.43	611.67
2004	4490.58	706.39	2278.61	1505.57	1424.10	84.38	626.92	712.80
2005	5092.31	712.06	2681.20	1699.05	1809.55	96.38	847.51	865.66
2006	5774.68	736.12	3077.00	1961.57	2324.79	101.08	1179.55	1044.15
2007	6513.84	863.92	3447.55	2202.37	2803.03	106.36	1464.23	1232.44
2008	7171.74	911.29	3897.32	2363.13	3293.73	143.66	1759.04	1391.03
2009	7888.91	1010.33	4101.04	2777.55	4738.97	197.98	2282.46	2258.53
2010	8851.51	1112.31	4647.34	3091.86	5598.87	207.73	2461.24	2929.90
2011	9851.56	1167.66	5274.97	3408.93	5766.83	207.73	2625.80	2933.30

2.2 Situation Analysis on Investment Efficiency

The paper selects ICOR as the primary indicator measuring investment efficiency. ICOR is also known as incremental capital output ratio or marginal efficiency of capital, and also refers to the incremental of capital when total output increased by one unit. The higher the value is, the more the increment of capital is. At the same time, the investment efficiency is lower. On the contrary, the lower the value is, the higher the investment efficiency is [11].

Calculate the value of ICOR based on the data in Table 1. The values are shown in Table 2.

According to Table 2, since the 1990s, fluctuation of investment efficiency was great in Hebei, as a whole showed a downward trend. Specifically, ICOR of all investments in Hebei fluctuated between 1.5 and 3 from 1991 to 1997, namely that the overall investment efficiency was higher. And ICOR fluctuated between 3 and 4. Obviously, the investment efficiency decreased compared to the first phase. While during 2008-2011, ICOR is greater than 5, the

investment efficiency further reducing. According to domestic and international experience, ICOR maintained at 1.5 to 3 in china, and basically maintained at about 1.5 in United States, Germany, France and Japan. Since 1911, the value of Hebei is in the experience range only in the first stage, while in the other two stages is not in the range and far beyond the developed country. That is to say, the investment efficiency of Hebei is overall low.

Table 2.ICOR of industry in Hebei Province during 1990-2011

Year	All Industries	Primary Industry	Secondary Industry	Tertiary Industry
1991	2.28	-2.1	2.48	1.65
1992	1.57	1.14	1.52	1.74
1993	1.54	1.01	1.04	4.43
1994	1.86	0.22	2.7	3.23
1995	2.15	0.45	3.15	2.8
1996	2.36	2.27	1.91	3.25
1997	2.74	1.82	2.21	3.87
1998	3.27	2.29	2.69	4.32
1999	3.8	2.8	3.56	4.23
2000	3.39	33.64	2.24	5.09
2001	3.56	1	3.47	4.76
2002	3.14	2.44	2.73	3.64
2003	2.85	1.71	2.05	4.74
2004	2.78	0.89	1.99	6.88
2005	3.01	16.99	2.11	4.47
2006	3.41	4.2	2.98	3.98
2007	3.79	0.83	3.95	5.12
2008	5.01	3.03	3.91	8.65
2009	6.61	2	11.2	5.45
2010	5.82	2.04	4.51	9.32
2011	5.77	3.75	4.18	9.25
Mean	3.37	3.92	3.17	4.80
Standard Deviation	1.36	7.51	2.00	2.09
Coefficient of Variation (%)	40.54	191.46	63.18	43.54

Seeing from three industries investment efficiency of Hebei, the averages of ICOR were 3.92, 3.17 and 4.8. In other words, the second industrial investment efficiency is the highest, followed by the primary industry, and the tertiary industrial investment efficiency is lowest. In addition, considering from fluctuation in investment efficiency, the three industries coefficients of variation were 191.46%, 63.18%, 43.54%. This means that fluctuation is the largest in the primary industry, followed by the secondary industry and the lowest in the tertiary industry. The primary industrial investment efficiency fluctuating significantly and the tertiary industrial investment being inefficient are main reasons for restricting the province's industrial investment efficiency.

CO-INTEGRATION AND ERROR CORRECTION ANALYSIS OF INVESTMENT EFFICIENCY

In order to eliminate heteroscedasticity, the paper respectively transforms GDP and fixed asset investment into LnGDP, LnGDP1, LnGDP2, LnGDP3 and LnFI, LnFI1, LnFI2, LnFI3. And process the data using Eviews 6.0.

3.1 *ADF* unit root test

The results of *ADF* unit root tests are shown in Table 3.

Seeing from table 3, LnGDP and InFI are both I(2). LnGDP1, LnFI1, LnGDP2 and LnFI2 are stationary time sequence data. In addition, LnGDP3 and LnFI3 are both I(1). In short, it's possible that there are co-integration relationships between the two corresponding variables.

3.2 Co-integration

Use the least squares method to estimate the equations based on the data from table 1. The equations are as follows.

All Industries:

$$LnGDP_t = 3.2640+0.6913LnFI_t \quad (5)$$

$$(26.0590) \quad (38.5644)$$

$$R^2=0.9867 \quad F=1487.2130 \quad DW=0.4209$$

Table 3.ADF unit root tests of gross industrial product and fixed asset investment in Hebei during 1990-2011

Variables	*ADF* Test Values	Inspect Forms (c, t, k)	Critical Values of 5%	P Values	Conclusion
LnGDP	-1.9008	(c, t, 0)	-3.6450	0.6184	Non-stationary
DLnGDP	-2.1549	(c, t, 0)	-3.6584	0.4869	Non-stationary
D(DLnGDP)	-3.9124	(c, t, 0)	-3.6736	0.0323	Stationary
$LnGDP_1$	-6.6908	(c, t, 3)	-3.6908	0.0002	Stationary
$LnGDP_2$	-4.0571	(c, t, 1)	-3.6584	0.0236	Stationary
$LnGDP_3$	-1.6566	(c, t, 2)	-3.6736	0.7303	Non-stationary
$DLnGDP_3$	-6.6559	(c, t, 1)	-3.6736	0.0002	Stationary
LnFI	-2.0021	(c, t, 1)	-3.6584	0.5651	Non-stationary
DLnFI	-2.8605	(c, t, 0)	-3.6584	0.1944	Non-stationary
D(DLnFI)	-5.7430	(c, t, 0)	-3.6736	0.0010	Stationary
$LnFI_1$	-4.7814	(c, t, 3)	-3.6908	0.0068	Stationary
$LnFI_2$	-4.0893	(c, t, 3)	-3.6908	0.0244	Stationary
$LnFI_3$	-1.4748	(c, t, 1)	-3.6584	0.8040	Non-stationary
$DLnFI_3$	-5.8284	(c, t, 0)	-3.6584	0.0007	Stationary

Primary Industry:

$$LnGDP_{1t} = 4.0011+0.5611LnFI_{1t} \quad (6)$$

(37.0098) (21.2865)

R^2=0.9577 F=453.1166 DW=1.0296

Secondary Industry

$$LnGDP_{2t} = 2.7567+0.7460LnFI_{2t} \quad (7)$$

(14.3996) (24.2479)

R^2=0.9671 F=587.9610 DW=0.2583

Tertiary Industry:

$$LnGDP_{3t} = 2.7327+0.6832LnFI_{3t} \quad (8)$$

(22.6197) (35.4049)

R^2=0.9843 F=1253.5040 DW=0.9155

R^2 above four equations are large, namely that equations fit better. In order to prevent spurious regression, the paper makes ADF unit root tests on the residual sequences of the four equations. The results are as table 4.

Table 4.ADF unit root tests of the residual sequences

Variables	*ADF* Test Values	Inspect Forms (c, t, k)	Critical Values of 5%	P Values	Conclusion
e_t	-2.1387	(0, 0, 1)	-1.9591	0.0343	Stationary
e_{1t}	-3.6482	(0, 0, 3)	-1.9614	0.0011	Stationary
e_{2t}	-2.3700	(0, 0, 3)	-1.9614	0.0210	Stationary
e_{3t}	-2.0180	(0, 0, 1)	-1.9591	0.0442	Stationary

Seeing from the results, there are co-integration relationships between the corresponding variables. In other words, there are long-term stable relationships. As equation (5) shown, the average of regional investment flexibility in Hebei is 0.6913, indicating that investment increase by 1%, the GDP will grow by 0.6913%.Next, the paper analyzes the degree of three specific industrial investment promoting increase in gross product. Firstly, the intercept of primary industry is 4.0011 and the largest in the three industries. This shows that primary industry of Hebei had a good economic foundation and played a crucial role in the economic development of Hebei in the early 1990s. However, the long-term elasticity of investment is only 0.5611 and the lowest in three industries. This indicates that investment being insufficient and slowing growth in primary industry are important reasons for restricting the investment efficiency. Secondly, the intercept of primary industry is 4.0011 and the long-term elasticity of investment is 0.7460 which is the highest in three industries. This indicates that from the beginning of the 1990s, Hebei Province has not only increased the scale of the secondary industrial investment, but also adjusted the investment structure, so that the reason for restricting the investment efficiency has gradually changed from the investment scale to the level of utilizing investment efficiently. Finally, the intercept of tertiary industry is 2.7327, indicating industrial development foundation is weak, and the long-term elasticity of investment is 0.6832. Analyzing combined with internal investment structure of the tertiary industry, the investment proportion of real estate is the largest that was 27.08% in 2011, and investments of the financial industry and information transmission, computer services and software industry are insufficient of which the proportions were respective only 0.14% and 0.48%. This shows that irrational allocation of internal resources in the tertiary industry is an important reason for restricting the investment efficiency.

3.3 Establish Error Correction Model

According to the co-integration regression equations, the paper uses the residuals to establish error correction models. The results are as follows.

All Industries: $$DLnGDP_t = 0.0972+0.1030DLnFI_t - 0.0490ECM_{t-1} \quad (9)$$

(10.0718) (1.9663) (-0.9121)

R^2=0.1827 F=2.0121 DW=0.9051

Primary Industry: $$DLnGDP_{1t} = 0.0620+0.1317DLnFI_{1t} - 0.1310ECM_{1t-1} \quad (10)$$

(3.7496) (1.9897) (-2.7510)

R^2=0.3615 F=5.0957 DW=2.1476

Secondary Industry: $$DLnGDP_{2t} = 0.0886+0.2251DLnFI_{2t} - 0.1029ECM_{2t-1} \quad (11)$$

(5.4232) (2.6623) (-2.5754)

R^2=0.3228 F=4.2901 DW=1.8822

Tertiary Industry: $$DLnGDP_{3t} = 0.0979+0.1200DLnFI_{3t} - 0.1438ECM_{3t-1} \quad (12)$$

(9.1645) (2.4681) (-1.9453)

R^2=0.2899 F=3.6743 DW=1.5068

Regression equations (9)-(12) reflect the short-term fluctuation relationships between GDP and the corresponding fixed asset investment of all and three industries in Hebei Province. Coefficients of ECM in these equations are negative that comply with the reverse correction mechanism.

Firstly, the short-term elasticity of investment is 0.1030 and the correction factor is -0.0490 in all industries. That is to say, when the short-term fluctuation deviates from the long-term equilibrium by 1%, it adjusts the non-equilibrium state to be long-term equilibrium by 0.0490%. Secondly, the short-term elasticity of investment is0.1317 and the correction factor is-0.1310 in primary industry. It indicates that when the short-term fluctuation deviates from the long-term equilibrium by 1%, it adjusts the non-equilibrium state to be long-term equilibrium by 0.1310%.Thirdly, the short-term elasticity of investment is0.2251 and the correction factor is-0.1029 in secondary industry. It shows that when the short-term fluctuation deviates from the long-term equilibrium by 1%, it adjusts the non-equilibrium state to be long-term equilibrium by 0.1029 %. Finally, the short-term elasticity of investment is0.1200 and the correction factor is-0.1438 in tertiary industry. It shows that when the short-term fluctuation deviates from the long-term equilibrium by 1%, it adjusts the non-equilibrium state to be long-term equilibrium by 0.1438 %.

Analyzing the four equations, we find that total fixed asset investment has played a good role in regulating GDP, so that economic growth does not deviate from the normal trend. However, the fit degree of the four equations is low and reflecting the reality is not very accurate. This also means that in the real economy, the economic development affected by not only the investment but also other factors such as consumption, exports and technology development.

CONCLUSION

Based on the above analysis, we can see that from 1990 to 2011 the overall industry investment efficiency of Hebei, and the investment efficiency of each industry needs to be improved. Moreover, economic development of Hebei relies mainly on secondary industry. At the same time, the large fluctuation of the primary industrial investment efficiency and low investment efficiency and unreasonable structure of the tertiary industry are the important factors restricting economic growth of Hebei Province. Specifically:

1) The investment of the primary industry not only is insufficient, but also increases slowly. In addition, investment efficiency fluctuates wildly. Although Hebei province is a major agricultural province, food security issues cannot be ignored. In the future, Hebei should moderately increase the scale of investment, particularly the mechanization investment, changing from traditional agriculture to the intelligent, automated operation mode in order to achieve adjustment of the investment structural and improvement of the investment efficiency.

2) The scale of secondary industrial investment is large and the growth is fast, but investment efficiency is still low. As we all know, industry is the pillar of the secondary industry. However, there are some problems in the

development of industry. For example, the product of heavy industry has a higher proportion in industry, while the proportion of processing industry in heavy industry is lower especially machinery manufacturing industry. In the future, relying on scientific and technological progress Hebei should improve the level of industrial investment management and adjust the investment structure, to improve production efficiency and allocative efficiency of investment.

3) Tertiary industry structure is irrational and investment efficiency is low. In the future, Hebei province should increase the investment in the financial, information technology services, modern logistics and other services industries which are high-return industries, and appropriately control the scale of investment real estate. At the same time, Hebei should decrease the lag effect of fixed assets investment and improve investment monitoring system of the public service industry in order to ensure transparency in investment flows. In addition, Hebei also should avoid duplication of investment and optimize investment structure to improve the industrial investment efficiency.

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