The Interaction Between Economic Level and Pipeline Logistics in China—Based on Vector Error Correction Model

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The interaction between the economic level and the pipeline logistics is analyzed by using the Granger causality test, error correction model, and impulse response analysis in this paper. The results show that the level of economic development will support pipeline logistics, but the level of pipeline logistics will not support the economic development obviously.

Keywords: economic level, pipeline logistics, error correction model, impulse response analysis

Introduction

With the “13th Five-Year” planning and “The Belt and Road” strategy, logistics industry has got the new opportunities in China. As the third source of profit, logistics has always been the interest of many people. Many scholars pay attention to this field, mainly in the road, railway, water, and aviation logistics. While there are few related researches on pipeline logistics. Since 1990s, with the rapid growth of Chinese GDP, the volume of freight traffic is rising year by year. Statistics show that the GDP increased from 1,877,430 million in 1990 to 63,613,870 million in 2014, the pipeline mileage also increased from 15,900 km to 105,700 km, the freight volume of pipeline increased from 157,500 thousand in 1990 to 737,520 thousand tons in 2014, the average annual growth rate is 6.92%. There is an internal relationship between the pipeline logistics, the total pipeline mileage and GDP (Zhong, 2009).

We select the time series data from 1990 to 2014 to carry out unit root test, cointegration test, Granger causality test, vector error correction model (VECM), impulse response analysis (IRF) to study the dynamic relationship between the freight volume of pipeline and GDP, pipeline mileage. The article uses Eviews 8.0 statistical software for analysis.

Literature Review

The relationship between economic level and logistics level has always been a hot topic; many scholars at home and abroad have studied the relationship between them.

In China, Liu (2012) studied the relationship between logistics and regional economic growth based on self-vector regression model, he found that the logistics industry is a new industry to stimulate economic

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growth, and economic growth will stimulate logistics in reverse (Liu, 2012). Lu (2016) uses cointegration model to get a long-term equilibrium relationship between regional logistics industry and regional economy. Xu and Huang (2011) studied the regional logistics and regional economy in Zhejiang province, and found that the regional economy was the foundation of regional logistics; regional logistics and regional economic development are interdependent and mutually supported.

Kuzu and Onder (2014) studied the long-term relationship between logistics development and economic growth in Turkey, pointed out that there was a cointegration relationship between logistics and economy; economy was the Grainger reason of logistics, and played an important role in the development of logistics. Marazzo, Scherre, and Fernandes (2010) conducted an empirical research on air traffic and economic growth in Brazil for nearly 40 years, and found that there was a long-term equilibrium relationship between them; the impulse response analysis indicated that GDP changes affected the air traffic.

The domestic and foreign literatures were mainly concentrated on two aspects: one was the relationship between regional logistics and regional economy; the other was the relationship between the level of logistics represented by traditional transportation and economic growth. Pipeline logistics has not been the focus of attention of scholars at home and abroad, there are few literatures on the relationship between pipeline logistics and economic growth.

Model building and Data Selection

Johansen Cointegration Test

Johansen cointegration test is a good method to test the multivariate cointegration relationship, which was put forward by Johansen in 1988. It's based on VAR model (Johansen, 1988).

In VAR model, we set variables including $y_{1t}, y_{2t}, \dots, y_{kt}$ as non-stationary first-order sequence, then $y_t \sim I(1)$. x_{1t} is a dimensional exogenous vector, representing the trend term, constant term, etc.

$$y_t = A_1 y_{t-1} + A_2 y_{t-2} + \dots + A_p y_{t-p} + Bx_t + \mu_t (t = 1, 2, \dots, n)$$

The first-order sequence of $y_{1t}, y_{2t}, \dots, y_{kt}$ is changed to zero-order sequence $I(0)$, as follows.

$$\Delta y_t = \Pi y_{t-1} + \sum_{i=1}^{p-1} \Gamma_i y_{t-i} + Bx_t + \mu_t$$

$$\Pi = \sum_{i=1}^p A_i - I$$

$$\Gamma_i = - \sum_{j=1}^p A_j$$

Among them, Δy_t and $y_{t-j} (j = 1, 2, \dots, p)$ are all vector variables in $I(0)$. If Πy_{t-1} is also a vector in $I(0)$, then there is cointegration relationship between $y_{1t-1}, y_{2t-1}, \dots, y_{kt-1}$ and Δy_t is stable.

Vector Error Correction (VEC) Model

Vector error correction (VEC) model is a vector autoregressive (VAR) model with cointegration constraints. VEC model can be constructed only when there is a cointegration relationship among variables.

The mathematical expression of VEC model is as follows:

$$\Delta y_t = \alpha \beta' y_{t-1} + \sum_{i=1}^{p-1} \Gamma_i y_{t-1} + \mu_t \quad (t = 1, 2, \dots, n)$$

Among them, the error term in each equation is smooth. The formula can be expressed as follows:

$$\Delta y_t = \alpha ecm_{t-1} + \sum_{i=1}^{p-1} \Gamma_i y_{t-1} + \mu_t \quad (t = 1, 2, \dots, n)$$

The obtained equation is the error correction model, $ecm_{t-1} = \beta' y_{t-1}$ is error correction, which can reflect the long-term equilibrium relationship between variables. The coefficient of variance α can adjust the equilibrium relation between variables deviates to the equilibrium state. The coefficient of variance difference on the right side of the error correction model reflects the influence of short-term fluctuation of each variable on the short-term variation of the explanatory variables.

Data Selection

We select annual data from 1990 to 2014 to conduct empirical research, all the data come from China Statistical Yearbook of 2015. Pipeline logistics is represented by freight volume of pipeline (HYL), the economic level is represented by GDP, and infrastructure construction is represented by pipeline mileage (LCS). Statistics data description is shown in Table 1.

Table 1

Statistics Data Description

Statistics data	GDP (billion yuan)	HYL (million tons)	LCS (million kilometers)
Mean value	30,711.20	206,100.50	4.28
Maximum value	73,752.00	636,138.70	10.57
Minimal value	14,783.00	18,774.30	1.59
Standard deviation	18,519.15	189,938.90	2.90
	N	$25 \times 3 = 75$	

Empirical Research Results and Analysis

The data trend can be linearized and the heteroscedasticity in time series can be eliminated by natural logarithm transformation. Therefore, in this paper, we take first difference of LnHYL, LnGDP, LnLCS, the difference of the data is shown in Figure 2.

Figure 1 shows that the data are on the rise trend, and it is a non-stationary time series data. Figure 2 shows that the data may be the first order sequence. The article uses ADF test, test results are shown in Table 2.

Table 2 shows that the variables including LnHYL, LnGDP, LnLCS will accept the original assumption of the existence of unit roots, at the significance level of 5%, so LnHYL, LnGDP, LnLCS sequences data are not stable. Variables like D(LnHYL), D(LnGDP), D(LnLCS), reject the original assumption of unit roots, so the first difference variables are stable. Therefore, LnHYL, LnGDP, LnLCS are I(1) sequence. There is cointegration relationship between them. In this paper, Johansen cointegration test is used to test whether there is a cointegration relationship between three variables.

The results of Tables 3 and 4 indicate that there's a cointegration relationship between three sets of data, and there are two cointegration vectors. According to the results, we make further analysis of these three sets of data by VECM.

Figure 1. Time sequence diagram of LnHYL, LnGDP, LnLCS.

Figure 2. Time sequence diagram of D(LnHYL), D(LnGDP), D(LnLCS).

Table 2

Results of Stationary Test of Unit Root

Variable	ADF value	Critical value of 5%	Test type	P value	Conclusion
LnHYL	-2.1612	-3.6122	CT0	0.4882	Unstable
D(LnHYL)	-4.5443	-3.6220	CT0	0.0076	Stable
LnGDP	-2.9870	-3.6736	CT5	0.1607	Unstable
D(LnGDP)	-4.3686	-3.6584	CT3	0.0129	Stable
LnLCS	-3.0775	-3.6122	CT0	0.1338	Unstable
D(LnLCS)	-3.9725	-3.6220	CT0	0.0250	Stable

Table 3

Johansen Cointegration Test—Trace Test Result

Number of association	Characteristic value	Trace test value	5% Critical value	P value
None*	0.6715	43.3251	29.7971	0.0008
At most 1*	0.5367	17.7180	15.4947	0.0228
At most 2	0.0010	0.0223	3.8415	0.8813

Note. * means the p value of it passed the test.

Table 4

Johansen Co Integration Test—Maximum Eigenvalue Test

Number of association	Characteristic value	Maximum eigenvalue	5% Critical value	<i>P</i> value
None*	0.6715	25.6071	21.1316	0.0109
At most 1*	0.5367	17.6957	14.2646	0.0138
At most 2	0.0010	0.0223	3.8415	0.8813

Note. * means the *p* value of it passed the test.

Grainger Causality Test

Results of cointegration test show that there is a long-term stable equilibrium relationship between the level of pipeline, logistics, and economic development, and whether this equilibrium relationship from the causal relation needs to be verified. In this paper, according to the principle of Granger causality test, we set the lag period as two, and take Granger causality test for LnHYL, LnGDP, and LnLCS. Test results are shown in Table 5.

Table 5

Grainger Causality Test Results

Original hypothesis	<i>F</i> value	<i>P</i> value	Result
LnGDP is not Granger reason of LnHYL	3.1374	0.0678	Accept
LnHYL is not Granger reason of LnGDP	2.4906	0.1109	Reject
LnLCS is not Granger reason of LnHYL	8.1960	0.0029	Reject
LnHYL is not Granger reason of LnLCS	3.5903	0.0486	Reject
LnLCS is not Granger reason of LnGDP	7.7530	0.0037	Reject
LnGDP is not Granger reason of LnLCS	3.9039	0.0391	Reject

As for interaction between GDP and pipeline logistics, at 10% confidence level, it's believed that GDP is the Grainger reason of pipeline logistics. It may be considered that, the increase of GDP caused by oil and natural gas, coal and other energy consumption will stimulate the rise of pipeline logistics. However, the pipeline logistics is not the Grainger reason for GDP, its contribution for the promotion of economic growth is not obvious.

As for interaction between infrastructure and pipeline logistics, at the 5% significant level, the original hypotheses are all rejected. Therefore they are Grainger reasons for each other. This conclusion is consistent with common sense.

As for interaction between GDP and infrastructure impact, at 5% confidence level, GDP is the Grainger reason of infrastructure, and infrastructure is also Grainger reason of GDP. GDP growth will promote the development of infrastructure, and as an investment, infrastructure construction will also stimulate economic growth.

Establishment of VECM

The cointegration test results show that there is a cointegration relationship among the variables. According to the characteristics of cointegration, the vector error correction model is established. The three order VECM with two cointegration vectors is established based on the choice of the lag order number as two.

$$\Delta y_t = \alpha ecm_{t-1} + \Gamma_1 y_{t-1} + \Gamma_2 y_{t-2} + \mu_t$$

y_t is a set of three column vectors representing the three sets of data.

$$y_t = \begin{pmatrix} \ln(HLY) \\ \ln(GDP) \\ \ln(LCS) \end{pmatrix}$$

The function includes the volume of freight, GDP, mileage increments, and they are all the logarithm value.

Parameter Estimation and Validation of VECM

Table 6

Parameter Estimation Results

Error correction	D(LnHYL)	D(LnGDP)	D(LnLCS)
CointEq1	-0.7423 [-2.2551]	-0.2172 [-1.1819]	-0.5657 [-2.6633]
CointEq2	-0.0538 [-0.5334]	-0.2634 [-4.6762]	-0.0160 [0.2464]
D(LNHYL(-1))	-0.2162 [-0.7317]	-0.0665 [-0.4032]	-0.0789 [-0.4137]
D(LNHYL(-2))	0.2407 [1.0881]	0.1733 [1.4033]	0.2820 [1.9752]
D(LNGDP(-1))	0.4727 [1.4011]	0.6576 [3.4920]	-0.0240 [-0.1102]
D(LNGDP(-2))	0.0385 [0.1006]	-0.0273 [-0.1280]	0.4199 [1.7005]
D(LNLCS(-1))	0.4060 [0.8245]	0.2009 [0.7310]	-0.2154 [-0.6778]
D(LOGLCS(-2))	0.1271 [0.3219]	-0.0397 [-0.1803]	-0.0639 [-0.2509]
C	0.0479 [-0.8617]	0.0295 [0.9500]	0.0361 [1.0050]
ADJ. R ²	44.40%	80.82%	46.40%

Table 6 is the result of parameter estimation of VECM. The number in brackets below each estimate is its t value. According to the results of parameter estimation, although some of the estimated values are not significant, on the whole, the estimated results are satisfactory, and the goodness of fit is better. For VECM, it is important to analyze the impulse response.

Impulse Response Analysis

Impulse response function analysis method can be used to describe an endogenous variable of errors caused by the impact of the reaction. Taking a standard deviation as the impact, the current values of endogenous will change. The following figure gives an image of some orthogonal impulse response functions.

In Figure 3, if GDP is given by a unit of positive impact, the utility of logistics pipeline will be accelerated, but it lasts only about two periods, and then followed by a period of negative influence, finally it will rise gradually and be stabilized, remained at about 0.02. It can be concluded that GDP growth will boost the level of pipeline logistics in the short term. With the rapid development of economy, the pipeline logistics industry of our country will encounter bottlenecks. The low technical conditions of pipeline equipment affect the development of the pipeline logistics. With the progress of science and technology, it gives positive effect.

Figure 3. The impact of GDP on pipeline logistics.

Figure 4. The impact of infrastructure on pipeline logistics.

Figure 4 shows the impact of infrastructure on the pipeline logistics. As we can see in the figure, from the beginning of the first phase, the role of pipeline logistics is accelerated. From the beginning of the fifth period, there's a decline, and it eventually stabilizes in the vicinity of 0.03. The whole process is maintained above zero. The construction of infrastructure will promote the development of logistics industry, which is in line with our expectations.

Figure 5 shows that with a positive impact on the pipeline logistics, there will be a reduction in GDP. The whole process shows that pipeline logistics has a negative impact on GDP. There are some gaps between the theory and our expectations, but at present, the level of pipeline logistics in our country is still in the initial stage, the proportion of pipeline logistics in the total freight volume is small, and the growth effect is not significant.

Figure 5. The impact of pipeline logistics on GDP.

Conclusions

In this paper, the stationary test is carried out, the three sets of data are all $I(1)$. After further study on the cointegration situation, we get the conclusion that there are two cointegration vectors between them. And then we establish error correction model. Through the Grainger causality test, at 10% of significance level, GDP is the reason for the pipeline logistics, indicating that the impact of GDP on the pipeline logistics really exists, but the pipeline logistics has no significant impact on GDP. Grainger reason exists among other variables. It can be seen from the impulse response function that the level of GDP and infrastructure will promote the development of pipeline logistics. At present, pipeline transportation in China is in the initial stage, the proportion of investment in pipeline logistics is smaller than that of road and railway. In the “13th Five-Year” planning, with “The Belt and Road” strategy, we should make full use of pipeline to strengthen the pipeline infrastructure construction, and develop the foreign market.

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