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The Relationship between Energy Consumption and Economic Growth in Jilin Province: An Empirical Analysis Based on 1980 - 2013 Data

Jianfei SHEN[1], Lincong HAN[2]

Abstract

In-depth understanding of the relationship between energy consumption and economic growth is of great significance to transform energy use in Jilin Province. Based on the data of Jilin energy consumption and economic growth from 1980 to 2013, the relationship between energy consumption and economic growth in Jilin Province is analyzed by using the theory and method of Granger causality based on cointegration theory and error correction model. The empirical results show that there is a long-term cointegration relationship between energy consumption and economic growth in Jilin Province. It is found that there is a one-way causal relationship between Jilin Province's long-term economic growth and energy consumption, that is, Jilin Province's economic growth promotes energy consumption rather than energy consumption promotes economic growth. Based on the conclusion of the study, it is necessary to change the mode of economic growth in Jilin Province from the extensive mode of economic expansion, which is a simple expansion of investment factors, to the need for intensive economic growth model with emphasis on the quality and efficiency of production factors and innovation driven.

Keywords: energy consumption, cointegration, Granger causality, economic growth, resources.

Introduction

Jilin Province is located in the central part of northeast China, with a total area of 18.7 square kilometers, 2% of the total area of the country, is one of important grain food production and commodity grain base, is also one of the important old industrial base in China (Liddle, 2013). From the type of energy resources

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reserve, the main energy sources of Jilin Province are coal, oil, natural gas and so on (Ahn, 2015). Hydropower resources and proven oil shale reserves are abundant. At present, the oil geology reserves of Jilin Province are 1.31 billion tons, the natural gas reserves are 24.6 billion tons, and the coal reserves are 1 billion tons. As for clean energy, Jilin Province's solar resources are relatively weak, wind and biomass resources are relatively abundant.

Jilin Province conventional primary energy (coal, oil, natural gas, water) resource shortage and a serious shortage of reserve resources limit the continued growth of energy production (York, 2007). In addition, energy self-sufficiency rate decreased year by year, and energy demand exceeds supply for several years have become a constraint to economic development "bottleneck". Jilin Province, the conventional primary energy resources per capita possession of 85 tons of standard coal, only 13.2% of the national average, is a "poor province", and there is a serious shortage of reserve resources (Ang, 1989). Coal as the main energy in 1.46 billion tons of standard coal, accounts for only 0.23% of the country's total, and has developed and utilized more than 53%, and resources that has not yet developed are scattered small mines, so there is no available for large and medium-sized coal mine resources, which determines the coal is difficult to significantly increase production (Metcalf, 2008). Oil resources are 574 million tons, accounting for 4% of the total amount of oil in the country, and only 10% has been developed. There is a certain potential for development, but the current production is not self-sufficient. Natural gas resources are scarce, and convert into 4.1 million tons of standard coal, accounting for 0.89% of the country, which can not solve the problem of its own needs. Water resource can be installed capacity of 5008,100 kilowatts, has been developed and utilized 65.8%, and the remaining large and medium-sized hydropower resources are not available.

The impoverishment of energy resources limits the sustainable development of energy production (Medlock & Soligo, 2001; Sioshansi, 1986). The rate of self-sufficiency of energy is declining year by year: 98% in 1970, 50% in 1995, and currently only about 40 percent. The amount of energy transferred from other provinces is often difficult to sustain when the country's transport capacity in short and energy is in short supply. Therefore, Jilin Province has long been insufficient energy supply, and coal, gas, oil have a larger gap. In particular, Jilin Province is located in Liaoning and Heilongjiang Provinces "canyon" among. Liaoning Province is a national heavy industry base, large energy consumption, and the province's energy reserve resources have been poor, with less than 50 percent of its energy supply, and more than 60 million tons of energy in annual transfers. Heilongjiang Province is abundant in coal resources, the current production self-sufficient to support the Liaoning Province and Jilin province, but after the completion of several large-capacity pithead power plant, the province's coal consumption will increase sharply, and coal call-out amount will decline dramatically. Therefore, it is difficult for Jilin province to transfer coal from Chinese inland areas, which will be subject to Liaoning's "throttling". In addition, it is difficult to guarantee in the quantity of coal transferred from Heilongjiang Province. Oil, in the country insufficient production, imports increase year by year and difficult to meet the demand, so the gap is getting bigger and bigger (Shakeel, Iqbal, & Majeed, 2014). Thus, the future energy supply and demand situation of Jilin Province is serious. If not take early strategic measures, it will restrict the construction speed of industrial province and ecological province (Mallick, 2009; Salahuddin & Khan, 2013).

Growth characteristics of energy consumption in Jilin Province

Table 1 is the total data on energy consumption in Jilin Province over the years from 1980 to 2013 (Unit: 10,000 tons of standard coal)

Table 1. Energy consumption of Jilin province in 1980-2013

year	1980	1985	1990	1995	2000	2005	2010	2011	2012	2013
Total energy consumption	1930	2658	3523	3954	3527	5258	8172	8886	9028	8546

Source: Jilin Province Statistical Yearbook

As can be seen from *Table 1*, energy consumption in Jilin Province is basically showing a gradual upward trend. In order to better describe the energy consumption situation in Jilin Province, we use *Figure 1* to illustrate the trend of total energy consumption in Jilin Province.

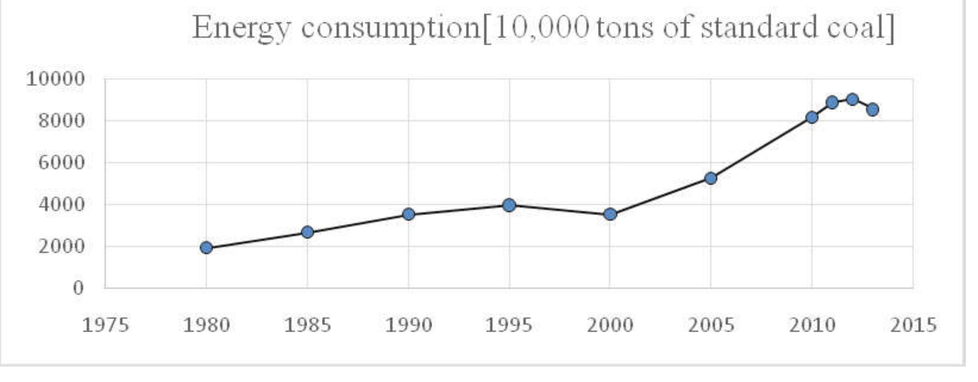

Figure. 1 Jilin Province over the years the total energy consumption time sequence diagram

From *Figure 1* can be clearly seen, the characteristic of the total energy consumption trends in Jilin Province varies with time. Overall, the total energy consumption in Jilin Province has shown a rising trend over time, but the rate of increase has different characteristics in different time periods. From 1981 to 1997, the slope of energy consumption growth in Jilin province was significantly lower than the slope of the period from 2001 to 2010.However, from 1997 to 2000, the total energy consumption in Jilin Province showed a significant downward trend. From the beginning of 2011, the magnitude of energy consumption rose in the inflection point. In the period from 2011 to 2013, Jilin Province, the growth rate of energy consumption is significantly lower than the slope between 2001 and 2011. The above is only a general description of the path of total energy consumption in Jilin Province.

The relationship description between total energy consumption, GDP and industrial added value of Jilin Province

The relationship between energy consumption, GDP and gross industrial production in Jilin Province can reflect the relationship between energy consumption and economic growth and industrial production in Jilin Province, so as to find out the quantity relationship between them on the whole (Frankel & Chinn, 1995). *Table 2* shows the specific values of energy consumption, real GDP, real industrial output and growth rate of three variables in Jilin Province from 1980 to 2013.

Table 2. Energy consumption, real GDP, real industrial output and its growth rate in Jilin Province

year	Total energy consumption [10,000 tons of standard coal]	Actual growth in energy consumption [%]	Actual GDP [billion]	Real GDP growth rate [%]	The added value of the secondary industry [100 million yuan]	Actual secondary industry growth rate [%]
1980	1930.2	10.85458	341.9855	6.454485	123.9909	8.096697
1985	2658.8	6.543779	569.6422	6.824886	187.2826	12.76803
1990	3523.4	3.852389	849.065	3.449778	262.9953	-2.12052
1995	3954.2	2.533385	1368.442	9.697942	454.95	11.60055
2000	3527.7	-4.48121	2182.401	9.201817	877.8221	31.40014
2001	3712.7	5.24421	2385.318	9.297906	975.2619	11.10017
2002	4209	13.36763	2611.974	9.502113	1077.659	10.49941
2003	4468.8	6.172488	2878.384	10.19956	1229.616	14.10067
2004	4778.7	6.934748	3229.521	12.19912	1416.509	15.19933

2005	5258.5	10.04039	3620.27	12.09927	1580.83	11.60042
2006	5871.5	11.65732	4163.314	15.0001	1849.57	16.99996
2007	6465.9	10.12348	4833.629	16.1005	2241.675	21.19977
2008	7100.1	9.808379	5606.975	15.99929	2654.139	18.39983
2009	7553.4	6.384417	6369.524	13.60002	3107.997	17.1
2010	8172.8	8.200281	7248.548	13.80046	3692.304	18.80009
2011	8886.9	8.73752	8248.836	13.79984	4345.837	17.69987
2012	9028.3	1.591106	9236.468	11.97299	4954.254	14
2013	8546	1.579478	10003.09	8.299982	5390.23	8.800049

Source: Jilin Province Statistical Yearbook

As can be seen from *Table 2*, the energy consumption, real GDP and secondary industry value-added are showing a rising trend, while the growth rate of the three is not smooth, and there has been a certain degree of ups and downs and fluctuations.

In order to better describe the relationship between the three, we use the form of line drawing. *Figure 2* illustrates the annual energy consumption, real GDP and the actual output added value of the secondary industry in Jilin Province over the years in the dual coordinate table.

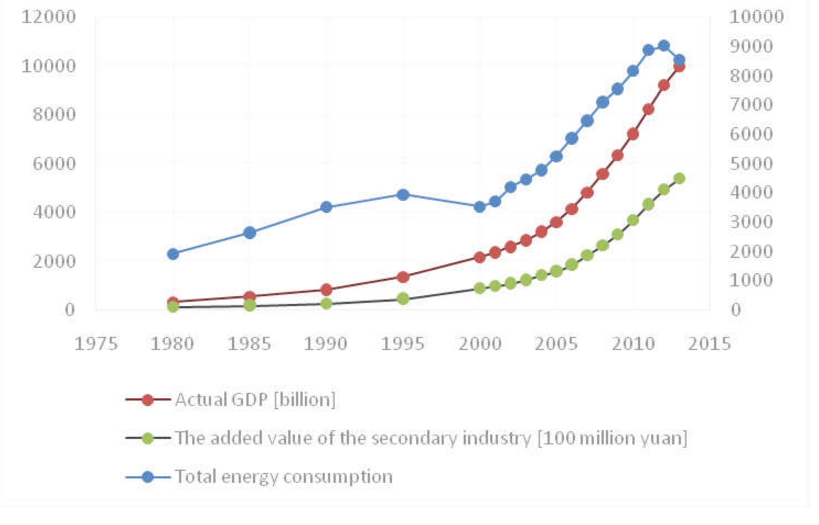

Figure 2. Energy consumption, GDP and 2nd industry value-added time sequence diagram

As shown in *Figure 2*, the total energy consumption in Jilin Province maintain the trend of growth in general, while in a small reduction phase in 1997-2001. Moreover, the growth rate between 1986 and 1997 was significantly lower than that of the period from 2001 to 2013. In comparison, the actual GDP and the actual industrial value-added trend is different from the province's total energy consumption trend, begin to appear upward inflection point in 2003, the upward trend is more steep, and the real GDP growth tilt is obviously higher than the degree of growth between 1980 and 2003. Similarly, the industrial value-added trend in Jilin Province also rises even steeper around 2005.

Empirical study on the relationship between total energy consumption, real GDP and industrial value added in Jilin Province

Table 2 and *Figure 2* show the general description of the relationship between energy consumption, real GDP and industrial value added in Jilin Province. In order to further characterize the quantitative relationship between the three, adopting the relevant econometric model can study the relationship between the three.

Variable selection and data selection

This report selects the annual total energy consumption data and real GDP data of Jilin Province from 1980 to 2013 with a total of 34 samples (Munasinghe, 1988). $NYXF_t$ stands for t year energy consumption of Jilin Province, and the unit is 10,000 tons of standard coal. Y_t stands for t year real GDP, and the 2005 as base period for the GDP index to increase or reduce. $GYZJZ_t$ stands for t year actual industrial added value, and the 2005 as the base period of the industrial value-added index to increase or reduce. The data of the above three variables are from the years of "Jilin Province Statistical Yearbook" , "China Energy Statistical Yearbook" , the China Economic Net and Jilin Provincial Bureau of Statistics published statistical bulletin over the years. In order to reduce the volatility of data and heteroskedasticity, take the natural logarithm of the three variables, respectively as $LNYXF_t$, LY_t, $LGYZJZ_t$, and the linear relationship between them is the elastic relationship.

Stability test of variables

Economic time sequence is usually not stable, so according to the unstable time series to directly establish the regression model may have pseudo-regression phenomenon. Although goodness of fit of the model is high, the equation can not reflect the real relationship between economic variables. Therefore, firstly, making the unit root test to verify whether the sequence is stable before concrete modeling.

If the sequence of variables is stable, you can model directly. If the sequence is not stable, the sequence must be differential until the sequence is smooth. In this paper, we use correlation measurement software to test the unit root of variable sequence $LNYXF_t$, LY_t, $LGYZJZ_t$. Test results as shown in *Table 3*:

Table 3. Unit root test

Variable	ADF test value	1% critical value	5% critical value	10% critical value	P value	Test result
$LNYXF_t$	-0.243	-3.633	-2.948	-2.613	0.923	unstable
LY_t	1.477	-3.646	-2.954	-2.616	0.999	unstable
$LGYZJZ_t$	-3.001	-3.646	-2.954	-2.616	1.00	unstable
$\Delta LNYXF_t$	-4.834	-3.639	-2.951	-2.614	0.0004	stable
ΔLY_t	-4.152	-3.639	-2.951	-2.614	0.0027	stable
$\Delta LGYZJZ_t$	-4.208	-3.639	-2.951	-2.614	0.0023	stable

It can be seen from *Table 3* that the ADF test values of $LNYXF_t$, LY_t and $LGYZJZ_t$ accept the original hypothesis at each significance level. The three time series are non-stationary. After the first order difference, ΔLNYXFt, ΔLYt, ΔLGYZJZt reject the original hypothesis at each significant level, so illustrate the first-order difference sequences of $LNYXF_t$, LY_t and $LGYZJZ_t$ are stationary sequences. $LNYXF_t$, LY_t and $LGYZJZ_t$ are first-order monotonic processes, which can be further cointegration analysis.

Simple regression analysis of Jilin Province energy consumption on real GDP and industrial added value

In order to explain the effect of real GDP growth on the total energy consumption of the province (Ahmad & Ahmed, 2014), we establish an ordinary linear regression model to analyze the effect of real GDP to the total energy consumption of Jilin Province. The regression model is as follows:

$$LNYXF_t=\beta_0+\beta_1 LY_t+\mu_t \quad (1)$$

In Eq.1, $LNYXF_t$ represents the total energy consumption of Jilin Province after taking logarithm; LY_t represents the real GDP of Jilin Province after taking logarithm. The regression results are as follows:

$$LNYXF_t=5.051+0.437LY_t \quad (2)$$
$$(37.36)(23.96)$$

The regression results of Eq.2 are specified as follows: the t-test value of the coefficients preceding the explanatory variable LY_t is 23.96, which is highly significant. It is explained that the real GDP after taking the logarithm has a strong explanatory power for energy consumption. The coefficient of determination R^2=0.944 indicates that real GDP has a strong ability to explain energy consumption. The DW value is 0.215, which indicates that the residual sequence of the equation has a first-order sequence correlation and needs to further eliminate the influence of sequence correlation. The statistic J-B value of the residual normality distribution test is 2.761 with a probability value of 0.251, indicating that the residual distribution is a normal distribution.

Although the explanatory variables and interpreted variables in Eq.1 are non-stationary variables, we are only doing approximate regression here. We will make cointegration regression to return in the following way (Engle & Granger, 1987; Lin & Tsay, 1996). In Eq.2, the value of the variable is the natural logarithm of the variable value, and the coefficients in front of it show the elasticity of variable change. The regression results show that the elasticity coefficient of actual GDP of Jilin province is 0.437, which indicates that the actual GDP of Jilin Province increases by 1 unit per increment, and the energy consumption will increase by 0.437 units. The increase in real GDP has a significant impact on the growth of energy consumption.

As shown in Fig. 1 and Fig. 2, since the slope of the rising trend of energy consumption in Jilin Province at different time periods is different, in order to analyze the effect of real GDP on energy consumption of Jilin Province at different time periods, we adopt the method of breakpoint regression to analyze the time series data of energy consumption and real GDP. The results of the analysis are shown below.

The results of breakpoint regression in Table 4 show that the return of energy consumption and real GDP in Jilin Province is reasonable in three time periods. After breakpoint regression results, the coefficient of determination R^2=0.944, the DW value is 1.492, and the results that testing the stability of the residual sequence after regression by virtue of the ADF test show that the residual sequence is stable. The value of the JB test statistic is 2.443, with the probability value of 0.295, which indicates that the residual distribution is normal distribution. The results of the three-stage regression analysis are given below:

In the first time period, 1978-1989.The regression results show that coefficient value in front of the explanatory variable is 0.68, indicating that elasticity coefficient in real GDP is 0.68 for energy consumption in Jilin Province, that is, one change per unit of real GDP resulted in an increase in energy consumption of 0.68 units. The t-test value of the regression equation is 23.45, which is highly significant, indicating that the real GDP after logarithm has a strong ability to explain energy consumption.

In the second time period, 1990-1997.The regression results show that coefficient value in front of the explanatory variable is 0.24, indicating that elasticity coefficient in real GDP is 0.24 for energy consumption of Jilin Province, that is, one change per unit of real GDP resulted in an increase in energy consumption of 0.24 units. The t-test value of the regression equation is 4.57, which is highly significant, indicating that the real GDP after taking the logarithm has a significant explanatory power for energy consumption.

In the third time period, 1998-2013.The regression results show that coefficient value in front of the explanatory variable is 0.62, indicating that elasticity coefficient in real GDP is 0.62 for energy consumption of Jilin Province, that is, one change per unit of real GDP resulted in an increase in energy consumption of 0.62 units. The t-test value of the regression equation is 38.92, which is highly significant, indicating that the real GDP after taking the logarithm has a significant explanatory power for energy consumption.

Table 4. Jilin Province energy consumption and real GDP breakpoint regression results

Variable	Coefficient	Standard deviation	T statistic	Probability value
1978-1989–12 observations				
C	3.553256	0.180126	19.72651	0.0000
LY	0.680087	0.029000	23.45102	0.0000
1990-1997–8 observations				
C	6.524252	0.376343	17.33593	0.0000
LY	0.243111	0.053135	4.575380	0.0001
1998-2013-16 observations				
C	3.451241	0.133491	25.85375	0.0000
LY	0.622983	0.016006	38.92168	0.0000
R-squared	0.995209	Mean dependent var		8.260557
Adjusted R-squared	0.994411	S.D.dependent var		0.410618
S.E.of regression	0.035184	Akaike info criterion		-3.705461
Sum squared resid	0.037137	Schwarz criterion		-3.441541
Log likelihood	72.69830	Hannan-Quinn criter.		-3.613346
F-statistic	1246.432	Durbin-Watson stat		1.491728
Prob(F-statistic)	0.000000			

The regression results of real energy consumption to real GDP in Jilin Province analyzed in three time periods show that the elastic coefficient of energy consumption in the first time period is 0.68, significantly higher than the elastic coefficient of 0.24 in the second time period, also higher than that of the third period energy consumption elasticity coefficient of 0.62 (Huntington, 2011).

This shows that along with the economic growth, before 1989, Jilin Province economic development mode has been high energy consumption, high input of the extensive economic growth model, and from 1990 to 1997, the elasticity coefficient of energy consumption of Jilin Province is markedly lower than the first time elasticity coefficient, suggests that during this period, due to the requirements of state-owned enterprises to adopt more stringent energy-saving emission reduction standards and the corresponding energy-saving technological reconstruction, Jilin Province's economic growth reflected the low energy consumption and high output of the intensive economic growth situation. However, from 1998 to 2013, the energy consumption elasticity coefficient of Jilin Province began to rebound, and the economic growth of the economy returned to the extensive model, with the emphasis on the economic growth model of the industrial development-based.

So why did the energy intensity of Jilin Province show a significant downward trend during the period 1990-1997? Some scholars have analyzed this, such as Zhang that analyze the terminal energy consumption and value-added data from the 29 major industrial sectors. He think changes in industrial structure (metallurgy, chemistry, mining, etc.) and changes in energy consumption intensity are the main reasons for the decline in energy consumption during this period (Zhang, 2003; Gardner & Joutz, 1996).

Analysis of long-term cointegration relationship between energy consumption and real GDP of Jilin Province

Considering the energy consumption data and real GDP data of Jilin Province are first-order single-time sequence data, in order to further analyze the long-term relationship between energy consumption in Jilin Province and the real GDP growth, cointegration analysis method are used to test the relationship of energy consumption, real GDP and the actual industrial added value (Chary & Bohara, 2010). The purpose of the cointegration test is to determine whether a linear combination of a set of non-stationary sequences has a cointegration relationship, or to determine whether the linear regression equation is reasonable by cointegration test.

Although the variable sequences $LNYXF_t$ and LY_t are nonstationary, if there are common stochastic trends in the two sequences, their linear combinations may counteract the pseudo-regression of the two time series due to the influence of the trend term, and we can resort to this common trend in correcting regression to make it reliable. We use E-G two-step method for cointegration analysis of two variable sequences. Firstly, the regression model between $LNYXF_t$ and LY_t is established according to the least squares method. Then, the ADF test is used to judge the smoothness of the unbalanced error, so as to judge whether there is a cointegration relationship between the variables.

$$LNYXF_t=5.051+0.437LY_t \quad (3)$$
(37.36)(23.96)

Its residual calculation formula is:

$$e_t= LNYXF_t-5.051-0.437LY_t \quad (4)$$

The coefficient of determination $R^2=0.944$ of Eq.3 indicates that real GDP has strong explanatory power on energy consumption. The coefficients preceding the explanatory variable LY_t is 0.437, and the corresponding t value is very significant, but the DW value is 0.215, indicating that the residual sequence of the equation exists the first-order sequence correlation, while the equation may exist pseudo-regression phenomenon. Then, the stability of the residual sequence can be verified to determine whether there is a co-integration relationship between $LNYXF_t$ and LY_t (Johansen, 1991). If the residual sequence is stable, that shows that there is a cointegration relation between $LNYXF_t$ and LY_t. Therefore, it is necessary to carry out unit root test of residual sequence. We use ADF to test the residual sequence of Eq.3, and in the ADF Stationary Test, the selected test equation does not include intercept term and time trend term. The test results are shown in *Table 5.*

Table 5. ADF test of residual sequence

Variable	ADF value	1% critical value	5% critical value	10% critical value	P value	Test results
e_t	-2.088	-2.637	-1.951	-1.61	0.037	smooth

As can be seen from *Table 5*, at 5% significance level, the residual sequence is stationary, indicating that there is a long-term equilibrium relationship between $LNYXF_t$ and LY_t. In order to eliminate the self-correlation of the residual term in Eq.3, the Lagrangian (ARDL) model of $LNYXF_t$ and LY_t variables can be obtained by adding appropriate hysteresis.

In order to obtain the reasonable order of the ARDL model, we set the maximum lag order of the two variables to 6 order, and use the AIC criterion to judge the optimal hysteresis order of the model. The value of the AIC corresponding to the 20 models that used to select the specific lag order of the distribution hysteresis model is presented in *Figure 3*.

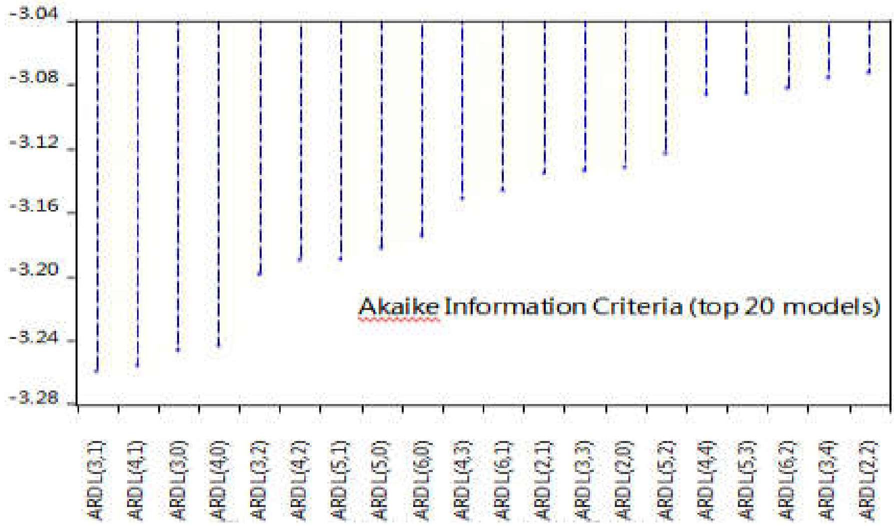

Figure 3. Numerical value of AIC information criterion in ARDL model

The results shown in FIG. 3 illustrate that in the selection of the lag order of the ARDL model, the AIC value corresponding to the ADRL (3,1) model is the smallest. Thus, the ARDL model results are as shown in Eq.4.

$$LNYXF_t=0.889+0.847LNYXF_{t-1}+0.429LNYXF_{t-2}-0.448LNYXF_{t-3}+0.568LY_t-0.5LY_{t-1} \quad (4)$$

(2.086) (4.959) (1.746) (-2.801) (2.504) (-2.146)

$R^2=0.989$ $F=489.34$ $DW=1.915$

In Eq.4, the DW value is equal to 1.915, and the residual autocorrelation is eliminated. It is further determined that there is a long-term stable relationship between $LNYXF_t$ and LY_t. They belong to (3,1) order cointegration, and Eq.4 is their long-term stable equilibrium relationship. From the ARDL model we conclude the long-term cointegration equation as shown below.

$$LNYXF_t=5.181+0.393LY_t \quad (5)$$

Eq.5 shows that the elasticity coefficient of energy consumption of real GDP in Jilin province is 0.393 in terms of long-term co-integration.

Granger causality test between energy consumption and real GDP of Jilin Province

There exists long-term cointegration relationship between energy consumption and real GDP of Jilin Province in the long term, but whether a causal relationship between them (Bruns, Gross, & Stern, 2014). If there is a causal relationship, whether the economic growth leads to energy consumption or energy consumption stimulates economic growth, need further verification. The Granger causality test method is used for the analysis, and the specific test results are shown in *Table 6*.

Table 6. Granger causality test between LNYXFt and LYt

Zero hypothesis	Lag phase	F statistic	P value	Test result
$LNYXF_t$ is not LY_t Granger cause	4	2.108	0.113	Do not refuse
LY_t is not $LNYXF_t$ Granger cause	4	3.114	0.034	refuse

It can be seen from *Table 6* that the optimal lag period is 4 years, and the variable $LNYXF_t$ is not the Granger cause of the variable LY_t, while LY_t rejects the original hypothesis in the case of lagging 4 times, that is, LY_t is the Granger cause of the variable $LNYXF_t$. This indicates that the economic growth of Jilin province has led to the growth of energy consumption in the province. The results of the Granger causality test further illustrate that the mode of economic growth in Jilin Province is the model of extensive economic growth with high energy consumption and high investment.

Conclusion

The paper empirical analyzes the relationship between energy consumption and economic growth in Jilin Province by using the data of energy consumption and real GDP growth in Jilin Province. The results of the breakpoint regression of energy consumption in Jilin province show that the change of elasticity coefficient of energy consumption in Jilin province is divided into three periods. The energy consumption elasticity coefficient of the first time period (1978-1989) is the highest. The energy consumption elasticity coefficient of the second time period (1990-1997) is significantly lower than the first time period, and the third time period (1998-2013) energy consumption elasticity is close to the first time period. The above explanation indicates that the economic development of Jilin Province is mainly driven by heavy energy and other heavy chemical industry.

The study of long-term co-integration relationship between energy consumption and economic growth in Jilin province shows that energy consumption in Jilin province has long-term co-integration relationship with economic growth. The study of the relationship between the two models with the distributed lag model indicates that ADRL(3,1) is a model with good fitting effect. This indicates that energy consumption itself in Jilin province has a three-year lag effect, which is basically in line with the period of construction of general high energy consumption projects.

The long-term cointegration relationship derived from the ARDL (3,1) model shows that the growth per unit of GDP drives 0.4 units of energy consumption in Jilin Province. It is more definite that the economic growth is the root cause of energy consumption in Jilin Province by Granger causality test. In the meantime, it also illustrates the necessity of transforming the pattern of economic growth in Jilin province. More specifically, the inputs of the simple expansion of the extensive economic growth model in Jilin province should be transformed into intensive economic growth model that focus on the factors of production quality and mainly driven by technological innovation.

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