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Co-integration Analysis on the Relationship between Methane Energy Development and Economic Growth in the City of Huixian

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Abstract Based on the statistical data of Huixian from 1992 to 2010, we analyze the long-term and short-term relationship between Huixian's methane energy development and GDP by using co-integration test and error correction model. The empirical results show that there is a long-term equilibrium relationship between methane energy and GDP in the city of Huixian, and which is the one-way Granger causality of methane and GDP. In conclusion, the paper puts forward some steps about spurring economic growth, methane development and utilization in Huixian.

Key words Methane energy, Economic growth, Co-integration analysis, China

Methane, as the clean energy and at the same time the recyclable chains of connecting resources of breeding and planting, has been paid more and more attention by all governments and becomes the key point in promoting the local economy and new-countryside construction in many areas. Therefore, researchers both at home and abroad have studied a lot on methane. Pallav Purohit made a technical and economic evaluation on the pumping watering systems which is based on methane. By evaluating the retrieving cycle, the pure values of the system, Pallav Purohit analyzed the situations of investment and profits^[1]; B. Amigun, *etc.* discussed the scaled economic profits of different types of methane tank with statistics from year of 1995 to year of 2005^[2]; Based on analyses, Hari Katuwal put forward that the construction of methane tank not only brings new energy for peasants, but also promotes the development of breeding and planting. And at the same time, it promotes the increment of peasants' income^[3]; By analyzing the construction projects of rural biological energies of Henan Province loaned by Asian bank, SHEN Lianfeng *etc.* concluded that the construction of methane system largely cuts down the consumption on traditional energies and the costs on traditional energy consumption. The construction of methane systems highly improves the economic incomes of farmers' breeding and planting industries^[4]; LIU Yezhi concluded with cost analysis that the economic profits of comprehensive usages of methane are obvious and worthy of promotion^[5]; According to TANG Yunchuan *etc.*, by using methane energy, farmers may create a value of from 559 to 938 Yuan and reduce forest land of 0.314 hm²^[6].

Obviously, it is acceptable to researchers both at home and abroad that methane energy could bring economic values. While, researches on the mutual relations between the exploitation and uses of methane energy and the economic rise are not

abundant. Therefore, under this circumstance, the author tends to make an empirical analysis on the relationship of the methane energy and economic development in Huixian City, exploring whether there are co-integration relationship and causal relationship existing.

1 Variables selection, data resources and research methods

1.1 General conditions of research areas Huixian City lies in north-west part of Henan Province, with north to Taihang mountain. It has a total area of 2 007 km² with a complicated hilly geography. And the hilly geography covers 70% of the total area. Huixian City has 22 towns and counties, 533 administrative villages, 220 000 households with a total population of 672 000 people and a total cultivation land of 57 500 hm². In 2010, the yearly output of crops is 526 000 tons, 20 000 tons of a total output of oil, 399 000 tons of a total output of vegetables, 85 000 tons of a total output of meats, 73 000 tons of a total output of eggs, 16 000 tons of a total output of milk. Obviously, it is a typical agricultural city.

In 2003, Huixian City has been officially selected as the project city which is loaned by Asian bank to carry out construction of rural biological energy, for 6 years having operated the project of government-supported methane tank. At present, the whole city has 49 159 methane tanks, 9 methane projects, 578 medium and small sized breeding methane projects, 200 four-in-a-whole green houses, 260 three-in-a-whole recyclable modes; the city has formed the development mode which is clustered with large sized methane projects, medium and small sized breeding places with gas and methane supplying, different kinds of modes, such as four-in-a-whole, three-in-a-whole, successive mending on tanks, methane electricity, methane cooking, keeping warm of pig shelter, lightening and air refreshing of green houses, energy daily life and comprehensive recyclable uses of methane and so on.

As the typical agricultural city and at the same time, the project city of biological construction supported by Asian bank, Huixian City has received lots of supports from all aspects. It gains fast development which can be viewed as an impressive symbol. Therefore, the paper selects Huixian City as the experimental zone, discussing the mutual relationships of which to the economic development during the development process.

1.2 Variables selection and data resources 2 variables are selected as the research objects. Among which, the GDP of Huixian City is used to reflect the economic development and the gas products of methane tanks Q is used to show the development and uses of methane tanks. The sample period is from the year of 1992 to the year of 2010. Among which, statistics of the GDP of Huixian City from 1992 to 2009 are from *Statistical Yearbook of Henan*^[7]. And statistics of 2010 are from the *Statistical Reports of the State Economic and Social Development of Huixian City in 2010*^[8]. Statistics of methane outputs are

Table 1 The total output of methane and local GDP from 1992 to 2010

Year	$Q//m^3$	GDP// $\times 10^8$ Yuan	Year	$Q//m^3$	GDP// $\times 10^8$ Yuan	Year	$Q//m^3$	GDP// $\times 10^8$ Yuan
1992	114 380	11.087 2	1999	589 000	37.138 2	2006	12 316 580	88.383 8
1993	159 980	17.883 7	2000	703 000	40.406 4	2007	14 286 980	104.679 7
1994	215 080	22.086 3	2001	1 120 000	44.608 6	2008	17 373 640	126.139 0
1995	271 700	26.150 2	2002	1 310 000	49.337 2	2009	20 817 200	146.447 4
1996	342 000	30.700 3	2003	4 117 260	56.047 0	2010	22 298 000	174.565 2
1997	418 000	30.945 9	2004	6 987 940	64.622 2			
1998	494 000	33.762 0	2005	9 799 940	75.220 2			

1.3 Research methods Co-integration theory and Granger's causal testing are adopted to analyze the relationship between energy using and economic development of Huixian City. In order to avoid the fake rising phenomenon brought by the retrieving timely order, the author tests firstly the timely order with steady co-integration and Granger causal empirical tests, mending the variation modes to explore the relations between the two variables.

2 Conclusion and analyses

2.1 Stability test In order to avoid the fake rise of variables brought by the instability of time series, the stability tests should be firstly done on the time series of the chosen variables. The stability of a sequence refers to a situation whether the averaging values, the variation and the co-integrated variance are stable or not. If a time series has stable averaging

from statistics tidied by agricultural department of Huixian City. The statistics of the total outputs and local methane production of Huixian City from the year of 1992 to the year of 2010 are in the following table (Table 1). In order to keep the consistency of the statistics, dealing with the statistics of GDP through GDP deflator to clear influences of fluctuation. At the thought of the transforming of natural logarithms could erase the severe fluctuations of economic statistics caused by timely arranging and making the statistics reflecting in a linear trend, at the same time, the transforming of natural logarithms could get rid of the possible existed different variations without changing the steady balanced by timely arrangement. So, adopt the GDP deflator on each variables. After transforming, $\ln GDP$ and $\ln Q$ are used to express the transformed statistics. The processing of statistics are realized generally through the SPS of micro-soft Eviews6.0.

values, variation and co-integrated variation, then this kind of series is stable, or it is not. The test methods are the following kinds. Such as the roots tests of Phillips-Person (PP), Augment Dickey-Fuller (ADF), KPSS and ERS and so on. The author makes the unit root tests on all variables with the most generous adopted method ADF and the lagging numbers are selected with AIC standards^[9].

Before the tests, it is necessary to make the linear charm of $\ln Q$ and $\ln GDP$ (Fig. 1) and the scattered points charms of $\ln Q$ and $\ln GDP$ (Fig. 2). From Fig. 1, it can be affirmed that it is not steady. While the first series of which (Fig. 2) becomes steady. And then adopt ADF test mode and carry out the stability tests on $\ln Q$ and $\ln GDP$ with micro-soft Eviews6.0 respectively. Then the test results are in the following Table 2.

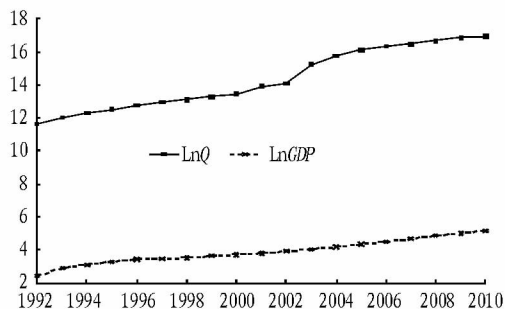


Fig. 1 Trends of $\ln Q$ and $\ln GDP$

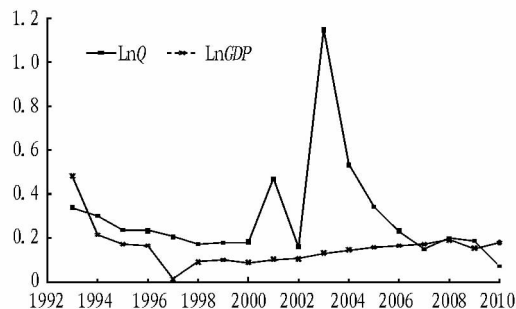


Fig. 2 Trends of $\Delta \ln Q$ and $\Delta \ln GDP$

Table 2 Test results of ADF unit root

Variables	ADF value	5% boundary values	10% boundary values	Test forms (c, t, k)	Test results	Single number
lnGDP	-3.352 7	-3.690 8	-3.286 9	(1, 1, 0)	Instable	The first single number
Δ lnGDP	-3.268 7	-1.962 8	-1.606 1	(0, 0, 0)	Stable	The first single number
lnQ	-2.557 8	-3.733 2	-3.310 3	(1, 1, 2)	Instable	The first single number
Δ lnQ	-3.176 4	-3.052 2	-2.666 6	(0, 1, 0)	Stable	The first single number

Note: *C* and *T* refer respectively the absolute terms and time series terms (0 referring to without and 1 referring to with) which are decided by the obvious features in the tests; *K* refers to the lagging feature of the figures which are selected with the Akaike information standards (AIC); *D* refers to the first variations.

From Table 2, it can be concluded that the horizontal series variables of lnGDP and lnQ cannot exist without the unit roots assumption, that is they averagingly have a unit root on the level of 5% which are instable first single process; while their first variance variables exist without the unit roots assumption, that is Δ lnGDP and Δ lnQ have not unit roots on the level of 5%. Therefore, the first variance series of Δ lnGDP and Δ lnQ are I (0). Based on these results, whether there are co-integrated relations between the two variables can be further checked.

2.2 Co-integration test Co-integration test means that if 2 or more than 2 variables were instable in time series, while their some kind of linear groups showing stability, then these variables would have long-term stable relation, that is co-integration relation. The author adopts E-G two-steps method to carry out the co-integration tests^[10]. It means that if the 2 time series were the same first single number, retrieving both of them. If the freely selected items are stable, it would be concluded that the two variables are co-integrated that is between the both of which and there is long-term stable relation existed.

Imaging that lnGDP is the variables to be analyzed and lnQ

Table 3 Results of Granger causal tests

The original assumption	F statistical figures	The ratio of accepting the original assumption	Lagging coefficients	Test conclusion
lnGDP not having the causal relation to lnQ	0.018 8	0.892 9	1	Accepted
lnQ not having the causal relation to lnGDP	17.901 6	0.000 7	1	Refused
lnGDP not having the causal relation to lnQ	0.084 8	0.919 2	2	Accepted
lnQ not having the causal relation to lnGDP	1.257 6	0.319 3	2	Accepted

From Table 3, it can be concluded that during the period of lagging coefficient keeping 1, the use of methane energy of Huixian City is the reason why the local economy rises. While the rise of economy is not the Granger cause of the further development of methane energy. Therefore, the uses of methane energy can promotes the development of farmers' breeding and planting industries and finally promotes the development of economy. When the lagging coefficient is smaller than 1, the uses of methane energy of Huixian City do not have Granger causal relations to the GDP.

2.4 Variation repairing mode According to Granger theory, if a group of variables has co-integration relations to each other, the co-integration regression can be transformed to the ECM. The co-integration among variables of time series only reflects the long-term balanced relations among them. However, ECM not only can reflect the long-term balanced relations among different variables of time series, but also reflect the mechanisms of short-term deviance from a long-term balanced

the variables used to explain others, analyzing with the smallest multiplication and the retrieving results are in the following:

$$\ln GDP = -1.685 2 + 0.388 1 \ln Q$$

$$\text{In the formula, Adjusted } R^2 = 0.937 7; DW = 0.520 3$$

Having (c, t, k) unit roots test on the variance series of the formula e based on the form of (0, 0, 0), the value of ADF is -2.470 9; the boundary values of 5% and 10% are -1.961 4 and -1.606 6. The test results show that the variance series refuse the original assumption at the obvious levels of 5% and 10%, accepting the conclusion that there is no unit root. It is a stable series which prove a fact that there is long-term stable balanced relations between lnGDP and lnQ which can be explained by each other.

2.3 Granger causal tests Because the Granger causal tests are very sensitive to the lagging coefficients, the author adopts the method of selecting many lagging coefficients to see whether there would have the same results. The results of the Granger causal tests on the methane energy uses and the increment on the local outputs in the rural areas of Huixian City are in the Table 3.

variables. So, the construction of ECM is to make up for the long still modes by constructing the short-term dynamic modes^[11]. According to the variance series calculated with the above formula, construct the ECM. And the ECM of this variance is in the following mode:

$$\Delta \ln GDP_t = 0.098 0 + 0.005 4 \Delta \ln Q_t + 0.234 9 \ln GDP_{t-1} - 0.140 6 ECM(-1) \quad (2)$$

From formula (2), it can be concluded that the short elasticity of lnGDP to lnQ is 0.005 4, that is in the short term, the every increasing of 1 percent could promote the development of economy by 0.005 4 percent. Among which, the coefficient of the variance repairing formula is negative which is consistent with the opposite mechanisms; the positive coefficient of the formula shows that when the short-term fluctuation deviates from the long-term balanced situation, the unbalanced situation would be draw back with a force of -0.140 6 to the balanced situation.

3 Conclusions and suggestion

3.1 Conclusions Firstly, in a long term, the usages of methane energy of Huixian City has co-integration relations to the local total products. It is a fact showing that from 1992 to 2010, both of which share a stable and balanced relation with each other. The usages of methane energy contributes to the development of the local economy of Huixian City.

Secondly, in the short term of research, from a perspective of Granger causal tests, when the lagging coefficient is 2, the uses of methane energy of Huixian City is the reason why the local economy rises. While the rise of economy is not the Granger cause of the further development of methane energy, which means the methane energy has played an important role in the process of exploitation, having a significant role in restructuring the energy frame and promoting the development of economy.

3.2 Suggestion

3.2.1 Increasing the supporting efforts to promote the construction of methane energy. From the results of Granger causal tests, it can be concluded like this. Methane, as the recyclable energy, needs mostly the supports in terms of policies and capital of the State during the process of exploitation. Therefore, the local should take advantages of the internal and outer situations, the great chance of accelerating the construction of methane energy by the government to activate all kinds of forces, carrying out the construction of methane energy. The local should extend its coverage of methane using from a household to a comprehensive large scaled methane projects.

3.2.2 Taking advantages of promotion function of methane energy on the development of economy. On one hand, economic investment should be enlarged to further perfect the techniques of methane energy. If the energy efficiency is raised, the energy consumption is reduced; on the other hand, the biological agricultural construction with methane as the buttons should be promoted. The local should guide farmers to construct methane tanks comprehensively, using methane energy to cook, to breed, to flush and so on. At the same time, making uses of techniques to promote the methane cleaner and methane wastes, using methane fertilizer with the non-harm production areas, such as orchids, vegetables and crops, to make power, to keep foods sage and fruits fresh and so on;

feeding pigs with methane liquid, watering seeds, leaves fertilizer; adding fertilizer of methane wastes to flowers, feeding fishes and cultivating edible fungus and so on. The comprehensive methane functions should be made good uses of and the comprehensive uses degree should be further improved to raise farmers' incomes and finally promote the development of local economy.

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