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Empirical research on the relationship between biomedicine industry and economic growth of Jiangxi Province

Chunhai Tao

Jiangxi University of finance and economics,Nanchang, (P.R.CHINA)

ABSTRACT

Biomedicine industry is an emerging industry of Jiangxi Province, whose healthy development is of great significance for the development of regional economy in Jiangxi Province and optimization regional industrial layout. Under this background, this thesis use econometrics methods to study the relationship between biomedicine industry development and the economic growth in Jiangxi Province, which provides help to the government while formulating corresponding macroeconomic regulations and control policies. And biomedicine companies can invest with a better understanding of the current market environment too.

KEYWORDS

Biomedicine industry; Economic growth; Cointegration test; Granger causality test.

INTRODUCTION

Biomedicine industry is one of the most important and special industry in national economy which is closely related to economic development, social stability and people’s health. Over the years, the biomedical industry continues to develop at a high speed, which is known as a sunrise industry. There are many reasons for this, such as economic development, the natural population growth, population aging society, increasing advances in science and technology and health needs[1].

Since the reform and opening up, the development of China's biomedical industry is growing very rapidly. According to MIIT, in 2009, the total industrial output value of China's biomedicine industry exceeded one trillion yuan at the first time with a year-on-year growth of 21.1%, reaching 1.0382 trillion yuan. Its total industrial added value grew by 14.9%, higher than the national industry average of 3.9 percentage points, keeping a rapid growth rate. Among them, the development of biomedicine industry in Jiangxi is very remarkable. In recent years, biomedicine industry of Jiangxi Province continues to expand its scale, optimize the industrial structure, and form relatively complete system of medicine production. It already has high industrial competitiveness. In 2010, Jiangxi pharmaceutical industrial output value reached 36.55 billion yuan, ranking in the top ten in China. There are 53,744 relevant institutions and 186 drug manufacturing companies. Therefore, studying the effect of Jiangxi medicine industry in boosting economy has rich theoretical and practical significance.

METHODS SELECTION AND DATA PROCESSING

Methods selection

There are a lot of empirical researches on the relationship between national pillar industries and the relationship between economic growth, acquiring great achievement. Most scholars usually use appropriate index to build multivariate time series model[2]. In contrast, research on the relationship between biomedical industry and economic growth is still rare. The current studies are mainly about theoretical analysis which is based on industrial development theory and economic growth theory. Empirical studies are rare. Therefore, this paper use multivariate time series model to analyze the relationship between the development of the biomedical industry and the economic growth in Jiangxi Province.

Data resources and processing

GDP is the most important indicator reflecting the economic situation of a region. Although it neither take the population growth into account nor is a good measure of changes in the level of the people in real life, it can better describe overall economic development of Jiangxi[3].

For the development of biomedicine industry descriptions, indicators often be selected are biomedicine product sales, industrial output and so on. The industrial output value reflects regional biomedical industry production scale and production capacity, while sales of pharmaceutical products visually reflect the economic situation of total biomedical industry[4].

Taking into account the availability of data, the development of biomedicine industry and the economy situation of Jiangxi Province[5], this paper select the regional gross product as the indicator of economic development level from 1985 to 2012, and industrial output of pharmaceutical manufactures above designated size as the indicator of the development of biomedical industry in Jiangxi.

In order to eliminate the effects of price and get the real gross regional product, this paper take GDP index of Jiangxi province in 1985 as base period to adjust the value of regional GDP of Jiangxi. Also, industrial output of pharmaceutical manufacturing enterprises above designated size is adjusted according to the consumer price index in 1985.

TABLE 1 : Variables, symbols and their meanings in empirical analysis

variable	symbol	meaning
Gross regional product	GDP	Real GDP of Jiangxi

Industrial output	PI	Industrial output of pharmaceutical manufacturing enterprises above designated size in Jiangxi

EMPIRICAL ANALYSIS

Stationary test

Before analyzing time series, it is usually need to test the stationary of data firstly. A time series is stationary refers to the mean and variance of time series does not change with time. The impact of any external shocks will temporarily for stationary time series, but can make the non-stationary time series to deviate from its mean value[6]. Regression modeling analysis based on non-stationary time series will lead to spurious regression. Unit root tests often used to determine whether the time series is stable. This paper use ADF unit root test (Augmented Dickey-Fuller test) which is the most common method.

Suppose an AR (P) model need to be ADF tested:

$$y_t = c + \alpha_1 y_{t-1} + \alpha_2 y_{t-2} + \dots + \alpha_p y_{t-p} + \varepsilon_t$$

There are three forms:

$$\Delta y_t = \rho y_{t-1} + \varepsilon_t \, ;$$

$$\Delta y_t = c + \rho y_{t-1} + \varepsilon_t \quad \Delta y_t = c + \rho y_{t-1} + \sum_{i=2}^{p} \phi_i \Delta y_{t-i+1}$$

Among them, $\rho = \left(\sum_{i=1}^{p} \alpha_i\right) - 1$; $\phi_i = -\sum_{i=i+1}^{p} \alpha_j$.

To test if AR (P) contains a unit root, only need to test whether the null hypothesis can be rejected. Rejecting the null hypothesis means that the model is stable, while accepting means AR (P) has unit root, not stable. The null hypothesis of the three form tests are same, but alternative hypothesis are different: the first is original sequence is a stationary sequence of zero mean, the second is stationary sequence but not zero mean, and the final one is original sequence is stationary sequence with time trend. Firstly, draw curve graph to determine which test model should be used:

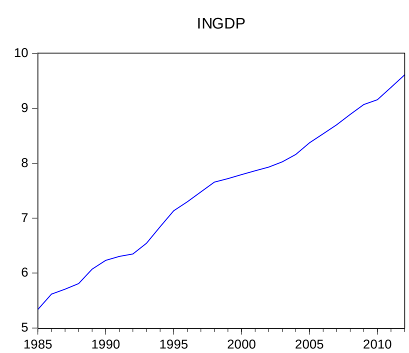

Figure 1 : LnGDP curve graph

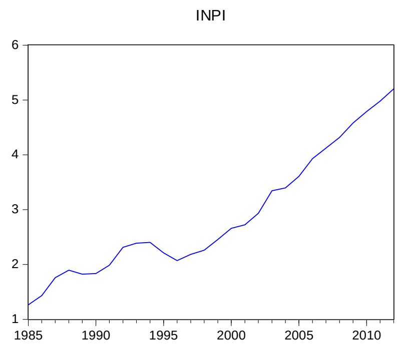

Figure 2 : LnPI curve graph

As can be seen from the above figures, the intercept of both graphs are not 0, and do not increase over time and fluctuate around zero value but a clear trend growth. Therefore, test model contain both trend and intercept (the third one) should be used to test the stationary of LnGDP and LnPI here. The test results are as follows:

TABLE 2 : Unit root test results

Variable	Test type (c, t, k)	ADF statistic	Thresholds		Conclusion
			5%	10%	
InGDP	(c, t, 1)	-2.164309	-3.595026	-3.233456	Non-stationary
InPI	(c, t, 1)	-1.250778	-3.595026	-3.233456	Non-stationary

As the result shows, the absolute values of the ADF test are both less than the threshold under the significant level of 5% and 10%, thus the null hypothesis can not be rejected. So LnGDP and LnPI have unit root and are not stationary time series. Differentiation treatment and co-integration analysis are needed. The ADF test results of difference series are as follows:

TABLE 3 : ADF unit root test results after differential

Variable	Test type (c, t, k)	ADF statistic	Thresholds		Conclusion
			5%	10%	
ΔInGDP	(c, 0, 0)	-3.120513	-2.981038	-2.629906	stationary
ΔInPI	(c, 0, 0)	-3.098560	-2.981038	-2.629906	stationary

As can be seen from the test results, the sequences do not have unit root under the significant level of 5% after differential, said one order integration.

Cointegration test

Traditional regression methods can only be used when all the variables are stationary sequences. When a variable sequence does not satisfy the requirements of stability, there are two ways to carry out further analysis generally.

One way is making original sequence into stationary time series through eliminating trend or doing difference. Other way is test whether there is cointegration relationship between non-stationary variable sequences. Cointegration relationship refers to several non-stationary time series can be linearly combined to a stationary series. If there is cointegration relationship between the variable sequences, these variables have a long-term balance relationship. Therefore, one can analyze this long-term balance relationship by estimating cointegration equation.

As known from the stationary test above, LNGDP and LNPI are both one order integration series that may exist cointegration relationship. To order to judge whether there is cointegration relationship between the two sequences, we need to do cointegration test. There are two ways: Johansen cointegration test and Engle-Granger two-step test method (EG test). Typically, Johansen test should be used when cointegration exist in several variables. EG test usually used when there are only two variables. Therefore EG test is more suitable here.

The null hypothesis of EG test is that there is no cointegration relationship between two variables. Firstly, build regression equation through ordinary least square method, and then test the regression residuals series. If the residuals series is stationary, then reject the null hypothesis, which means that the two variables have cointegration relationship.

The hypothesis of EG test can be expressed as:

Null hypothesis: There is no cointegration relationship between $LnGDP_t$ and $LnPI_t$.

Alternative hypothesis: There is cointegration relationship between $LnGDP_t$ and $LnPI_t$.

Suppose regression model:

$$LnGDP_t = \beta_0 + \beta_1 LnPI_t + \varepsilon_t$$

Estimate parameters in the model by least square method and obtain the residual sequence. The unit root test results of residual sequence are as follows:

TABLE 4 : The unit root test results of residual sequence ε_t

Variable	Test type (c, t, k)	ADF statistic	Thresholds		Conclusion
			5%	10%	
ε_t	(0, 0, 1)	-2.00410	-1.954414	-1.609329	stationary

The results show that, the residual sequence is a stationary series without unit root in the 5% significance level. Therefore, alternative hypothesis should be accepted as there is cointegration relationship between $LnGDP_t$ and $LnPI_t$. The regression results are as follows:

$$LnGDP_t = 4.216967 + 0.840919 LnPI_t$$

$$t = (31.21913)\ (24.10428)$$

$$R^2 = 0.96,\ F = 581.02,\ DW = 0.305276$$

$R^2 = 0.96$ indicates that the model fit very well, t =24.10428 shows that the development of bio medicine industry has a significant impact on GDP. At the 5% significance level, the lower limit and upper limit of DW statistic are 1.3 and 1.46 respectively. The DW statistic in model is 0.305276, less than the lower limit which means that the model exists autocorrelation. Residuals are fitted to meet AR (2), the equation is as follows:

$$\varepsilon_t = 1.25738\varepsilon_{t-1} - 0.475833\varepsilon_{t-2}$$

$$t = (6.652506)\ (-2.484192)$$

$$R^2 = 0.78$$

The results of generalized least square estimation of $LnGDP_t$ and $LnPI_t$ are as follows:

$$LnGDP_t = 4.75376 + 0.706517 LnPI_t$$

t = (14.64966) (9.385875)

p = (0.0000) (0.0000)

$$R^2 = 0.80, \ F = 88.1, \ DW = 1.56886, prob(F - statistic) = 0.0000$$

$R^2 = 0.80$ indicates that the explanatory variables explains most of the explained variable difference. t =9.385875 means that the development of bio medicine industry has a significant impact on GDP. At the 5% significance level, $1.45 < DW = 1.56886 < 2.73$, which means that autocorrelation is eliminated. This model shows that when other variables remain unchanged, log GDP will be affected in the same direction by a unit change of log biomedical industry output value on the number of changes 0.70651 units.

Granger causality test

The above model can only indicate the presence of stable relationship between LnGDP and LnPI in long term. In order to further analyze the causal direction of this relationship, Granger causality test should be applied. Principle of Granger causality test is that do the least square estimation of variables and their lag, and then do significant test of the lags' coefficients. If the lag of one variable has a significant impact on the current value of another, then this variable is Granger cause of the other, otherwise not. Because of the existence of cointegration relationship, Granger causality test is applicable. According to SIC minimum standards, lag period is 2, test results are as follows:

TABLE 5 : Granger causality test results

Lags	Null hypothesis	F statistic	P
2	InGDP does not Granger cause InPI	2.26782	0.1308
	InPI does not Granger cause InGDP	7.69973	0.0036

At the 5% significance level, the null hypothesis "InPI not InGDP Granger cause" doesn't pass the F test which means that growth of biomedicine industry in Jiangxi Province is Granger cause of the region's economic growth. While the null hypothesis "InPI not InGDP Granger cause" pass the F test, indicating that region's economic growth is not the Granger cause of the growth of biomedicine industry. Development of biomedicine industry promotes economic growth a lot, while economic growth does not promote the growth of biomedicine industry significant.

Error correction model

The existence of cointegration between two variables means the existence of a long-term stable relationship between the two, but in short term, LnGDP and LnPI are likely to have short-term fluctuations, deviating from the long-run balance. In order to explain the fluctuations, error correction model (ECM) links short-term fluctuation and long-term balance by adding a correction term into the cointegration model. Assuming a first order error correction model:

$$\Delta LnGDP = \beta_1 \Delta LnPI - \lambda ECM_{t-1} + \mu_t$$

In the formula, ECM_{t-1} is error correction, $-\lambda$ is its coefficient which means the correction degree when variable fluctuate. Based on EG test, the step of building ECM is figuring out relationship about ECM and residual series, and then estimating the parameters in above model. The results are as follows:

$$\Delta LnGDP = 0.032271 - 0.42573ECM_{t-1} + 0.141047\Delta LnPI$$

t = (3.17367) (-3.923338) (2.078867)

$$R^2 = 0.435143,\ DW = 2.2$$

The regression in above model pass significant test. Error correction coefficient is negative, consistent with reverse revision mechanism. In this model, Jiangxi Province GDP fluctuations are divided into two parts: one is the short-term impact of the biomedical industry output caused by changes; the other part is the disequilibrium error deviate from GDP's long-run equilibrium.

On the one hand, short-term fluctuations in the biomedical industry output will cause fluctuations in gross regional product, the impact factor is 0.14, which means the adjustment of short-term fluctuations to GDP. On the other hand, bias in the previous period also have a significant impact on current GDP, error correction coefficient -0.42573 shows that when short-term fluctuations deviate from the long-term equilibrium, ECM will pull the non-balance state back to long-term balance by 0.42573. These show that, current GDP is not only affected by current changes of pharmaceutical output, but also affected by changes of the last phase of economic growth and pharmaceutical output. Jiangxi's regional economic growth is not only affected by short-term fluctuations in the biomedicine industry, but also by its regulation of long-term equilibrium relationship between GDP and the biomedical.

CONCLUSIONS AND SUGGESTIONS

Conclusions

There is a cointegration relationship between pharmaceutical manufacturing output and GDP in Jiangxi province. In the other words, it exists a long-term and stability relationship between the two. We find when log value of pharmaceutical manufacturing output increases every 1%, GDP will grow 0.71% according to cointegration model. This suggests that the development of biological medicine industry contribute to the regional economic growth a lot.

Through the Granger analysis, we find at the 95% significant level, the pharmaceutical manufacturing output growth of Jiangxi province is the cause of the regional economic growth, but the regional economic growth is not the main cause of pharmaceutical manufacturing growth. One reason is the current health care per capita consumption in Jiangxi province is still at lower level, and the demand for biomedical products is mostly rigid demand, so the development of the economy has little impact for the demand of the biological pharmaceutical products. Another reason is few resources of the whole economy allocate to the biological pharmaceutical industry in Jiangxi province. The results also show that the biological medicine industry in Jiangxi province has great market potential and have a broad development prospects. In view of the high input and output efficiency, it has high investment value.

Through the establishment of error correction model we find that in Jiangxi province, there is a dynamic equilibrium mechanism between pharmaceutical manufacturing output and economic output. The current regional economic growth is not only affected by changes in the current pharmaceutical manufacturing output, but also by the long-term relationship between last phase of economic growth and pharmaceutical output. Meanwhile, regional economic growth of Jiangxi province is not only affected by the biological medicine industry short-term fluctuations, but also by the adjustment regulation of long-term equilibrium relationship between GDP and the biomedical. It shows that in the short run, biological medicine products—a important manufactured goods—make a great contribution to the economy growth. In long term, biological medicine industry and regional economic influence each other in many aspects, and this mechanism makes them stability.

Suggestions

(1) Increase the scale of the biological medicine industry in Jiangxi.

Biological pharmaceutical enterprise can get capital investment by many ways through capital market operation. Large companies can merges or buy other enterprise directly to expand its scale. Middle size companies can also get resource by merging and acquisition to integrate the resource[7]. Government should increase the support of biological pharmaceutical industry, and provide financing convenience to enterprises. Meanwhile, government should take some policy to increase investment, pay attention to support high-quality enterprises, attract FDI and large companies from other provinces to establish factories in Jiangxi.

(2) Promote the development of biological medicine industry agglomeration in Jiangxi province.

Nowadays, biological medicine industry in Jiangxi province has already formed Nanchang-Yichun industry districts through the construction of six industrial bases. Government could use the experiment from these two areas to construct biomedical industry park, through which can expand and reinforce the development of biological medicine industry in Jiangxi province.

(3) Expand R&D investment of biomedicine industry in Jiangxi.

For enterprises, they should develop long-term development plan, and understand that technological innovation is the source of enterprise competitiveness[8]. So enterprises should enhance the attention and investment to the R&D. Government could set up some special funds to support the key research project of biomedicine enterprise.

(4) Cultivate professionals of biomedicine.

For enterprises, they can provide training system to their employees, and encourage them to enhance their capacity by some incentive mechanism. For the government, they could strengthen the construction of the department of biological medicine in colleges and universities to provide capital support to key disciplines. Government should also help construct cooperation relationship between biomedicine enterprises and universities.

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