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Research on Hysteresis Effects of Authorized Patent on the Development of Regional Economy in Hunan Province

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Abstract: This paper used Eviews6.0, the econometric software packages, to study the relationship between three kinds of authorized patents and the GDP changes of Hunan Province. The experimental result demonstrated three facts: firstly, the fitting result of simple regression model effects better than that of multiple regression model; secondly, authorized inventive patent plays a more important role in boosting economic growth than utility model patent and design patent; thirdly, most of authorized patent had hysteresis effect, and as the duration of lag adds, effects on economics increases.
Keywords: Authorized patent; GDP; Lagging Effect; Econometrics

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INTRODUCTION

DUAN Deng-chun, the president of the China Science-technology and Law Association, considered that intellectual property serves as an inexhaustible source of the continuous competitive power in enterprises. And we should create intellectual property with technological innovation, and reinforce the core competency of enterprises with intellectual property; intellectual property is a significant support in composing the core competency of a enterprise, the quantity and quality of which shows the competitive strength of the enterprise.[1] Patent is one of the important components of intellectual property. The promulgation of the Patent Law protects benefits of inventors, which allows them to use their own patent technology in public during the patent protection. Since the publishing of those patent technology avoid labor repetition, social resources has been allocated efficiently. These two functions of the Patent Law encouraged inventors to do their utmost to take part in the invention activity, and then push the human technique forward constantly.

1. LITERATURE REVIEW

Scholars both in China and abroad are doing research on the relationship between authorize patents and economic development, and the research is basically based on national macro level and industrial level. Foreign scholars including YS Chen and KC Chang(2010) used neural network technique to study the non-linear relationship between company performance and patent features in pharmaceutical industry. They measured pharmaceutical companies in three ways: the Patent HHI Index, Patent Citations Rate, and the most important field of technology (RPPMI) which is the Relative Position Patent Measure Index. The results show that the patent of HHI index and RPPMIT influence the corporate performance nonlinearly and monotonely. And the influence of patent citations has a nonlinear U-shape relation.[2]Albert G.Z. Hu and I.P.L. Png(2009) studied how patent right changes influenced economic in 54 manufacturing industry of 72 countries during 1981and 2000. Research shows that, in a general knowledge-concentrated industry, the increase of a patent-SD (equivalent to the gap between Spain and the USA) is related to the annual economic growth during 1991-1995 with the added value of 0.69%. This result is one-sixth of the average industrial added value during 1991-1995.[3] Iain M.Cockburn, et al(2010) found that if internal permitted companies has a system of patents, more and higher interests will be earned. The effect that sporadic patents gave to innovations depends on the size of companies' patent combination.[4] Tapio Palokangas(2009) thought that the increase of the length and width of patent will decrease the rate of economic growth. For enterprises which hold patents, if they are more patient and unwilling to take risks, the length will be longer and width narrower.[5]

In this respect, domestic scholars also concentrate on studying macroscopic and industrial fields. JU Shucheng(2005) used Granger Causality Test and regression analysis to make a empirical study on the economic growth of China. The result showed that there is no obvious causal relationship between the economic growth and patent output; during 1985-2002, the contribution rate of patent output is about 17.87%, which shows that in some extent the patent output boosts our economic growth, but the effect is quite limited.[6] ZHANG Jihong(2007) utilized three models and some data to do empirical analysis. Models including the Spatial Autocorrelation Moran Exponential Model, Spatial Lag Model and Spatial Error Model are utilized to do the research. And the data contains the total number of authorized patent in province, three kinds of authorized patent and economic growth figures. In order to analyze the relationship between the innovation patent in 31 provinces of China and regional economy growth, Zhang used the method of empirical analysis in spatial econometrics. And the research showed that in the 31 provinces of China, innovation patent and the composition of which has spatial dependence. And in the Geo Spatial, innovation patent also expresses a cluster phenomenon. However, only utility model and inventive patent has spillover effect. The innovation crossed the geographic boundary of administrative divisions and spill to districts nearby. In the composition of the patent which promoted our economic growth, the utility model and patent on invention made more contributions than the innovation of appearance design.[7] ZHANG Wei (2008) checked the relation between the R&D input and patent output in Zhejiang Province by using empirical data. Research showed that different subjects of research input have different effect on patent output. And this kind of difference not only showed the benefit mechanism that input subjects had in each level, but also showed the fundamental defect of the original patent output system. Further research suggested that the difference mentioned above would obviously effected the regional industry economic growth.[8] CHEN Wei and YU Liyan (2009) studies the situation of patent development in 34 provinces of China basis on the factorial analysis. The result showed that the development level of regional patent has certain relationship with economic growth, but this relation was relative rather than absolute. Different area would have various comparative advantages. In that case, in areas that share an average level may get different advantage, and on the contrary, areas of different levels may get the same advantage.[9]

From the view of three kinds of authorized patent in Hunan Province, this paper will study the impact that authorized patent in different period had on Hunan's economy growth. And meanwhile, compare effects that the three kinds of patent brought to the economy horizontally.

2. THE RELATIONSHIP BETWEEN THREE KINDS OF AUTHORIZED PATENT AND THE GDP OF HUNAN PROVINCE

The author selected statistic data, which are related to three kinds of authorized patent figurea and the GDP of Hunan province during year 1990 to 2009.The data displayed in chart 1was originated from government websites of State Intellectual Property Office, National Bureau of Statistics and the Statistics Bureau of Hunan Province.

The data in table 1 evidently illustrates that:

(1) From 1990 to 2009,the amount of those three kinds of authorized patent in Hunan province achieved an obvious promotion. The amount of Inventive Patent, Utility Model Patent and Appearance Design Patent increased from 48 pieces, 1016 pieces, 62 pieces to 1752 pieces, 4218 pieces and 2399 pieces respectively. By contrast, the GDP of Hunan province also ascended form 11.4 billion yuan in 1990 to 1293.069 billion Yuan in 2009.

(2) Changes on the amount of those three kinds of authorized patent experienced a fluctuate process year by year rather than a stable increasing one. This can be easily found in year 2003. The amount of invention patent decreased from 1600 pieces in 2002 to 346 pieces in 2003. The amount of Utility model dropped from 3689 pieces in 2002 to 1888 pieces in 2003. However, the GDP of Hunan province surged from 415.154 billion Yuan to 465.999 billion Yuan. Thus, it is obvious that the authorized patent is not the only factor influencing the GDP of Hunan Province. There exist many other factors which affect the economic development in Hunan province. This paper only focuses on the effect that authorized patent have on the economic growth.

3. THE MULTIPLE REGRESSION ANALYSIS OF THE THREE KINDS OF AUTHORIZED PATENT NUMBER AND THE GDP OF HUNAN PROVINCE

3.1 The Normality Test of Random Errors

In regression analysis, we often make assumptions about random errors and explanatory variables in order to search for effective methods of parameter estimations and carry out statistical tests on models. The process of statistical tests is based on the assumption that Radom error U_t obeys normal distribution. We use residual error e_t to learn the normality of U_t.

Use Jarque-Bera test to examine whether the random error U_t obeys the normal distribution.

H_0: Residual error of total output value regression obeys normal distribution

H_1: Residual error of total output value regression is disobedient normally distribution

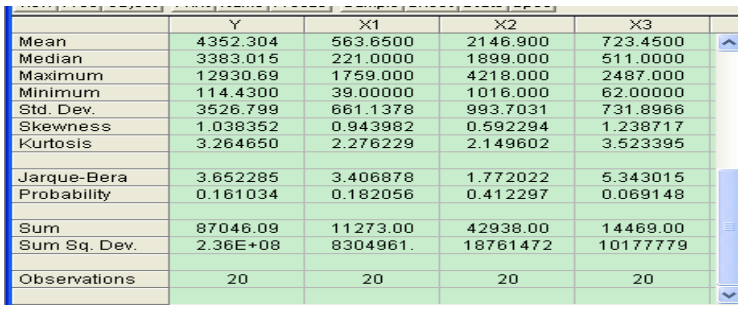
We carry out the JB test with the help of Eviews6.0 software and obtain the results as follow:

The results in Fig.1 shows that the coefficient of skewness $x1$ is 0.943982. The coefficient of kurtosis K is 2.278229. The value of statistic JB is 3.406878. As for significance level $\alpha = 0.05, \chi^2(2) = 5.99147$, we get $JB = 3.406878 < x2(2) = 5.99147$. This means that the statistic JB statistic which come from calculating is not significant. Therefore, we should not reject null hypothesis, which illustrates that the residual error of total output value regression obeys normal distribution. In the same way, we can draw the conclusion that the residual error of X_2 and X_3 obey normal distribution as well.

Table 1
The Amount of Three Kinds of Authorized Patent and the Gross Value of Hunan Province in the Year 1990 to 2009

	2009	2008	2007	2006	2005	2004	2003
Inventive patent	1752	1196	735	581	533	436	346
Utility model	4218	3446	3438	2540	2137	1801	1888
Appearance design	2339	1491	1514	2487	989	1044	941
GDP (billion Yuan)	1293.07	1115.664	914.5	749.317	647.361	564.194	465.999
	2002	2001	2000	1999	1998	1997	1996
Inventive patent	1600	1730	1759	96	70	66	40
Utility model	3689	3100	2595	1910	1261	1174	1023
Appearance design	589	505	599	517	292	247	193
GDP (billion Yuan)	415.154	383.190	355.149	321454	302.553	284.927	254.013
	1995	1994	1993	1992	1991	1990	—
Inventive patent	51	56	93	46	39	48	—
Utility model	1318	1486	2431	1441	1026	1016	—
Appearance design	146	78	242	85	109	62	—
GDP (billion Yuan)	213.213	165.002	124.471	82.457	41.479	11.443	—

Note: Data sources from
The statistics annual report of SIPO (the State Intellectual Property Office) http://www.sipo.gov.cn/sipo2008/tjxx/
National Bureau of Statistics http://www.stats.gov.cn/zgjjpc/cgfb/t20060317_402311312.htm
The data is from statistical yearbook of Hunan province in year 2007~2009



	Y	X1	X2	X3
Mean	4352.304	563.6500	2146.900	723.4500
Median	3383.015	221.0000	1899.000	511.0000
Maximum	12930.69	1759.000	4218.000	2487.000
Minimum	114.4300	39.00000	1016.000	62.00000
Std. Dev.	3526.799	661.1378	993.7031	731.8966
Skewness	1.038352	0.943982	0.592294	1.238717
Kurtosis	3.264650	2.276229	2.149602	3.523395
Jarque-Bera	3.652285	3.406878	1.772022	5.343015
Probability	0.161034	0.182056	0.412297	0.069148
Sum	87046.09	11273.00	42938.00	14469.00
Sum Sq. Dev.	2.36E+08	8304961.	18761472	10177779
Observations	20	20	20	20

Figure 1
Descriptive States/Common Sample

3.2 The Scatter Diagram Analysis on the Authorized Patent Number and Total Output Value

Generally, we use scatter diagram analysis to judge the function type of the models. The scatter diagram of data provides guidance for the setting of theoretical model. [10]From the scatter diagram about $X1, X2, X3$ and y below we could apparently see that this provide us a linear relation between the authorized patent number and the GDP.

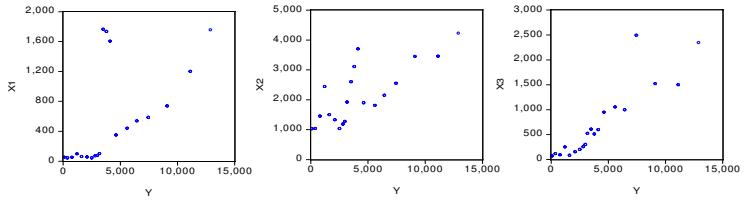


Figure 2
The Scatter Diagram of the Three Kinds of Authorized Patent and the GDP of Hunan Province

Therefore, we can set the model of Hunan's GDP and the amount of authorized patent as follow:

$$y_t = b_0 + b_1 x_1 + b_2 x_2 + b_3 x_3 + u_t \tag{1}$$

3.3 The Regression Analysis of Three Kinds of Authorized Patent and Total Output Value

According to the random error test and scatter diagram analysis above, we determined the feasibility of using Eviews analysis and the form of models. We process regression analysis by putting the data of three kinds of authorized patent and GDP into Eview6.0. The results are displayed in Fig.3:

View | Proc | Object | Print | Name | Freeze | Estimate | Forecast | Stats | Resids

Dependent Variable: Y
Method: Least Squares
Date: 08/28/10 Time: 09:23
Sample: 1990 2009
Included observations: 20

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-424.2391	1087.490	-0.390108	0.7016
X1	-0.149573	0.994758	-0.150361	0.8824
X2	1.139534	0.793783	1.435574	0.1704
X3	3.337321	0.650716	5.128693	0.0001

R-squared	0.856514	Mean dependent var	4352.304
Adjusted R-squared	0.829610	S.D. dependent var	3526.799
S.E. of regression	1455.803	Akaike info criterion	17.58136
Sum squared resid	33909788	Schwarz criterion	17.78051
Log likelihood	-171.8136	Hannan-Quinn criter.	17.62023
F-statistic	31.83634	Durbin-Watson stat	1.586476
Prob(F-statistic)	0.000001		

Figure 3
Regression Analysis Results of Three Kinds of Patent Licensing and GDP in Hunan Province

(1) The results of estimation model are as follows:

$Y_t = -424.2391 + -0.149573x_1 + 1.139534x_2 + 3.337321x_3$

$s = (1087.490)(0.994758)(0.793783)(0.650716)$

$t = (-0.390108)(-0.150361)(1.435574)(5.128693)$

$R2 = 0.856514 \text{Adjusted} R^2 = 0.829610 F = 31.83634 S.E = 1455.803$

(2)Economic significance test of the model

The regression coefficient estimates $b1 = -0.149573 < 0$, which indicates that the amount of authorized patent and GDP are in adverse proportion. Once a new patent was authorized, the GDP of Hunan province will reduce 14.9573 million Yuan, and other conditions remain stable. **Obviously, it doesn't fit the realistic economic development circumstances.** The regression coefficient estimate b2=1.139534, which illustrates that GDP in Hunan province will increase 113.9534 million yuan when a new utility model patent was authorized. The regression coefficient estimate b3=3.337321, which illustrates that the GDP of Hunan province will increase 333.7321 million yuan when the amount of practical design patent increases one. According to the two latter data, design patent make greater contributions to economic growth than utility model.

(3) The standard error evaluation of regression equation

The standard error evaluation of regression equation S.E=1455.03, which shows that the average error of the regression equation and each observation points is 1455.803 yuan. **Apparently, we get a larger error**.

(4) Test of goodness of fit

The adjusted integrated goodness Adjusted R2=0.829610, which shows that the explanatory power of regression equation is 82.96%. This means that the amount of three kinds of authorized patent could explain about 82.96% changes of the GDP in Hunan province. The fitting results of regression equation are basically good.

(5) The overall model significance test

From the whole influences of all factors we know that on the significant level of 5%, $F = 31.83634 > F0.05(k, n-k-1) = F0.05(3, 16) = 3.24$), which indicates that the amount of three kinds of authorized patent have significance influences on Hunan's GDP. This could also be found from P=0.000001, which shows that as long as the significance level is greater than 0.001%, the influence on GDP is obvious.

(6) Single regression coefficient test

From the influence caused by single factor, we will see that on the significant level of 5%, $|t(b_1)| = 0.150361 < T0.025(n-3) = t0.025(20-3) = t0.025(17) = 2.1098$. It indicates that the influences on GDP caused by patent are not obvious. In the same way, $|t(b_2)| = 1.435574 < t0.025(17) = 2.1098$, so the influences on GDP caused by utility model is not obvious, either. And we could also see that $|t(b_3)| = 5.128693$, then the influences on Hunan's GDP caused by design patent isn't apparent.

(7) Autocorrelation test

$DW = 1.586476$, which shows that this model does not have the problem of autocorrelation.

(8) Model structure stability test

We could see from the equation fitting residual figure (Fig.4) that the residuals of 2006 crossed the lower bound. Therefore, the explained variable y and explanatory variables $x1$, $x2$, $x3$ may change with the change of social system, economic policies and the society.

In order to check the stability of model, since this model satisfies the classical assumed conditions, this text uses Chow test to analyze whether authorized patent and GDP of Hunan Province experienced an obvious diversity in the two periods of 2006. We used the Chow Breakpoint Test of Eviews6.0 to get the result. Result shown in Fig.5:

According to chart F, at the significant level of 1%, the critical value of F is 5.41(the molecular degrees of freedom is 4, and the denominator degrees of freedom is 12). As a result of that, we get the probability of $F \geqq 12.13642$ is less than 1%. Therefore, we can draw the conclusion that regression equation was different in the two periods of 2006, and it means that the regression equation experienced changes. This may be caused by economic policies of that period or other factors in Hunan province.

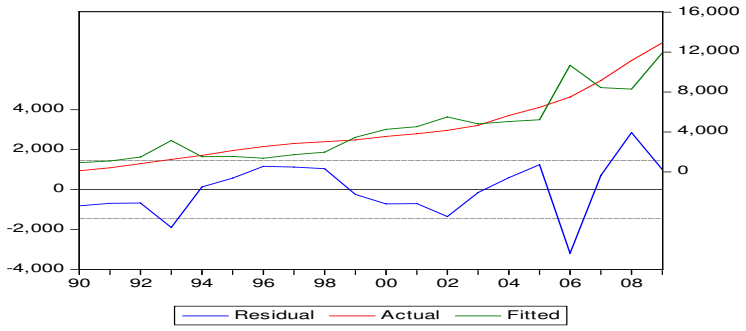


Figure 4
The Fitting Residual Plots

View | Proc | Object | Print | Name | Freeze | Estimate | Forecast | Stats | Resids

Chow Breakpoint Test: 2006
Null Hypothesis: No breaks at specified breakpoints
Varying regressors: All equation variables
Equation Sample: 1990 2009

F-statistic	12.13642	Prob. F(4,12)	0.0004
Log likelihood ratio	32.36982	Prob. Chi-Square(4)	0.0000
Wald Statistic	48.54566	Prob. Chi-Square(4)	0.0000

Figure 5
Chow Breakpoint Test

To sum up, the deviation between some of the indicators and the reality is quite large, and we didn't get a satisfied result of the multivariate linear model. Therefore, this text should use linear regression model to analyze the influences on GDP in Hunan province caused by authorized patent, utility model and design patent separately.

4. THE UNITARY HYSTERESIS REGRESSION MODEL ANALYZE OF THE THREE KINDS OF AUTHORIZED PATENT AND THE GDP OF HUNAN PROVINCE

In real economic life, as both of the decision making of economic entity and acting needs a certain process, and additionally, peoples' living habit would be limited by systems, technical conditions, expectation effect that related to economic and such factors, there usually exist a time-lag effect during the changing of economic variable.[10] And this paper suggest that authorized patent should also have hysteresis effect on the regional economy. For example, patent authorized this year would influence the economy next year or years after. The article would choose the design patent of inventive patent and utility model patent to offer data, and study the hysteresis effect that each of them brought to the GDP of Hunan Province.

4.1 The Lag Variable Model of Authorized Patent

Suppose the general form of Lag Variable Model is:

$$y_t = a + b_0 x_t + b_1 x_{t-1} + \ldots + b_k x_t - k + r_1 y_{t-1} + r_2 y_{t-2} + \ldots + r_p y_{t-p} + u_t \tag{2}$$

First, check the hysteresis effect of patent authorized amount. Use Almon method of estimation in EViews. Type Y C PDL(X1,k,r) in the quick estimate window, in which the x1 is the independent variable, k is the model of duration of lag, and r is the order of the coefficient polynomial. When k takes the value from 1 to 9, we will get different lag variable model. Through comparing the 9 values of Akaike and Schwartz information criteria, we could find that when k is 9, AIC=15.4, SC=15.5, the sum of AIC and SC is the minimum. Here, we take the number of periods k=9. Suppose the form of this model is:

$$y_t = a + b_0 x_t + b_1 x_{t-1} + \ldots + b_5 x_{t-9} + u_t \tag{3}$$

In consideration of the autocorrelation issues of the data that may exist, use fist-order difference to eliminate autocorrelation. Type ls Y C PDL(X1,9,1) ar(1) in the command window of Eview6.0, we will get the result as shown (Fig.6)

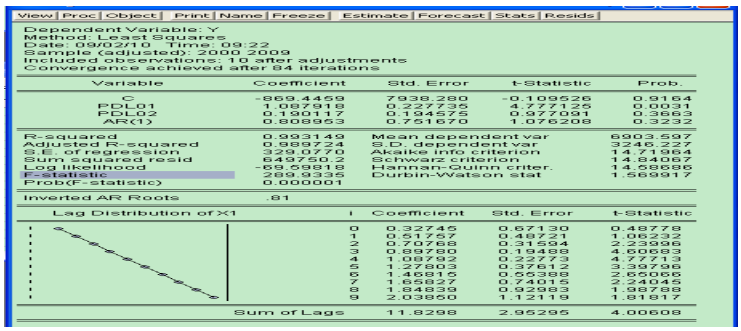


Figure 6
The 9th Period of Authorized Patent in Lag Variable Model

(1) the result of estimating model are as follow:

$Y = -869.445934197 + 0.327449432103 * X1 + 0.517566521375 * X1(-1) + 0.707683610647 * X1(-2) + 0.897800699919 * X1(-3) + 1.08791778919 * X1(-4) + 1.27803487846 * X1(-5) + 1.46815196774 * X1(-6) + 1.65826905701 * X1(-7) + 1.84838614628 * X1(-8) + 2.03850323555 * X1(-9) + [AR(1) = 0.80895322238]$

Limited by the page, Model S and the value of t were shown in Fig.6.

$R2 = 0.993149$ Adjusted $R^2 = 0.989724 F = 289.9335 S.E. = 329.0770$

(2) the economic significance check of the model.

The estimated value of regression coefficient b1=0.32745, which explains that the influence degree of authorized patent number of current period to the GDP of Hunan Province is only 0.32745. It means that when other conditions remain unchanged, the GDP of Hunan will increase 0.032745 billion yuan. And with the increase of the lagging period, the influence that authorized patent has on the GDP adds.

(3) the standard error evaluation of regression equation.

The standard error evaluation of regression equation S.E=329, it shows that the mean error of the regression equation and each observation points is 32.9 billion yuan.

(4) The test of goodness of fit.

After adjusting, the goodness of fit Adjusted R2=0.989724. It shows that the interpret ability of regression equation is 98.97%, which means that the authorized patent could explain 98.7% of the GDP change in Hunan Province. We get desirable result.

(5) The total significance test of the model.

From the total influence of all the factors, in the significance level of 5%, $F = 289.93 > F0.05(k, n-k-1) = F0.05(3, 16) = 3.24$, which means that the influence that authorized patent has on the GDP of Hunan Province is obvious and significant. We could see that from $p = 0.000001$, it shows that as long as the significance level is greater than 0.001? the influence is significant.

(6) Single regression coefficient test.

From the influence of single factor, on the significance level of 5%, $|t(b1)| = 0.48778 < T0.025(n-3) = t0.025(20-3) = t0.025(17) = 2.1098$, it shows that the influence authorized patent of current period has on the GDP is not significant. Similarly, $|t(b2)| = 1.06232 < t0.025(17) = 2.1098$, it shows that the influence of lagging period 1 is not significant, either. During the lagging period 3 to 7, the value of t is greater than 2.1098, which shows that the influence becomes significant. And period 8 to 9 turns to insignificant again. The coefficient of lagging period 9, $B9 = 2.03850$, it means that the influence of the 9th year is 2.03850. But $t9 = 1.81817 < t0.025(17) = 2.1098$, so the influence is not significant.

From the coefficient of each lagging period and the value of t we could find that from period 1 to 7, the influence increases with the lagging period, and decrease from period 8.

(7) Autocorrelation test.

DW=1.569917, which means that this model does not have autocorrelation.

(8) Model structure stability test.

From the figure of corresponding equation residual(Fig.7) we could see that the residual value is between the upper and lower bound, that means the stationarity meet the request.

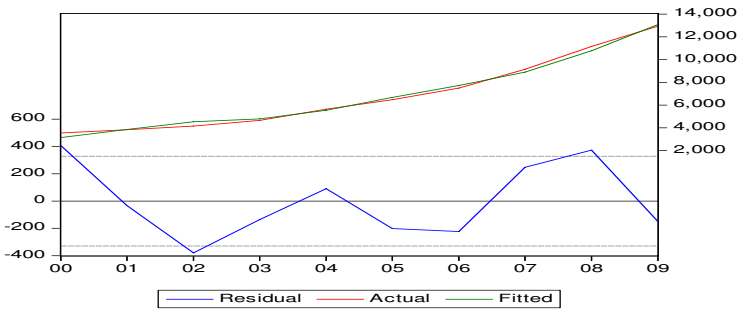


Figure 7
The Residual Figure of Authorized Patent

4.2 The Lag Variable Model of Authorized Patent for Utility Model

The result of estimating model as follow:

$Y = -7077.91199437 + 0.0257064985768 * X2 + 0.181866161632 * X2(-1) + 0.338025824688 * X2(-2) + 0.494185487744 * X2(-3) + 0.650345150799 * X2(-4) + 0.806504813855 * X2(-5) + 0.962664476911 * X2(-6) + 1.11882413997 * X2(-7) + 1.27498380302 * X2(-8) + 1.43114346608 * X2(-9)$

As we know that LS Y C PDL(X2, 9, 1) , the calculated results shows in Fig.8.

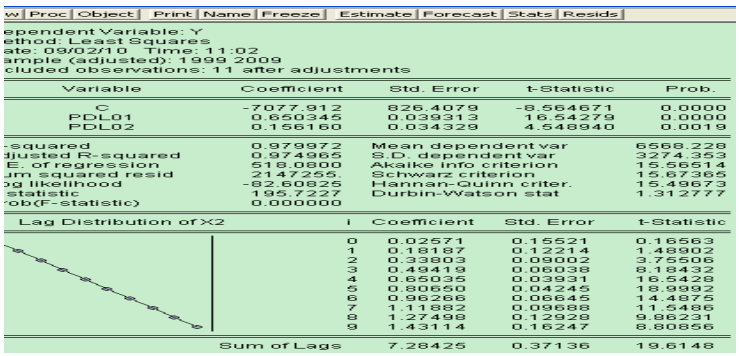


Figure 8
The 9th Period Lag Variable Model of Authorized Patent for Utility Model

What needs to explain is that the authorized patent for utility model of current period $t = 0.16563 < T0.025(n-3) = t0.025(20-3) = t0.025(17) = 2.1098$. It shows that the authorized patent of current period have no obvious effect on Hunan's GDP. Besides, the effect of that in the previous year is not significant either (1.48902). The other indicators, including economic significance test and statistical indicator test seem to be quite ideal. Due to space limitations, the illustration of the specific indicators could consult the steps of patent authorization, details are omitted here.

4.3 The Lag Variable Model of Authorized Design Patent

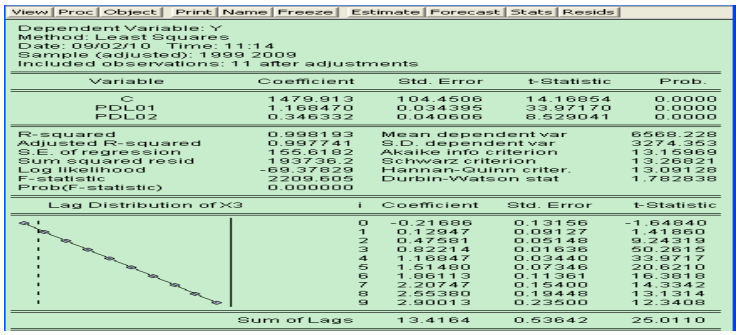


Figure 9
The 9th Period Lag Variable Model of Authorized Design Patent

The result of estimating model as follow:

$$Y = 1479.91268915 - 0.216859605473 * X3 + 0.129472700522 * X3(-1) + 0.475805006516 * X3(-2) + 0.822137312511 * X3(-3) + 1.16846961851 * X3(-4) + 1.5148019245 * X3(-5) + 1.8611342305 * X3(-6) + 2.20746653649 * X3(-7) + 2.55379884249 * X3(-8) + 2.90013114848 * X3(-9)$$

Just as a slight clarification, the design patent authorized in current period $t = -1.64840 < T0.025(n-3) = t0.025(20-3) = t0.025(17) = 2.1098$, it shows that the design patent authorized in current period has little effect of Hunan's GDP. Furthermore, the effect of the previous year is also inconspicuous (1.41806). Other indicators including economic significance test and statistical indicator test seem to be quite ideal. Due to space limitations, details are omitted here.

CONCLUSION

To sum up, this paper uses econometrics software Eviews6.0 to analyze the influences on GDP in Hunan province caused by authorized patent, utility model and design patent separately. The results are as follows:

(1) From the three kinds of authorized patent data, the amount of three kinds of authorized patent experienced fluctuations instead of increasing year by year. At this point, we see that there are many other factors have influences on the economy growth of Hunan rather than authorized patent only. On the other side, the quality of authorized patent itself is a factor which is more important to affect GDP than the quantity of authorized patent. In other words, less authorized patent may make greater contributions to stimulate economic according to the ABC law.

(2) From the actual results of simple regression model and multiple regression model we could see that the fitting results of simple regression model are much better than the results of multiple regression model. Since all of the data of each periods of authorized patent had autocorrelation functions, the authorized patent of each period may have some relation due to the relevance of technology.

(3) From the fitting model of one authorized patent, the factor of time-lag increased progressively with the retardation of time-lag. This illustrates that the influences of authorized patent is accumulate gradually in Hunan province. To compare the three time-lag factors of three models horizontally, the authorized patent made greater contributions to the economic booming than utility model and design patent.

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