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Research Article

Modeling and Estimation of the Contribution of the Rural Hydropower Resources to Agricultural Economic Growth

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Abstract: In this study, we make the theoretical model and estimate the contribution rate of rural hydropower resource to economic growth by using the Cobb-Douglas production function in Zhejiang province, china. The result shows that there is a long-term equilibrium relationship between GDP and labor, capital stock and hydropower consumption quantity. The output elasticity of capital, labor and energy consumption were 1.62, 2.19, 0.189, that is to say, electricity consumption increased by 1%, GDP will increase by 0.189%, so we can calculate the real GDP pulled by per kW•h, then it multiply the number of rural hydropower resources, We draw the following conclusions: Real GDP pulled by rural hydropower resources is 40.70 billion RMB in Zhejiang province during 1990-2012; the primary industry is 3.49 billion RMB, the second industry is 21.29 billion RMB and the third industry is 15.92 billion RMB.

Keywords: Agricultural economy, Cobb-Douglas production function, rural hydropower resource, Zhejiang province

INTRODUCTION

Energy is an important material basis for the development of contemporary economic society and is one of the essential elements of economic growth. Therefore, the correct understanding of the relationship between energy consumption and economic growth has great significance for the sustainable development of the national economy.

Since Kraft and Kraft (1978) found the one-way causality relationship between energy consumption and economic growth based on the data from 1947 to 1974, many researchers have analyzed the relationship between energy consumption and economic growth and established a number of econometric models. Masih's (1997) research results showed that there was a cointegration relationship between energy consumption and economic growth in most countries and regions, such as India, Pakistan, Indonesia and other countries. Stern (2000) found that there was a cointegration relationship between the United States of America's GDP, capital, labor and energy. Soytas and Sari (2003) found there was a cointegration relationship between energy consumption and economic growth in the 16 countries in the emerging markets, in addition to China. Sari and Soytas (2004) found that different energy consumption items had different effects on real output, where lignite, waste, oil and hydraulic power were the top four alternative energy sources in Turkey. Using a bivariate panel error correction model, Sadorsky (2009) presented evidence of bidirectional causality between non-hydroelectric renewable energy consumption and economic growth for a panel of 18 emerging economies. Apergis and Payne (2010) found evidence of bidirectional short-and long-run causality between non-hydroelectric renewable energy consumption and economic growth for a panel of 20 OECD countries.

Some scholars have studied the relationship between China's energy consumption and economic growth. Lin (2003) used cointegration and error correction methods, research showed that there existed a long-term equilibrium cointegration relationship, power consumption and GDP had a significant one-way Granger causality; Shiu and Lam (2004) used the error correction model of the co integration theory and Granger causality test, they drew the conclusion of the long-term cointegration of electricity consumption and GDP and a one-way Granger causality between China's electricity consumption and GDP. Ma and Chu (2004) found that there was a Cointegration relationship between GDP and energy consumption, coal consumption and there were no association between GDP and oil, gas and water. According to 25 (1978-2002) years of power and gross domestic product data as a sample, Huang (2005) used Engel-Granger two-

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step method; he found that there was a cointegration relationship between power production and economic growth. Using the time series data from 1952 to 2002, Wang *et al*. (2006) built the state space model for power consumption and economic growth, the results showed that there was a two-way Granger causality between China's electricity consumption and economic growth, economic growth depends on power, power shortage will have a serious negative impact on economic growth. Based on the panel data from 1985 to 2002 in 30 provinces of China, Wang and Shen (2008) used panel unit root, panel Granger causality test and panel cointegration method to study the relationship between energy consumption and economic growth, results showed that the energy consumption and economic growth had a one-way Granger causality, If the energy supply decreases 1%, the economic growth will fall by 0.5%. Using the state space model of variable parameter analysis method, Tao (2009) found that the energy had an important role in the sustainable growth of economy during 1978-2004, but with the economic structure, technological progress and alternative energy, economic growth on energy dependence showed a gradually decreasing trend.

With the increase of the energy and environment pressure, as one of the clean energy, hydropower resources development and utilization has more and more attention. But most Chinese scholars focused more on the qualitative analysis between the hydropower resources and regional economic development (Chen and Bing, 1998; Tian, 2007), only a few scholars studied the contribution of hydropower resources development to economic growth. Zhou *et al*. (2007) established the quantitative model of the hydropower contribution to the national economic growth based on the theory of the multiplier; they got the quantitative relationship between the hydropower investment and economic growth in Hunan province, the contribution of hydropower investment to the economic growth of Hunan province was between 6.85~7.96% from 1995 to 2003. Wang *et al*. (2009) used C-D production function theory method to quantitatively analyze the contribution rate of hydropower resource investment to the national economy growth, the results showed that the development speed of the national economy was greater than the scale of hydropower resources, water resources as the basic elements of the investment was difficult to be effectively replaced by capital and labor factors, the average contribution rate to the second industry growth was 6.66%, the average contribution rate to GDP growth was 3.08%.

In summary, there was still lack of quantitative research on the contribution of rural hydropower resource to economic growth. Based on the data analyzed with the C-D production function with EViews6.0 statistical software package, its influence of the rural hydropower resources on the economic growth in Zhejiang province were analyzed and discussed.

MODEL DESIGE AND STATISTICAL ANALYSIS

Cobb-Douglas production model: Dependent relationship by the expression of production function between input and output in the production exist in a variety of production processes, here, we are concerned with the dependent relationship between hydropower development and economy growth, we can put the electricity factor as third inputs into the production function (Stern, 2001; Apergis and Payne, 2010). Because the Cobb-Douglas production function is widely used, so we use the C-D production function, it can be expressed as Eq. (1); the logarithmic form is expressed as Eq. (2):

$$Q = A \cdot e^{mt} L^{\alpha} \cdot K^{\beta} \cdot W^{\lambda} \tag{1}$$

$$\ln Q = \ln A + \mathrm{m}t + \alpha \ln L + \beta \ln K + \lambda \ln W \tag{2}$$

where,
Q = Gross domestic product
A = Constant
m = Technical progress factor
t = Time
L = Labor
K = The stock of capital
W = Electricity consumption
α = Labor elasticity
β = Capital elasticity
λ = Electricity elasticity

Once production function is established, we can use electricity elasticity to calculation electricity benefit. In economics, the elasticity is used to represent the degree of sensitivity; it is equal to the ratio of the percentage change in the dependent variables and percentage change in the independent variables.

Data acquisition and pre-processing:
Gross domestic product (Q): calculated at comparable prices at 1952 constant price, the data from the "Zhejiang province statistical yearbook".

The capital stock (K): Measurements of capital stock have the perpetual inventory method and capital rental price method. Capital stock is measured by different scholars from different perspectives, such as Zhang (2002), Zhang and Zhang (2003), Shan (2008). Where, we use the method of Shan to estimate the capital stock of Zhejiang province.

Labor (L): input of labor according to the number of social workers, based on data from the "Zhejiang province statistical yearbook".

Electricity consumption (W): data from the "Zhejiang province statistical yearbook".

Table 1: Input data in Zhejiang province during 1990~2012

Year	Real GDP (10^8 RMB)	Electricity consumption (10^8 kW•h)	Labour (10^8 people)	Capital stock (10^8 RMB)
1990	389.490	208.580	2554.50	554.7000
1991	458.950	242.250	2579.40	616.5700
1992	546.210	284.130	2600.40	712.5000
1993	666.500	308.520	2615.90	867.7400
1994	799.560	340.900	2640.50	1075.970
1995	933.740	407.110	2621.50	1323.260
1996	1052.19	448.360	2625.10	1607.720
1997	1169.08	485.770	2619.70	1883.760
1998	1287.94	539.160	2612.50	2186.080
1999	1417.18	597.260	2625.20	2501.060
2000	1573.60	696.590	2726.10	2863.040
2001	1741.12	790.350	2796.70	3277.580
2002	1961.23	887.820	2858.60	3755.930
2003	2249.47	1090.86	2918.70	4376.180
2004	2575.16	1258.81	2992.00	5112.120
2005	2904.34	1456.42	3100.80	5917.400
2006	3308.24	1765.93	3172.40	6785.170
2007	3794.50	2080.41	3405.00	7727.270
2008	4177.75	2133.87	3486.50	8641.830
2009	4549.57	2250.71	3591.98	9681.710
2010	5090.96	2567.51	3636.02	10868.82
2011	5549.15	2790.24	3674.11	12066.73
2012	5993.08	2846.91	3691.24	13264.63

The actual GDP and capital stock are calculated based on 1952 price according to "Zhejiang province Statistical Yearbook"

Table 2: Results of unit root test

			Critical value in the different significant levels			
Variables	Type of test (C,T,K)	ADF statistics	1%	5%	10%	Test conclusion
LnQ	(C,0,1)	-1.500	-3.809	-3.021	-2.650	Stationary
LnL	(C,0,1)	1.922	-3.789	-3.012	-2.646	Non-stationary
LnK	(C,0,4)	0.687	-4.616	-3.710	-3.298	Non-stationary
LnW	(C,0,1)	-0.383	-3.809	-3.021	-2.650	Non-stationary
ΔLnQ	(C,0,4)	-7.026	-3.920	-3.066	-2.673	stationary
ΔLnL	(C,0,1)	-2.644	-3.809	-3.021	-2.650	10% stationary
ΔLnK	(0,0,4)	-1.816	-2.718	-1.964	-1.606	10% stationary
ΔLnW	(C,0,1)	-2.668	-3.809	-3.021	-2.650	10% stationary

According to the above method, we get the number of GDP, capital stock, labor, electricity consumption during 1990~2012 in Zhejiang province, shown in Table 1. The subsequent data processing and analysis were made by the Eviews 6.0 statistical software package.

RESULTS AND DISCUSSION

Stationary test: Classical regression analysis implies an assumption that the data is stable, but for the time series data, if there are two columns of time series data showed similar trends (non-stationary), even if they do not have any meaningful relationship, but the regression also showed high coefficient of determination. Because of the non-stationary data, it often leads to spurious regression. So, we must carry out stationary test about GDP Logarithm (LnQ), labor logarithm (LnL), capital stock logarithm (LnK) and electricity consumption logarithm (LnW) during 1990-2012, the test results are shown in Table 2.

Stationary test shows that LnQ, LnL, LnK and LnW are first-order single whole sequence, have unit root and are non-stationary time series.

From the survey of the residents in the whole, the participation of urban residents in the ecological compensation age trend was younger (average age 32.62 years), with higher disposable monthly income (2104.76 RMB), as shown in Table 2. In occupational composition, this investigation has object with civil servants (12.23%), Enterprise staff (24.46%) and Business & service personnel (40.28), students (14.38). The cultural degree, college degree above investigation residents total ratio reached 82% (among them, college education accounted for 48.92%, graduate education accounted for 33.09%) and a high school diploma is only 17.98%, which fully shows that the potential demand of ecological compensation reflect the characteristic of high degree, positive correlation between the degree of education and ecological compensation. As shown in Table 3.

Table 3: Results of Johansen Cointegration

The number of Cointegration equation	Eigenvalue	Trace statistic	5% critical value	p
0	0.987	136.7	47.85	0.000
1	0.874	54.09	29.79	0.000
2	0.499	14.65	15.49	0.066
3	0.076	1.501	3.841	0.220

Cointegration test: Although some of the variables are non-stationary and are the same order of integration,

Table 4: Real GDP pulled by electricity consumption in Zhejiang province

Year	Electricity consumption increase by 1% (10^8 kW•h)	Real GDP Increase pulled by electricity consumption increase by 1% (10^8 RMB)	Real GDP pulled by each kW•h (RMB/ kW•h)	Year	Electricity consumption increase by 1% (10^8 kW•h)	Real GDP Increase pulled by electricity consumption increase by 1% (10^8RMB)	Real GDP pulled by each kW•h (RMB/ kW•h)
1990	2.090	0.740	0.35	1991	2.420	0.870	0.36
1992	2.840	1.030	0.36	1993	3.090	1.260	0.41
1994	3.410	1.510	0.44	1995	4.070	1.760	0.43
1996	4.480	1.990	0.44	1997	4.900	2.210	0.45
1998	5.390	2.430	0.45	1999	5.970	2.680	0.45
2000	6.970	2.970	0.43	2001	7.900	3.290	0.42
2002	8.880	3.710	0.42	2003	10.91	4.250	0.39
2004	12.59	4.870	0.39	2005	14.56	5.490	0.38
2006	17.66	6.250	0.35	2007	20.80	7.170	0.34
2008	21.34	7.900	0.37	2009	22.51	8.600	0.38
2010	25.68	9.620	0.37	2011	27.90	10.49	0.38
2012	28.47	11.33	0.40				

Table 5: Real GDP benefits pulled by rural hydropower resources in Zhejiang province

Year	Real GDP pulled by each kW•h (RMB/ kW•h)	Rural hydropower generation (10^8 kW•h)	Real GDP pulled by rural hydropower (10^8 RMB)	Primary industry pulled by Rural hydropower (10^8 RMB)	Second industry pulled by rural hydropower (10^8 RMB)	tertiary industry pulled by rural hydropower (10^8 RMB)
1990	0.35	17.2000	6.060	1.51	2.730	1.820
1991	0.36	18.5500	6.650	1.50	3.020	2.140
1992	0.36	19.9100	7.240	1.38	3.440	2.420
1993	0.41	21.2600	8.670	1.42	4.430	2.820
1994	0.44	21.6300	9.590	1.56	4.980	3.040
1995	0.43	19.5200	8.460	1.31	4.410	2.740
1996	0.44	25.4400	11.29	1.60	6.020	3.670
1997	0.45	26.9800	12.17	1.61	6.630	3.930
1998	0.45	37.1900	16.80	2.03	9.200	5.570
1999	0.45	42.9300	19.26	2.15	10.52	6.590
2000	0.43	40.4900	17.28	1.78	9.210	6.290
2001	0.42	46.9300	19.55	1.87	10.12	7.550
2002	0.42	45.1900	18.86	1.61	9.640	7.610
2003	0.39	40.2800	15.70	1.16	8.240	6.290
2004	0.39	41.5600	16.07	1.12	8.620	6.320
2005	0.38	69.3400	26.14	1.74	13.94	10.46
2006	0.35	67.6000	23.93	1.41	12.94	9.590
2007	0.34	67.0300	23.11	1.21	12.49	9.410
2008	0.37	68.5200	25.35	1.29	13.66	10.40
2009	0.38	70.0100	26.74	1.35	13.85	11.54
2010	0.37	74.3000	27.84	1.37	14.36	12.11
2011	0.38	77.2000	29.02	1.42	14.87	12.73
2012	0.40	78.5000	31.23	1.50	15.60	14.13
Total		1037.56	407.00	34.90	212.93	159.17

Rural hydropower data is internal data from water resources department of Zhejiang province

but if we observe the relationship between them from long-term, we will find that they are the inherent relation between them in the long run, that is to say there is a stable equilibrium relationship (namely cointegration relationship). In this study, Johansen cointegration test results are shown in Table 3.

There are at most two cointegration equations from the test results; therefore, we first establish OLS regression of LnQ on the remaining variables, the regression equation is:

$$\begin{aligned} LnQ &= -18.33 + 0.174t + 1.62\ln L \\ &+ 2.19\ln K + 0.189\ln W \end{aligned} \tag{3}$$

Then, we carry out stationary test of the residual of the equation, we choose ADF test of no intercept and no trend, the ADF test statistics is -2.408, we can refuse hypothesis that residual has unit root at the 5% significance level, so there is a long-term equilibrium relationship between GDP and capital labor, capital stock and electricity consumption.

Analysis of the results: According to regression analysis results, there is a positive correlation between GDP and electricity consumption in Zhejiang, the estimation of parameter K is 0.189, namely, the output elasticity of electricity consumption is 0.189, that is to say, electricity consumption increased by 1%, GDP will increase by 0.189%. Accordingly, we can calculate the real GDP benefit pulled by per kW•h in Zhejiang province, as shown in Table 4.

According to real GDP benefit pulled by each kW•h, then it multiply the number of rural hydropower resources, We draw the following conclusions: Real GDP pulled by rural hydropower resources is 40.70 billion RMB in Zhejiang province during 1990-2012;

the primary industry is3.49 billion RMB, the second industry is21.29 billion RMB and the third industry is 15.92 billion RMB,, shown in Table 5.

Countermeasures and suggestions: according to the above estimates and analyses, some countermeasures and suggestions were pointed out and brought out: to ensure the coordinated development of energy and economy. according to the principle of electric power development speed in advance of economic development, that is, the power elasticity coefficient is greater than 1, but the results of this study is 0.189. Zhejiang is a large province of energy consumption, but a small province of energy resources, an external dependence of the energy is more than 90% and there is a long term shortage of energy supply in Zhejiang province. Therefore, we should expand the energy supply; adjust the energy demand, to ensure the coordinated development of energy and economy.

Adjust the coal based energy consumption structure and vigorously develop renewable energy, such as hydropower and other renewable energy. Along with the high-speed economic development and increasing energy consumption, the Zhejiang province Government faces a growing pressure to maintain the balance between energy supply and demand as well as reduce environmental pollution, so the inappropriate energy consumption structure should be changed. Zhejiang province has rich hydropower resources; the development capacity of hydropower is about 8 million kW. Zhejiang vigorously developed hydropower, which could provide clean energy for the country and protection of the ecological environment. Continue to promote the reform of the small hydropower system.

At In the early 90's of 20 Century, Zhejiang Province has performed a series of reform about investment system and electricity tariff, which greatly promoted the development of rural hydropower, annual rural hydropower generation increased rapidly, which not only provided a lot of power resources and infrastructure construction, but also effectively increased the local fiscal revenue and farmer’s income, promoted the development of society and economy.

CONCLUSION

Based on the analyses of data modeling and estimating above, the result shows that: there is a positive correlation between economic growth and the amount of power consumption in Zhejiang, the output elasticity coefficient was 0.189 from power resources. Output elasticity from power resources is minimum in the three elements (capital, labor and power resources). The economic growth pulled by rural hydropower resources in Zhejiang province: GDP is 165.920 billion RMB (1952 as the base), 0.75% of GDP (1952 as the base) in Zhejiang province; the primary industry is 14.226 billion RMB, the second industry is 86.804 billion RMB and the third industry is 64.889 billion RMB from 1990 to 2012.

Because the hydropower resources are limited, the development speed of hydropower resources will be more and more below the development speed of economic scale. To solve this contradiction, it needs technology updates, factor substitution and so on, which has not been discussed. Moreover, the amount of power consumption includes thermal power, hydropower, etc., this study treat them equally, however, hydropower and thermal power may is not the same contribution to the economic growth, which has not been discussed. Hydropower can be from large and medium-sized hydropower Station or small hydropower stations, rural hydropower is mainly from small hydropower stations, rural hydropower station mainly drive the development of the rural economy, the effect may be less than the effect on the urban economy, but due to the limit data, we assume that the unit effect is consistent, it may have some errors, but does not affect the overall judgment.

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