Economic Development of Xinjiang under Energy Constraint

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Abstract: Xinjiang is one of the most important reserve bases of energy resources in China. Exploring and developing Xinjiang's resources can increase domestic energy supply and promote China's economic development. However, along with inducing rapid economic growth in China, it also leads to serious depletion of energy resources and unsustainable economic development. This paper studies how to achieve sustainable development under energy constraints in Xinjiang.

1. Introduction

Since central government has implemented the policy of developing western China, Xinjiang's economy has got a rapid development, and has brought obvious economic benefit. However, along with the rapid economic development in Xinjiang, there are also unsustainable exploitation and waste of energy, which result in ecological and environmental problems. Related statistics show that to produce 1million yuan GDP, China in average used 0.793 tons of standard coal, where in Xinjiang the figure is 1.631 tons of standard coal, this is 2.06 times of that of the country as a whole. This figure can fully demonstrate that effectiveness of resources usage is very low in Xinjiang. Utilizing energy inappropriately leads to destruction of environment, even it may threaten human life. Sustainability of a region's or country's energy support system and establishment of energy utilization in an eco-friendly way is an absolute requirement to the country's or region's strategy.

The demand for energy is continually increasing worldwide, because world economy is developing so fast and the population is also growing. As energy consumption increases, energy has become a scarce resource. This in turn influences not only Gross Domestic Product (GDP) but also the development of domestic economy, becoming one of the main reasons which limit the increase in GDP. According to analysis, loss in domestic economy due to scarcity of energy resources amounts to 20 to 60 times of the value of energy itself.

Consequently, there is a close relationship between the increasing energy consumption and national economy. Producing and consuming energy in eco-friendly manner allows a country or region to realize a sustainable development. Thus, energy consumption and economic development are closely linked. Energy should be produced and consumed in a sustainable manner in order to realize the sustainable economic development of a country or region. Therefore, modern economic growth model established for the study of sustainable development of Xinjiang's economy contains a constraint of energy use equation. How to realize the sustainable development of Xinjiang's economy under the energy constraints, is one of the major problems in studying the economic growth of Xinjiang.

2. Literature review

In the 70 's of the last century, two oil crisis in the Western world which occurred one after another made the research of energy issues to enter a new stage, the report "the Limits of Growth" of the Club of Rome in the early1970's, warned the world: "we not only inherit father Earth, but we also borrow from the children and grandchildren of the Earth". Therefore, if we are to continue to pillage and take away from nature willfully, it is impossible to build a better future for human

society. "The United Nations Environment Program" also used the same words to warn the world. This makes the study of the issue of energy enter a new stage. Mason Willrich (1975) proposed in his book of *Energy and World Politics* that energy issue, in essence, belongs to international political issue. The book raised the possibility of international mechanisms for the management of the world's energy problems, and discussed how to establish a harmonious global energy relationship. The book drew the following conclusion: facing the world's energy problem, in the case of the lack of international mechanisms, "self- control" is the best strategy for the countries, because "self-control" strategy will enable sustainable use of energy in the country, and lay the foundations for the establishment of long-term and effective international mechanism. Forman thinks that sustainable development is to sustain a survival environment for human beings by seeking the best ecological system to support ecosystem integrity and fulfillment of human desire. On the ecological dimension of sustainable development focuses on environmental protection and the sustainable use of resources. Brown believe that sustainable development is a kind of social development which retains population size stable, utilizes renewable energy effectively, intensifies effective agriculture, earns protection and improvement for eco-system base and sustainable development not only for traffic and transport systems as well as for the economic growth in the long-term, also creates new industry and new jobs. Scholars such as Welsch, Morse, S, Fraser and Jesinghaususe ESI (environmental sustainability index) to analyze the sustainability of different countries and provided a favorable analysis tool for ecological decision-making, facilitating the quantification of the environmental policy, environmental management and systemization. Dowers proposes four levels of framework for achieving sustainable development, which reflects a kind of view of sustainable development in Australia economy. His framework of four levels includes social goals, policy objectives, policies, and action. As energy security issues become more and more prominent, domestic economists, too start to conduct research and analysis on energy eco-systems as well as on sustainable development of economy. HaoXiaoHui from National land development and Regional Economic Research Institute of the State Planning Commission proposes sustainable development indicator system which consist of four major components such as society (includes 23 indicators), economy (includes 18 indicators), resources (includes 6 indicators) and environment (includes 20 indicators). Chinese Sciences Academy of Sustainable development strategy and Research Group made an associated external and internal self-consistent logical analysis on related elements and indicators included in the index are divided into overall level, system level, State level, variable and element level, a total of five levels in accordance with China's own development characteristics and evaluation needs. Song Rui in “the Analysis of the Relationship Between Energy and the Quality of Economic Growth in Xinjiang” wrote: "since the reform and opening, Xinjiang's economic growth rate has been significantly improved and realized rapid growth of 10.1 per cent, this figure was 0.7% faster than the national average, at the same time, the stability of Xinjiang's economic growth was further enhanced, both urban and rural people's living standards improved significantly, labor productivity has also increased.

But notably, the quality of economic growth is not very high, this is specifically manifested in the following aspects: the pace of economic structural adjustment lag behind the pace of economic development, the efficiency of economic growth in general is still relatively low, production technology is relatively backward, production costs are high, investment efficiency is low, the local industry benefit decreases, resource utilization efficiency is low energy consumption is high, environmental pollution and destruction of ecological environment is very severe etc.. Therefore, transformation in current patterns of energy development has important meaning to ensure rapid development of Xinjiang's economy as well as to keep it sustainable, healthy. "And analyzes the problem of sustainable development of Xinjiang energy ecosystem and economy development.

The domestic and foreign experts put forward their views of sustainable development from the ecological, social and economic aspect. Related researches include more descriptive and inductive components on the comprehensive research of developing and maintaining sustainable economic development, however in this researches theoretical research is very weak and theoretical discussion on sustainable development issues is clearly insufficient, so is the originality aspect of

constructing relevant theories. Particularly with regard to energy ecosystem in Xinjiang - energy reserve base of China, there is very little research on sustainable development of economy. By establishing neo-classical model of economic growth under energy constraint, this paper studies how to develop energy realizing sustainable development of Xinjiang's economy.

3. Energy demand of sustainable development

Practices all over the world show that no resource can produce polarized effects like energy resources in the process of energy development in modern society (as shown in figure 1). On the one hand, speed of economic development of countries and regions and the extent of development increasingly depends on the ability of modern energy supply system construction; on the other hand, the rapid growth of energy consumption has become increasingly apparent disturbance and destruction of the ecological environment evolution. Therefore, the rational development and utilization of energy resources has become a common basic tasks and major issues all country around the world face.

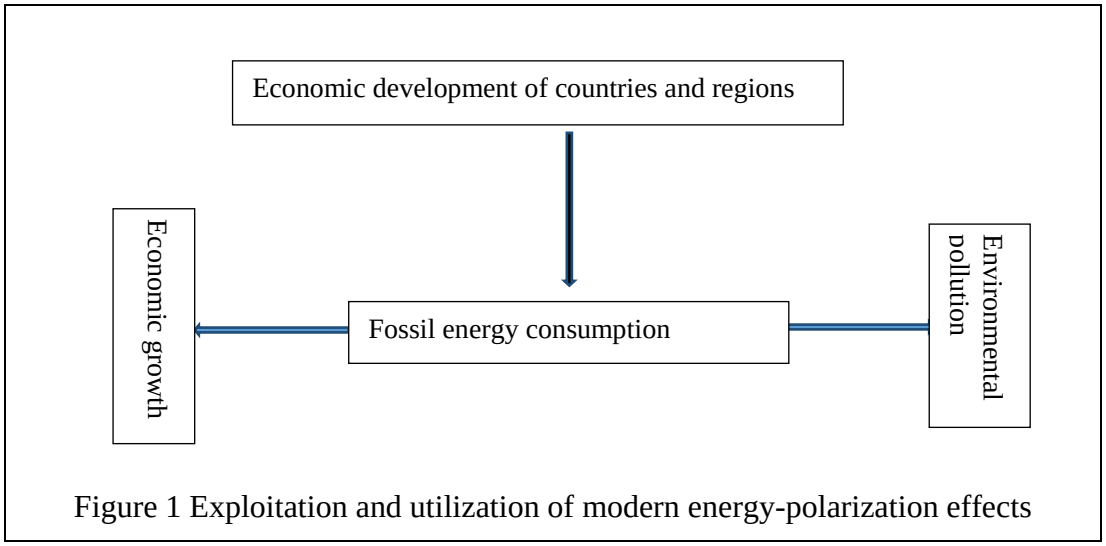

Figure 1 Exploitation and utilization of modern energy-polarization effects

China is a developing country and is in the process of industrialization, is still in the energy-intensive phase of socio-economic development, there is a high level of dependency on energy whether in the present or future. Current energy situation of China is that there is severe energy shortage in the eastern part and suffering from shortage of energy supply, whereas the Western region is rich in energy resources. Implementation of the Western development strategy of China's energy development is to use energy advantages of the Western region to develop its abundant energy resources, achieve optimal allocation of energy throughout the country. Although development of energy resources in the Western region can contribute significantly to economic development in West China, lessening the tension of energy shortages in East, excessive exploitation could undermine the sustainability of energy as a scarce resource. As one of the energy resource-rich regions in western regions, mass energy exploration and development in Xinjiang will certainly increase our domestic energy supply, and to a certain extent, ease the contradiction of insufficient energy supply, being of immeasurable importance in enhancing the energy security of our country. But with social progress and the economic development, human energy needs and depth and breadth of energy utilization are constantly increasing, causing people to neglect sustainability and protection of ecological environment in order to gain the maximum economic benefit, development and resource utilization, this in turn has negative impact on the sustainable development of Xinjiang' economy and has led to unsustainable economic development in Xinjiang. To speed up the economic development in Xinjiang, it should be ensured that energy consumption grows correspondingly, and the road of sustainable production and consumption is a prerequisite for sustainable economic development. In view of this, exploring ways to achieve sustainable economic development in Xinjiang under energy constraint is the key to future energy development strategy of Xinjiang. In order to achieve systematic rational evolution that constitute of population,

resources, environment and development and even to ensure sustainable economic development, we must rely on scientific and technological capabilities and human reason. Since ancient times, scientific and technological progress have been regarded as the foundation and the number one driving force for the development of human society and the law of development of human society is classified as intellectual development. In order to create a more advanced model of human civilization, humans must increasingly rely on technological and scientific civilization, thereby being able to quickly form regions and generations of sustainable development.

4. Energy-constrained economic growth model

On the assumption that labor force is constant and normalized to 1, let's assume Y, S, K, C represents per capita output, energy stock, capital stock and consumption of the national economy system during t period. In order to achieve sustainable economic growth, policy makers will decide to use a certain amount of energy for production in the period t. Assume that e represents the energy volume used in the production during period t. Because we can divide energy into renewable and non-renewable energy resource, energy stock (s) change as time (t) changes due to different exploration techniques and exploration level. If we assume that σ is natural growth or regrowth rate of energy stock (s), then rate of change of energy stocks at t period satisfies the following equations:

$$\dot{S} = \sigma S - E \tag{1}$$

Various energies are introduced into production function as production factors, under constant returns to scale, production function takes the following Cobb-Douglas model,

$$Y = F(K, E) = AK^{\alpha}(E)^{1-\alpha} \tag{2}$$

A in equation (2) represents the production technology in certain period, and A>0, and it is a constant. K is capital per person, E and A,1-a represents energy investment per capita and output elasticity of capital and energy respectively, (0<a<1). Any technological advances are ignored. Then k satisfies the following equation:

$$\dot{K} = Y - C - \beta K = AK^{\alpha}(E)^{1-\alpha} - C - \beta K \tag{3}$$

In (3) β is capital depreciation rate, C is consumption per capita, $\dot{k}$ is change rate of capital per worker. On this basis, we assume that economic output, the energy inputs are necessary, if E=0, then Y>0, then E>0. From an economic point of view it is clear that this assumption is reasonable, In other words "there is no free lunch". F is an increasing function of E as well as diminishing marginal productivity, and relationships between factors of production output and energy meet the basic assumptions of Economics about the factors of production.

In this article under the precondition of ensuring sustainable economic growth, sustainable use of energy is defined as: energy stocks s has non-negative growth rate in the long development process, or E (energy production in period t) has negative growth. Non-negative growth of energy stock indicates that energy stock remains the same over the period (zero sum growth), or it increases over the time (positive growth),E(energy production in period t) does not exceed the amount of energy regeneration σ s, that is, $e \leq \sigma s$. when input of energy production during period t experience negative increase, the amount of the energy put into production diminishes with the change of time and economic dependence on energy increasingly weakens with the technological progress and economic development. Let's assume consumers utility function is $U(C) = \ln C$, constant P represents utility discount rates in different periods, according to assumption premise above, problems policy makers face is restricted by formula (1) and (3) in period t,

$$\max \int_0^{\infty} \ln C \ e^{-pt} dt$$

$$\text{s.t.} \dot{K} = AK^{\alpha}(E)^{1-\alpha} - C - \beta K$$

$$\dot{S} = \sigma S - E$$

Based on the analysis and research of modern economic growth theories, we can find economic growth in most countries or regions have characteristics of steadiness in long-term, meaning the all variables of growth rate per capita are constant in long-term growth. We can explain these optimization problems with Hamilton function:

$$J=\ln C+\lambda_1(AK^{\alpha}\ E^{1-\alpha}-C-\beta K)+\lambda_2(\sigma S-E)$$

Shadow price of capital and energy are respectively represented by λ 1 and λ respectively.

In the optimization problems above, S and k are state variable, e and c are control variables.

$$Jc=0\Rightarrow C^{-1}=\lambda_1 \tag{4}$$

$$Je=0\Rightarrow\lambda_1 AK^{\alpha}\ (1-\alpha)EK^{\ -\alpha}\ =\lambda_2 \tag{5}$$

$$\dot{\lambda_1}=p\lambda_1-Jk=p\lambda_1-\lambda 1A\alpha K^{\alpha-1}\ E^{1-\alpha}\ +\lambda_1\beta \tag{6}$$

$$\dot{\lambda}_2=p\lambda_2-Js=p\lambda_2-\lambda_2\sigma \tag{7}$$

From equation (3) -(7), we can get that:

$$\frac{\dot{\lambda}1}{\lambda 2}=-\frac{\dot{C}}{C} \tag{8}$$

$$\frac{\dot{\lambda}1}{\lambda 2}=p+\beta-\alpha M \tag{9}$$

$$\frac{\dot{\lambda}1}{\lambda 2}=p-\sigma \tag{10}$$

$$\frac{\dot{K}}{K}=M+N-\beta \tag{11}$$

$$\frac{\dot{\lambda}1}{\lambda 1}+\alpha\frac{\dot{K}}{K}-\frac{\dot{E}}{E}=\frac{\dot{\lambda}2}{\lambda 2} \tag{12}$$

Where $M=A\alpha K^{\alpha-1}\ E^{1-\alpha}$, $N=\frac{C}{K}$. Due to the fact that growth rate of variables per capita is constant under the steady state, we also know that M and N are constants, and take the Logarithmic and derivative of M and N.

From (8)-(12), (13) to (17)

$$y_{\lambda_1}=-y_c \tag{13}$$

$$y_{\lambda_2}=p-\sigma \tag{14}$$

$$(\alpha-1)y_K\ +(1-\alpha)y_E\ =0 \tag{15}$$

$$y_K=y_c \tag{16}$$

$$y_{\lambda_1}+y_K\ -\alpha y_E\ =\ y_{\lambda_2} \tag{17}$$

$$y_K=y_c=y_E=\ -y_{\lambda_2}=p-\sigma \tag{18}$$

Sustainable economic growth is a necessary condition for sustainable economic development, so the process of long-term development requires the positive growth of consumption and capital per person, namely $y_K=Y_c>0$. From equation (18), it can be known$\lambda_E>0$. Under the assumptions models above, the realization of sustainable economic growth requires the corresponding growth of energy input volume as a support.

However, we must take energy stock (S) trend into account in the course of economic development, from the dynamics equation of energy stock (S):

$$y_s=\sigma-\frac{E}{S} \tag{19}$$

In this equation, $\frac{E}{S}$ represents the proportion of energy production during period. Because energy

input registers positive growth trend, namely$y_E > 0$, inducing $y_s < 0$， leading to negative growth of energy stock (S). This conclusion is inconsistent with the requirements of sustainable energy use. What are the reasons of this contradiction? This is because technological advances are not considered in the above model.

In this regard, from an economic perspective the explanation could be like this: sustainable economic growth is achieved at the expense of the large consumption of energy, if not by depending on technological progress. Or we can say that Economic growth and development is "extensive" without the usage of technological progress. If this continues, it will eventually lead to the depletion of energy, achieving sustainable social development and sustainable economic growth is not possible. Therefore, technological progress is the driving force of sustainable economic development. In order to eventually achieve sustainable social development and sustainable economic growth, we must reduce energy consumption, enhance the scientific and technological content and competitiveness of their products.

5. Conclusion

This paper concluded that the technological progress is the driving force of sustainable economic development. Backwardness in technology results in the massive consumption of energy resources, ultimately leading to depletion of energy. Therefore, technological advances role is very important in promoting sustainable development of economy of Xinjiang under energy constraint. Thus, rational and efficient use of energy resources in Xinjiang should be achieved, while focusing on technology innovation in the energy industry.

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