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Environment, energy and sustainable economic growth

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Abstract

Sustainable energy utilization and environmental protection are important to sustainable economic growth. In this paper, we develop an endogenous economic growth model and discuss the optimal path of sustainable economic growth with the constraints of energy and environment. We find that sustainable economic growth can be achieved only when the relative contribution rate of environment protection investment to environmental quality is more than the relative contribution rate of combined input of energy and environment to production. The results indicate that long-run growth requires not only a continuous energy intensity decrease and technology progress in the fields of energy resources exploitation, exaction, refinement and utilization, but also an optimal structure adjustment from depending on nonrenewable energy to renewable energy.

Keywords: Energy Research; Source of Supply; Technology Progress; Endogenous Growth; Dynamic Optimization

1. Introduction

The sustainable energy utilization and the environmental protection are very important to sustainable economy and society development. In the past twenty years, many several developing countries have made amazing achievements in economic development. However, as concomitance of rapid economic growth and industrialization advance, the energy shortage and the environmental degradation poses a grave threat to the progress of industrialization and civilization. How to get mutual benefits between the energy development and environmental protection has drawn a lot of attention in the past twenty years. Whether can economy pursues the optimal growing path under the dual restraints of the energy and environment is the focus of sustainable growth.

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Exhaustible resources, mainly including nonrenewable energy and mineral resource, were once the focus of research work concerned with economy growth in 1970's. Quite a number of research works introduced exhaustible resources into neoclassic growth model and discussed the consequent influences on economic growth. They introduced the exhaustible resources into the Cobb-Douglas production function and tried to seek the relationship between the exhaustion of the natural resources and the long term economic growth. It was found that optimal distribution of exhaustible resources will take the intergenerational equity of the total wealth in a society into account and the sustainable development should be measured by total capital stock. Although the introduction of exhaustible resources into neoclassic growth pattern confirmed their restraint mechanism in as well as impacts on economy growth, the inherent contradictions in the neoclassic growth pattern was still left unsolved. Given Hicks neutral technical progress, the long term economic growth depends on the marginal factor income increasing, while the theoretical premise of the neoclassic growth theory was the marginal factor income decreasing. So, the decreasing marginal income led to an increasing resource exhausting rate. If the regenerating rate of resources cannot exceed the exhausting rate, economy would come to the zero growth inevitably.

Since 1980s, some researchers developed new growth theory on the foundation of neoclassic pattern, which took the internal technique change as the core of economic growth and pay much attention to the knowledge overflow (P.M. Romer, 1986), human capital externality (R. E. Lucas, 1988), the new product introduction (G.M. Grossman, E. Helpman, 1991), learning by doing (Young and Allyn, 1991) and so on. By introduction of the knowledge and the specialized human capital, the new growth theory revealed that the human capital accumulation may cause an increasing marginal return as well as an increasing return to scale. Based on these theories, H. L Yang et al (2004) introduced energy into the Lucas endogenous growth model as a factor of production and discussed the function of the human capital accumulation in breaking out of the exhaustible energy reserve restraint. B. Yu et al (2006) introduced both energy exhaustion and environment protection into endogenous economic growth model and discussed the requirements of the sustainable growth. Omer and A Mustafa (2008) discussed several issues relating to renewable energies, environment and sustainable development from both current and future perspectives. Recently, some researchers attempt to use these models to anticipate the future of environment, energy and economy. For example, Z. G. Hu, J. H. Yuan and Z. Hu investigated the low-carbon development of China. According to their prediction of China's economic growth, energy reserves and emissions mitigation till 2030, China could save energy by more than 4 billion ton oil equivalences and reduce carbon dioxide emissions by nearly 17 billion tons during the coming 20 years. They also pointed out that China had to reconstruct its economy and depend much on technology progress in the future.

These research works succeeded in introducing the energy and the environment restraints into the economic growth. Nevertheless, most of them only considered the negative impacts of environment, i.e. pollution, and little attention had been paid to the positive environment quality which could make contribution to the economic growth. Also little literature investigated the ability of environmental protection investment in improving environment quality. In the following sectors, we will introduce the energy and the environment into the production function and discuss the double influences of energy and environment and the optimal path of economic growth under these restraints.

2. The Model

2.1. Energy, environment and output

Quite different from the neoclassical growth theory, we construct a model in which economic growth will not depend on the energy reserve heavily due to deceased marginal return of capital. In our work, we introduce accumulated human resource into production function. We assume that labor force is constant,