R&D, ENERGY POLICY AND SUSTAINABLE GROWTH

Youngho Chang, Nanyang Technological University, +65-6316-8781, isyhchang@ntu.edu.sg

Overview

It has been shown that energy puts constraints on economic growth through the rise of price mainly caused by depletion of energy. However, rising energy prices might not be a constraint on economic growth. This study examines whether a persistent increase in energy price constrains economic growth and presents in what conditions rising energy prices could work towards economic growth.

Methods

Extending Romer (1990), this study constructs an endogenous growth framework incorporating energy both in the production of intermediate and final goods and the division of capital for the intermediate and final goods. There are three input in the Cobb-Douglas production process: capital, labor, and energy, and energy is broadly defined so that it could be fuels, precious metals and minerals, and renewable or nonrenewable. There are also three sectors in the model: the final output sector, the intermediate goods sector, and the R&D sector. The final output of a representative firm is determined by labor, intermediate goods and capital – the capital invested in final good production and the capital allocated for intermediate goods. The effective services of the intermediate goods are supplied by the capital and raw energy allocated for the production process, which is assumed as a constant return to scale Cobb-Douglas function. The prices and quantities of the intermediate goods are derived by solving a profit maximization problem facing the representative firm. This gives in turn the growth rate of output equals the sum of the growth rate of innovations and of profits for producing intermediate goods. Any factor favoring innovations or monopolistic rent for producing intermediate goods is likely to promote economic growth. In the R&D sector, R&D activities for energy-related technologies are understood to accelerate a smooth substitution between capital and raw energy. R&D activities are compensated by the monopolistic profits accrued from the patents of innovations, and the value of an innovation for the *i*-th intermediate good determines the allocation of resources between producing intermediate goods and carrying out R&D activities.

Results

This study finds an increase in energy price (i.e., the growth rate of energy price) does not necessarily impede the rate of economic growth under the following conditions: first, the output elasticity of energy is sufficiently low (e.g., equal to or lower than 0.08), second, the intertemporal elasticity of substitution is sufficiently high (e.g., equal to or higher than 5), and third, the energy price shock is moderate. The growth rate of energy price, due to higher energy tax rate or the depletion of energy among others, would induce the improvements of energy-related technologies, which could accelerate the substitution of capital for energy and hence would favor economic growth.

Conclusions

This study presents under what conditions rising energy prices do not impede economic growth. It also demonstrates that the conservation policy such as the imposition of carbon tax on energy use has no effects on economic growth if the rate of tax on energy consumption and subsidy for capital used in the intermediate goods are constant. However, an increasing energy consumption tax with a constant subsidy for capital appears to lead to a higher rate of economic growth.

References

Dasgupta, P. S. and G. M. Heal (1979): *Economic Theory and Exhaustible Resources*, Cambridge University Press.
Davison, R. (1978): "Optimal depletion of an exhaustible resource with research and development toward an alternative technology," *Review of Economic Studies*, 45(2): 355-367.

Grossman, Gene M. and Elhanan Helpman (1991): *Innovation and Growth in the Global Economy*. Cambridge, MA, MIT Press.

Halvorson, Robert and Tim R. Smith (1986): "Substitution Possibilities for Unpriced Natural Resources: Restricted Cost Functions for the Canadian Metal Mining Industry," *Review of Economics and Statistics*, 68(3): 398-405.

Hartwick, J. M. (1977): "Intergenerational equity and the investing of rents from exhaustible resources," *American Economic Review*, 67(5): 972-974.

Herfindahl, O. and A. Kneese (1974): *Economic Theory of Natural Resources*. Columbus: Merrill.

Hotelling, Harold (1931): "The Economics of Exhaustible Resources," *Journal of Political Economy*, 39(2): 137-175.

Romer, Paul M. (1990): "Endogenous Technological Change," *Journal of Political Economy*, 98(5): S71-102.

Solow, R. W. (1974): "The economics of resources or the resources of economics," *American Economic Review*, 64(2): 1-14.

Zon, A. van and I. H. Yetkiner (2003): "An endogenous growth model with embodied energy-saving technical change," *Resource and Energy Economics*, 25: 81-103.