IDENTIFYING OBSTACLES TO AUTONOMOUS ENERGY EFFICIENCY IMPROVEMENT

Akira Maeda, The University of Tokyo; 3-8-1 Komaba, Meguro-ku, Tokyo 153-8902, Japan
Phone: +81-3-5465-7740, maeda(at)global.c.u-tokyo.ac.jp
Makiko Nagaya, Showa Women's University; 1-7-57 Taishido, Setagaya-ku, Tokyo 154-8544, Japan
Phone: +81-3-3411-7143, makiko.nagaya(at)gmail.com

Overview

This study extends an analysis presented at 4th AIEE Energy Symposium (December, 2019) by the same authors (Maeda and Nagaya, 2019) to analyze what is behind energy efficiency improvement as a determinant of it. In typical energy modeling, energy efficiency improvement is one of key factors that influence the model behavior and calculation results. While there are several types of energy modeling, for example, optimization models, general equilibrium models, agent-based models, etc., parameters used in the model are generally critical to the model building. In particular, the parameters that reflect assumptions for energy efficiency improvement are one of the most critical ones. They are usually set as annual rates of improvement, and in most cases, they are set as constant numbers. Such a constant annual rate of improvement assumes that energy efficiency improves at a constant rate regardless of other economic conditions. This is sometimes called Autonomous Energy Efficiency Improvement (AEEI).

The introduction of the assumption of AEEI into the modeling framework is practical in that otherwise there must be some mechanisms that can shift rates of improvement in the model, which needs some theoretical background for these mechanisms. In other words, there is no consensus among modelers about theory of driving force for energy efficiency that can explain how energy efficiency improvement happens. In the context of general economic theory, there are some theories that try to explain the source of technological change and/or technology innovation, including so-called endogenous growth theory (e.g. Romer, P. (1990), Acemoglu, D. (2002)). However, these existing theories are understood to be still subject to empirical study and have not gained full support from economists for the purpose of practical use such as energy modeling. So does with the mechanism of energy efficiency improvement. In fact, it is even more ambiguous. This study is an attempt to challenge that ambiguity.

Methods

The analysis is done with a simple partial equilibrium model. We consider an energy-related good and work on its supply and demand market equilibrium. Supply and demand functions are written as follows:

$$Q_D = ap^{-\varepsilon}$$
$$Q_S = bp$$

where b represents a technology parameter.

With this setting of the market, AEEI is understood as autonomous and constant increase in the parameter b. Then, the question is whether or not the increase in the parameter b brings benefits to stake holders including consumers, producers, and the economy as a whole. If the change is beneficial to some of them, that economic entity may let that autonomous change happen. Otherwise, it will try to hinder such change. To investigate the answer to the question, a comparative statics analysis is utilized. The analysis allows us to examine not only cases that all parameters in the model are deterministic, but also cases with uncertain parameters.

Results

To examine benefits to stake holders, standard welfare measures are a useful tool. We calculate consumer surplus, producer surplus, and social welfares as functions of the parameter b. Examining the signs of derivatives of these measures helps identify who is welfare/surplus-improving and who is not. The result shows in any cases, consumers and the whole economy will get better off with the increase in the parameter b, which is quite natural to our intuition. To the contrary, the effect on the producer is ambiguous. In fact, the increase in b does not necessarily help the producer, which means that as a subjective entity of introducing or accepting better technology, they may be willing to stop or hinder such technology improvement, staying with an old-fashioned technology. It is found that the difference between a possible driver and a possible obstacle for efficiency improvement is entirely due to the price elasticity of demand, ε, and nothing else.

The entire dependance of acceptance of better technology on ε raises another interesting question: When it is uncertain or undeterministic, how can such uncertainty alter the result? This question was explored by analyzing risk premium regarding that uncertainty. The result was the following: The relative risk premium to the producer (risk premium when ε is considered as a random variable, divided by the market size) is propertional to variance of ε.

This mean that decision on whether to accpet better technology or not under the uncertainty of ε is dependent on that uncertainty only, which further highlights the importance of the price elasticity of demand.

Conclusions

The results show that only the price elasticity of demand determines whether the energy producer is motivated to the improvement or not. The finding is quite insightful. Improvement is considered to be done by the subjective entity. Thus, the justification of it is entirely determined by the producer in a liberalized economy while the criterion is related only to the demand-side, not supply-side. Moreover, it has nothing to do with producer's technology itself. This means that any intervening policy by the government that intends to promote more efficient technologies should be targeted to demand-side, not directly technology-holders. It may allow us to emphasize an importance of financial measures rather than efforts on hard technology itself. It also emphasizes a need for governmental intervention.

References

Acemoglu, D. (2002), Directed technical change, *Review of Economic Studies*, v. 69, pp. 781-810.
Romer, P. (1990), Endogenous technological change, *Journal of Political Economy*, v. 98, n. 5, pp. S71-S102.
Maeda, A. and M. Nagaya (2019), What Drives or Hinders Autonomous Energy Efficiency Improvement, presented at 4th AIEE Energy Symposium held at LUMSA University, Rome.