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Validation of an R&D-based computable general equilibrium model

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ABSTRACT

A computable general equilibrium (CGE) model is useful for the calculation of macroeconomic effects caused by policy impacts, but it has been considered a sticking point to evaluate how well the CGE model describes the real economy. Among various possible reasons for the difference between the standard CGE model and the real world, this paper focuses on a limited number of primary input factors and a fixed figure for the calibrated coefficient. A CGE model incorporating research and development (R&D) activity is suggested as an alternative to address the problems with the standard CGE model. The proposed model includes the following two setups: (1) a sector's own knowledge is adopted as a production factor, and (2) others' knowledge is regarded as a source of spillover effect to increase the total factor productivity (TFP) coefficient. This R&D-based CGE model is evaluated on whether its correspondence with reality is better than the standard model that omits the two setups. The two models compute baseline scenarios of South Korean economic growth from 1995 to 2010, and these results are compared to actual data. The results show that the R&D-based model fits better than the standard model in cases where the country has high TFP growth.

1. Introduction

In July 2013, the Bureau of Economic Analysis (BEA) at the U.S. Department of Commerce began producing modified statistical data based on a new standard: the System of National Accounts 2008 (2008 SNA). The U.S. became the third country after Australia and Canada to adopt this standard. The European Union (EU) and South Korea will also follow in 2014. For the 2008 SNA, the United Nations Statistical Commission (UNSC) updated the former version of the System of National Accounts 1993 (1993 SNA) in dealing with investment and trade data. What is essential on the investment side is that expenditures on research and development (R&D), weapon systems, and artistic originals are treated as investments. Here, the capitalization of R&D expenditure has an important meaning because the influence of knowledge-based industries is getting bigger in the modern era. Nonetheless, the amount of R&D expenditure is under 3% of Gross Domestic Product (GDP) in most countries. In particular, South Korea is spending 4.03% (in 2011) of GDP on R&D and is ranked as the top five countries for absolute R&D expenditure,[1] and thus, its national economy is thought to get a large effect from R&D investments.

One of the reasons why R&D expenditure is important is that R&D activity is the procedure used to produce "knowledge". As the concept of human capital is widely accepted since Becker (1964), it is regarded as both a source of creative outcomes and an accumulation through continuous investment. In this regard, human capital is also named knowledge capital. Many studies have considered knowledge as a productive asset and recognized it as a key factor in the analysis of the knowledge economy in highly industrialized countries.

In classical production theory, R&D expenditure has been a reason for TFP growth. TFP is a residual that cannot be explained by input factors, and represents the productivity of the process. TFP covers all possible explanations, including industrial structure, law, and institutions. However, Griliches (1973) and Terleckyj (1974) proposed a relationship between TFP growth and R&D activity. Empirical studies afterwards have reported on a positive correlation between R&D activity and TFP growth. That means that countries eager to invest in R&D show long-term increases in their TFP. Fig. 1 exhibits the TFP trends for the last 20 years for certain Organization for Economic Cooperation and Development (OECD) members, based on the calculations from the OECD Productivity Database.[2]

Although TFP is growing from a long-term perspective, ordinary CGE models assume the TFP coefficient as a fixed number in the process of calibration. This is appropriate in either the case of nations with relatively low TFP growth or the case of analysis with short-term impacts. However, in other cases, such as fast TFP growth or long-term analysis, neglecting TFP changes could lead to a distortion in the results of the analysis.

This study claims that incorporating R&D as a factor in the CGE model is necessary to get higher validity in the case of countries with

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[1] Source: Main Science and Technology Indicators, OECD. (Figures at current PPP dollars.)

[2] This productivity calculation is based on all other factors except labor and capital. The detailed methodology is described in OECD (2004).

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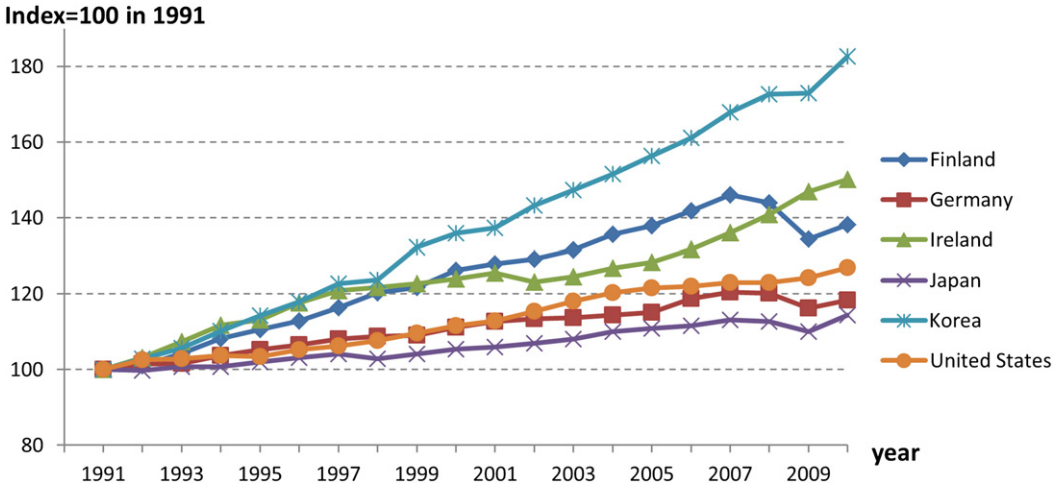

Fig. 1. Trends in TFP growth.

a knowledge economy, and investigates the argument by comparing an R&D-based model with a standard one. The results will demonstrate whether the introduction of knowledge and the endogenous explanation of TFP are significant for improving the validity of the CGE model.

The study is organized as follows. Section 2 briefly summarizes the preceding literature on the R&D-based CGE model and validation issues concerning the CGE model. Section 3 explains the difference in structure between the standard and R&D-based models, and then Section 4 compares the calculations of industry growth by the two models to actual historical data. Section 5 concludes the main findings with a discussion.

2. Previous literature

2.1. R&D-based CGE models

It was the late 1990s when the CGE model gave attention to R&D. Goulder and Schneider (1999) dealt with policy-induced technological changes as a main feature of their model despite a theme of climate change. They divided knowledge stock built by R&D into two classes: spillover knowledge (like public goods) and appropriable knowledge (like private goods). TFP was defined as a function of the former, but it was a simple linear function that became a constant in the long run.

The research that concentrated on R&D in the CGE model originated with Diao and his colleagues. They proposed a way of incorporating R&D into the CGE model based on the endogenous growth theory of Romer (1990). Their model separated differentiated capital, similar in concept to knowledge, as an input factor produced through activity in the R&D sector. Preliminary work by Diao et al. (1996) made the productivity coefficient a constant. However, subsequent research by Diao et al. (1999) introduced the productivity change by the spillover effect, although it was limited to the R&D sector. This setup was in line with Coe and Helpman (1995): the embodied technology in imported goods induces international spillover of R&D, so that productivity grows. This method is also adopted by others like Ghosh (2007) and Lecca (2009).

Since Diao, researches concerning the R&D-based CGE model have focused more attention on the implementation of TFP, with a few exceptions such as Bye et al. (2009) and Bor et al. (2010) who introduced exogenous factor-augmenting productivity. Visser (2007) assumed that a TFP change was affected by various elements in the R&D version of the Worldscan model, of the Netherlands Bureau for Economic Policy Analysis (CPB). That is, TFP is changed by exogenous and endogenous causes, and the latter is a function of spillovers from three ranges: intrasectoral, intersectoral, and international spillovers. This model tried to accept multiple channels of spillover propagation from its own sector, other domestic sectors, and foreign sectors. Verbič et al. (2009) expressed TFP change with regression equation using two variables: the share of nationally produced R&D in GDP and the share of foreign trade in GDP. This setup allows TFP to net direct positive effects from R&D production and foreign trade.

Zürn et al. (2007) did not express TFP with an explicit coefficient. However, they nested knowledge stock at the top level of the production tree: this means that an increase in knowledge augments the productivity of other input factors. This is a Hicks-neutral type of technology progress, which was also adopted in an R&D-based CGE model of Křístková (2012). In her following work (Křístková, 2012), she assorted private and public R&D sectors. The R&D commodity in the public R&D sector was designed not only to improve the TFP of its own sector, but also to have spillover effects on the private R&D sector.

The above studies individually proved that R&D-related policy can be analyzed by incorporating R&D as an element in the CGE model. These researchers had different ways of implementing R&D. For example, some did not separate the R&D account in the Social Accounting Matrix (SAM), while others designed their own channel of the spillover effect to production technology. Since the CGE model for R&D has a shorter history than the ones for trade, tax, energy, and environment, its validity test has not gotten sufficient attention yet.

2.2. Validation of the CGE model

As Dixon and Jorgenson (2013) pointed out, tests of goodness-of-fit for the CGE model were not investigated enough after the early studies (Cook, 1980; Dixon et al., 1978; Johansen, 1960; Taylor et al., 1980). This may be because CGE modelers have been mainly interested in comparative analysis between baseline and political-impact scenarios, which was a reason for other modelers to raise doubts about how well the CGE model fit.

It was Kehoe who offered a detailed report on the validation issue of the CGE model. Kehoe et al. (1995) made a CGE model of the Spanish economy to analyze the impact of fiscal reform in 1986, which was related to Spain's entry into the European Community, and compared the estimations with actual data for 1985–87. The results showed that the model tracked the actual value of major macroeconomic variables relatively well when it accepted both policy changes (i.e., changes in tax and tariff rates) and exogenous shocks (i.e., changes in food and energy prices).

Kehoe (2005) also tried to evaluate multi-sectoral CGE models for changes in Canada, Mexico, and the United States after the North American Free Trade Agreement (NAFTA). The three target models, however, did not fit well with actual data. He thought that one of the reasons was a long-term TFP change, and modified the model by