Economic evaluation of transportation projects: An application of Financial Computable General Equilibrium model

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ABSTRACT

We develop a Financial Computable General Equilibrium (FCGE) model that analyzes the economic impacts of infrastructure investment projects and their financing options on growth and distribution in the Indonesian economy. The FCGE model integrates the real economy with the financial one within a unified economic system, and traces the flows of financial and real resources among economic agents. The model is designed to analyze the economic effects of fiscal policies such as the transportation investment expenditures and alternative procurement approaches on economic growth and distribution among socio-economic classes, linking the investment expenditures with specific financial resources. It is possible to estimate growth and distributional effects of each project based on the financing method over the construction and the operation and maintenance periods once the information on the investment expenditures, the construction location and the changes in the accessibility generated by the project are injected into the FCGE model. The simulations on the Indonesian transportation projects reveal that the government financing with tax revenues could generate higher effects on GDP than other financing methods.

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1. Introduction

In general, transportation investments have generative and distributive effects on economic values and activities across regions; these effects can be classified into construction (temporary or short-term) and operation and maintenance (structural or long-term) impacts. The former refers to impacts of investment expenditures on outputs and prices through the demand channel of the commodity and service markets during the construction phase. The latter includes impacts of capital accumulation in the transportation sector on economic growth as a result of improved accessibility during the operation and maintenance phase (Kim, Hewings, & Hong, 2004). These long-term benefits arise from a combination of direct and indirect effects. The sources of direct effects are reductions in travel times and transportation costs; in turn, these changes generate indirect effects through the functional inter-linkages of economic activities. These indirect effects, as a form of spillovers, include impacts on productivity, change of location pattern, industrial agglomeration, spatial range of commuting and travel behavior, migration, spatial business opportunity, and knowledge sharing (Koike, Ishikura, Miyashita, & Tsuchiya, 2015; Koopmans & Oosterhaven, 2011).

It is necessary to formulate an innovative tool to calibrate these effects of transportation projects, if the government attempts to assess the development priorities in terms of economic efficiency and income distribution. The method should measure the direct and indirect effects on not only benefits but also costs because both impacts are generated through the production and consumption linkages among economic agents. The purpose of this paper is to develop a Financial Computable General Equilibrium (FCGE) model as a new approach to assess economic contributions of transportation projects. There are two highlights in the FCGE model. One is to integrate a real economy with a financial one within a unified economic system and to trace out the flows of financial and real resources among economic agents. Another is to analyze the economic effects of fiscal policies such as the transportation investment expenditures and their procurement approaches (e.g., from current taxes or through bonds) on economic growth and income

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distribution among socio-economic classes in Indonesia, linking the investment expenditures with specific financial resources. As application examples, the model is applied to the economic evaluation of two highway projects in Jakarta and East Kalimantan shown in Fig. 4. Each project is assumed to have three financing options such as government financing with (1) tax revenues or (2) government bond issues, and (3) private financing. The benchmark year of the FCGE model is 2005, the most recent year that an official Financial Social Accounting Matrix published by the Bank of Indonesia (2009) was available.

This FCGE model has at least three distinguishing features from conventional analytical tools of transportation investments such as Cost—Benefit Analysis (CBA) and a standard CGE model. First of all, the model carries out the economic policy evaluation in a general equilibrium framework in the real and financial side of all markets. The results from the CBA might be biased due to a partial equilibrium approach if there are government interventions and distortion of market prices. In addition, the model assesses economic benefits and costs of transportation projects through the development of functional links between the expenditure in the commodity market and their financing methods in the financial market. The FCGE model is an extended CGE model to integrate financial asset (loanable fund) markets with the commodity and the factor input markets, examining implications of financial policies for the infrastructure development and management. Finally, the model measures the economic impacts of transportation investments using the spatial accessibility based on the transportation network (quality side) as well as investment amounts (quantity side). The rest of the paper is structured as follows. Major research studies are reviewed on the CGE models of Indonesia in the next section. Section 3 develops the FCGE model for the investment analysis of the highway, and carries out three counterfactual simulations as case studies. Conclusions and suggestions for further research are discussed in the final section.

2. Review on transportation-economic and Indonesian CGE models

The CGE model is an analytical and numerical tool based on Walrasian equilibrium theory to estimate the impacts of economic policies on growth (per capita GDP) and equity (income equality and poverty reduction). The model accounts for functional interactions of economic agents in a market-based system, and has been applied to development issues such as public finance, structural adjustment, trade liberalization, human capital and education, labor market and migration, infrastructure investment, climate change, and population ageing. For example, the OECD in the early 1990s attempted to extensively calibrate effects of stabilization and structural adjustment policies on the income distribution in Chile, Cote d’Ivoire, Indonesia, Malaysia and Morocco using a common CGE model. Also, the CGE model has been used to assess the long-term effects of transportation investments, and is classified into (1) the cost-based approach and (2) the network-based approach of spatial accessibility in terms of selection of transportation policy variables for the economic model.1

Until the early 2000s, the cost-based approach was prevalent in exploring the impacts of transportation infrastructure investment on economic growth, and was again disaggregated into (1) productivity method and (2) congestion cost method (Brocker, 2002; Conrad, 1997; Conrad & Heng, 2002; Friesz, Sue, & Westin, 1998; Haddad & Hewings, 2001; Kim, 1998; Rioja, 1998; Roson & Dell’Agata, 1996; Seung & Kraybill, 2001). In the productivity method, Roson and Dell’Agata (1996) showed that an increase in transport investment would reduce both traffic congestion and the gap between the user optimum and system optimum. Kim (1998) found that the elasticities of infrastructure investment with respect to GDP and inflation were determined by institutional restrictions on the foreign capital and financing alternatives for infrastructure projects. Haddad and Hewings (2001) analyzed the long-term effect of the total factor productivity of the transportation sector on logistic costs and spatial price differentiation with a mark-up structure using the Brazilian Multi-sectoral and Regional-Interregional Analysis Model. Brocker (2002) estimated the impacts of transportation costs and road development of the Trans-European Transport-Networks on the spatial distribution of the benefit using a static CGE model with three major blocks such as final demand, production, and transport cost and equilibrium.

The key factor in the congestion method is travel and congestion costs, input variables to the CGE model. The costs are usually derived from bottom-up engineering processes or determined as a policy variable. Conrad (1997) measured the optimal size of the infrastructure in terms of productivity effect and congestion costs, and Seung and Kraybill (2001) found that the magnitude of the effect of the public investments depended on public capital elasticity, public capital stock, per-capita stock of private capital, and the congestion level. Conrad and Heng (2002) developed a road congestion CGE model using road bottlenecks and congestion cost functions, and showed that the effective transportation services were determined through the optimal allocation of transportation capital from the minimization of total transportation costs and congestion costs. Berg (2007) linked a household demand function for transport services with a stylized environmental CGE model in order to estimate the impact of a carbon target on the Swedish economy. Koike et al. (2015) compared the economic effects of high-speed rail policies on the national economies for China, Taiwan, Korea and Japan using Spatial CGE models. The infrastructure policies resulted in changes in traffic volume, price, and travel time, which in turn caused an allocation of spatial resources in urban real estate market.

In a network-based approach, the key variable is an accessibility index that is an indicator of the level of services or ease of access (spatial interaction) between spatial opportunities provided by the transport network.2 It is usually estimated by calculating the minimum travel distances and the levels of activities (population or employment distribution) at the origin and destination. A typical example of the partial equilibrium models using the spatial accessibility is an economic potential model with as illustrated in the work of Gutierrez and Urbano (1996) and Vickerman, Spiekermann, and Wegener (1999) for the Trans-European network and Linneker and Spence (1996) for the M25 London orbital motorway, and Rietveld and Bruinsma (1998) for the European agglomerations.

Haddad and Hewings (2005) and Kim et al. (2004) integrated transportation activity with spatial and economic equilibrium approaches in a consolidated structure. They specified the

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1 They could be disaggregated into sequential and non-sequential models in terms of treatment of the economic model (Kim et al., 2004).

2 The integrated transportation network model is another type of the network-based approach, but is not a CGE-type model. Cho, Gordon, Richardson, Moore, and Shinozuka (2000) measured economic impacts of industrial and transportation structure on the Los Angeles economy, using an integrated system of bridge and other structural performance models, transportation network models, spatial allocation models, and input–output models. Sohn, Hewings, Kim, Lee, and Jang (2004) and Kim, Ham, and Boyce (2002) incorporated the transportation network model with the input–output model in order to calibrate an economic loss of catastrophic earthquake on regional commodity and transportation network flows.
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