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Project Evaluation of Transportation Projects: an Application of Financial Computable General Equilibrium Model

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Project Evaluation of Transportation Projects: an Application of Financial Computable General Equilibrium Model

ABSTRACT

We develop a Financial Computable General Equilibrium Model (FCGE) model that can analyse the economic impacts of the infrastructure investment projects and their financing options on growth and distribution in Indonesia economy. It is possible to estimate growth and distributional effects of each project based on the financing method (government financing with tax revenues, government bond, and private financing) over the construction and operation periods if the information on the investment expenditures, the construction location and the accessibility of the project are injected into the FCGE model. The government financing with tax revenues could generate higher effects on GDP than two other financing methods regardless of projects. However, the presented values of benefits over costs are less than one for two sample highway projects, so they cannot be sustainable with regard to economic assessment.

KEY WORDS: Transportation Investment; Infrastructure Policy; Financial CGE Model

JEL: C68, D58, H54, O18

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1. Introduction

In general, transportation investments have generative and distributive effects on spatial economic value and activities, which can be classified into construction (temporary or short-term) and operation (permanent or long-term) benefits. The former refers an impact of investment expenditures on the output and the price through the demand channel of the commodity and service market during the construction phase. The latter includes an impact of capital accumulation in the transportation sector on the economic growth by improving production potential and lowering an average production cost during the operation phase (Kim *et al.*, 2004). The change in spatial accessibility can lead to the relocation of economic activities to the places to maximize utility and profit levels of economic agents based on the connectivity with the transportation network system, too. These long-term benefits are distinguished into direct and indirect benefits. The sources of direct effects are reductions in travel times and the transportation costs, which generate indirect effects through functional linkages of economic activities. The indirect effect as a form of spillover effect includes impacts on productivity, change of location pattern, industrial agglomeration, spatial range of commuting and travel behavior, migration, sightseeing and leisure travel, spatial business opportunity and knowledge sharing (Koike et al, 2015; Koopmans and Oosterhaven, 2011).

It would be necessary to establish a quantitative 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. In a sense that the benefits and costs of projects are generated through the production and consumption linkages among economic agents, their outcome needs to be measured in a systematic approach to take into account direct and indirect effects on not only benefits but also costs. This paper is focused on a development of a Financial Computable General Equilibrium (FCGE) model for evaluating economic effects of the projects on growth and equity of Indonesia. The FCGE model integrates a real economy with a financial one within the unified economic system, and can trace out the flows of financial and real resources among economic agents. In particular, the model is designed 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 distribution among socio-economic classes, linking the investment expenditures with specific financial resource. The model has eight economic institutions: four household groups (Rural Low, Rural High, Urban Low and Urban High), corporations, financial institutions (including the central bank), government, and rest of the world. The portfolio choice for financial instruments (assets) is disaggregated into real wealth, government bond, and composite financial assets including private bonds, equity, and deposits (money). As application examples, there are two alternatives of highway projects in Jakarta and East Kalimantan in Figure 3 in Section 3. Each project is assumed to have three financing options such as government financing with (1) tax revenues, (2) government bond issues and (3) private financing. A base year of the FCGE model is 2005, the latest year that an official Financial Social Accounting Matrix was published in Indonesia. 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

CGE Models on Transportation Investment Analysis

There are a few methods to quantify economic contribution of the transportation investment such as econometric input-output model, transportation network model, spatial price equilibrium model and spatial CGE model (Kim et al, 2004). These approaches have placed more emphasis on the calibration of the long-term effects to affect the economic behaviour of users. They can be classified into (1) the cost-based approach to use transportation price and congestion cost from the trip demand analysis and (2) the network approach to employ a spatial accessibility with a transportation network with respect to type

of transportation variables for the economic model¹. Until the early 2000s, the former approach was prevalent in exploring the impacts of transportation infrastructure investment on economic growth (Roson and Del'Agata, 1996; Conrad, 1997; Kim, 1998; Rioja, 1998; Friesz *et al.*, 1998; Seung and Kraybill, 2001; Haddad and Hewings, 2001; Conrad and Heng, 2002; and Brocker, 2002). With respect to productivity in the cost-based approach, Roson and Del'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, and Rioja (1998) discussed the infrastructure investment might cause a negative effect on welfare levels. Haddad and Hewings (2001) analysed the long-term effect of the total factor productivity of the transportation sector on transportation costs and spatial price differentiation with a mark-up structure using the Brazilian Multisectoral And Regional/Interregional Analysis Model. Brocker (2002) estimated the impacts of transportation costs and road development of the Trans-European Transport-Networks (TEN-T) 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.

Congestion costs have been derived from bottom-up engineering process in the cost-based approach. The reduction of congestion costs by transportation investments results in cost savings, which can be exogenous shocks to the CGE models. Conrad (1997) determined the optimal size of the infrastructure in terms of productivity effect and congestion costs using the CGE model. Seung and Kraybill (2001) estimated the effects of public capital on regional output and welfare in Ohio using a regional dynamic CGE model. They found that the magnitude of the effect of the public investments depends on public capital elasticity, public capital stock, per-capita stock of private capital, and congestion level. Conrad and Heng (2002) developed a road congestion CGE model using road bottlenecks and congestion cost

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

functions. 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 to estimate the impact of a carbon target on the Swedish economy.

In the network approach, the key variable is an accessibility index by region, which is an indicator of the level of services or ease of access (spatial interaction) between spatial opportunities provided by the transport network. It was measured by using the minimum travel distances and the levels of activities (population or employment distribution) at the origin and destination. Accessibility by spatial unit was a major input variable for the calibration of the long-term effects of the transportation investments on economies. One of examples for this approach is an economic potential approach with the spatial accessibility; Gutierrez and Urbano (1996) and Vickerman *et al.* (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. The integrated transportation network model is another type of the network approach. Cho *et al.* (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 *et al.* (2001) and Kim *et al.* (2002) integrated 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.

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 interactions between the transportation sector and real side economy through a price mechanism, and measured transportation inputs in monetary terms as well as other dimensions such as accessibility. The economic activities by region and sector were differentiated with changes in the transportation network, which has direct and indirect effects on both regional economic growth and interregional trade patterns in the long term.

Haddad and Hewings (2005) developed a multiregional CGE model to capture non-constant returns to scale for the manufacturing sector, and the moving costs on origin-destinations pairs. They argued that the welfare impacts were much more sensitive to changes in transportation costs than scale economies. Ferraz and Haddad (2009) formulated a seaport-based multiregional CGE model of the Brazilian economy to estimate the effect of import barriers on the distribution of economic activity. The unique feature of this model was an explicit modelling of the land-maritime transport costs in addition to the scale economies and port efficiency. The maritime transport cost was estimated with an exponential function of the distance between the foreign port of origin and the domestic port of entry to take into account long-haul economies. Haddad *et al.* (2010) incorporated a transport network system into their multiregional CGE model to simulate the impacts of increases in port efficiency in Brazil.

The transport network–multiregional CGE model of Kim *et al.* (2004) and Kim and Hewings (2009) was composed of a transport model and a multiregional CGE model. The transport model measured changes in interregional shortest distances and accessibility by the highway project, while the CGE model estimated the spatial economic effects of the projects on the GDP, price, exports, and the regional distribution of wages and population. The model was applied to estimate the synergy effects of a set of highway projects on the value added by region and industrial sector for construction and operation periods (Kim and Hewings, 2009). This synergy effect is defined as a difference between the summation of the net GDP increase from the development of each highway sub-link without spatial linkage and the change in GDP resulting from the concurrent development of all links with spatial linkages. For example, Korea's East-West 9 Highway increased the nation's GDP by 0.3% over the 30-year time period horizon, with 0.016% of the GDP arising from the synergy effect. Kim *et al.* (2011) examined the impacts of highway development according to the ways in which they were financed. The results indicated that imposing regional earmarked taxes had larger effects on income growth and the reduction of regional income inequality than the current tax system.

CGE Models on Indonesian Economies

The recent works on the CGE models of Indonesia have been primarily applied to the impact analysis of fiscal instruments and environmental policies on the growth and income distribution. Their major approaches include INDONESIA-E3 (Economy, Equity, and Environment) model, AGEFIS (Applied General Equilibrium model for FIScal Policy Analysis)-E3 model and IRSA-INDONESIA5 model. As a national model, INDONESIA-E3 model had three incorporated modules of carbon emissions, income distribution and taxation with a prototype CGE model. It could be used to estimate effects of environmental reforms such as carbon emission and energy pricing on the inequality and poverty (Yusuf, 2008). Yusuf *et al.* (2010) developed AGEFIS-E3 model to focus on linkages between energy sector and fiscal instruments. The model was applied to examine how Indonesia could achieve the economic goal to reduce greenhouse gasses emission by 26% by 2020. The model had explicit renewable energy sectors such as geothermal and hydropower, so exploring an effective mix of instruments to reduce emissions from the energy sector. They showed that a removal of energy subsidy for fuel and electricity could contribute to significant reduction in carbon emissions. In addition, Warr and Yusuf (2011) analysed the effectiveness of utilization of forests as a means of achieving the emission target, and Yusuf and Resosudarmo (2008, 2011) analysed effects of fuel price inflation on the income distribution. Yusuf and Resosudarmo (2011) argued that the price reform could have been progressive with increasing only vehicle fuel prices, but the inequality in urban areas could be worsened with the price inflation of the domestic fuel. Resosudarmo (2003) examined the impact of air pollution policies on the economic performance and household incomes using an interaction approach between economic activities and the air quality. It showed that the improvement of urban air quality could induce a higher GDP and increase the income of poor households. Amir *et al.* (2013) evaluated the impacts of Indonesia's income tax reforms on poverty and income distribution. They found that the reductions in personal income tax and corporate income tax increased the economic growth under a balanced budget assumption. The policy

reforms resulted in a small reduction in the incidence of poverty, but they caused an increase in the income inequality because the tax cut was more beneficial to households in the highest income categories.

In terms of regional economic issues, Resosudarmo *et al.* (2011) showed that the best way to reduce the development gap among regions would be to operate effective programs to accelerate the growth of human capital in the less developed regions, using an inter-regional CGE model, IRSA-INDONESIA5. The recent work on regional CGE model is the Indonesian version of TERM², developed by Horridge *et al.* (2012) to analyse the impact of reducing transport costs in Indonesia. They argued that the shortage of transportation investments decreased the competitiveness of the products and increased imbalances between regions in Indonesia. Even though the study did not discuss how to reduce the transport costs, the simulation results showed that the improvement in transport network (to or from peripheral regions, within non-peripheral regions) could lead to reduction in the costs of foreign trade and saving in logistic costs.

For the fiscal and financial policy analysis, Azis *et al.* (2000) attempted to develop a model to incorporate transmission mechanisms of the Asian Financial Crisis with political instability with poverty in Indonesia during the period 1997-1999, and Robilliard *et al.* (2001) combined a micro-simulation model of household's income generation with a standard CGE model to quantify the effects on poverty and inequality of the financial crisis of Indonesia in 1997. The household heterogeneity was specified in terms of income sources, area of residence, demographic composition, endowment in human capital, and consumption preferences using household samples of the 1996 SUSENAS survey. The framework estimated the impact of alternative social policy packages such as food subsidies, household transfers and public work programs during the crisis. Dartanto (2011) measured the impact of volatility in the world price and import tariffs of soybeans on poverty using a micro-simulation CGE approach and the endogenous poverty line. It showed that the price volatility during 2007–2009 had a significant effect on increasing poverty, and the increase in the world price by 40% raised the head count index by 0.204%.

² Information and references about TERM may be found at www.monash.edu.au/policy/term.htm.

In sum, the network model, in particular the CGE model, succeeded in endogenously determining the prices and transport costs from inter-sectoral linkages, but often neglects an interaction between the transportation investment expenditures and their financing method in calculating the economic impacts. So the model structure needs to be transformed to practically integrate transportation activity with financing approaches in a consolidated structure. With this approach, the commodity and service levels by sector react to changes in the transportation network and the financing method, generating direct and indirect effects on both regional economic growth and trade patterns in the long run.

3. Model

The FCGE model in this paper is an integrated model combining the real side of the economy with financial asset choices and an accessibility module to address the impacts of changes in transportation networks³. It is possible to analyze the economic effects of the transportation investment expenditures and their procurement approaches on economic growth. The FCGE model is composed of interactions between the real-side and financial-side blocks, and production activities are disaggregated into nine sectors: agriculture, mining, manufacturing, utility, construction, hotel and restaurant, transportation and communication, finance, and other sectors. There are eight economic institutions: households (Rural Low, Rural High, Urban Low and Urban High), corporations, financial institutions (including the central bank), government, and rest of the world. The real-side block accounts for the economic behavior of producers and consumers on the real side economy, following market-clearing prices, the maximization of firm profits, and a household utility maximization. The commodities for economic agents are composed of domestic demands (supplies) and foreign imports in terms of product origin, whereas the products are spatially distributed among domestic supplies and foreign exports in terms of product destination. Commodity prices are assumed to adjust toward a balance between supply and demand in

³ The model framework is based on Kim and Bae (2015)'s approach for economic assessment of transportation policies for Korea.

terms of factor inputs and commodity markets. Total wealth is composed of the real wealth and financial wealth, which is again classified into government bonds and a composite of financial instruments for the simulation. Figure 1 shows the schematic structure of the FCGE model.

<Insert Figure 1>

Our production structure model has two stages. At the top of the structure, the gross output by industry is determined by a separable two-level production function for value-added and composite intermediate inputs; that is, in accordance with the Leontief production function, the producer coordinates the level of intermediate demands and value-added elements against a fixed proportion of gross output. The labor input is assumed to be homogeneous and to possess inter-sectoral mobility, whereas capital stock is assumed to be fixed in the short run. The labor demand by industry is derived from the producers' value-added maximization of the first order condition, whereas the average wage level is derived by balancing out total labor demand against total labor supply. The intermediate inputs are derived from input-output coefficients. The value-added element is determined by a production function of labor, private capital inputs and an external factor such as accessibility. The accessibility reflects the importance of both the scale and proximity of population and economic activity, and is a proxy for the quality of transportation services and development potential. It is measured as the weighted sum of the population in 440 basic administration units in Indonesia in a gravity-typed form (Kim *et al*, 2004). The travel time is calibrated by the shortest time distance among the administration units by Arc-GIS, a tool external to the FCGE model, and the elasticity of the accessibility with respect to the value added is estimated as 0.0175 using data from 33 Indonesian provinces. For the second stage of the model, the domestic market is assumed to be a price taker at the given world price. That is, foreign trade follows a small-country assumption and adopts an Armington approach. Imperfect substitutions are allowed

between domestically produced goods and foreign imports on the demand side as well as between the domestic supplies and the foreign exports on the supply side.

The total demand for goods and services consists of intermediate demands, total consumption expenditures for households, government consumption expenditures, and investment. The household incomes include wages, capital income, and transfer from other institutions. Households pay interest costs and rents, transfer to other institutions including taxes and allocate their disposable income between consumption and savings. Corporations and financial institutions have capital incomes from real capital investments and property incomes such as interest incomes and rents and dividends, and transfers from other institutions. Government expenditures are composed of consumption and investment expenditures, subsidies to producers and households, transfers to the financial institutions and the rest of the world, and savings. Revenue sources are tax revenues from household incomes, value-added, and foreign imports, and the government-owned stock of financial assets.

The FCGE model specifies loanable fund markets such as money (deposits), domestic bonds, equity and real capital. Total wealth is composed of the real wealth and the financial wealth. Real wealth includes machinery and buildings; financial wealth is classified into government bonds, and a composite of financial assets such as equity, deposits (money) and private bonds in this paper. The specification of the portfolio behavior on asset holders (institutions) is based on Kim (1990) as shown in figure 2. If an investment return increases compared to the interest rate, an institution would purchase more real assets, such as buildings and machinery, for investment. Similarly, if a bond rate is higher than the interest rate of the competing asset, institutions would be more willing to buy more bonds to increase their property income from dividends. The institution is designed to make a decision regarding how much it purchases of two competing financial assets in the portfolios in every successive stage. In the top stage, the total wealth is divided into real wealth acquisition and the financial assets purchase in the ratio of $g_1 : (1-g_1)$. The ratio, g_1 , of real wealth to total wealth is endogenously determined by the rate of return on the investments and the average rate of return on the financial wealth. The latter is again distributed to

national bond and composite financial assets in the ratio of $g_2: (1-g_2)$. Financial decisions also depend on their net returns. To reflect this asset demand relationship with its rate of return, we derive the elasticity of demand parameter with respect to relative return rate.

<Insert Figure 2>

In addition, we restructured the Bank of Indonesia Financial Social Accounting Matrix (FSAM) as a benchmark for the development of the CGE model. The FSAM is treated as an initial equilibrium for the model, and the values of some parameters are adjusted to replicate the equilibrium conditions for the base year, 2005. Economic activities are largely disaggregated into six balanced expenditure-receipt accounts: production, value-added, current account of institution, capital account of institution, financial flows, and investment. The current account spends income on consumption, transfers among institutions, and savings. Transfers include direct taxes, social contributions, social benefits, and other transfers on a national account basis. Savings of each institution are residually determined through total income minus total expenditure. The capital account is expanded to include the capital accounts of all institutions. It matches the savings of each institution with its investment through financial instruments.

<Insert Table 1>

The FCGE model consists of a within-period model and a between-period model. Due to the difficulty of solving the simultaneous system, the dynamics of the model follow an adaptive and recursive pattern. The within-period model determines equilibrium quantities and prices under objectives and constraints for each economic agent in the context of a static model. The between-period model finds a sequential equilibrium path for the within-period model over the multiple periods by updating the values of all exogenous variables such as government expenditures. On the real side, the current capital stock

is expanded with new investment but also reduced by a constant depreciation rate. The within-period model is a square system of equations with 308 equations, and the exogenous variables include world market prices and labor supply. The *numeraire* of the model is set as the consumer price index.

<Insert Table 2>

2) Simulation

As examples of counterfactual analysis, the FCGE model is applied to the following two transportation projects. Each is assumed to have three financing options such as government financing with tax revenues and government bond issues and private financing.

- 1) North–South Jakarta Highway in Java (hereafter NS project): 40 trillion RP investment expenditures for six years
- 2) Balikpapan–Samarinda Highway in East Kalimantan (hereafter BS project): 12 trillion RP investment expenditures for four years

<Insert Figure 3>

The FCGE model with a base year of 2005 is designed to run for 15 years from 2006 to 2020 in a recursive pattern. The current stock variables on capital and financial assets are determined by one period lagged stock and current flows of investment and financial assets. There are two kinds of temporal effects on economic sectors generated in this period. One is the short-term or construction-flow effect; changes in employment and income during the construction period are generated through the demand side. The magnitude of the effect depends on the size of the investment expenditure and how the infrastructure is financed. Another is the long-term or operation-stock effect; changes in the distribution of economic resources through capital accumulation and productivity gains will be realized through improved accessibility. We assume that the construction of all the projects starts in 2006 for a

simplification of the dynamic adjustment process in the FCGE model. For example, the construction period of NS project is from 2006 to 2011, and the facility is assumed to be operated over nine years from 2012 to 2020 for the analysis.⁴ The economic effects of each project under different financing option are compared with the base case without the transportation developments. All exogenous variables of each project have the same values as in the base case. The major input variables for the simulation of the FCGE model are (1) the annual construction expenditure, (2) the annual amount financed by each procurement option (tax revenues, government bond, and private fund) during the construction period, (3) the length of construction period (e.g., six years for NS project and four years for BS project), (4) the length of operation period (e.g., nine years for NS project and 11 years for BS project), and (5) the average value of accessibility. That is, the effects of the investments and financing of the project rely on differences in the capital costs, the investment amounts and periods, and the accessibility. The financing costs are endogenously determined in the model; while the accessibility of project is calculated in the GIS analysis is external to the FCGE model. The accessibility levels of all the projects increase with the reduction in total travel time distances over 440 basic administration units; NS project by 3.8% and BS project by 9.4% compared with base case.

Table 3 summarizes the resulting outcomes of the projects on the GDP and two income ratios between low and high income groups and between urban and rural areas in the case of the government financing with tax revenues. NS project has a positive effect on the GDP growth by 0.038% points, which is higher than BS project (0.028% points). The former could reduce marginally the income gap between the high and low income groups on the other hand the latter generating a negative effect on the income distribution. However, both the projects do not have few effects on the income disparity between the urban and rural areas.

⁴ Obviously, the project life will extend beyond 2020 but the accessibility impacts are likely to have been fully realized by this time.

<Insert Table 3>

The government financing with tax revenues could generate higher effects on GDP than two other financing methods regardless of projects, as shown in table 4. The results imply that the investment activity of the government could be more efficient than the government consumption in terms of the resource allocation since the increases in the former should come with the reduction in the latter under the government budget constraint. The second best for the GDP growth is to raise the investment funds in government bonds. The advantage of this financing approach is to increase the total amount of the government expenditures without a significant decrease in the government consumption, but the government should pay for the bond costs (yields) to the buyers in every year thereafter. Finally, the private financing results in relatively low economic effect due to its crowding-out effect on other investment activities. If the expected efficiency of private-financed project is taken into account in the model specification, there might be a positive economic contribution of the private financing case on the growth.

<Insert Table 4>

If the net change in the GDP and the investment expenditures are defined as benefits and costs of the project, it is possible to calculate the present values of benefits and costs with the discount rate of 6.0% for the 30 years as shown in Table 5. However, the presented values of benefits over costs are less than one for two sample highway projects, so they cannot be sustainable with regard to economic efficiency.

<Insert Table 5>

4. Summary and further research

In this paper, we develop the FCGE model that can analyze the economic impacts of the infrastructure investment projects and their financing options on growth and distribution in Indonesia economy. It is possible to estimate growth and distributional effects of each project based on the financing method (government financing with tax revenues, government bond, and private financing) over the construction and operation periods if the construction information and changes in the accessibility of the project are injected into the FCGE model.

Regarding further research directions, one of major challenges in CGE modelling is developing a unified framework for feedback and interactions between a regional CGE model and a transportation network model (Zhang *et al.*, 2011). In general, the two types of models have different theoretical foundation and spatial units, so it is not easy for them to share a common platform and assumptions. For example, a regional CGE model is a macro-micro simulation model with state-level data, while a transport model is purely a micro-simulation model with zone-level data. In the case of Kim and Hewings (2009), the population variable was exogenous in their transport-network model but endogenous in their regional CGE model. Given that the spatial unit of the regional CGE model is hard to downsize (due to a lack of adequate economic data such as trades and factor inputs as well as computational challenges), major efforts are required to identify whether the two models maintain convergence trends for key economic indicators through an iterative top-down-bottom-up approach.

Another challenge is the disaggregation of the transportation sector into sub-sectors—including roads, railroads, seaports, and airports—because each has distinctive features in terms of the types of network and flow, as well as in delivery of services. The effect of each transportation sub-sector on the economy can be calibrated by estimating the aggregate transportation production function in a two-stage hierarchy system due to the insufficient time series data of the capital stock and by employing sub-sectors at the regional level (Zhang and Peeta, 2011). That is, the aggregate transportation services can be determined by the CES function of the services of the ground transportation (roads and railroads) and of the non-

ground transportation sectors (seaports and airports) in the upper level. Again, the service levels of the ground transportation depend on those of the roads and the railroads in the lower level. The transportation services of the non-ground sector are estimated by the CES function of the seaports and the airports at the same level. In final, key economic and sectoral variables need to be compiled and re-classified in a time-series pattern for the modeling. This work would include the consistent classification of household groups between the Financial SAM and the real SAM, the disaggregation of demands for financial assets (instruments) by socio-economic group, and the development of transportation network data for road and railroad. The extension of the model is focused on the development of transportation network equilibrium model and its interaction with the current FCGE model. The current model takes into account only one-way directional causality from the accessibility block to non-spatial economic block with 440 spatial units in the transport network.

References

- Amir, H., J. A. Adjaye and T. Ducpham (2013), "The Impact of the Indonesian Income Tax Reform: A CGE Analysis," *Economic Modeling*, 31: 492-501.
- Azis, I. J., E. E. Azis and E. Thorbecke (2000), *Modeling the Socio-economic Impact of the Financial Crisis: The Case of Indonesia*, mimeo.
- Berg, Charlotte (2007), "Household Transport Demand in a CGE-Framework," *Environmental & Resource Economics*, 37: 573-597.
- Brocker, Johannes (2002), "Spatial Effects of European Transport Policy: a CGE Approach," in Hewings, Geoffrey J. D., M. Sonis, and D. Boyce (eds.), *Trade, Networks and Hierarchies*, New York: Springer.
- Cho, Sungbin, P. Gordon, H.W. Richardson, J.E. Moore and M. Shinozuka, (2000) "Analyzing Transportation Reconstruction Network Strategies: a Full Cost Approach," *Review of Urban and Regional Development Studies*, 12(3), 212-27.
- Conrad, Klaus (1997), "Traffic, Transportation, Infrastructure and Externalities: A Theoretical Framework for a CGE Analysis," *The Annals of Regional Science*, 31: 369-389.
- Conrad, Klaus and S. Heng (2002), "Financing Road Infrastructure by Savings in Congestion Costs: A CGE Analysis," *The Annals of Regional Science*, 36(1): 107-122.
- Dartanto, T. (2011), "Volatility of World Soybean Prices, Import Tariffs and Poverty in Indonesia: A CGE-Microsimulation Analysis," *The Journal of Applied Economic Research*, 5(2): 139-181.
- Friesz, Terry L., Z. Suo, and L. Westin (1998), "Integration of Freight Network and Computable General Equilibrium Models," in Lundqvist, Lars, L. Mattsson, and T. J. Kim (eds.) *Network Infrastructure and the Urban Environment*, New York: Springer.
- Graham, D. J. (2007), "Agglomeration, Productivity and Transport Investment," *Journal of Transport Economics and Policy*, 41(3): 317-343
- Gutierrez, Javier and P. Urbano (1996), "Accessibility in the European Union: the Impact of the Trans-European Road Network," *Journal of Transport Geography*, Vol.4, No.1, pp. 15-25
- Haddad, Eduardo A. and G. J. D. Hewings (2001), "Transportation Costs and Regional Development: An Interregional CGE Analysis," in Friedrich, Peter and S. Jutila (eds.), *Policies of Regional Competition*, Nomos Verlagsgesellschaft, Baden-Baden, 83-101.

- Haddad, Eduardo A. and G. J. D. Hewings (2005), "Market Imperfections in a Spatial Economy: Some Experimental Results," *The Quarterly Review of Economics and Finance*, 45: 476–496.
- Haddad, Eduardo A., G. J. D. Hewings, F. S. Perobelli and R. A. C. dos Santos (2010), "Regional Effects of Port Infrastructure: A Spatial CGE Application to Brazil," *International Regional Science Review*, 33(3): 239-263.
- Horridge, J. M., A.A. Yusuf, E. Ginting, and P. Aji (2012). *Effects of Reducing Transport Costs in Indonesia*. Retrieved 22 March 2013, from <http://www.monash.edu.au/policy/archive/tpmh0118.zip>
- Kim, Byung H. (1990), *Structural Adjustment Policies under External Shocks: A Computable General Equilibrium Analysis for the Case of Indonesia*, Unpublished Ph. D. Dissertation, Cornell University.
- Kim, Euijune. (1998), "Economic Gain and Loss of Public Infrastructure Investment: Dynamic Computable General Equilibrium Model Approach," *Growth and Change*, 29(4): 445-468.
- Kim, Euijune, G. J. D. Hewings, and C. Hong (2004), "An Application of Integrated Transport Network Multiregional CGE Model I: A Framework for Economic Analysis of Highway Project," *Economic System Research*, 16(3): 235-258.
- Kim, Euijune and G. J. D. Hewings (2009), "An Application of Integrated Transport Network –Multiregional CGE Model to Calibration of Synergy Effects of Highway Investments," *Economic Systems Research*, 21(4): 377-397.
- Kim, Euijune, H. S. Kim and G. J. D. Hewings (2011), "An Impact Analysis of Government Financed Highway Project using Integrated Transport Network –Multiregional CGE Model," *Journal of Transportation Economics and Management*, 45(2): 223-245.
- Kim, Euijune and Yujin Bae (2015), "Economic Contribution of the Private Sector on Financing and Operation of Highway: Financial CGE," *Journal of Transportation Economics and Policy*, 49(3): 397-414
- Kim, Tschangho John, H. Ham, D. E. Boyce (2002), "Economic Impacts of Transportation Network Changes: Implementation of a Combined Transportation Network And Input-Output Model," *Papers in Regional Science*, Vol.81, No.2, pp.223–246
- Koike, Atsushi, Tomoki Ishikura, Mitsuhiro Miyashita, and Kazuyuki Tsuchiya (2015), "Spatial Economic Analysis for Intercity Transport Policies." In Hayashi, Yoshitsugu, Shigeru Morichi, Tae Hoon Oum, and Werner Rothengatter (Eds.). *Intercity Transport and Climate Change: Strategies for Reducing the Carbon Footprint*, (Springer International Publishing), pp.177-213
- Koopmans, C., and J. Oosterhaven (2011), "SCGE Modelling in Cost-benefit Analysis: The Dutch Experience," *Research in Transportation Economics*, 31(1), 29-36.
- Levinson, D. M. (2002), *Financing Transportation Networks*, Northampton, MA: Edward Elgar Publishing.
- Linneker, Brian and N. Spence (1996), "Road Transport Infrastructure and Regional Economic Development: the Regional Development Effects of the M25 London Orbital Motorway," *Journal of Transport Geography*, Vol.4, No.2, pp. 77-92
- Resosudarmo, B. P. (2003), "Computable General Equilibrium Model on Air Pollution Abatement Policies with Indonesia as a Case Study," *The Economic Record*, 79: 63-73.
- Resosudarmo, B. P., A. A. Yusuf, D. Hartono and D. A. Nurdianto (2011), "Regional Economic Modelling for Indonesia: Implementation of IRSA-INDONESIA5," *Journal of Indonesian Economy and Business*, 26(3): 287-309.
- Rietveld, Piet and F. Bruinsma (1998), *Is Transport Infrastructure Effective?*, New York: Springer.
- Rioja, Felix K. (1998), "Productivity and Welfare Implications of Public Infrastructure: A Dynamic Two-Sector General Equilibrium Analysis," *Journal of Development Economics*, 58(2): 387-404.
- Robilliard, A. S., F. Bourguignon and S. Robinson (2001), *Crisis and Income Distribution: A Micro-Macro Model for Indonesia*, mimeo.
- Robinson, S. (1991), "Macroeconomics, Financial Variables, and Computable General Equilibrium Models," *World Development*, 19(11): 1509-1525.
- Roson, Roberto and G. Dell'Agata (1996), "Environmental Externalities, Transport Costs and Interregional Trade in a General Equilibrium Model," in Fossati, Amedeo (ed.) *Economic Modeling under the Applied General Equilibrium Approach*, Aldershot: Avebury.
- Seung, Chang K. and D. S. Kraybill (2001), "The Effects of Infrastructure Investment: A Two-Sector Dynamic Computable General Equilibrium Analysis for Ohio," *International Regional Science Review*, 24(2): 261-281.
- Sohn, Jungyul, G. J. D. Hewings, T. J. Kim, J. S. Lee, and S. Jang (2001), "Economic Assessment of Earthquake Impacts On Transportation Networks: A Scenario Analysis," Regional Economics Applications Laboratory

Discussion Paper, REAL 01-T-16

- Sugiyarto, G., A. Blake and M. T. Sinclair (2003), "Tourism and Globalization," *Annals of Tourism Research*, 30(3): 683-701.
- Vickerman, Roger, K. Spiekermann and M. Wegener (1999), "Accessibility and Economic Development In Europe," *Regional Studies*, Vol. 33, No.1, pp.1-12
- Warr, P. and A. A. Yusuf (2011), "Reducing Indonesia's Deforestation-Based Greenhouse Gas Emission," *The Australian Journal of Agricultural and Resource Economics*, 55(3): 297-321.
- Yusuf, A. A. (2008), *Indonesia-E3: An Indonesian Applied General Equilibrium Model for Analyzing the Economy, Equity, and the Environment*, Working Paper in Economics and Development Studies, No. 200804, Padjadjaran University
- Yusuf, A. A. and B. P. Resosudarmo (2008), "Mitigating Distributional Impact of Fuel Pricing Reform," *ASEAN Economic Bulletin*, 25(1): 32-47.
- _____ (2011), "Is Reducing Subsidies on Vehicle Fuel Equitable? A Lesson from Indonesian Reform Experience," *Fuel Taxes and the Poor*, Ch.9, RFF Press.
- Yusuf, A. A., D. Hartono, W. Hermawan and Yayan (2008), *AGEFIS: Applied General Equilibrium for FIScal Policy Analysis*, Working Paper in Economics and Development Studies, No.200807, Padjadjaran University
- Yusuf, A. A., K. Ahmad, H. Wawan, D. Hartono and K. R. Sjahrir (2010), *Scenarios for Climate Change Mitigation from the Energy Sector in Indonesia: The Role of Fiscal Instruments*, Working Paper in Economics and Development Studies, No.201005, Padjadjaran University
- Zhang, Pengcheng and S. Peeta (2011), "A Generalized Modeling Framework to Analyze Interdependencies among Infrastructure Systems," *Transportation Research Part B*, 45: 553-579.

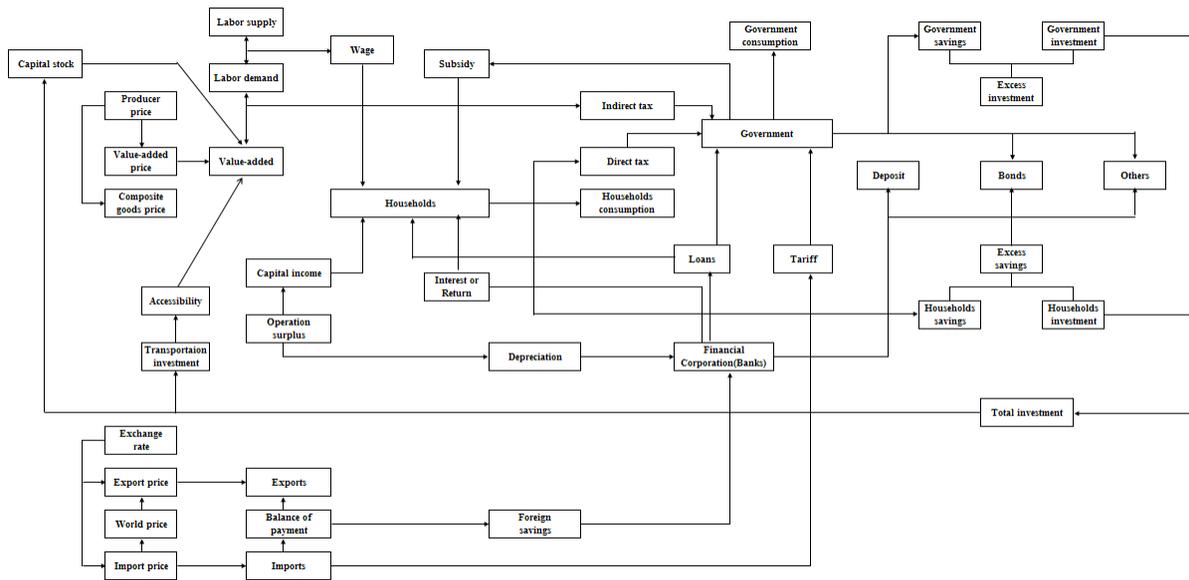


Figure 1 Schematic Structure of FCGE Model

Source: Kim and Bae (2015)

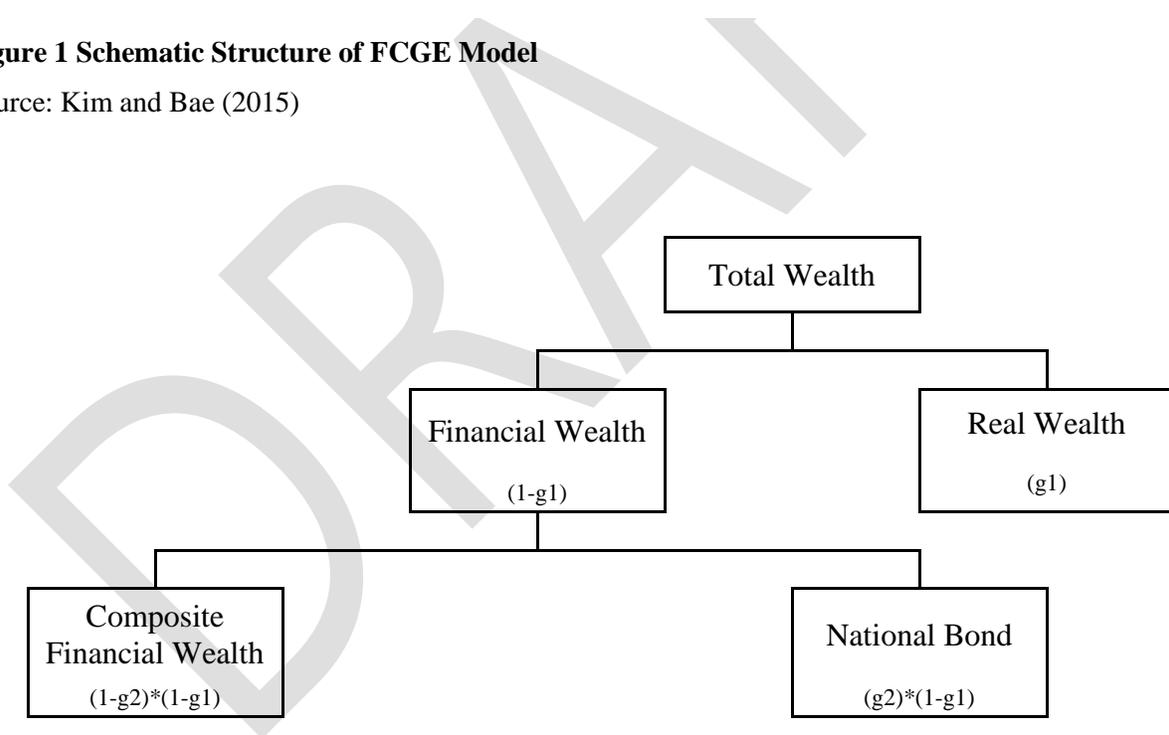


Figure 2 Total Wealth Demand Structure



Figure 3 Two Highway Projects in Indonesia

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Table 1 Schematic Structure of Financial Social Accounting Matrix

	Production	Value-added	Current account of institution	Capital account of institution	Financial flows	Investment	Total income
Production	Intermediate inputs		Consumption			Investment	Total market demand
Value-added	Value-added						Value-added
Current account of institution	Imports / Tariff	Factor income / Indirect tax	Transfer				Institution revenue
Capital account of institution		Depreciation	Savings		Liabilities		Aggregate savings
Financial flows				Assets			Financial assets
Investment				Investment			Total investment
Total expenditure	Total market supply	Value-added	Institution expenditure	Aggregate investment	Financial liabilities	Total investment	

Table 2 Major Equations in FCGE Model

Output	Output = Leontief (Value added, Intermediate demand)
Value added	Value added = Accessibility*CD (Capital stock, Labor)
Supply	Output = CET (Foreign exports, Domestic supply)
Demand	Demand = Armington (Foreign imports, Domestic demand)
Labor demand	Labor demand = LD (Wage, Value added, Net price)
Incomes	Incomes = Wage + Capital returns + Transfer
Consumption	Consumption by commodity = CC (Price, Incomes)
Government revenues	Government revenues = Indirect tax + Direct tax + Tariff + Property income
Government expenditures	Government expenditures = Government current expenditure + Government transfer + Government investment expenditure + Property cost
Labor market equilibrium	Labor demand = Labor supply
Capital market equilibrium	Savings = Total investments
Commodity market equilibrium	Supply of commodities = Demand for commodities
Government budget equilibrium	Government expenditures = Government revenues
Financial market equilibrium	Wealth = Real wealth + Bond + Composite financial asset

Table 3 Growth Impacts and Income Distribution of Three Transportation Projects with Government Revenue Financing (unit: %)

	GDP		Income Ratio of High / Low Class			Income Ratio of Urban / Rural Class		
	NS	BS	Base	NS	BS	Base	NS	BS
2006	0.005	0.002	29.237	29.232	29.234	1.719	1.719	1.719
2007	0.010	0.005	29.380	29.375	29.378	1.720	1.720	1.720
2008	0.016	0.007	29.516	29.511	29.513	1.720	1.720	1.720
2009	0.022	0.010	29.645	29.640	29.642	1.721	1.721	1.721
2010	0.027	0.037	29.767	29.762	29.769	1.722	1.722	1.722
2011	0.031	0.037	29.883	29.878	29.886	1.722	1.723	1.722
2012	0.054	0.036	29.994	29.994	29.996	1.723	1.723	1.723
2013	0.053	0.036	30.099	30.099	30.102	1.724	1.724	1.724
2014	0.051	0.035	30.199	30.200	30.202	1.724	1.724	1.724
2015	0.049	0.035	30.295	30.295	30.298	1.725	1.725	1.725
2016	0.048	0.034	30.386	30.386	30.389	1.725	1.725	1.725
2017	0.046	0.033	30.472	30.473	30.475	1.725	1.726	1.725
2018	0.044	0.033	30.554	30.556	30.558	1.726	1.726	1.726
2019	0.043	0.032	30.633	30.635	30.637	1.726	1.726	1.726
2020	0.041	0.031	30.708	30.710	30.712	1.726	1.727	1.727
average	0.038	0.028	30.157	30.156	30.159	1.724	1.724	1.724

NS: North–South Jakarta Highway

BS: Balikpapan–Samarinda Highway in East Kalimantan

Table 4 Impacts of Financing Methods for Highway Projects on the GDP (unit: %)

	Accessibility			NS Project			BS Project		
	NS	BS	GO	NP	PR	GO	NP	PR	
2006	0.000	0.000	0.005	-0.005	-0.006	0.002	-0.002	-0.003	
2007	0.000	0.000	0.010	-0.008	-0.011	0.005	-0.004	-0.005	
2008	0.000	0.000	0.016	-0.010	-0.014	0.007	-0.005	-0.006	
2009	0.000	0.000	0.022	-0.009	-0.016	0.010	-0.005	-0.007	
2010	0.000	9.400	0.027	-0.008	-0.017	0.037	0.020	0.016	
2011	0.000	9.400	0.031	-0.006	-0.017	0.037	0.022	0.018	
2012	3.800	9.400	0.054	0.010	-0.004	0.036	0.023	0.019	
2013	3.800	9.400	0.053	0.015	-0.001	0.036	0.025	0.020	
2014	3.800	9.400	0.051	0.020	0.003	0.035	0.026	0.021	
2015	3.800	9.400	0.049	0.024	0.006	0.035	0.027	0.022	
2016	3.800	9.400	0.048	0.027	0.008	0.034	0.028	0.022	
2017	3.800	9.400	0.046	0.030	0.011	0.033	0.029	0.023	
2018	3.800	9.400	0.044	0.033	0.013	0.033	0.030	0.024	
2019	3.800	9.400	0.043	0.036	0.015	0.032	0.030	0.024	
2020	3.800	9.400	0.041	0.038	0.017	0.031	0.031	0.025	
Average	2.280	6.893	0.038	0.015	0.000	0.028	0.020	0.015	

IP: North–South Jakarta Highway

2P: Kertapati–Simpang–Tanjung Railroad in South Sumatra

GO: government financing with tax revenues NB: government financing with bond PR: private financing

Table 5 Present Values of Benefits (Net GDP Changes) and Costs (Investment Costs) during 2006-2035

(Unit: Billion US\$, Discount Rate = 6%)

	Financing Method	NS Project		BS Project	
Present Value of Net GDP Changes	GO	19.16	15.63		
	NP	15.64	13.87		
	PR	7.16	11.39		
Present Value of Investment Costs		32.78	20.79		

GO: government financing with tax revenues NB: government financing with bond PR: private financing