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

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- **David Alan Aschauer (1989),**
  - "Is Public Expenditure Productive?," Journal of Monetary Economics, 23(2): 177–200

Journal of Monetary Economics 23 (1989) 177–200. North-Holland

IS PUBLIC EXPENDITURE PRODUCTIVE?*

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This paper considers the relationship between aggregate productivity and stock and flow government-spending variables. The empirical results indicate that (i) the nonmilitary public capital stock is dramatically more important in determining productivity than is either the flow of nonmilitary or military spending, (ii) military capital bears little relation to productivity, and (iii) a 'core' infrastructure of streets, highways, airports, mass transit, sewers, water systems, etc. has most explanatory power for productivity. The paper also suggests an important role for the net public capital stock in the 'productivity slowdown' of the last fifteen years.

1. Introduction

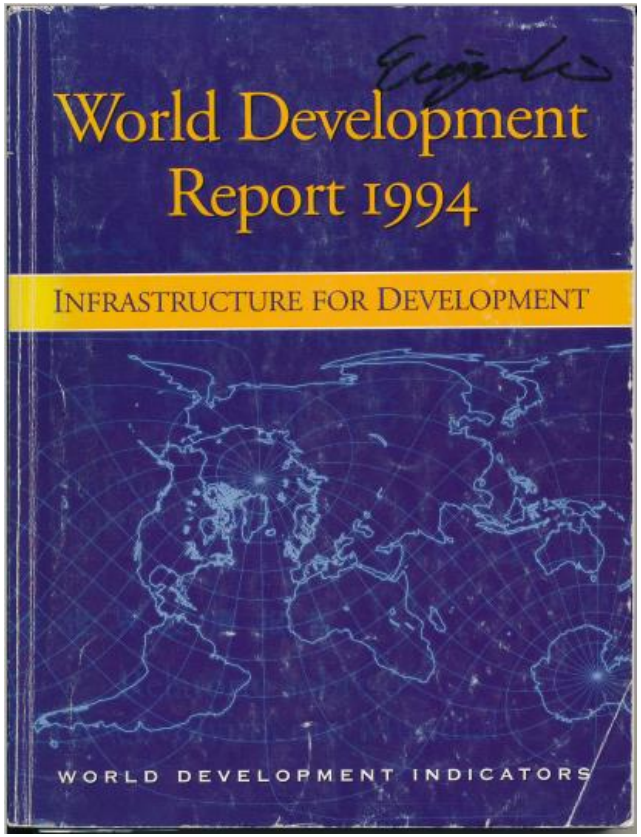
This paper considers the recent behavior of productivity in the private United States economy and the extent to which its movements can be explained by public-sector capital accumulation as well as by the flow of government expenditures on goods and services. Much of the traditional discussion of fiscal policy centers on the public-sector deficit and the importance of the decision of the fiscal authorities to issue debt rather than utilize contemporaneous taxes to cover a particular spending level. Government deficits are thought to have a variety of effects on the private economy, ranging from forcing up real interest rates and 'crowding out' private investment in additional plant and equipment to raising wealth and stimulating household consumption demand.[1]

The equilibrium or newclassical approach to fiscal policy presents a different analysis of the impact of fiscal decisions on the private sector. At the core of this perspective on fiscal policy lies the proposition that, to a first approximation, the (lump-sum) *financial* policies of the government are irrelevant to private-sector outcomes. This hypothesis of an equivalence between tax and

*Earlier versions of this paper were presented at the Federal Reserve Bank of Minneapolis and the National Bureau of Economic Research. The author would like to thank, without implicating, participants in the above seminars as well as an anonymous referee, Robert Barro, Charles Calomiris, Randall Eberts, Bruce Peterson, Steven Strongin, and Lawrence Summers.

[1]See, for instance, Eisner (1986).

- **World Development Annual Report 1994: Infrastructure for Development**

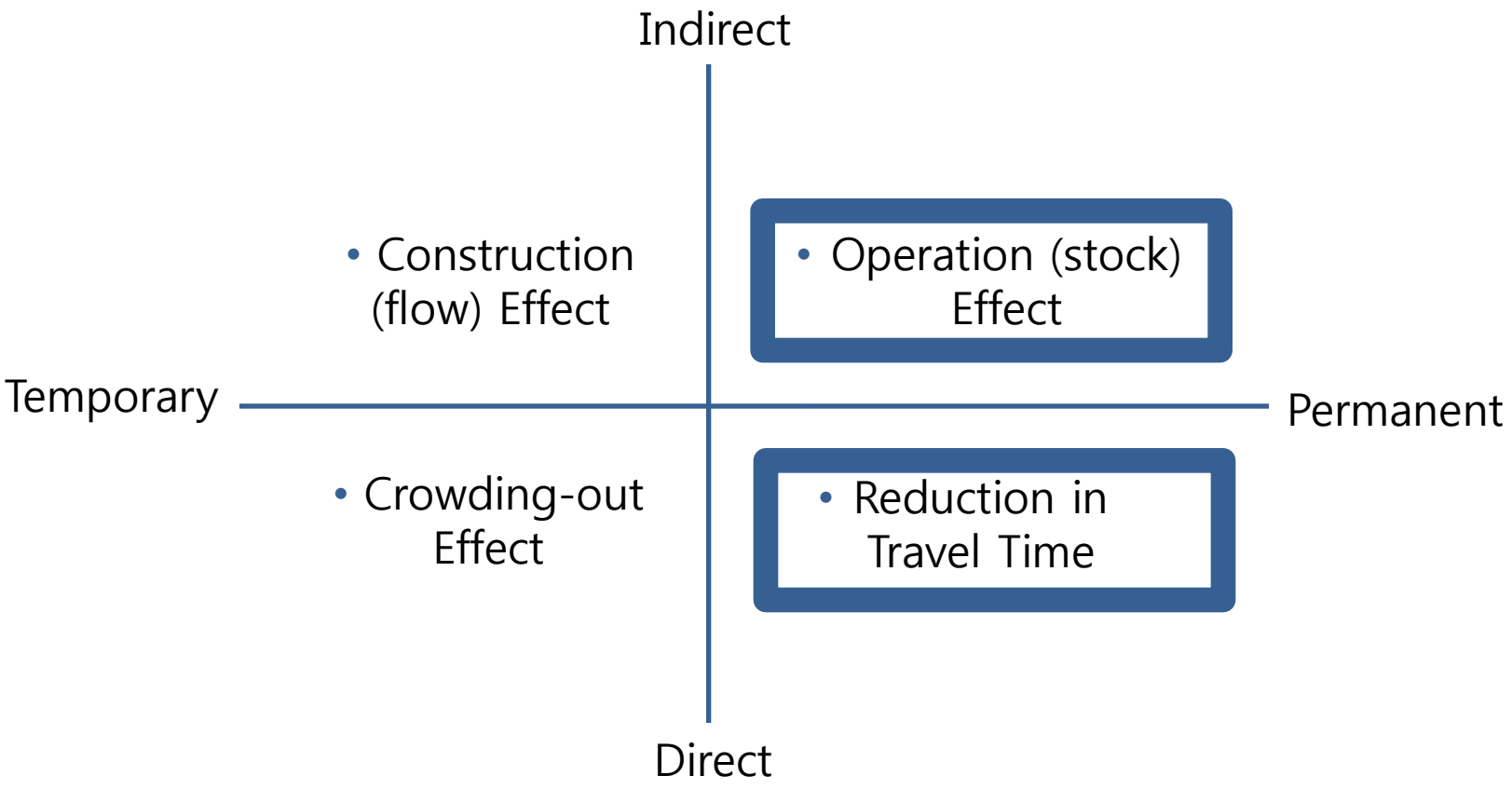


1. Background (2): Classification of Benefits

- **Direct and indirect effects in terms of 'who gets benefits'**
  - Direct effects
    - Decrease in transport time for user (driver) and in operation cost per passenger
    - Improvement of transport service
  - Indirect effects
    - Production and agglomeration economies
    - Location and migration (commuting)
    - Communication, and knowledge spill-over effect

- **Temporary and permanent effects in terms of benefit duration**
  - Temporary (flow, construction or short run) effects
    - To be generated during construction period
  - Permanent (stock, operation or long run) effects
    - To be generated by consuming infrastructure services: transport cost and time benefits for people and freight
    - Backward effect of the infrastructure expenditures (excluding construction)
    - Re-location of people and firms

1. Background (3): Classification of Benefits



1. Background (4): Estimation of Economic Benefits

- **Econometric model: supply effect**
  - GDP = f(X, Transportation stock)
- **Input-Output model: demand effect**
  - Output = Transportation investment / (I-A)
- **Spatial-econometric model: supply, network and agglomeration effects**
  - GDP = f(X, Transportation stock, Network)
- **Computable general equilibrium (CGE) model: supply, price, and demand effects**
  - GDP = f(X, Transportation stock)
  - Transportation investment = g(Y, GDP)
  - Market equilibrium in transportation service
- **Spatial CGE model: supply, price, demand, network, and agglomeration effects**
  - City and country levels
  - New Economic Geography

1. Background (5): Research Motivation

- **Research Issues**
  - Infrastructure as an impure public good
    - Congestion
  - Optimality of provision of infrastructure capital Infrastructure
    - MB = BC
  - Financing of infrastructure
    - Infrastructure is paid through a variety of taxes, fees, and user changes
  - Spatial spillover of infrastructure supply
    - Location and network matter in determining impacts

- **Economic assessment on efficiency and distribution**
  - To generate benefits and costs of projects through the production and consumption linkages among various economic agents
  - To establish a systematic approach to take into account direct and indirect effects on benefits as well as costs

1. Background (6): Purpose and Method

- **To develop a Financial Computable General Equilibrium – Transportation Network (FCGE-TN) model for the economic impact analysis of transportation projects of Indonesia**
  - To estimate economic effects of fiscal policies such as the investment expenditures and their procurement approaches (e.g. from current taxes or through bonds) on economic growth and distribution in an unified economic system
- **Model structure**
  - Three components
    - Commodity flow from real-side market
    - Money flow from financial market
    - Accessibility (development potential) from transportation network
  - Two key features
    - Investment expenditures and financing methods
      - Borrowing = Lending (financial resource)
    - Location and accessibility by project (network connectivity)
  - Base Year: 2005 (Financial Social Accounting Matrix)
- **Nothing new but distinguished factors**
  - FCGE model (Kim, 1990) for financial market
  - SCGE model for transportation sector in the late 1990s
  - Integration: real-side + financial-side + transportation network (location)

2. Model (1): Types of Model Structure

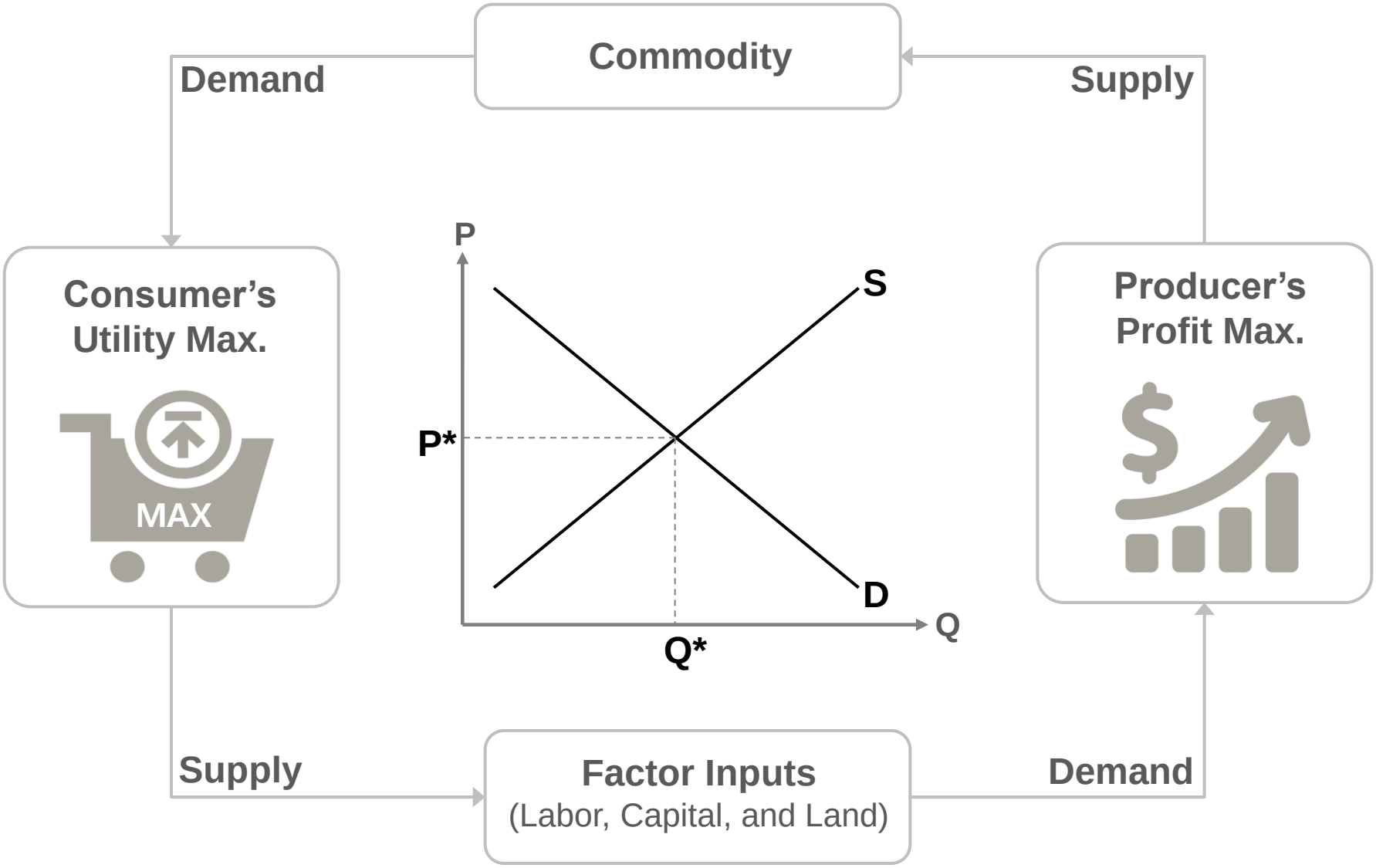
- **Causality between transportation and economic models (Kim *et al.*, 2004)**
  - Sequential (mutually feedback) model
    - Transportation ↔ resource allocation
  - Non-sequential models (computational issue)
    - Transportation → resource allocation

- **Selection of transportation policy variables**
  - Transportation service price or congestion cost (Cost-based approach)
    - Cost (price) derived from transportation planning (demand) model
    - 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), Brocker (2002), Kim and Bae (2015)
  - Distance or time (Network-based approach of spatial accessibility)
    - Distance (time) derived form GIS or transporatation model
    - Gutierrez and Urbano (1996), Vickerman *et al.* (1999), Linneker and Spence (1996), Cho *et al.* (2000), Sohn *et al.* (2001), Kim *et al.* (2002), Kim *et al.* (2004), Haddad and Hewings (2005), Kim and Hewings (2009), Haddad *et al.* (2010), Kim *et al.* (2011)

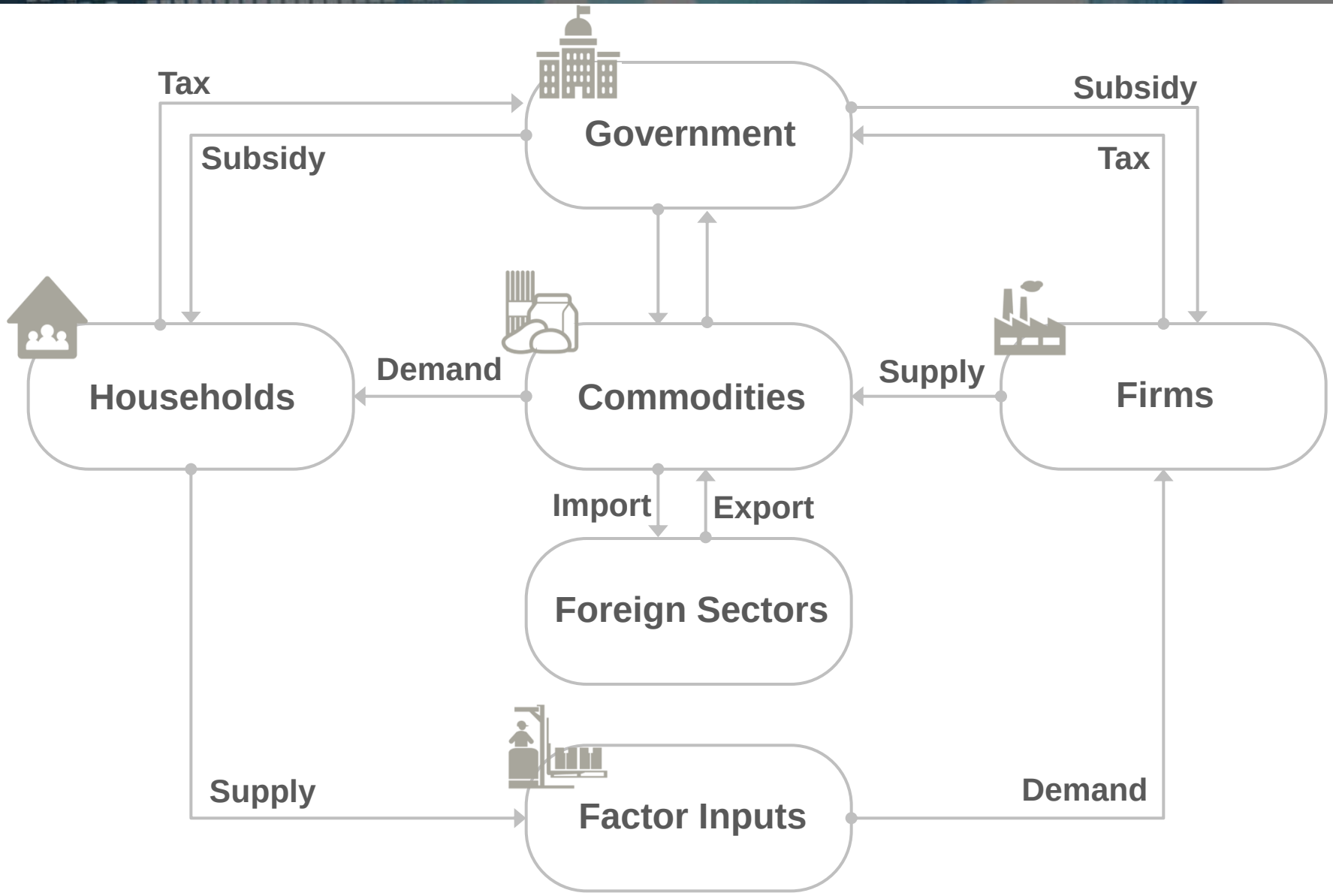
2. Model (2): Overview of CGE Model

- **A stylized CGE model in this paper: neoclassical elasticity approach of Robinson (1989)**
  - Supply: output, value added, wage and employment, and trades
  - Demand: consumptions and investments of private and government
  - Equilibrium: price (foreign exchange rate and consumer price index)
- **General specification**
  - Each producer and household as a price-taker
    - To choose an optimal set of factor inputs and commodity demands under the maximization principles of constrained profit and private utility
  - Supply and demand of goods and services
    - Two-level production function of value added and intermediate inputs
    - Domestic supply, exports and imports
  - Macroeconomic closure rule: saving driven model and neoclassical labor market rule
  - Average cost pricing rule by clearing any excess demand in the markets
  - Exogenous variables: world market prices, government expenditure, and numeraire price index (CPI)

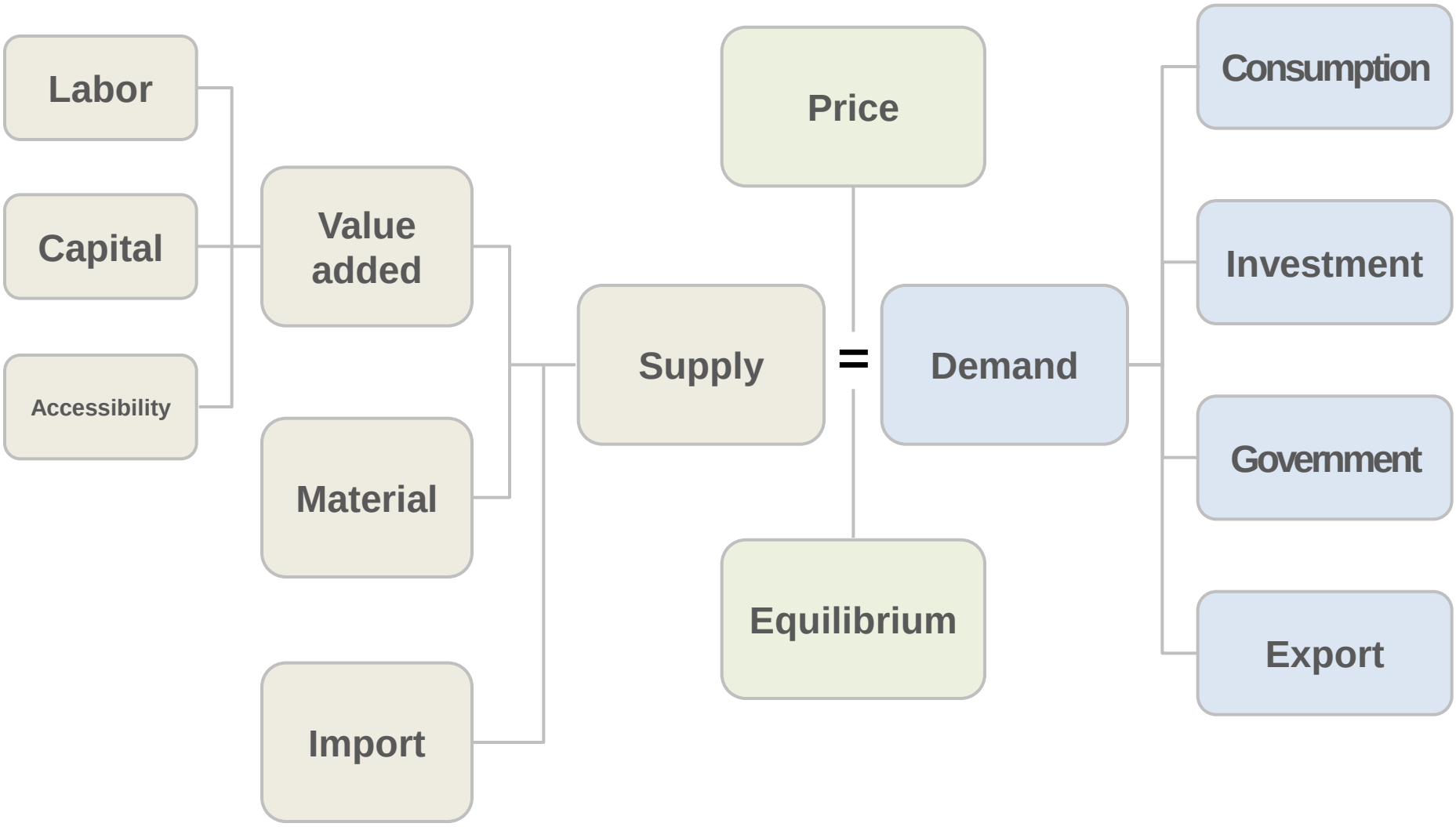
2. Model (3): Two-Sector Model



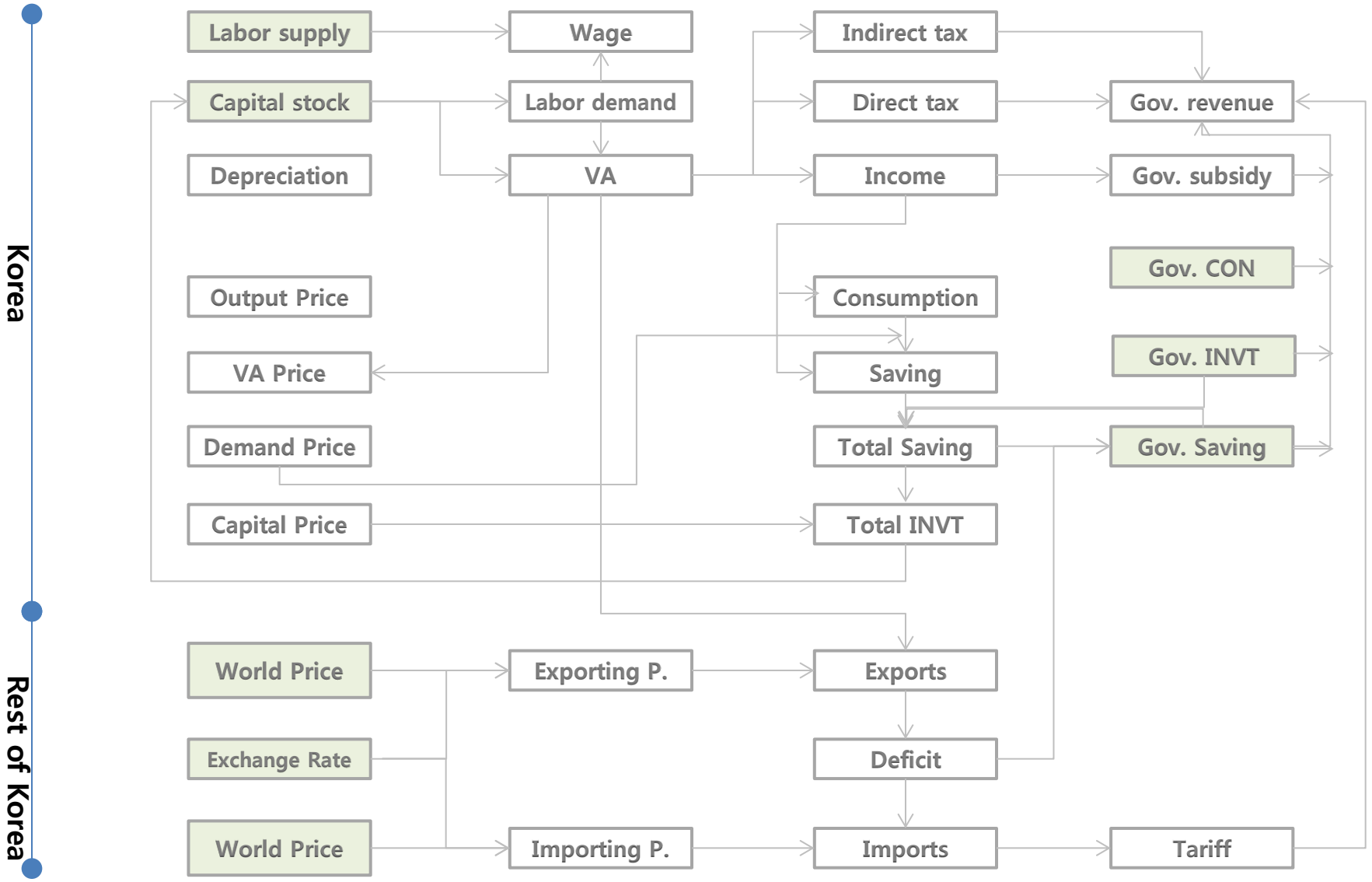
2. Model (4): Four-Sector Model



2. Model (5): Supply and Demand



2. Model (6): Stylized Model



2. Model (7): Sectoral Classification

- **Seven institutions (households, government and firms)**
  - Central bank, Company and Government
  - Rural Poor, Rural High, Urban Poor and Urban High

- **Nine industrial sectors**
  - Agriculture, Mining, Manufacturing, Utility, Construction, Trade-Hotel-Restaurant, Transportation-Communication, Finance, and Other Sector

- **Three financial instruments for infrastructure investments (Bank of Indonesia)**
  - Government revenues
  - National bond
  - Composite Financial Asset (Cadangan Valas Pemerintah, Cartel, Giro, Saving, Deposito, Certificate of Bank Indonesia, Other Long-Term Securities, Short-Term Securities, Working Capital Credit, Investment Credit, Consumption Credit, Non-Bank Credit, Trade Credit, Capital Stock and Inclusion, Insurance Reverse and Pension)

2. Model (8): Linkages

- **Extensions to financial market**
  - Linkage between total factor productivity and accessibility (infrastructure networking) in manufacturing sector
  - Supply-demand-price mechanism of financial instruments (assets)
  - Inclusion of property incomes and costs for economic agents
  - Flows of financial income among economic agents

- **What we need for the impact analysis**
  - Amounts and period of infrastructure investments
  - Location (connectivity to the network)
  - Financing method: tax revenues, national bonds and private funds

2. Model (9): Model Comparison

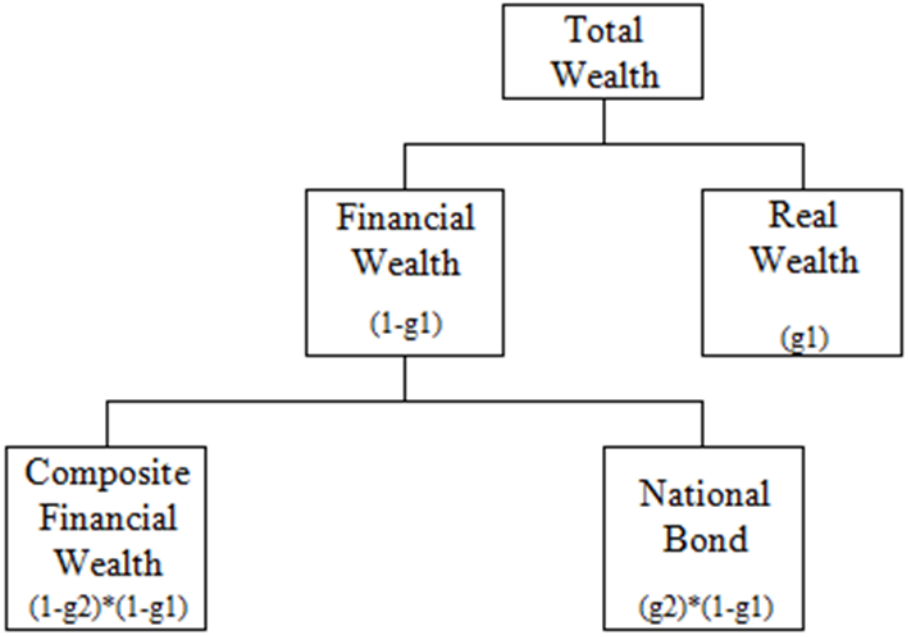
	Stylized CGE Model	FCGE-TN Model
Market	Real side market	Real side market Financial market
Sub-markets and wealth	Labor Commodity Real wealth (physical investment)	Labor Commodity Real wealth Financial instruments
Closure rule	Saving-driven or Investment-driven	Saving and investment endogenously determined
Capital cost	-	Endogenously determined
Dynamics	Labor and capital stock	Labor and capital stock Property (asset) stock uses

2. Model (10): Major Equations

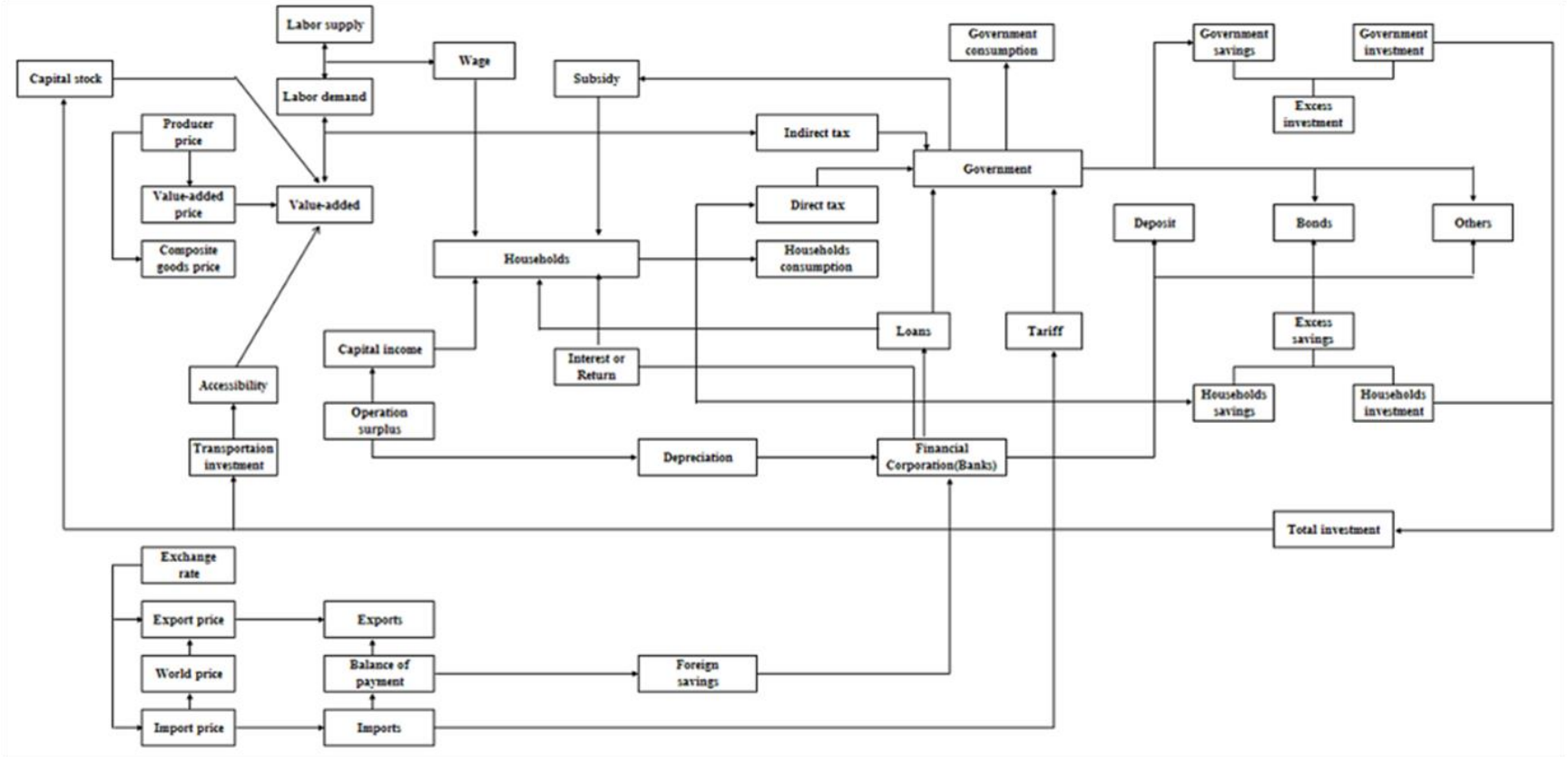
- Output = LEONTIEF (intermediate input, value added)
- Value added = VA (accessibility, labor, capital)
- Accessibility = PD (minimum travel time, population) (=weighted average of population discounted by distance)
- Labor = FOC (value added, wage)
- Output = CET (domestic supply, export)
- Demand = ARMINGTON (domestic supply, import)
- Demand = intermediate demand + final demand
- Income = Expenditure (for all institution)
- Investment (exogenous or endogenous)
- Supply = Demand → Price (adjusting variable)
- Tax revenues
- Demand and supply of financial instruments (asset)
- Wealth = W (physical investment (real wealth), composite financial instrument)
- Return and cost of financial instrument

2. Model (11): Demand for Financial Asset

- **Maximizing wealth by institution under imperfect substitution**
  - Parameters borrowed from Korean case
- **Total wealth = TW (financial wealth, real wealth)**
- **Financial wealth = FW (composite financial wealth, national bond)**



2. Model (12): FCGE-TN Model Structure



2. Model (13): FSAM (Bank of Indonesia)

	Production	Factor input	Current account of institution	Property	Capital account of institution	Financial instrument	Investment	Total
Prod	IN.INPUT		CONS				INVT	Market demand
Factor input	VA							Value added
Current A. institution	IM	FAC. INC	TRSF	PROP. INCOME				Institution revenues
Property			FIN. COST					Property costs
Capital A. institution		DEPR	SAVINGS			LIABILITY		Aggregate savings
Financial instrument					ASSETS			Financial assets
INVT					INVT			Total INVT
Total	Market supply	Value added	INST. EXP.	Property incomes	Aggregate INVT	Financial liabilities	Total INVT	

3. Simulation (1): Overview

- **Key variables for the simulation**
  - Infrastructure (transportation) investments
  - Construction periods and location
  - Operation periods and accessibility
  - Financing methods: government revenue, national bond and private fund
  - Key exogenous variables: labor supply and world price inflation
  - Numeraire: CPI

- **Three financing options**
  - GO option: replacing (switching) with government consumptions
  - NB option: paying for financial costs and interest payments in next generations
  - PR option: crowding-out (or crowding-in) of other investments (manufacturing sector)

3. Simulation (2): Process

Stage	Task	Works
1	Model Design	Classification (sector, linkage, market, and agent)
2	Data Collection	Economic and spatial data / Financial SAM
3	Parameter Estimation	Production, imports and exports, and demands for financial assets (instruments)
4	Development of Model	Identification and closure rules
5	GAMS Code	Components (set, variables, parameters, equations and solver)
6	Project Design	Type, investment amounts, location and period
7	Spatial Analysis	Modification of road network and calibration of accessibility (ARC-GIS or transportation network equilibrium model)
8	Input	Base run and counter-factual analysis
9	Output	Macro and micro economic variables
10	Implication	Numerical comparison and interpretation

3. Simulation (3): Examples

Project	Cost (trillion Rp)	Location	Construction Period
North - South Jakarta Highway (NS)	40	Jakarta	2013-2018
Balikpapan - Samarinda Highway (BS)	12	East Kalimantan	2014-2017

4. Simulation (4): Road Network

3. Simulation (5): Project Evaluation

Discount rate (6%) (construction +operation)	Financing Method	NS	BS
Present Value of Net GDP Changes	GO	19.16	15.63
	NP	15.64	13.87
	PR	7.16	11.39
Present Value of Construction Costs		32.78	10.40
Issues: inclusion of (expected) private efficiency in operation and management and operational costs and quantifying of values of time saving, accident and fuel reduction and environmental pollution			

4. Further Research Works

- **Summary**
  - Positive impacts on the economic growth, but depending on the financing methods and location
  - Not substantial impact on the income distribution

- **Research issues**
  - Data
    - Consistency of FSAM with Real SAM
    - Classification of household groups (types of works and income sources)
    - Extension of transportation network: road and railroad
    - Direct effects (benefit): time savings and reductions in accidental and environmental costs
  - Spatial unit
    - Decomposing accessibility into intra- and inter-islands
    - Infrastructure policies: seaport and airports
    - Migration
  - Operation efficiency by ownership
    - BOT and privatization

Thank you