Well integrated with graphical output methods

For geographical simulations, it is quite important to check the data graphically. As the geographical database is complicated, these data should be checked graphically to see if each city is located in the correct place and if the routes between them are topologically correct. When the results of the simulation come out, it is also necessary to check them graphically in order to analyze the geographical tendency of the distribution of population and industries as well as the routes, mode, and volume of transportation.

IDE/ERIA-GSM is well integrated with graphical output methods. It is able to check the location of cities and the routes between them using an Ajax application based on Google™ Maps, and a more detailed graphical analysis is possible by using R (statistical language) and *maptools* package.

4. Explanation of the Model

4.1. Brief explanation of spatial economics

Before going into the detailed structure of IDE/ERIA-GSM, allow us to explain spatial economics, which is sometimes called the “new economic geography.” This is the theory behind the model. Spatial economics explains the spread of economic activities within a general equilibrium framework. The main ingredients of the spatial economics are (1) increasing returns; (2) imperfect competition; (3) love for variety; and (4) endogenous agglomeration forces. With increasing returns in production activity, firms can enjoy externalities as explained by A. Marshall (1890, 1920). Imperfect competition avoids the backyard capitalism implied in the spatial impossibility theorem, that is, imperfect competition (monopolistic competition) guarantees the demand for goods even if transport costs are incurred. Love for variety implies that a large variety of consumer goods improves consumers' welfare as explained by Haig (1926), and a large variety of inputs improves firms' productivity. Love for variety spurs demand for goods produced in distant markets. With regard to endogenous agglomeration forces, economic activities agglomerate as a consequence of the exogenous uneven distribution of resources or as a consequence of the economic activities themselves. Call the former "first nature" and the latter "second nature." Spatial economics focuses mainly on the second nature, although the following simulation models adopt both the first and second natures.

The distribution of economic activities is decided by the balance of agglomeration forces against dispersion forces. There are many types of agglomeration and dispersion forces. Therefore, the observed spatial configurations of economic activities are also varied. With exogenous shocks, the spatial structure is organized by itself, and the core-periphery structure evolves through structural changes.

The endogenous agglomeration forces bring circular causality. Circular causality is formed by market-access effects and cost-of-living effects. In terms of market-access effects, concentration (or an increase in demand by immigrants) enlarges the market. Suppliers locating in a large market can sell more, since goods that are not transported between regions are cheaper. Obviously, this effect becomes weak when transport costs are low. More important, under the increasing-returns-to-scale production technology, the increase in the number of suppliers in a larger market is more than proportional to the expansion of the home market. As a result, goods in excess of local demand are exported.

The second force causing a concentration is cost-of-living effect. The price index of goods becomes lower in a region where many suppliers gather. As goods are produced locally, the prices of most of these goods do not include transport costs. This allows prices of goods to remain low, which then induces more demand in the region.

This effect works better when transport costs are high and the mill price is low. The market-access effects and cost-of-living effects reinforce each other. Because the former lures supply and the latter attracts demand, these two effects form a circular causality in which economic activities agglomerate in a region. That is, an increase in either upstream or downstream firms encourages further increase in the other type of firms in the region, as explained by Hirschman (1958). For this same reason, an increase in either consumer or producer provides the incentive for the other to agglomerate in the region.

On the other hand, Krugman (1991) uses market-crowding effects as the dispersion force. Because of the decrease in the general price index due to concentration, the price charged by a specific firm becomes relatively high, resulting in lower demand for the goods. This effect becomes weaker as transport costs decrease.

Summing up these three effects, Krugman (1991) shows that the symmetric structure is maintained when transport costs are high enough, whereas core-periphery structure emerges when transport costs are low enough. In the formalization, transport costs between regions are exogenous factors and express all distance resistance. Mobile workers choose among regions based on wage rates and prices. When transport costs are high enough, the dispersion force overcomes the agglomeration forces. Firms cannot afford to engage in a harsh price competition even in a slightly larger market because the profit from the distant market is small. Thus, economic activities disperse. On the other hand, as transport costs decrease enough, agglomeration forces surpass the dispersion force. Firms can enjoy the benefits of large markets and low procurement cost even with harsh price competition by locating in a large market. This is because the profits from distant markets are large. Therefore, economic activities agglomerate in a region.

By introducing another dispersion force (such as land use and agricultural goods) with positive transport costs, economic activities may disperse even if the transport costs are extremely low.

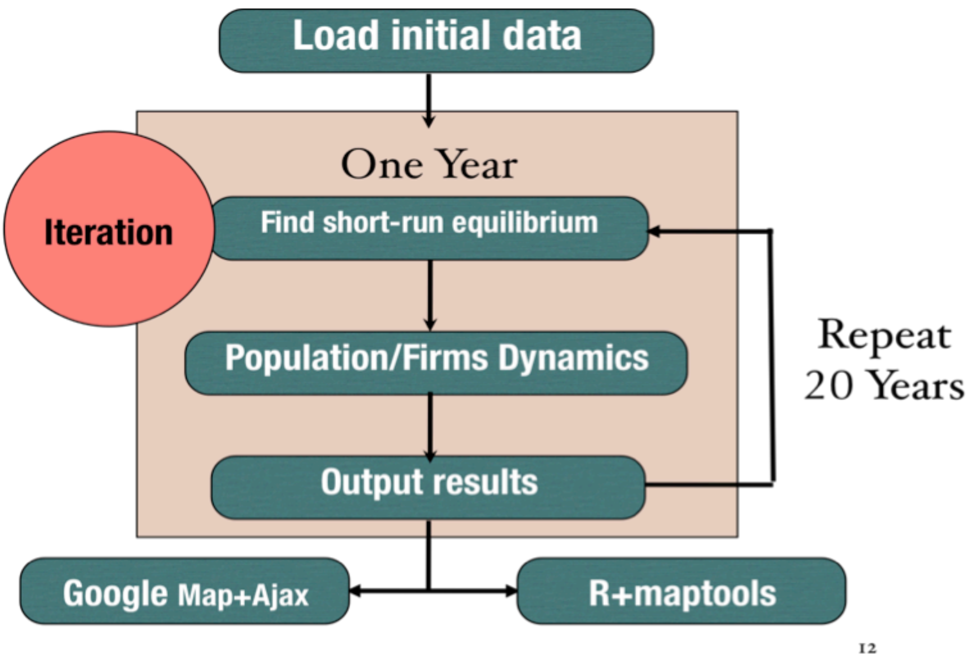
Consequently, to derive a policy implication for a circumstance, one may need to consider more realistic settings. Furthermore, the interaction described here is applicable in a situation where the economy consists of two or three regions in literature. For an economy with more regions, the use of a computer in the study becomes more crucial.

4.2. The structure of the model

IDE/ERIA-GSM was essentially based on Krugman (1991) and then extended to incorporate multiple industrial sectors and intermediate goods. So the structure of the current-generation IDE/ERIA-GSM is quite similar to the model in Chapter 14 of FKV. The detailed model structure is explained in Appendix A.

IDE/ERIA-GSM works as Figure 3.

Figure 3: The Computational Procedure of IDE/ERIA-GSM



1. Load initial data

The data on regions and routes are loaded from prepared CSV files. The regional data and the routes data should be compatible. For instance, all the names of cities on the routes data should appear in the regional data together with the other attributes of the city (region), especially the latitude and longitude.

2. Find short-run equilibrium

IDE/ERIA-GSM calculates the short-run equilibrium (equilibrium under a given distribution of population) values of such items as gross domestic product (GDP), employment, nominal wage, price index and so on, by sector based on the distribution of population. IDE/ERIA-GSM uses the iteration technique to solve the multiequation model. The detailed equations are proposed in Appendix A.

3. Population Dynamics

Once the short-run equilibrium values are found, IDE/ERIA-GSM calculates the dynamics of the population, or the movement of labor, based on the difference in real wages among countries/regions/industries. IDE/ERIA-GSM is able to set the speed of adjustment differently for intercountry/inter-region/interindustry labor movement.

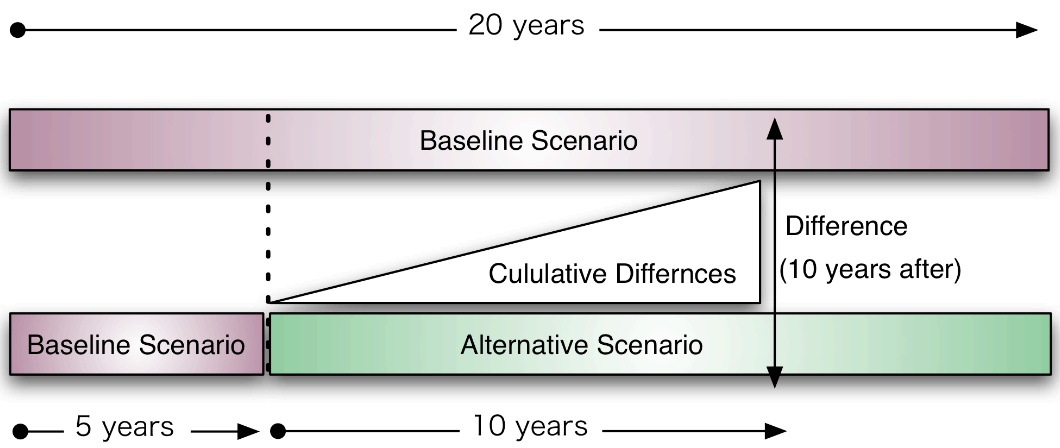
4. Output Results

To examine the related variables in time series, IDE/ERIA-GSM exports the equilibrium values of GDP by sector, employment by sector, nominal wage by sector, price index, and so on, for every single year in CSV and XML formats. These can be checked using Google™ Maps or a statistical language.

5. Back to #2.

Now back to the second step—find the new equilibrium under the new distribution of population. The return to the second step in the calculation process implies that time has advanced one year. In the analyses in this paper, the simulation is run for 20 years, and the cumulative difference during the 10 years after the scenario change and the difference at 10 years after are used to compare the two scenarios (Figure 4).

Figure 4: Comparing the Scenarios



4.3. Important parameters

Transport Costs

Transport costs are defined by industry. The first two generations of IDE/ERIA-GSM implemented the traditional "iceberg" transport costs. Thus, for instance, T=1.20 means that 1.00 out of 1.20 units of goods shipped from one part of CSEA arrived in another part of CSEA. It is understood that bringing goods from one part of CSEA to another requires a 20 percent overhead cost on the price of the goods.

In the third-generation IDE/ERIA-GSM model, transport costs are handled in a completely different way compared with the past two models. First, we calculated the money equivalent transport costs of transporting one 20-foot container by industry, mode, and distance. Then we calculated the percentage of these transport costs against the value of one 20-foot container filled with the following goods, namely, automotive products, electrical and electronic products (E&E), textile and garments, food, and other manufactured goods. This number is treated as T_{ijkm}, the transport costs between city *i* and *j* for goods *k* by mode *m*. The details are described in Appendix B.

Elasticity of Substitution

The elasticity of substitution between goods is also defined by industry and is represented by the symbol σ. The symbol σ in the manufacturing sector ranges from 5 to 10; in the service sector, σ equals 3. (See Appendix C for detailed explanation.) If σ=1.0, it means that two goods are perfectly differentiated and cannot substitute for each other. On the other hand, if σ is quite large, two goods are almost perfect substitutes for each other. So σ=3 means the goods are highly differentiated for the service sector.

Parameters on Labor Mobility

Parameters on labor mobility is set on three levels, namely, international labor mobility (γ_N), intranational (or intercity) labor mobility (γ_C), and interindustry labor mobility (γ_I) within a region. What does γ mean? If γ=0.1, it means that a country/region/industry with two times higher real wages than the average attracts 10 percent labor inflow a year.

Set γ_N=0. This means that the international migration of labor is prohibited. Although this looks like a rather extreme assumption, it is reasonable enough, taking into account the fact that most ASEAN countries strictly control incoming foreign labor.

Set γ_C=0.02. This means that a region with two times higher real wages than the national average induces 2 percent labor inflow a year.

Set γ_I=0.05, too. This means that an industrial sector with two times higher real wages than the average in the region induces 5 percent labor inflow from other industrial sectors a year.

Other parameters

Set consumption share of manufactured goods (μ) at 0.279 and the same share of services at 0.636. Thus, that of agricultural goods is at 0.088. The value of μ is based on the aggregate production share of each industry in the region. This must be calibrated and differentiated for each country. However, for simplicity's sake, identical utility function is currently used for consumers for all countries.

Set costs share of labor in the production of agricultural goods (β) at 0.633 and that of manufactured goods at around 0.2 to 0.3. Thus, the input share of intermediate goods in the production of manufactured goods is around 0.7 to 0.8. These parameters are set based on the Input-Output (I-O) table for Thailand in 2000. This should be calibrated for each industry more carefully in the future.

Parameters by industry

The first generation of IDE/ERIA-GSM had three sectors: (1) agriculture, (2) manufacturing, and (3) service. The service sector was incorporated as just a sector that incurs extremely high transport costs, other things being equal to the manufacturing sector. The second generation of IDE/ERIA-GSM had seven sectors, namely, (1) agriculture, (2a) automotive, (2b) electric and electronics, (2c) textile and garments, (2d) food processing, (2e) other manufactured goods, and (3) service. There are three possible sources of difference of industry in this model, as well as the configurations of transport costs and initial geographical distribution:

a) Elasticity of substitution (σ)

b) Share of labor input (β)

c) Share in consumption (μ)

From various sources, we specify the parameters for each sector temporarily as Table 1, and it is assumed to be common in all countries. For future expansion, we need to use different parameters for different countries. The values for σ are calibrated considering various factors and the previous studies like Hummels (1999), and β are calculated based on I-O table for Thailand in 2000 by IDE. The value of μ is based on the aggregate production share of each industry in the region.

Table 1: Parameters specifying each industry

Industry	σ	β	μ
Automotive	7	0.262	0.009
Electronics & Electric	7	0.228	0.044
Textile, Garments	9	0.329	0.043
Food Processing	9	0.303	0.035
Others	8	0.281	0.154

4.4. On the modal choice

The third generation IDE/ERIA-GSM model incorporates "modal choice." In the model, each firm decides the route and mode of transport considering both money and time costs. The details of the procedure to derive the transport costs are shown in Appendix B. IDE/ERIA-GSM adopts the modal mix that minimizes the total transport costs and calculates an iceberg-like transport parameter, dividing minimum transport costs by the standardized value of the goods by industry.

Figures 5-1 and 5-2 are examples of the modal choice between Jakarta, Indonesia and Kunming, China. Figure 5-1 shows the routes used by the textile and garments industry, which incur relatively small time costs. Figure 5-2 shows the routes adopted by the E&E industry, which incurs relatively large time costs. The former industry tends to use land/sea routes, while the latter industry tends to select air route.

Note that the current model of modal choice in IDE/ERIA-GSM has room for improvement. For instance, air/sea route data do not fully reflect current reality. So the modal choice in IDE/ERIA-GSM tends to choose routes that use the minimum distance to transport goods while neglecting the "hub-ness" of nearby ports/airports.

Figure 5-1: Modal Choice between Jakarta and Kunming (Textile & Garments Industry)