Preliminary Draft (Do not quote)

A COMPUTATIONAL GENERAL EQUILIBRIUM ANALYSIS OF THE EFFICIENCY EFFECTS OF PORTS IN JAPAN.

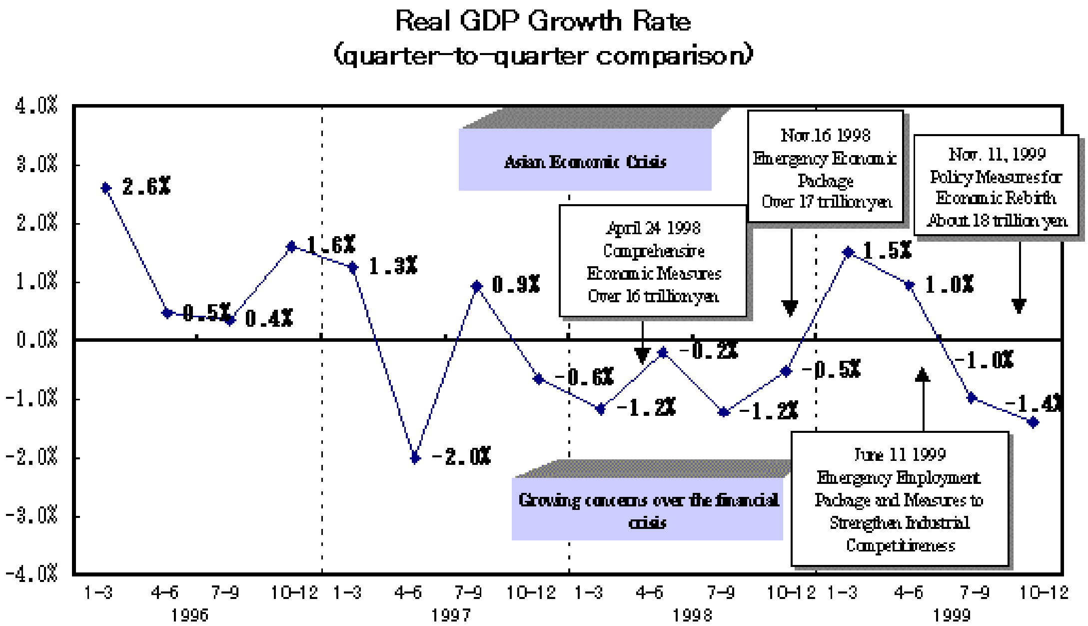
Masayuki Doi, Piyush Tiwari and Hidekazu Itoh
Institute of Policy and Planning Sciences
University of Tsukuba
Tsukuba, Ibaraki 305-8573 Japan
Fax and Tel: +81-298-535546
E-mail: doi@sk.tsukuba.ac.jp

Abstract

In this paper we investigate the system-wide impact of increased efficiency of ports in Japan using a computable general equilibrium model developed for 1995. Japanese Ministry of Transport has been implementing programs of the 9th Five-year Port Development Plan to improve port efficiency. The port efficiency reduces the cost of shipping transportation and the forward and backward linkages of imports and exports introduce some positive gains in the national GDP. Our analysis proves that the spillover effects are substantial on the shipping transportation and to a lesser extent on the Japanese economy.

1. Introduction

In the early 1990s, due partly to adjustment of excessive stocks of production facilities during the “bubble” period, the Japanese economy entered a recessionary phase, starting at the beginning of 1991 just after the “bubble” economy collapsed. In the four years from 1992 to 1995, Japan’s growth rate was around 1 percent or lower. Although, the recession touched the bottom in October 1993, the recovery had been very weak. However, since the autumn of 1997, adverse domestic and overseas factors, such as failures of financial institutions in Japan and financial and economic turmoil in Asia, had combined to deteriorate household and corporate sentiment. As a result, the Japanese economy was driven into an extremely severe situation. Consequently, the real GDP had declined for five consecutive quarters since the fourth quarter of 1997. As indicated in Figure 1, many economic packages were introduced to kickstart the economic turnaround but the Japanese economy continued to slump.



Japan's growth record, especially from the 1950s to 1990, was certainly respectable for an economy without major resources. Several institutional factors like lifetime employment, which enhances productivity due to innovations in manufacturing process and less job mobility, the banking system where banks held shares of firm and firms borrowed from banks, which fostered strong relationship between a firm and bank and reduced aggressive market competition, industrial policy, which subsidized key industries and protected them against international competition during infancy, education system and high savings rate, were often cited as the reasons for Japan's booming economic growth. The very features for which the Japanese economy was praised in the past by academia and policy watchers is being cited as the problem for economic recession. Labour and Capital productivity has been slowing over the past three decades.

Table 1: Productivity Growth in Japan

	1960-71	1971-81	1981-92
Tradable			
Total	10.22	5.67	4.59
Agriculture	4.64	3.18	2.79
Manufacturing	10.16	5.31	3.99
Non Tradable			
Total	6.83	2.53	1.90
Energy and transportation	8.08	1.95	2.82
Construction	5.81	0.27	1.99
Distribution and finance	8.75	4.79	2.86
Services	4.00	1.06	0.48
Whole Economy	8.92	3.96	2.88

Source: Ito (1997)

The effect is seen across the board, but is especially noticeable in the nontradable sector. Slower productivity growth, particularly after the very high levels reached by Japan from 1960s to 1970s, may be inevitable as the economy matures. However, it may be a signal to review basic institutional structure. The detailed analysis of the institutional imperfections in Japan is beyond the scope of this paper. Low factor productivity growth in Japan is often cited as the key economic phenomenon responsible for slow down of Japanese economy. Other authors have examined the impact of total productivity shocks on Japanese economic recovery. Using a dynamic CGE model, Lee and Roland-Holst(2000) conclude that a factor productivity growth in Japanese economy would lead to a growth not only in Japan but also in other ailing Asian economies through spillover effects. A number of studies have investigated the extent to which rapid output growth in postwar Japan resulted from capital inputs, labour inputs and total factor productivity. Most of these studies conclude that the postwar economic growth in Japan was attributable to total factor productivity and capital productivity. Most authoritative authors have concluded that a structural reform of the economy is necessary to enhance total factor productivity in Japan. Each sector is very special in its own way and requires very different policy changes. It would be more pertinent to analyze the impact of sector specific policy changes on the economic growth.

One sector that we have been keenly following is the port sector in Japan, which has undergone many changes during last decade. Port sector has little direct linkages with the sectors of the economy. This sector has major inputs to shipping industry, imports and exports. Through exports and imports the effects on this sector effect the economy. Therefore, the efficiency of the port sector has significant implications on the production structure of various sectors. Recently, Japan has invested heavily in ports infrastructure and also has constructed one new major port. The precise reasons why we have chosen ports for our study are elucidated in the next section in details. Briefly, the motivation to incorporate efficiency gains in the port sector is based on the study by Doi and Ito (1999), which concludes that in Japan, the improved port operations and new port investment has led to enhanced efficiency in this sector and is likely to reduce the cost of port operations.

Using a static CGE model for Japan, we analyze the impact of the efficiency shock to the port sector on the Japanese economy. We model the efficiency shock by assuming that an improvement in labour productivity and capital productivity would lead to reduction in the cost of intermediate inputs from this sector. Capital efficiency can be achieved through better port design and operations.

Rest of the paper is organized as follows: Section 2 briefly presents the developments in the port sector in Japan. Section 3 overviews the Computable General Equilibrium model and the database. Section 4 presents the results and section 5 concludes.

2. Port Sector in Japan

As a component of the overall economy, the port sector is only 0.24% of the GDP. Share of this sector in total employment is 0.09% and capital stock is 0.14%. The structure of port sector is very typical with intermediate inputs to this sector being around 35% of the output from this sector. Most of the intermediate input is from the real estate sector, constituting around half of all intermediate inputs. Factor income constitutes 65% of GDP with 82% of it accruing to labour and 4% to capital.

Table 2: Cost Structure of Port Sector

Sectors	Percentage share in total cost
Labour	53.2
Capital	11.8
Non Durable Manufacturing	2.38
Infrastructure manufacturing	0.38
Durable manufacturing	1.38
Construction	0.79
Utilities	0.12
Water	0.07
Trade	0.74
Finance and insurance	6.07
Real estate	17.73
Shipping	0.03
Other transportation	1.85
Communication	1.52
Education	0.09
Other Services	4.15

Ports are the service sector catering to the incoming and outgoing cargo. Port requires an extensive set of both water- and land-side infrastructure to handle various types of cargoes. Shippers and shipping lines as well as many other related port users require various administrative and related financial and other services[i].

The efficiency of port operations is dependent on the design and maintenance of berths, channels, navigation aids, other water-side facilities, stacking areas, cargo handling equipment, warehouses, container freight stations, accessibility, and other land-side facilities. Port management, particularly the type of port ownership and administration, stevedoring labor, and the existence of competition in port network determine the operating efficiency of port facilities. Information technology helps make their operating performances better.

In turn, port efficiency can be improved by a number of approaches to improve port design, maintenance, operations, redevelopment, management, labor management, or inter-port network reform or by a mixed strategy of the approaches.

The types of economic impacts arising from port efficiency improvement differ depending on the flows of cargo handled at ports. There are three types of the cargo flows handled at ports: they are local exports and imports, transshipments, and re-exports[ii]. Ports with regional hub functions transship cargoes between large ships of trunk routes and small ships of feeder routes, and tend to have higher transshipments ratios[iii]. The Port of Singapore is a typical example of the regional hub port covering South-East Asian countries. Its transshipment rate is as high as 0.6. Another example is the Port of Hong Kong for which the rate of transshipments of more than 0.5. The Port of Rotterdam and Port of Hamburg have regional hub functions in Europe, and the Port of Miami, Port of Evergrades, Port of Jamaica have similar functions serving Middle and South America.

Contrary to the countries of hub ports, Japan is a country of shippers, or cargo origination. The Port of Kobe used to have the transshipment rate of more than .4 about 20 years ago when Korea had rapid economic growth but Korean ports were underdeveloped. Major ports in Japan still carry some transshipments of China origin and destination. However, in Japan, local exports, imports, and domestic cargoes would be the main beneficiaries of efficiency improvement of Japanese ports.

Ministry of Transport announced, in 1995, a new long-term port policy called “Ports in the age of global exchange: Towards ports which provide advanced networks to the world and vitalize regional communities and economies”. Ministry of Transport carries out the programs of the 9th Five-year Port Development Plan in line with the long-term port policy[iv].

As part of the programs, international multi-purpose terminals will be developed at about 20 regional main ports to promote direct international exchanges with Asian countries. High-standard container terminals capable of receiving container ships carrying 5,000 to 6,000 TEUs will be developed at the gateway ports in the Tokyo Bay, Ise Bay, Osaka Bay, and Kyushu. High-standard container terminals will be also developed at the 8 subsidiary gateway ports selected out of the 20 regional main ports. The improvement of port service quality and the introduction of advanced information systems will be also carried out.

A number of mechanisms through which port efficiency is improved can be discussed in and out of the port policy change in Japan. For example, the Port of Hitachinaka is a completely new port located to the north of the Tokyo Bay, and is one of the subsidiary gateway ports. While most cargoes in the Tokyo Metropolitan Region are currently captured to use the ports in the Tokyo Bay, the Port of Hitachinaka is expected to enhance inter-port competition and to improve the overall port efficiencies.

We experimentally evaluate the economic impacts of port efficiency improvement by the CGE model, assuming the port sector exogenously reduces its price by 20% due to the port efficiency improvement, and the user-oriented factors will react to the shock

3. The Computable General Equilibrium Model and the Database

The computable general equilibrium models (CGE) have provided an especially useful tool to understand and manage structural change. These models incorporate production at a level of aggregation that permits the analysis of structural change and also captures the essential interdependent nature of production, demand, and trade within a general equilibrium that incorporates market mechanisms and works through price incentives. The CGE model that we have used is a static, Dervis, De Melo and Robinson type model. The model has twenty sectors and has detailed disaggregation of non-tradable and services sectors. There are three transportation sectors: shipping, port operations and other transportation. All sectors of the model are assumed to be perfectly competitive and operate under constant returns to scale. Production technology is modeled by nesting of a CES function. The model has three factors of production: labour, capital and sector-specific fixed factors. The labour supply is determined by a variable linear expenditure system. The labour supply is variable and labour moves freely between the sectors. Thus there is a single equilibrium wage rate in the economy. The total capital stock is fixed in the model. However, capital is free to move among sectors.

All income generated by economic activity is assumed to be distributed to consumers. The income is divided between consumption and savings. The final demand for goods is divided between households, government and investment. Household's demand function is a linear expenditure system. Government and investment demand for each sector is fixed. This avoids any question regarding substitution between present and future consumption, which makes the static welfare comparison difficult.

One of the key features of the model is that goods are differentiated between domestic and traded. On the import side, this is reflected by the implementation of the Armington assumption where a constant elasticity of substitution (CES) specification is used to incorporate imperfect substitution of the imported goods with respect to domestically produced goods. A symmetric specification is used to model export supply, the latter being implemented with constant elasticity of transformation (CET) functions.

The model closure involves fixed real investment demand, fixed real government demands, a fixed price index, and variable government transfers. The exchange rate in the model is the real exchange rate.

Model equations and other relevant details are given in appendix 1. The model is calibrated to social accounting matrix of Japan, as well as to various parameters. The SAM is constructed from the I-O table and National Accounts data for 1995. The parameters are taken from various sources[1] to the extent they are available and the rest are informed guesstimates.

4. Modeling Efficiency and Results

We impute shocks to the port sector in the CGE model by giving a port price shock to the economy.

Price shock is very typical and we assume that the domestic purchaser price of port usage reduces by 20%. We do not model the typical path of how these prices would be reduced but assume that at the end period port prices would be less by 20% of the initial

[1] For LES consumption function elasticities: Sasaki (1993).
CET and CES function elasticities: Lee and Roland-Holst(1999)

base period. In this experiment, we have made the price of port sector exogenous. The results indicate the impact on the economy and other sector for the end period equilibrium. Intermediate equilibrium is not commented upon.

It may be emphasized here that we are trying to model the impact of reduction in prices of domestic input from this sector. This may be assumed mistakenly to be akin to the administered prices in this sector. This is not our intention. We argue that changes in the productivity of various inputs and productivity induced through competition, enhances the supply from this sector, which reduces the prices. Another way to argue the same phenomenon is to introduce total factor productivity in this sector. This is conceptually a less quantifiable for future periods by port economists and difficult to understand by policy maker. We, therefore, assume that the purchaser price from the port sector would reduce by 20% due to productivity gains in this sector. The gains acquired would be transferred to the purchasers of port sector.

The changes in macro variables are presented in Table 3, and Table 4, presents sectoral changes in various components of our model.

Table 3: Changes in Macro variables

Macro Variables	Percentage Change
Private GNP	0.40
Real GDP	0.19
Value added at market prices	0.19
Gross Labour income	0.23
Gross Capital Income	0.78
Average wage rate	0.43
Average rental rate	0.57
Labour Supply	0.06
Total Savings	0.27
Private Savings	0.37
Government Savings	0.24
Household demand	0.08
Income tax revenue	0.40
Indirect tax revenue	-2.14
Tariff revenue	-9.85
Exchange rate	-2.08
Expenditure	0.37

With ports becoming efficient, the most significant impact is on the shipping sector, as expected, to which port is a major input. Shipping industry sees significant growth in their domestic and international demand.

Because there are few linkages between the port sector and the economy except through imports and exports. The effects on the other sectors of the economy are related to the exchange rate, consumer spending, and the price of production inputs in the model caused by the price changes in the port sector. In this experiment, exchange rate depreciates slightly. This tends to move firms along the CET frontier away from domestic supply to exports. On the import side, this tends to move firms along the CES composite good isoquant away from imports towards domestic output. The tariff structure plays a key role. The sectors, which have relatively higher tariff rates put a further wedge on the composite good price of imports. The productivity improvements also reallocate primary factors of production. Since in our model capital stock is fixed and only reallocation is permitted. The factors move to those sectors, which benefit from exchange rate and are losers because of high tariff rates. Average wage rate and capital rental rate in the economy also grows. This raises the household demand and leads to income effect by increasing the demand for agricultural goods and non durable consumption goods.

Table 4: Percentage Change in quantities

	Import	Export	Output	Domestic demand	Domestic Sales	Intermediate uses	Household demand	Capital demand	Labour Demand
Agriculture	-14.76	22.22	7.86	4.60	7.83	5.18	3.50	7.69	8.36
Mining	3.90	-5.26	-0.52	2.71	-0.53	2.51	1.76	-1.02	0.00
Non Durable Manuf.	-9.15	14.71	5.34	3.49	5.01	2.25	5.95	4.72	5.68
Infrastructure Manuf.	5.41	-3.65	-0.78	-0.20	-0.62	-0.24	0.53	-1.43	-0.50
Steel	4.41	-3.84	-1.95	-1.60	-1.76	-1.61	0.64	-2.60	-1.73
Durable Manuf.	5.28	-5.12	-2.38	-0.96	-1.47	-0.53	-0.11	-3.15	-2.07
Construction			0.01	0.01	0.01	0.13	0.50	-0.65	0.12
Shipping	-5.23	27.00	20.57	6.88	14.98	7.42	4.96	19.83	23.33
Port	1.81	-6.67	4.30	7.91	7.12	7.70	19.15	3.64	4.26
Services	3.06	-3.93	-0.59	-0.49	-0.54	0.16	-1.24	-0.91	-1.27

5. Conclusion

This is a preliminary analysis of the impact of port efficiency on the Japanese economy. The port sector contributes only 0.24% to the GDP. The intermediate inputs to this sector are 35% or the output and the primary factors constitute 65% of output. Recent developments in the port sector in Japan indicate that due to enhanced competition the prices would come down. We have modeled the impact of decreased price in this sector on the economy using a static CGE model.

The results indicate that the impact on the economy is positive. The real GDP grows by 0.19%. The major impact is on the shipping industry which grows all round. The reduction in price of ports depreciates the exchange rate. The implication of this is seen on sectors, which have high import tariffs. Imports of these sectors decline and factor of production move into these sectors. The average rental rate and wage rates increase and this leads to income effect and domestic demand for consumption good increases.

The model requires many ramifications and may at most be considered as rudimentary and indicative. A further model should investigate in a dynamic framework, which allows investment decision to be undertaken in a dynamic way. The future possible expansion of our CGE model analysis in terms of port policy evaluation includes the following.

(1) The level of the port efficiency improvement to be evaluated in our CGE model evaluated as 20% reduction in purchaser price of this sector's input to other sectors of the economy. Depending on the types of cargo the industrial sectors ship out, however, they use different port terminals. The room for efficiency improvement differs depending on the port terminal types due to their technological, operational, administrative, and economic management conditions. Further implications can be expected if more detailed port efficiency improvement levels are evaluated in consideration of different cargo types of the industrial sectors.

(2) Japan is an island country suffering from the shortage of flat lands. Therefore, ports and their surrounding areas take the role also act as distribution centers, industrial zones and energy supply bases, trading centers, recreational centers, and other productive and environmental preservation bases. Improved port efficiency brings about changes to the economy through these additional functions of the ports, which are not considered in the SAM nor CGE modeling. Efforts will be made to incorporate at least part of such externalities in the CGE analysis.

References

1. Alderton, Patrick, 1999, *Port Management and Operations*, LLP.
2. Bureau of Ports, Tokyo Metropolitan Government, 1996, *Economic Impacts of the Port of Tokyo*, Tokyo Metropolitan Government.
3. Dervis, K., De Melo, J. and Robinson, S. (1982) *General Equilibrium Models for Development Policy*, Cambridge University Press.
4. De Melo, J. and Robinson, S.(1989) Product Differentiation and the Treatment of Foreign Trade in Computable general Equilibrium Models of Small Economies," *Journal of International Economics*, 27, pp. 489-497.
5. Devarajan, S. and Rodrik, D. (1991), "Pro-competitive effects of trade reform: Results from CGE model of Cameroon," *European Economic Review*, 35, 1157-1184.
6. Doi, Masayuki, 1995, *Transportation Economics for Developing Countries* (in Japanese), Keisoshobo.
7. Ibaraki Prefecture et al., 2000, *A Study of Logistics Management in the Northern Kantoh Region*, Ibaraki Prefecture.

8. Jasson, Jan Owen and Shneerson, Dan, 1982, *Port Economics*, The MIT Press.
9. Lee, H. and Roland-Holst, D. (2000), Trade and Transmission of Endogeneous Growth Effects: Japanese Economic Reform as an Externality for East Asian Economies," mimeo.
10. Lee, H. and Roland-Holst, D. (1999), "Cooperation or Confrontation in U.S.-Japan trade? Some General Equilibrium Estimates," *Journal of the Japanese and International Economies*, 13, 119-139.
11. Ports and Harbours Bureau, Ministry of Transport, 1998 (a), *Ports and Harbours in Japan*, The Government of Japan.
12. Ports and Harbours Bureau, Ministry of Transport, ed., 1998 (b), *Ports in Statistics* (in Japanese), The Port Association of Japan.
13. Sasaki, K. (1993), *An Analysis of Consumer Demand in Japan*, University of Tsukuba, Japan.

Appendix 1: Generalized CGE Model Specification

The model specification is briefly presented here. To simplify the presentation, we have removed indirect tax, capital tax, government foreign borrowing and remittances from the system. Though the actual model in use includes all these parameter.

Final Demand Behavior

The model considers three separate components of domestic final demand: household consumption, government demand, and investment demand. The consumption behavior of households is given in equation (1):

$$P_i^Q C_i = P_i^Q \mu_i + s_i \left[(1 - mps) Y - \sum_h P_h^Q \mu_h \right] \quad \forall_i \qquad (1)$$

where C_i represents households demand for composite consumption good i, P_i^Q denotes the domestic purchaser price of the composite consumption goods i, s_i is the marginal budget share for composite goods i, mps is the marginal propensity to save, Y is domestic income, and μ_i is the subsistence minimum for composite consumption good i. The functional form is a linear expenditure system (LES). The LES is a generalization of the Cobb-Douglas utility function in which the origin is translated to a point in the positive quadrant. While the income expansion paths are linear, the displaced origin allows preferences to be nonhomothetic. That is, income elasticities of demand can differ from unity.

Government and investment spending in each sector (any overall) is held constant in real terms:

$$I_i = is_i I \quad \forall_i \qquad (2)$$

$$G_i = gs_i G \quad \forall_i \qquad (3)$$

where I and G are total investment and government demand, respectively, and is_i and gs_i are the share of the total investment and government demand each sector receives. This specification avoids questions concerning the substitution between present and future consumption which would make static welfare comparisons difficult.

Production Technology

Production technology is modeled by using a constant elasticity of substitution (CES) value added function specified as

$$X_i = a_i\left(b_i L_i^{(\phi_i-1)/\phi_i} + (1-b_i)K_i^{(\phi_i-1)/\phi_i}\right)^{\phi_i/(\phi_i-1)} \quad \forall_i \qquad (4)$$

where X_i denotes gross domestic output for sector i, L_i is labor used in sector i, K_i is capital used in sector i, and ϕ_i is the elasticity of substitution between labor and capital for sector i. The parameter ϕ_i is exogenous and is estimated outside the model. a_i and b_i are the respective intercept and share parameters that allow the CES production function to be calibrated for each sector i. A Leontief (fixed coefficients) function is assumed between value added and intermediate products as well as between various intermediates:

$$D_i = \sum_h io_{ih} X_h \quad \forall_i \qquad (5)$$

where D_i is the intermediate demand for composite consumption goods i, X_h is the gross domestic output of sector h, and io_{ih} is the input-output coefficient between sectors i and h. The input-output coefficients are determined by calibration to the SAM.

Factor Supplies and Demands

Factor demands are derived from the CES production function:

$$L_i = a_i^{(\phi_i-1)} X_i \left(\frac{b_i P_i^V}{w}\right)^{\phi_i} \quad \forall_i \qquad (6)$$

$$K_i = a_i^{(\phi_i-1)} X_i \left[\frac{(1-b)_i P_i^V}{r}\right]^{\phi_i} \quad \forall_i \qquad (7)$$

where P_i^V is the value added price in sector i, w is the economywide wage rate, and r is the economywide rental rate on capital.

While the total capital stock is fixed in the model, we specify a variable labor supply function using a nested linear expenditure system as in de Melo and Tarr (1992) and the Appendix to this chapter:

$$L = L_0 - \left(\frac{\lambda_l}{w}\right)\frac{\left[(1-mps)Y - P^{LES}\Gamma\right]}{(1-\lambda_l)} \qquad (8)$$

$$P^{LES} = \frac{\left[(1-mps)Y - \sum_i P_i^Q \Gamma_i\right]}{\prod_i (C_i - \Gamma_i)^{\lambda_i}} \qquad (9)$$

where L_o is maximum labor supply, λ_l is the marginal budget share for leisure, λ_i is the marginal budget share of composition goods i, P^{LES} is the LES aggregate price index, Γ_i is the LES subsistence minimum for composition good i, and Γ is the aggregate

LES subsistence minimum. This represents just one possible labor market closure. One alternative is to fix L and maintain a flexible w. Another alternative is to fix w and allow L to vary.

Treatment of Traded Goods

The treatment of traded goods is the most important component of the model specification. As mentioned, the model views each sector as consisting of three goods, where imports and exports in each industry category are imperfect substitutes for their domestic counterparts. On the import side, the model treats foreign and domestic commodities as imperfect substitutes in domestic use. Therefore, the import composition of domestic demand is influenced by the ratio of domestic and import prices, as well as by any administrative quantity restrictions. The model aggregates imports and their domestic counterparts into an aggregate good for each sector, Q_i, using a CES aggregation:

$$Q_i = \alpha_i \left[\beta_i M_i^{(\sigma_i - 1)/\sigma_i} + (1 - \beta_i) S_i^{(\sigma_i - 1)/\sigma_i} \right]^{\sigma_i/(\sigma_i\ 1)} \quad \forall_i \qquad (10)$$

$$\left(\frac{M_i}{S_i} \right) = \left[\left(\frac{\beta_i}{(1 - \beta_i)} \right) \left(\frac{P_1^S}{P_i^M} \right) \right]^{\sigma_i} \quad \forall_i \qquad (11)$$

Equation (10) is the aggregation relation in which Q_i denotes the composite good for domestic consumption in sector i, M_i is the imports of sector i, S_i is the domestic supply in sector i, α_i and β_i are the respective intercept and share parameters in this CES product aggregation function for each sector i, and σ_i is the elasticity of substitution between imports and domestic competing goods in sector i. Equation (11) is the tangency condition in which P_i^S is the sector i's price of the domestic good and P_i^M is sector i's domestic price of imports.

The use of CES functional form for aggregation implies that preferences with respect to imports and domestic goods within a sector are homothetic, while preferences between sectors are not. For a given level of demand for a product category, determined by the specification of the three components of final demand, the shares of imports and domestic goods are determined in response to relative prices.

On the export side, the model assumes that domestic firms allocate their output between domestic and foreign markets according to a transformation function which depends on the ratio of domestic and foreign prices. Therefore, the export composition of domestic supply is influenced by the ratio of domestic and export prices. The functional form used is a constant elasticity of transformation (CET) as indicated in the following equations.

$$X_i = \gamma_i \left[\delta_i E_i^{(\tau_i + 1)/\tau_i} + (1 - \delta_i) S_i^{(\tau_i + 1)/\tau_i} \right]^{\tau_i/(\tau_i + 1)} \quad \forall_i \qquad (12)$$

$$\left(\frac{E_i}{S_i} \right) = \left[\left(\frac{(1 - \delta_i)}{\delta_i} \right) \left(\frac{P_i^E}{P_i^S} \right) \right]^{\tau_i} \quad \forall_i \qquad (13)$$

Equation (12) is the allocation relation in which S_i is domestic supply in sector i, E_i is exports of sector i, τ is the elasticity of transformation between domestic supply and exports, and γ_i and δ_i are the respective intercept and share parameters used to calibrate the model for each sector i. Equation (13) is the tangency condition in which P_i^E is the domestic price of exports in sector i. The shares of domestic supply and exports are determined in response to relative prices.

Domestic Prices

We next turn to the equations for domestic prices, including those of import and export goods. These are given in the following five equations:

$$P_i^X X_i = P_i^S S_i + P_i^E E_i \quad \forall_i \qquad (14)$$

$$P_i^Q Q_i = P_i^S S_i + P_i^M M_i \quad \forall_i \qquad (15)$$

$$P_i^V = P_i^X - \sum_h io_{hi} P_h^Q \quad \forall_i \qquad (16)$$

$$P_i^M = (1+t_i)(1+\rho_i) erPW_i^M \quad \forall_i \qquad (17)$$

$$P_i^E = erPW_i^E \quad \forall_i \qquad (18)$$

where t_i is the tariff rate on imports in sector i, ρ_i is the quota premium rate in sector i, PW_i^M is the world price of import good in sector i, PW_i^E is the world price of the export in sector i, and er is the exchange rate (U.S. dollars per unit of foreign currency).

Domestic Market Equilibrium

Three equations are required for domestic market equilibrium, one for the commodity market and two others for the factor markets:

$$Q_i = D_i + C_i + G_i + I_i \quad \forall_i \qquad (19)$$

$$\sum_i K_i = K \qquad (20)$$

$$\sum_i L_i = L \qquad (21)$$

Income and Government Revenue

Income and government revenue are summarized by the following six equations:

$$R_T = \frac{\sum_i t_i P_i^M M_i}{(1+t_i)} \qquad (22)$$

$$R_Q = \sum_i \rho_i erPW_i^M M_i \qquad (23)$$

$$Y = Y_L + Y_K + GT + R_Q \qquad (24)$$

$$\sum_i P_i^Q G_i + GS + GT = R_T \qquad (25)$$

$$S = mpsY + GS + erFS \qquad (26)$$

$$I = \sum_i P_i^Q I_i \qquad (27)$$

Equation (22) and (23) represent tariff revenue (R_T) and domestically capital quota rents (R_Q), respectively, Equation (24) defines income, which is the sum of labor income ($Y_L = wL$), capital income ($Y_K = rK$), government transfer payments (GT), and domestically captured quota rents. The government budget constraint is captured in equation (25), where GS is government savings. Finally, total investments and savings are defined in equations (26) and (27), respectively, where FS is foreign savings. As indicated, by Walras's Law we leave out any savings-investment balance equation.

Foreign Sector Closure

To characterize the foreign sector we specify the following balance of payments equation:

$$\sum_i PW_i^M M_i + \frac{R_Q}{er} = \sum_i PW_i^E E_i + FS \qquad (28)$$

With foreign savings (FS) held constant, the balance of payments is maintained in equation (28) via changes in the exchange rate, er. An alternative foreign sector closure is to fix the exchange rate and allow foreign savings to vary. The closure used here better supports welfare analysis, however. With a numeraire price index held fixed (see the section Macro Closure), the exchange rate behaves as a real exchange rate.

Macro Closure

Because the model is SAM-based, a macroeconomic closure must be specified. A numeraire price index is held fixed, as suggested by de Melo and Robinson (1989). Government and investment demands by sector are fixed in real terms as described. As in Devarajan and Rodrik (1991), real government transfers adjust to maintain the savings-investment balance. The model is homogeneous of degree zero in prices.

---

[i] See, for example, Alderton (1999), for the introduction of port systems.

[ii] Cargoes are unloaded to ports and then loaded to ships without any or much increases in their value added.

[iii] This is the rate of transshipment cargo to the total cargo handling at a port.

[iv] See Ports and Harbours Bureau, Ministry of Transport (1998a) for details.