The Structure and Application of a Price-Linked International Input-Output Model

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Abstract: The purpose of this paper is to develop a price-linked international input-output model and to demonstrate its application. The model has the following features: 1) the model is constructed by using multi-period Asian International Input-Output Tables in constant prices, 2) most parameters of the model are econometrically estimated, 3) the monopoly model is incorporated as producer behavior, 4) input coefficient varies over time, 5) sectoral price and output are simultaneously determined. As an application, the effects of tariff reduction between Japan and the United States in the Asia-Pacific region is quantified. Based on our results, the United States would have positive impact whilst Japan's findings would be negative with respect to output. The main cause of Japan's output decline is the shift in demand from domestic products to U.S. products due to improved U.S. price competitiveness in Japan's market.

KEYWORDS: Price-linked international input-output model, monopoly, trade liberalization, Asia-Pacific

1. Introduction

Economic interdependence at the sector levels is becoming tighter and tighter in the current world economy. Due to this nature of the world economy, multi-country multi-sectoral models are inevitably required to analyze global policy issues. At present, three modeling strategies have been applied. The first strategy is computable general equilibrium (CGE) modeling. A CGE model has rigorous theoretical foundation; however, it typically lacks econometric foundation.[1] Widely applied CGE models are the Michigan model (Deardorff and Stern, 1986), the GTAP model (Hertel, 1997) and the G-Cubed model (McKibbin and Wilcoxen, 1999). The second strategy is the INFORUM approach (Almon, 1991; Uno, 2002)[2]. In this approach, an input-output (IO) model with a macroeconometric model is constructed per country. Linking these domestic systems by trade at the commodity level establishes the INFORUM system. In general, classifications of an IO table and trade data are not consistent. In addition, sector classification of

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[1] An exception is McKibbin and Wilcoxen (1999). They built a multi-country CGE model by econometrically estimating parameters.
[2] INFORUM stands for Interindustry Forecasting at the University of Maryland.

an IO table also differs among countries. Hence, this approach may have a problem with data consistency. The last strategy is international IO modeling (Torii *et al*., 1989; Kosaka, 1994; Yano and Kosaka, 2003). This strategy develops an international IO model following the structure of an international IO table. Thus, inconsistency with respect to classification would not occur. However, this strategy heavily relies on an international IO table. If the table is not available, this strategy does not work.

In this paper, we present another variety of multi-country multi-sectoral models; *i.e.*, a price-linked international IO model. Additionally, we demonstrate, as an example of its application, simulation analysis on trade liberalization between Japan and the United States in the Asia-Pacific region. With respect to the use of international IO tables, our modeling strategy is close to the third one; however, several novel features are incorporated in ours. The first feature is construction of multi-period international IO tables in constant prices and econometric estimation of parameters.[3] Since a multi-sectoral model is generally constructed by using a single-period IO table, the parameters are calibrated, not estimated. By contrast, we convert multi-period international IO tables in current prices to those in constant prices. With these tables, we estimate parameters econometrically by applying a panel data model. The second feature is the introduction of imperfect competition; specifically monopoly framework. This allows us to determine the sectoral price by monopoly behavior, which differs from the traditional IO approach. The last feature is the treatment of final demands. The INFORUM approach, Kosaka (1994), and Yano and Kosaka (2003) determine final demands by interlinking macroeconometric models. In contrast, our model explains final demands internally. In particular, household consumption is derived from utility maximization, employing household behavior in Ballard *et al*. (1985) as the benchmark model.

A price-linked international IO model is a powerful tool to analyze global policy issues such as topics on trade and environment. As an application of the model, this paper analyzes the effects of trade liberalization between Japan and the United States in the Asia-Pacific region.[4] Concerning outcomes on Japan and the United States, we find that sectoral prices for both Japan and the United States would decline in exception to the agricultural sector of the United States. Additionally, outputs in all sectors of the United States would increase whereas those of Japan would decrease.

The remainder of this paper consists of four sections. Sections 2 and 3 illustrate theoretical and empirical structures of the model, respectively. Section 4 presents an application of the model. Finally, section 5 provides conclusions.

2. Theoretical Structure of the Model

The most important variables of the model are sectoral price and output. In a traditional IO model, these variables are determined separately; however, our model computes them simultaneously. This enables us to obtain consistent price and output at the sector level. The model is built by using price-linked international IO tables, which makes a distinction from past international IO

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[3] Uno (2002) also estimates parameters by econometric techniques; however, his estimation is based on single-country IO tables, not international IO tables.

[4] The Asia-Pacific region consists of Indonesia (IDN), Malaysia (MLS), the Philippines (PHL), Singapore (SGP), Thailand (THA), China (CHN), Taiwan (TWN), South Korea (KOR), Japan (JPN), and the United States (USA).

models (Torii *et al*., 1989; Kosaka, 1994; Yano and Kosaka, 2003). With these tables, most parameters are estimated by employing a panel data model. Concerning the other features of the model, household behavior is illustrated by the modified version of Ballard *et al*. (1985) whereas producer behavior is by a monopoly framework (*i.e*., the sectoral price is determined by monopoly pricing, not by adding up cost factors). Although input coefficient is normally fixed, it is estimated and varies over time in the model. Furthermore, household consumption is explained within the model: that is, none of the macroeconometric models is employed.

2.1. Sectoral Output

Following the identity with respect to demand, sectoral output equals the summation of intermediate and final demands as:

$$\begin{aligned} XXR_i^h &= \sum_k \sum_j XR_{ij}^{hk} + \sum_k CPR_i^{hk} + \sum_k CGR_i^{hk} + \sum_k IR_i^{hk} + \sum_k IVR_i^{hk} \\ &\quad + EXR_i^h + QXR_i^h \end{aligned} \tag{1}$$

where XXR_i^h is the real output in the *i*th sector of the *h*th country, XR_{ij}^{hk} is the real input of the *h*th country's *i*th goods used in the *j*th sector of the *k*th country, CPR_i^{hk} is the *k*th country's real household consumption of the *i*th goods produced in the *h*th country, CGR_i^{hk} is the *k*th country's real government consumption of the *i*th goods produced in the *h*th country, IR_i^{hk} is the *k*th country's real investment of the *i*th goods produced in the *h*th country, IVR_i^{hk} is the *k*th country's real inventories of the *i*th goods produced in the *h*th country, EXR_i^h is the real export to the rest of the world (ROW) in the *i*th sector of the *h*th country, and QXR_i^h is the real statistical discrepancy in the *i*th sector of the *h*th country.

2.2. Household Behavior

Household behavior of the model principally follows that of Ballard *et al*. (1985).[5] This behavior employs the two-stage utility maximization. A representative household determines current consumption and savings in the first stage while the household allocates current consumption into

[5] Although Ballard *et al*. (1985) explain labor supply by household utility maximization, its determination is omitted in the model. Instead, sectoral employment is determined by producer behavior.

consumption by sector in the second stage. Following the Armington's (1969) approach, consumption by sector is further distributed with respect to country.

2.2.1. Consumption-Savings Decision

In order to determine current consumption and savings, a representative household of the *k*th country solves the following utility maximization problem as:

$$\max_{\overline{CPR}^k, CR_F^k} U^k = \left[\alpha^{k\,1/\sigma^k}\, \overline{CPR}^{k\,(\sigma^k-1)/\sigma^k} + \left(1-\alpha^k\right)^{1/\sigma^k} CR_F^{k\,(\sigma^k-1)/\sigma^k} \right]^{\sigma^k/(\sigma^k-1)} \tag{2}$$

subject to

$$YI^k = \overline{P}_{CP}^k \overline{CPR}^k + P_S^k SR^k \tag{3}$$

where U^k is a constant elasticity of substitution (CES) utility function of the household in the *k*th country, $\overline{CPR}^k$ is current consumption in constant prices of the *k*th country, CR_F^k is future consumption in constant prices of the *k*th country, α^k is distribution parameter of the *k*th country, σ^k is the elasticity of substitution between $\overline{CPR}^k$ and CR_F^k, YI^k is income in current prices of the *k*th country, $\overline{P}_{CP}^k$ is the price for $\overline{CPR}^k$, P_S^k is the price for SR^k, and SR^k is savings of the *k*th country. Current consumption is a composite of consumption by sector, which is written in the following Cobb-Douglas form as:

$$\overline{CPR}^k = \prod_i CPR_i^{k\,\lambda_{CP_i}^k} \tag{4}$$

where $\sum_i \lambda_{CP_i}^k = 1$.

The representative household purchases capital goods through savings. Firms borrow capital goods and pay returns to the household. The household's expected return per unit of savings can be written as $P_K^{Dk}\zeta^k$, where P_K^{Dk} and ζ^k are the price and unit service of capital goods in the *k*th country, respectively. The household purchases future goods by the return of savings. We assume that the price for future goods is identical to the price for the current consumption of the *k*th country: *i.e.*, $\overline{P}_{CP}^k$. Hence, we have the following relationship between nominal savings and future consumption of the *k*th country as:

$$P_S^k \; SR^k = P_F^k CR_F^k \tag{5}$$

where $P_F^k = \dfrac{P_S^k \overline{P}_{CP}^k}{P_K^{Dk} \zeta^k}$. Same as Ballard *et al*. (1985), the price for savings is defined as:

$$P_S^k = \sum_i P_i^k \left(\frac{XXR_i^k}{\sum_i XXR_i^k} \right) \tag{6}$$

where P_j^k is the price in the *j*th sector of the *k*th country. Using this relationship, we rewrite the constraint of the utility maximization problem as:

$$YI^k = \overline{P}_{CP}^k \overline{CPR}^k + P_F^k CR_F^k \tag{7}$$

The Lagrangian for this problem is written as:

$$\begin{aligned} L_1^k = & \left[\alpha^{k\,1/\sigma^k} \, \overline{CPR}^{k\,\left(\sigma^k - 1\right)/\sigma^k} + \left(1 - \alpha^k\right)^{1/\sigma^k} CR_F^{k\,\left(\sigma^k - 1\right)/\sigma^k} \right]^{\sigma^k/\left(\sigma^k - 1\right)} \\ & + \mu^k \left(YI^k - \overline{P}_{CP}^k \overline{CPR}^k - P_F^k CR_F^k \right) \end{aligned} \tag{8}$$

where μ^k is the Lagrange multiplier of the *k*th country. The first-order conditions are given by:

$$\alpha^{k\,1/\sigma^k} U^{k\,1/\sigma^k} \overline{CPR}^{k\,-1/\sigma^k} = \mu^k \overline{P}_{CP}^k \tag{9}$$

$$\left(1 - \alpha^k\right)^{1/\sigma^k} U^{k\,1/\sigma^k} CR_F^{k\,-1/\sigma^k} = \mu^k P_F^k \tag{10}$$

$$YI^k = \overline{P}_{CP}^k \overline{CPR}^k + P_F^k CR_F^k \tag{11}$$

Combining equations (9) and (10) and substituting the resultant into equation (11) yield the optimal current and future consumptions of the *k*th country as:

$$\overline{CPR}^k = \frac{\alpha^k YI^k}{\overline{P}_{CP}^{k\,\sigma^k} \Theta^k} \tag{12}$$

$$CR_F^k = \frac{\left(1-\alpha^k\right)YI^k}{P_F^{k\,\sigma^k}\Theta^k} \tag{13}$$

where $\Theta^k = \alpha^k \overline{P}_{CP}^{k\;1-\sigma^k} + \left(1-\alpha^k\right)P_F^{k\;1-\sigma^k}$. The optimal savings of the kth country can be obtained by substituting equation (13) into equation (5) as:

$$SR^k = \frac{\left(1-\alpha^k\right)YI^k}{P_S^k P_F^{k\;\sigma^k-1}\Theta^k} \tag{14}$$

2.2.2. Determination of Consumption by Sector

For the determination of sectoral consumption of the kth country, the household of the kth country solves the following problem:

$$\max_{CPR_i^k} \overline{CPR}^k = \prod_i CPR_i^{k\;\lambda_{CP_i}^k} \tag{15}$$

subject to

$$YI^k - P_S^k SR^k = \sum_i P_{CP_i}^k CPR_i^k \tag{16}$$

where $P_{CP_i}^k$ is price for CPR_i^k. We set up the Lagrangian as follows:

$$L_2^k = \prod_i CPR_i^{k\;\lambda_{CP_i}^k} + \psi^k\left(YI^k - P_S^k SR^k - \sum_i P_{CP_i}^k CPR_i^k\right) \tag{17}$$

where ψ^k is the Lagrange multiplier of the kth country. The first-order conditions for this optimization are:[6]

$$\lambda_{CP_i}^k \frac{\overline{CPR}^k}{CPR_i^k} = \psi^k P_{CP_i}^k, \qquad i = 1, 2, \ldots, n \tag{18}$$

$$YI^k - P_S^k SR^k = \sum_i P_{CP_i}^k CPR_i^k \tag{19}$$

[6] In these first-order conditions, the number of sectors is assumed to be an n.

Hence, the optimal consumption in the *i*th sector of the *k*th country is given by:

$$CPR_i^k = \frac{\lambda_{CP_i}^k}{P_{CP_i}^k}\left(YI^k - P_S^k SR^k\right) \tag{20}$$

Substituting equation (20) into the corresponding objective function gives the price for $\overline{CPR}^k$. This substitution yields the following equation as:

$$YI^k - P_S^k SR^k = \overline{CPR}^k \prod_i \left(\frac{P_{CP_i}^k}{\lambda_{CP_i}^k}\right)^{\lambda_{CP_i}^k} \tag{21}$$

Since $YI^k - P_S^k SR^k = \overline{P}_{CP}^k \overline{CPR}^k$,

$$\overline{P}_{CP}^k = \prod_i \left(\frac{P_{CP_i}^k}{\lambda_{CP_i}^k}\right)^{\lambda_{CP_i}^k} \tag{22}$$

Additionally, $P_{CP_i}^k$ is explained as follows:

$$P_{CP_i}^k = \sum_h P_i^h \left(\frac{CPR_i^{hk}}{\sum_q CPR_i^{qk}}\right) \tag{23}$$

where P_i^h is the price in the *i*th sector of the *h*th country.

2.2.3. Determination of Consumption by Sector and Country

Employing the Armington's (1969) approach, the optimal consumption by sector is allocated with respect to country. The expression for the allocation is written as:[7]

[7] This type of income variable is employed in Ichioka (1991).

$$\frac{CPR_i^{hk}}{CPR_i^k} = \left(\frac{P_i^h}{\sum_q f_{CP_i}^{qk} P_i^q} \right)^{-s_{CP_i}^{hk}} \left(\frac{YIR^k}{YIR_{2000}^k} \right)^{\vartheta_i^k} \tag{24}$$

where CPR_i^{hk} is the *k*th country's real household consumption of the *i*th goods imported from the *h*th country, $f_{CP_i}^{hk}$ is the share of the *i*th goods imported from the *h*th country in the real household consumption of the *k*th country, $s_{CP_i}^{hk}$ is the elasticity of substitution of the *i*th goods imported from the *h*th country in the real household consumption in the *k*th country, YIR^k is the real household income of the *k*th country, YIR_{2000}^k is the real household income of the *k*th country in the base year 2000, and ϑ_i^k is the income elasticity of the *i*th goods in the *k*th country.

2.2.4. Determination of Household Income

Household income of the *k*th country is simply explained by wages of the corresponding country as:

$$YI^k = YI^k \left(\sum_j w_j^k L_j^k \right) \tag{25}$$

where w_j^k and L_j^k are the wage rate and employment in the *j*th sector of the *k*th country, respectively. The deflator for household income of the *k*th country is determined by the weighted average of the sectoral price (*i.e.*, the price for savings in the model) of the corresponding country as:

$$P_{YI}^k = P_{YI}^k \left(P_S^k \right) \tag{26}$$

2.3. The Other Demand Components

The other final demand components (government consumption, investment, inventories) and export to the ROW are exogenously given in the model. In addition, statistical discrepancy is also exogenous.

2.4. Producer Behavior

Producer behavior is described by the theory of monopoly. Profit maximization of a monopoly firm gives the following inverse elasticity rule as:

$$\frac{\left(P^m - C'\right)}{P^m} = \frac{1}{\varepsilon} \tag{27}$$

where P^m is the monopoly price, C' is the marginal cost, and ε is the absolute value of the price elasticity of demand.[8] Solving equation (27) for P^m yields the price determination equation as:

$$P^m = \frac{\varepsilon}{\left(\varepsilon - 1\right)} C' \tag{28}$$

For simplicity, we assume that the firm produces goods by using intermediate inputs and labor; *i.e.*, capital stock is omitted. As a result of cost minimization, the firm has slightly modified Nakamura's (1990) generalized Ozaki unit cost function with factor limitationality as:

$$UC_j^k = \sum_i a_{ij}^k \left(XXR_j^k\right)^{b_{ij}^k} PA_{ij}^k \exp\left(b_{Tij}^k T\right) + a_{Lj}^k w_j^k \tag{29}$$

where UC_j^k is the unit cost in the *j*th sector of the *k*th country, PA_{ij}^k is the price for $XR_{ij}^k \left(= \sum_h XR_{ij}^{hk}\right)$, T is time trend, a_{Lj}^k is employment coefficient in the *j*th sector of the *k*th country, a_{ij}^k, b_{ij}^k, and b_{Tij}^k are parameters. Particularly, the parameter b_{ij}^k represents the degree of scale economies in the *j*th sector of the *k*th country with respect to the *i*th input. Applying the Shephard's lemma, we obtain the optimal unit derived demand as:

$$\frac{\partial UC_j^k}{\partial PA_{ij}^k} = \frac{XR_{ij}^k}{XXR_j^k} = a_{ij}^k \left(XXR_j^k\right)^{b_{ij}^k} \exp\left(b_{Tij}^k T\right) \tag{30}$$

$$\frac{\partial UC_j^k}{\partial w_j^k} = \frac{L_j^k}{XXR_j^k} = a_{Lj}^k \tag{31}$$

Similar to the formulation of consumption by sector and country, intermediate input by sector and country is determined by the Armington (1969) approach as:

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[8] See Tirole (1988, pp.66-7).

$$\frac{X_{ij}^{hk}}{X_{ij}^{k}} = \left[\frac{\left(1+t_i^k\right)P_i^h}{PA_{ij}^k}\right]^{-s_{ij}^{hk}} \tag{32}$$

Manipulating partial derivative of equation (29) with respect to output, we obtain the marginal cost as:

$$MC_j^k = \sum_i a_{ij}^k\left(b_{ij}^k + 1\right)\left(XXR_j^k\right)^{b_{ij}^k} PA_{ij}^k \exp\left(b_{Tij}^k T\right) + a_{Lj}^k w_j^k \tag{33}$$

where MC_j^k is the marginal cost in the *j*th sector of the *k*th country. Hence, the sectoral monopoly price can be written as:

$$P_j^k = \frac{\varepsilon_j^k}{\left(\varepsilon_j^k - 1\right)}\left[\sum_i a_{ij}^k\left(b_{ij}^k + 1\right)\left(XXR_j^k\right)^{b_{ij}^k} PA_{ij}^k \exp\left(b_{Tij}^k T\right) + a_{Lj}^k w_j^k\right] \tag{34}$$

where $\varepsilon_j^k = -\frac{\partial XXR_j^k}{\partial P_j^k}\frac{P_j^k}{XXR_j^k}$. The price for XR_{ij}^k, PA_{ij}^k, is expressed as:

$$PA_{ij}^k = \sum_h \left(1+t_i^k\right)P_i^h\left(\frac{XR_{ij}^{hk}}{XR_{ij}^k}\right) \tag{35}$$

2.5. Sectoral Wage Rate

Slightly modifying the wage rate equation in McKibbin and Nguyen (2004, p.47), we explain the sectoral wage rate as follows:

$$w_{j,+1}^k = w_j^k\left(\frac{EPC_{+1}^k}{EPC^k}\right)^{\beta^k}\left(\frac{EPC^k}{EPC_{-1}^k}\right)^{1-\beta^k}\left(\frac{L_j^k}{L_j^{k*}}\right)^{\gamma^k} \tag{36}$$

where EPC^k is the expected consumer price of the *k*th country, L_j^{k*} is full employment in the *j*th sector of the *k*th country, β^k and γ^k are parameters of the *k*th country.[9] In order to incorporate the

[9] Assuming perfect mobile labor among sectors, McKibbin and Nguyen (2004) formulate the wage

effect on the wage rate of labor productivity, we rewrite equation (36) as:

$$w_{j,+1}^{k} = w_{j}^{k} \left(\frac{EPC_{+1}^{k}}{EPC^{k}} \right)^{\beta^{k}} \left(\frac{EPC^{k}}{EPC_{-1}^{k}} \right)^{1-\beta^{k}} \left(\frac{L_{j}^{k}}{L_{j}^{k*}} \right)^{\gamma^{k}} \left(\frac{XXR_{j}^{k}}{L_{j}^{k}} \right)^{\xi_{j}^{k}} \tag{37}$$

where ξ_{j}^{k} is the parameter on sectoral labor productivity for the *j*th sector of the *k*th country.

Due to the shortage in the degree of freedom and unavailability of data on full employment at the sector level, equation (37) is further modified as:

$$w_{j}^{k} = \left(EPC^{k}\right)^{\beta^{k}} \left(\frac{XXR_{j}^{k}}{L_{j}^{k}} \right)^{\xi_{j}^{k}} \tag{38}$$

3. Empirical Structure of the Model

3.1. Data

The model is constructed by using the Asian International Input-Output Tables 1985, 1990, 1995, and 2000 (Institute of Developing Economies, 1993, 1998, 2001; Institute of Developing Economies-Japan External Trade Organization, 2006a, 2006b) which covers the ten economies (Indonesia, Malaysia, the Philippines, Singapore, China, Taiwan, South Korea, Japan, and the United States).[10] In order to convert these IO tables in current prices to those in constant prices, we use the nominal and real GDP by industry in national currencies which are included in the United Nations' (UN) System of National Accounts (SNA).[11] To begin, we compile the six-sector version of the IO tables and the UN data, since their original sector classifications differ from each other. The unified sector classification is provided in Table 1.[12] Following, we compute GDP deflators by industry (base year = 2000) in U.S. dollars for the ten economies.[13] Multiplying these deflators for sectoral GDP by the corresponding country's purchasing power parity (PPP) per its

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rate at the macro level. In contrast, without their assumption on labor mobility, we model the sectoral wage rate by incorporating the labor market factor at the sector level instead of at the macro level.

[10] The layout of the Asian International Input-Output Table is available at http://www.ide.go.jp/Japanese/Publish/Books/Tokei/xls/AIO(85-00).xls.

[11] The UN data are downloadable from the United Nations' National Accounts Main Aggregates Database (http://unstats.un.org/unsd/snama/Introduction.asp).

[12] Although inconsistency of industrial coverage for the fifth and sixth sectors between the UN data and the IO tables occurs, we ignore it in the computation of sectoral price.

[13] Deflator for the mining and utilities sector of China cannot be computed due to missing data. Therefore, we use the GDP deflator as its proxy.

exchange rate gives the relative price deflators.[14] The PPP data are taken from the Penn World Table Version 6.2 (Heston *et al*., 2006) whilst data for the exchange rate come from the International Monetary Fund's International Financial Statistics and the Central Bank of the Republic of China.[15] These relative deflators for GDP by industry correspond to those for value added in our international IO framework. Omitting international freight and insurance, imports from Hong Kong, the EU, and the ROW, and duties for simplicity, we have the following identity on relative deflator for value added as:

$$PVA_j^k = \frac{XXV_j^k - \sum_h \sum_i XV_{ij}^{hk}}{\frac{XXV_j^k}{P_j^k} - \sum_h \sum_i \frac{XV_{ij}^{hk}}{P_i^h}} \tag{39}$$

where PVA_j^k is the relative deflator for value added in the *j*th sector of the *k*th country, XXV_j^k is the nominal output in the *j*th sector of the *k*th country, XV_{ij}^{hk} is the nominal input of the *h*th country's *i*th goods used in the *j*th sector of the *k*th country. Manipulating this identity yields:

$$P_j^k = \frac{XXV_j^k}{\sum_h \sum_i \frac{XV_{ij}^{hk}}{P_i^h} + \frac{XXV_j^k - \sum_h \sum_i XV_{ij}^{hk}}{PVA_j^k}} \tag{40}$$

Solving equation (40) simultaneously gives the relative sectoral price for our model. The resultant relative sectoral price is applied for converting the Asian International Input-Output Tables in current prices to those in constant prices.[16]

The Institute of Developing Economies-Japan External Trade Organization (2006a, 2006b) provides employment matrices in only the year 2000 for the ten economies. Therefore, sectoral employment coefficient in equation (31) is fixed at the figures in the year 2000. This coefficient is applied for the computation of sectoral employment and wage rate in the other years (1985, 1990, and 1995).

<Table 1 near here>

3.2. Computation of Household Income and Savings

[14] In this step, the PPP by sector must be applied; however, we use the PPP over the GDP due to data limitation.

[15] Taiwan's exchange rate data are available online at http://www.cbc.gov.tw/Enghome/Eeconomic/Statistics/Category/Foreign.asp.

[16] The use of the relative price for compiling international IO tables in constant prices is proposed in Shimizu and Ikeda (1996).

Following the definition of savings (*i.e.*, income less consumption), we can compute household income of the *k*th country as $\sum_j WAGE_j^k - \sum_h \sum_i CP_i^{hk}$. Yet, wages in an international input-output table only covers those of employees. Income of the other workers (*e.g.*, self-employed and workers in the agricultural sector) is included in the operating surplus. Since the income is just part of the operating surplus, we must estimate its portion. In order to estimate income, we utilize the consumption function in Klein's (1950) Model I. Simplifying his formulation, we consider the following consumption function:

$$\sum_h \sum_i CP_i^{hk} = c(1)^k \left(\frac{\sum_j WAGE_j^k}{P_{CP}^k} \right) + c(2)^k \left(\frac{\sum_j YC_j^k}{P_{CP}^k} \right) \tag{41}$$

where YC_j^k is the operating surplus in the *j*th sector of the *k*th country. Rearranging equation (41), we obtain:

$$\sum_h \sum_i CP_i^{hk} = c(1)^k \frac{\left[\sum_j WAGE_j^k + \left(\frac{c(2)^k}{c(1)^k} \right) \sum_j YC_j^k \right]}{P_{CP}^k} \tag{42}$$

Nominal income of the *k*th country can be defined as:

$$YI^k = \sum_j WAGE_j^k + \frac{c(2)^k}{c(1)^k} \sum_j YC_j^k \tag{43}$$

Using this income, savings can be computed by the following identity as:

$$S^k = YI^k - \sum_h \sum_i CP_i^{hk} \tag{44}$$

We estimate equation (41) by pooling data of the ten economies for the years 1985, 1990, 1995, and 2000. In this estimation, the White heteroscedasticity-consistent standard errors are applied. To maintain the degree of freedom, we assume that the parameter $c(1)^k$ is common among the ten economies; *i.e.*, $c(1)^k = c(1)$. The estimation results are provided in Table 2.

<Table 2 near here>

3.3. Calibration of Parameters of the CES Utility Function

Following Ichioka (1991, pp. 153-155), we calibrate the parameters of the CES utility function.

To begin, P_F^k must be defined. We use $PI^k r^k$ as a proxy for $P_K^{Dk}\zeta^k$ where PI^k and r^k are the investment deflator and the long-term interest rate of the kth country, respectively. PI^k is explained by P_S^k whilst r^k is given in this model. Data for the long-term interest rate come from the International Monetary Fund's International Financial Statistics and the Central Bank of the Republic of China.[17]

The parameter σ^k is calibrated by using the elasticity of savings with respect to the real rate of return which is defined as $r_S^k = \dfrac{P_K^{Dk}\zeta^k}{P_S^k}$.[18] Regarding the saving elasticity, we utilize Boskin (1978) and Ogaki *et al*. (1996). Same as Ballard *et al*. (1985), we employ the value of 0.4 in Boskin (1978) for the saving elasticity of the United States. Concerning the saving elasticities of the other economies (in exception to Indonesia, China, and South Korea), we compute them by multiplying the U.S. saving elasticity (0.4) by the ratio of the corresponding economy's value to the U.S. value in Ogaki *et al*. (1996).[19] As for Indonesia, China, and South Korea, Ogaki *et al*. (1996) do not provide their saving elasticities. Thus, the saving elasticity of low income countries is applied to Indonesia and China whereas that of upper-middle income countries to South Korea. This income classification follows the World Bank (1994), on which Ogaki *et al*. (1996) is also based. The saving elasticity, the parameters α^k and σ^k for the ten economies are given in Table 3.

<Table 3 near here>

3.4. Estimation Results of Selected Variables

Parameter estimation is carried out by employing panel data methods because each variable of an economy has only four observations. The sectoral wage rate equation economy is estimated by economy whereas the rest of the stochastic equations are by sector. In our estimation, the unobservable individual effects represent sector or economy-specific factors. Thus, these specific factors have potential correlations with explanatory variables. With this consideration, we apply the fixed-effect model. Regarding several variables, some estimator for a simultaneous-equation model is required. However, Mariano (1982) points out that ordinary least squares (OLS) is favorable to the two-stage least squares under severe specification errors. Since we suspect that structural change of each economy is quite substantial, OLS or generalized least squares is applied for the estimation of all stochastic equations.

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[17] Taiwan's interest rate data are available online at http://www.cbc.gov.tw/Enghome/Eeconomic/Statistics/Category/Monetary.asp.

[18] Calibration procedure of the parameter α^k in Ichioka (1991) is identical to that in Ballard *et al.* (1985). Concerning the parameter σ^k, however, the calibration procedure of Ichioka (1991) differs from that of Ballard *et al.* (1985). To begin, Ichioka (1991) assumes that the only factor which changes r_s^k is ζ^k. This assumption enables us to derive the saving elasticity of the kth country analytically. Solving the derived equation of the saving elasticity for the parameter σ^k, we obtain its expression.

[19] The saving elasticities in Ogaki *et al.* (1996) are not directly applied since they compute the saving elasticities by employing a simple endogenous growth model with parameters estimated from data of low and middle income countries.

3.4.1. Consumption Share by Sector: Equation (20)

In CGE modeling, the parameter $\lambda_{CP_i}^{k}$ is normally calibrated by using data in the base year and the calibrated value is applied for the simulation period. However, it varies over time. Therefore, we endogenize it after calibrating by using data in the years of 1985, 1990, 1995, and 2000. Specifically, the parameter $\lambda_{CP_i}^{k}$ is explained as follows:

$$\lambda_{CP_i}^{k} = c(3)_i^k + c(4)_i \left(\frac{1}{EDR^k} \right) \tag{45}$$

where EDR^k is the ratio of population aged over 65 to the total population in the *k*th country. Population data are taken from the World Bank's World Development Indicators and the Statistical Yearbook of the Republic of China. Table 4 illustrates estimation results for equation (45). Due to the shortage in the number of (non-zero) observations, we cannot estimate equation (45) for sector 4 (construction). Since a reciprocal model is employed, negative coefficient implies that the consumption share of the corresponding sector rises in parallel to the ratio of elderly people. Among six sectors, the estimated coefficients for sectors 2 (mining and utilities) and 6 (services) are negative. These results show that demands for utilities and services would increase while those for goods would decrease.

<Table 4 near here>

3.4.2. Consumption by Sector and Country: Equation (24)

Adding time trend and assuming common coefficient among source countries (*i.e.*, the *h*th country in this equation), the estimated equation (after taking logarithms) is written as:[20]

$$\ln\left(\frac{CPR_i^{hk}}{CPR_i^k} \right) = c(5)_i^{hk} + c(6)_i^k \ln\left(\frac{P_i^h}{\sum_q f_{CP_i}^{qk} P_i^q} \right) + c(7)_i^k \ln\left(\frac{YIR^k}{YIR_{2000}^k} \right) + c(8)_i^k T \tag{24'}$$

To begin, we estimate this full model. However, we remove time trend if its elimination makes the unsuitable coefficients on relative price, income, or both turn to coefficients which satisfy the sign condition and statistical significance.[21] Estimation results for consumption in sector 5 (trade and transportation) of the ten economies (*i.e.*, i = 5, k = Indonesia, Malaysia, the Philippines,

[20] Adding time trend to the trade share equation is also employed in Hickman and Lau (1973).
[21] This principle is applied to the remaining estimation.

Singapore, Thailand, China, Taiwan, South Korea, Japan, the United States) are shown in Table 5.[22]

<Table 5 near here>

3.4.3. Intermediate Demand by Sector: Equation (30)

Regarding coefficients on output and time trend, we assume that they are common among the ten economies. Taking logarithms, we rewrite the estimated equation as:

$$\ln\left(\frac{XR_{ij}^{k}}{XXR_{j}^{k}}\right)=\ln c(9)_{ij}^{k}+c(10)_{ij}\ln\left(XXR_{j}^{k}\right)+c(11)_{ij}T \tag{30′}$$

The White heteroscedasticity-consistent standard errors are applied for the estimation of this equation. Table 6 demonstrates estimation results for the agricultural sector (*i.e.*, $i = 1, 2, \ldots, 6$; $j = 1$). In equation (30′), $c(10)_{ij} < 0$ and $c(11)_{ij} < 0$ indicate economies of scale and the corresponding input-saving technological change, respectively. According to the results, sector 1 (agriculture) exhibits economies of scale with respect to every input. We find no technological change on input from sector 3 (manufacturing). Sector 1 has technological progress on input from sector 1 whereas technological retrogression on inputs from sectors 2 (mining and utilities), 4 (construction), 5 (trade and transportation), and 6 (services).

<Table 6 near here>

3.4.4. Intermediate Demand by Sector and Country: Equation (32)

Similar to the estimation of consumption function by sector and country, we add time trend and assume common coefficients on the relative price and time trend among source economies. The estimated equation (after taking logarithms) is written as:

$$\ln\left(\frac{X_{ij}^{hk}}{X_{ij}^{k}}\right)=c(12)_{ij}^{hk}+c(13)_{ij}^{k}\ln\left[\frac{\left(1+t_{i}^{k}\right)P_{i}^{h}}{PA_{ij}^{k}}\right]+c(14)_{ij}^{k}T \tag{32′}$$

Table 7 illustrates estimation results for equation (32′) regarding sector 3 (manufacturing) of the United States (*i.e.*, $i = 1, 2, \ldots, 6$; $j = 3$; k = the United States). Due to the shortage in the number of observations, we cannot estimate equation (32′) for sectors 4 (construction). Input from sector 5 (trade and transportation) in sector 3 of the United States is determined by fixed input coefficient since the estimated coefficient on the relative price has the positive sign, which is theoretically incorrect.

<Table 7 near here>

[22] Although there are several estimated coefficients which are not statistically significant, we utilize them in simulation analysis as long as they have correct signs. This principle is also applied to the rest of the coefficients.

3.4.5. Sectoral Price: Equation (34)

The estimated equation of the sectoral price is expressed as:

$$P_j^k = c(15)_j^k MC_j^k + c(16)_j^k D00 \tag{34′}$$

where $D00$ is a dummy variable (1 for 2000; 0 otherwise). Table 8 demonstrates estimation results for equation (34′). In exception to sector 6 (services) of Malaysia, substantial markup factors are found.

<Table 8 near here>

3.4.6. Sectoral Wage Rate: Equation (38)

Taking logarithms, we write the estimated equation as:

$$\ln w_j^k = c(17)^k \ln\left(EPC^k\right) + c(18)_j^k \ln\left(\frac{XXR_j^k}{L_j^k}\right) \tag{38′}$$

We employ $\overline{P}_{CP}^k$ as a proxy for EPC^k. Dummy variables $D85$ (1 for 1985; 0 other wise) and $D00$ are added to the estimated equation for the Philippines and Malaysia, respectively. It is worth noting that the coefficient, $c(18)_j^k$, is obtained as the sector-specific intercept since labor productivity is constant as explained in subsection 3.1. Estimation results for equation (38′) are shown in Table 9.

<Table 9 near here>

3.5. Final Test

The final test was performed from 1990 to 2000. The test results for sectoral price and output are demonstrated in Figures 1 to 12.[23] Although errors for sectoral price of Malaysia are relatively large, we can conclude that the overall results are sufficient.

<Figures 1 to 12 near here>

4. Application

[23] The unit of figures 7 to 12 is U.S.$ 1,000.

Currently, bilateral or regional free trade agreements (FTAs) have become widespread. The Association of Southeast Asian Nations (ASEAN) has formed the ASEAN Free Trade Area (AFTA) since 1993. The United States, Canada, and Mexico initiated the North American Free Trade Area (NAFTA) in 1994. The economic partnership agreement between Japan and Singapore has been effective since 2002. In 2007, the FTA between the United States and South Korea was concluded, although it is not yet officially effective. These examples are only a portion of the many other FTAs which have been negotiated or are under review. Following the interests in FTAs, many studies have quantified the effects of FTAs by employing a general equilibrium framework. Recent examples for analysis on FTAs in the Asia-Pacific region are Tsutsumi and Kiyota (2002), Brown *et al*. (2003, 2006), Kawasaki (2003), Fujikawa and Yin (2006), Sulamaa and Widgrén (2006), Urata and Kiyota (2006), and Zhai (2006). Since Japan and the United States are major trade partners to the rest of the world, both countries are included in most empirical studies on FTAs. However, analysis on the FTA between Japan and the United States is rarely carried out in exception to Tsutsumi and Kiyota (2002). Therefore, we analyze the effects of trade liberalization between Japan and the United States as an application of our price-linked international IO model. Specifically, we completely remove the tariff rates between Japan and the United States in the year 2000. Since this is in-sample simulation, the results are quite preliminary.

To begin, the tariff rates of Japan and the United States in the year 2000 are shown in Table 10. Using the Asian International Input-Output Tables, the tariff rates are computed as duties and import sales tax divided by the total import. For all sectors, Japan levies heavier tariff rates than the United States.

<Table 10 near here>

Table 11 presents percent deviations of sectoral price, output, and household utility from the baseline. The sectoral prices of Japan and the United States would decline in exception to the agricultural sector of the United States.[24] The sectoral prices for Malaysia and Singapore would decline whereas that for China would rise. Regarding the other economies, changes in the sectoral prices would differ. These dispersive changes would come from trade and production structures. As for sectoral output, the United States would have positive impact whereas the other nine economies would have negative ones. Household utility of the United States and Singapore would be improved whilst that of the other eight economies would fall.

<Table 11 near here>

An interesting outcome of this simulation is the decrease in output for Japan, which differs from the other study (Tsutsumi and Kiyota, 2002). Table 12 demonstrates decomposition of output changes into contributions of changes in intermediate and final demands. According to this table, output changes result from changes in intermediate demand rather than final demand. We further

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[24] Sectoral price is affected by the corresponding sector's output, composite input price $\left(PA_{ij}^{k}\right)$, and wage rate. The signs of these three factors and ascendancy of one of the three over the other two rely on industrial and trade structures as well as trade balance of an economy. As a result of tariff reduction between Japan and the United States, demand for U.S. products would increase while that for domestic products would decrease in the market of Japan, the reverse occurring in the U.S. market. Depending on the magnitude of demand changes, sectoral output change possesses either positive or negative impact on sectoral price change. The signs of change in the composite input price and the sectoral wage rate are theoretically unclear. It is considered that, in the United States, the positive output change effect would be dominant in price change of the agricultural sector whilst it would be trivial compared to the other negative factor(s) in the rest of the six sectors. As for Japan, we consider that the negative output change effect would be critical to the fall of sectoral price.

decompose changes in intermediate demand for Japanese products in terms of destination economies. The results are shown in Table 13. This table indicates that intermediate demand for Japanese products would substantially decrease in the home market (over 100 percent) whilst it would increase in the other markets (excluding the agricultural sector of South Korea).[25] Consider the case of the manufacturing sector as an example. Table 14 illustrates percent deviations of price competitiveness for Japan and the United States in the Japanese and U.S. market from the baseline.[26] In the Japanese market, price competitiveness of Japan is slightly deteriorated whilst that of the United States is greatly improved (over 5 percent in exception to the trade and transportation sector). By contrast, price competitiveness of Japan is somewhat improved (less than 2 percent) whilst that of the United States falls in the U.S. market. The difference between U.S. price competitiveness change in the Japanese market and vice versa reflects the difference in the tariff rates between the two countries. Consequently, demand shift from Japanese products to U.S. products in the home market due to significant changes in price competitiveness become a dominant factor to the decrease in output for Japan.

<Tables 12, 13, and 14 near here>

Due to its fast growing popularity, no country can disregard FTAs. However, these results show that FTAs would not always provide profits to the participating countries. FTAs generally reduce price levels of all countries which are engaged in the FTAs. Thus, it might be required for a member country of a FTA to make domestic policies to reduce international price differentials concurrently in order to acquire gains from the FTA. Regarding the FTA between Japan and the United States, it is imperative for Japan to make such policies.

5. Conclusions

This paper constructs price-linked international IO tables for the Asia-Pacific region and develops another variety of multi-country multi-sectoral models by using these tables. In contrast to typical models, most parameters of the model are econometrically estimated and the monopoly framework is employed as producer behavior. Estimation of the monopoly price equation principally yields positive markups, which show suitability on the incorporation of monopoly. Applying the model, we analyze the effects of trade liberalization between Japan and the United States. From our results, the United States might have an output increase whilst Japan might have a decrease. The main cause of Japan's output decline is the shift in demand from domestic products to U.S. products due to improved U.S. price competitiveness in Japan's market.

Due to its small number of sectors, our price-linked international IO model is relatively compact and easy to operate. However, a model with more detailed sectors is required in order to thoroughly analyze policy issues. Constructing data and a model which are based on more detailed sectors is crucial for further analysis. Additionally, recent financial deregulations strengthen the interdependence of countries with respect to investment. In fact, foreign direct investment is one of the major factors for Asia's high economic growth. Incorporation of a

[25] Since intermediate demands for the Japanese products decline, positive values in Table 13 indicate decreases in the corresponding markets.

[26] Price competitiveness in the ith sector of the hth country is defined as: $\dfrac{\left(1+t_i^k\right)P_i^h}{PA_{ij}^k}$.

consistent mechanism to explain household savings and investment by sector and country is also one of the topics for our future research.

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Table 1. Sector classification

AIIO (6 sectors)	UN-SNA (7 sectors)	AIIO (24 sectors)
1 Agriculture, livestock, forestry, and fishery	1 Agriculture, hunting, forestry, and fishery	1 Paddy
		2 Other agricultural products
		3 Livestock
		4 Forestry
		5 Fishery
2 Mining, quarrying, and utilities (electricity, gas, and water supply)	2 Mining, quarrying, and utilities (less manufacturing)	6 Crude petroleum and natural gas
		7 Other mining
		20 Electricity, gas, and water supply
3 Manufacturing	3 Manufacturing	8 Food, beverage, and tobacco
		9 Textile, leather, and the products thereof
		10 Timber and wooden products
		11 Pulp, paper, and printing
		12 Chemical products
		13 Petroleum and petro products
		14 Rubber products
		15 Non-metallic mineral products
		16 Metal products
		17 Machinery
		18 Transport equipment
		19 Other manufacturing products
4 Construction	4 Construction	21 Construction
5 Trade and transportation	5 Trade, restaurants, and hotels	22 Trade and transportation
	6 Transportation and communication	
6 Services	7 Other activities	23 Services
		24 Public administration

Note: This table is tabulated following the Institute of Developing Economies-Japan External Trade Organization (2006b). AIIO stands for Asian International Input-Output. UN-SNA denotes the United Nations' System of National Accounts data.

Table 2. Estimation results for equation (41)

Parameter	Estimate	S.E.	p-value
$c(1)$	0.71462	0.00399	0.00000
$c(2)^{IDN}$	0.64291	0.03370	0.00000
$c(2)^{MLS}$	0.25966	0.00159	0.00000
$c(2)^{PHL}$	0.81666	0.07959	0.00000
$c(2)^{SGP}$	0.18004	0.03406	0.00001
$c(2)^{THA}$	0.63905	0.03542	0.00000
$c(2)^{CHN}$	0.54307	0.02823	0.00000
$c(2)^{TWN}$	0.53075	0.04269	0.00000
$c(2)^{KOR}$	0.65319	0.06906	0.00000
$c(2)^{JPN}$	0.72389	0.03630	0.00000
$c(2)^{USA}$	0.67459	0.01563	0.00000
Adj. R^2	0.99922		

Note: S.E. is standard error. The White heteroscedasticity-consistent standard errors are applied. Adj. R^2 is adjusted R-squared. The number of observation is 40.

Table 3. Saving elasticity and calibrated parameters of the CES utility function

Year	Indonesia	Malaysia	Philippines	Singapore	Thailand	China	Taiwan	South Korea	Japan	United States
Saving elasticity										
	0.21223	0.38083	0.34182	0.39405	0.35306	0.21223	0.37752	0.38083	0.39537	0.40000
σ^k										
1985	1.31963	1.73314	1.43734	1.54177	1.42362	1.27588	1.61618	1.49667	1.54071	1.56782
1990	1.30702	1.80990	1.45933	1.46895	1.48567	1.29323	1.56094	1.56253	1.56716	1.56546
1995	1.27902	1.97875	1.43462	1.56231	1.52279	1.30157	1.52866	1.57543	1.56019	1.55898
2000	1.30869	1.53290	1.54595	1.57398	1.47897	1.29669	1.51462	1.50811	1.54167	1.55502
α^k										
1985	N.A.	N.A.	0.80508	0.74894	0.84530	0.78039	0.63213	0.77610	0.73618	0.72118
1990	0.71057	0.56437	0.78022	0.85402	0.74636	0.73490	0.69486	0.69779	0.70401	0.72095
1995	0.77292	0.48994	0.80942	0.71012	0.70134	0.71606	0.73087	0.68177	0.70457	0.72467
2000	0.70431	0.74143	0.66225	0.68733	0.75657	0.72044	0.74613	0.75904	0.72591	0.72397

Note: N.A. denotes not available. The parameter α^k for Indonesia and Malaysia in 1985 are not available due to missing data in the long-term interest rate.

Table 4. Estimation results for equation (45)

Parameter	Estimate	S. E.	*p*-value	Adj. R^2
$c(4)_1$	0.62393	0.11668	0.00001	0.95421
$c(4)_2$	-0.07477	0.03519	0.04230	0.47497
$c(4)_3$	0.57717	0.30145	0.06545	0.78860
$c(4)_4$	N.A.	N.A.	N.A.	N.A.
$c(4)_5$	0.25970	0.18182	0.16387	0.73502
$c(4)_6$	-1.40401	0.40338	0.00160	0.79979

Note: Economy-specific control is suppressed. N.A. denotes not available. S.E. is standard error. Adj. R^2 is adjusted R-squared. The number of observation is 40 for each estimation.

Table 5. Estimation results for equation (24′): trade and transportation sector

Parameter	Indonesia	Malaysia	Philippines	Singapore	Thailand	China	Taiwan	South Korea	Japan	United States
$c(6)_5$	-	-	-	-1.70734	-1.64958	-1.12223	-2.54238	-1.96101	-1.79964	-1.70517
	-	-	-	(0.65706)	(0.92043)	(0.64183)	(0.52656)	(0.64451)	(1.11016)	(0.84463)
	-	-	-	[0.01522]	[0.08432]	[0.09316]	[0.00005]	[0.00531]	[0.11663]	[0.05354]
$c(7)_5$	2.06317	0.84858	4.23897	-	0.69588	9.07037	1.32630	1.25068	2.26359	2.30168
	(0.44732)	(0.40368)	(0.80184)	-	(0.30338)	(2.84137)	(0.20951)	(0.24020)	(1.63481)	(0.66834)
	[0.00008]	[0.04501]	[0.00001]	-	[0.02981]	[0.00391]	[0.00000]	[0.00002]	[0.17750]	[0.00189]
$c(8)_5$	-	-	-	-0.02755	-	-0.52718	-	-	-	-
	-	-	-	(0.01521)	-	(0.19683)	-	-	-	-
	-	-	-	[0.08163]	-	[0.01314]	-	-	-	-
Adj. R^2	0.88501	0.84049	0.88736	0.92120	0.92102	0.93664	0.96870	0.95628	0.89467	0.90604
Number of observations	39	38	39	38	39	37	38	38	39	39

Note: Economy-specific control is suppressed. Hyphen denotes dropped variables. Adj. R^2 is adjusted R-squared. Standard errors and p-values are in parentheses and brackets, respectively.

Table 6. Estimation results for equation (30′): agricultural sector

Parameter	Estimate	S. E.	p-value	Adj. R^2
$c(10)_{11}$	0.17598	0.03186	0.00001	0.92068
$c(11)_{11}$	-0.00864	0.00285	0.00517	
$c(10)_{21}$	0.61609	0.22858	0.01480	0.97115
$c(11)_{21}$	0.02400	0.00668	0.00208	
$c(10)_{31}$	0.42752	0.04817	0.00000	0.92381
$c(11)_{31}$	-	-	-	
$c(10)_{41}$	-1.91608	0.40203	0.00006	0.76297
$c(11)_{41}$	0.04397	0.01121	0.00057	
$c(10)_{51}$	-0.44790	0.18336	0.02114	0.83832
$c(11)_{51}$	0.02134	0.00453	0.00006	
$c(10)_{61}$	-0.15670	0.13215	0.24567	0.89227
$c(11)_{61}$	0.01383	0.00375	0.00096	

Note: Economy-specific control and a dummy variable (1 for 2000; 0 otherwise) in estimation of sector 2 are suppressed. The White heteroscedasticity-consistent standard errors are applied. Hyphen denotes dropped variables. The number of observation is 40 for each estimation. S.E. is standard error. Adj. R^2 is adjusted R-squared.

Table 7. Estimation results for equation (32′): manufacturing sector of the United States

Parameter	Estimate	S. E.	p-value	Adj. R^2	Number of observation
$c(13)_{13}$	-1.58038	0.76349	0.04780	0.93085	40
$c(14)_{13}$	-0.04827	0.02135	0.03169		
$c(13)_{23}$	-0.11487	1.91015	0.95249	0.88365	39
$c(14)_{23}$	-0.05551	0.04397	0.21760		
$c(13)_{33}$	-1.27009	0.41968	0.00526	0.95821	40
$c(14)_{33}$	0.08110	0.01053	0.00000		
$c(13)_{43}$	N.A.	N.A.	N.A.	N.A.	N.A.
$c(14)_{43}$	N.A.	N.A.	N.A.		
$c(13)_{53}$	N.A.	N.A.	N.A.	N.A.	N.A.
$c(14)_{53}$	N.A.	N.A.	N.A.		
$c(13)_{63}$	-1.88109	1.06398	0.09613	0.95455	27
$c(14)_{63}$	-	-	-		

Note: Economy-specific control is suppressed. N.A. denotes not available. Hyphen denotes dropped variables. S.E. is standard error. Adj. R^2 is adjusted R-squared.

Table 8. Estimation results for equation (34′)

Parameter	Indonesia	Malaysia	Philippines	Singapore	Thailand	China	Taiwan	South Korea	Japan	United States	Adj. R^2
$c(15)_1$	2.89948	1.01424	1.85077	1.33625	2.05855	1.02971	1.12761	2.06232	1.79917	1.34438	0.99596
	(0.19036)	(0.03325)	(0.09147)	(0.02984)	(0.08451)	(0.07026)	(0.02308)	(0.03996)	(0.01909)	(0.01892)	
	[0.00000]	[0.00000]	[0.00000]	[0.00000]	[0.00000]	[0.00000]	[0.00000]	[0.00000]	[0.00000]	[0.00000]	
$c(15)_2$	2.58808	1.03772	1.64723	1.96292	1.38658	1.19603	1.43945	1.53668	1.51867	1.43549	0.94238
	(0.69769)	(0.14682)	(0.28808)	(0.13722)	(0.21127)	(0.24716)	(0.10024)	(0.12224)	(0.06230)	(0.07225)	
	[0.00139]	[0.00000]	[0.00001]	[0.00000]	[0.00000]	[0.00010]	[0.00000]	[0.00000]	[0.00000]	[0.00000]	
$c(15)_3$	1.69678	1.16010	1.90876	1.30622	1.55914	1.33748	1.24234	1.29779	1.19511	1.22300	0.99438
	(0.10916)	(0.04177)	(0.10509)	(0.03144)	(0.07222)	(0.08490)	(0.02681)	(0.02780)	(0.01442)	(0.02042)	
	[0.00000]	[0.00000]	[0.00000]	[0.00000]	[0.00000]	[0.00000]	[0.00000]	[0.00000]	[0.00000]	[0.00000]	
$c(15)_4$	1.38527	1.14309	1.65093	1.30569	1.51194	1.22162	1.17720	1.20122	1.13914	1.09887	0.99203
	(0.09887)	(0.04381)	(0.09760)	(0.02804)	(0.07435)	(0.08544)	(0.02679)	(0.02860)	(0.01407)	(0.02110)	
	[0.00000]	[0.00000]	[0.00000]	[0.00000]	[0.00000]	[0.00000]	[0.00000]	[0.00000]	[0.00000]	[0.00000]	
$c(15)_5$	2.53439	1.04982	2.11455	1.58879	2.30967	1.54325	1.37095	1.77715	1.22699	1.26293	0.98946
	(0.23161)	(0.05795)	(0.19250)	(0.05105)	(0.17710)	(0.18898)	(0.04893)	(0.05640)	(0.02110)	(0.03121)	
	[0.00000]	[0.00000]	[0.00000]	[0.00000]	[0.00000]	[0.00000]	[0.00000]	[0.00000]	[0.00000]	[0.00000]	
$c(15)_6$	1.42012	0.96749	1.47019	1.31288	1.39779	1.20673	1.38405	1.28328	1.30612	1.14741	0.99629
	(0.08067)	(0.02895)	(0.08904)	(0.02554)	(0.05940)	(0.12012)	(0.02916)	(0.02894)	(0.01370)	(0.02099)	
	[0.00000]	[0.00000]	[0.00000]	[0.00000]	[0.00000]	[0.00000]	[0.00000]	[0.00000]	[0.00000]	[0.00000]	

Note: Estimates on dummy variable are suppressed. The number of observation is 40 for each estimation. Adj. R^2 is adjusted R-squared. Standard errors and p-values are in parentheses and brackets, respectively.

Table 9. Estimation results for equation (38′)

Parameter	Indonesia	Malaysia	Philippines	Singapore	Thailand	China	Taiwan	South Korea	Japan	United States
$c(17)_5$	0.88251	1.50914	0.19233	1.37699	0.90998	0.49470	1.24095	1.17544	1.14530	0.98016
	0.35844	0.27004	0.01924	0.15051	0.19806	0.44413	0.15667	0.13511	0.03888	0.22265
	0.02479	0.00016	0.00000	0.00000	0.00026	0.28084	0.00000	0.00000	0.00000	0.00039
$c(18)_1$	0.61073	0.79964	0.65367	0.69153	0.58218	0.74813	0.73599	0.62650	0.60554	0.69799
	0.01568	0.01480	0.00292	0.01176	0.00980	0.02003	0.01527	0.01390	0.00635	0.01773
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
$c(18)_2$	0.67591	0.83726	0.68778	0.71901	0.72883	0.73076	0.74240	0.73310	0.73305	0.77645
	0.01034	0.01091	0.00695	0.00921	0.00641	0.01418	0.01245	0.01059	0.00471	0.01610
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
$c(18)_3$	0.66381	0.76191	0.64017	0.69073	0.67615	0.68951	0.71285	0.71956	0.74535	0.80051
	0.01203	0.01221	0.02377	0.00996	0.00690	0.01423	0.01298	0.01118	0.00509	0.01692
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
$c(18)_4$	0.70605	0.71399	0.67232	0.74201	0.66216	0.71032	0.73824	0.75493	0.77085	0.81101
	0.01241	0.01365	0.00425	0.01152	0.00778	0.01456	0.01421	0.01205	0.00546	0.01795
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
$c(18)_5$	0.65560	0.79977	0.65592	0.74508	0.68153	0.70936	0.77848	0.73736	0.80823	0.83591
	0.01410	0.01362	0.00499	0.01074	0.00763	0.01622	0.01425	0.01306	0.00569	0.01815
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
$c(18)_6$	0.74441	0.81367	0.72931	0.76202	0.75289	0.70490	0.77709	0.77409	0.78417	0.81816
	0.01317	0.01354	0.01366	0.01096	0.00747	0.01580	0.01382	0.01221	0.00540	0.01768
	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Adj. R^2	0.96136	0.98907	0.98975	0.97435	0.98859	0.91139	0.93526	0.97630	0.99721	0.97015

Note: Economy-specific control is suppressed. Hyphen denotes dropped variables. The number of observation is 24 for each estimation. Adj. R^2 is adjusted R-squared. Standard errors and p-values are in parentheses and brackets, respectively.

Table 10. Tariff rates of Japan and the United States in the year 2000 (%)

Sector	Japan	United States
1	6.88595	0.89851
2	7.84240	0.27530
3	8.71629	0.98240
4	5.70450	1.61754
5	1.17631	0.53438
6	6.62278	0.81790

Table 11. Percent deviations of sectoral price, output, and household utility from the baseline

Sector	Indonesia	Malaysia	Philippines	Singapore	Thailand	China	Taiwan	South Korea	Japan	United States
Price										
1	0.00893	-0.02092	0.00226	-0.06489	-0.00004	0.00118	-0.00172	0.00114	-0.29788	0.01417
2	-0.01279	-0.02237	-0.00383	-0.00923	0.00377	0.00262	-0.00098	0.00567	-0.20676	-0.01142
3	0.02207	-0.01139	0.00865	-0.04125	0.00268	0.00219	-0.00850	-0.00092	-0.31365	-0.03365
4	0.00845	-0.00547	0.00571	-0.01878	-0.00212	0.00217	-0.00036	0.00159	-0.16410	-0.03181
5	0.01000	-0.00440	0.00552	-0.00801	0.00220	0.00226	0.00223	0.00425	-0.13070	-0.02550
6	0.00840	-0.00988	0.00107	-0.01087	-0.00079	0.00169	0.00123	0.00340	-0.16005	-0.02387
Output										
1	-0.01421	-0.02199	-0.01785	0.03134	-0.01003	-0.00492	-0.01791	-0.01297	-0.16656	0.10454
2	-0.07004	-0.03804	-0.02291	-0.00865	-0.00981	-0.00615	-0.01101	-0.00725	-0.04466	0.05792
3	-0.04017	-0.02404	-0.02547	-0.01276	-0.02787	-0.00958	-0.03004	-0.02699	-0.02768	0.06949
4	-0.00113	-0.00105	-0.00062	-0.00029	-0.00020	-0.00021	-0.00103	-0.00035	-0.00725	0.00838
5	-0.02689	-0.01285	-0.02362	-0.00464	-0.01073	-0.00760	-0.01246	-0.00919	-0.12979	0.07300
6	-0.01473	-0.00766	-0.01021	-0.00566	-0.00701	-0.00347	-0.00996	-0.00664	-0.05439	0.04861
Utility										
	-0.02161	-0.00208	-0.02663	0.00043	-0.01106	-0.00579	-0.01332	-0.01039	-0.01089	0.08935

Table 12. Contributions of changes in intermediate and final demands to output change (%)

	Sector					
	1	2	3	4	5	6
Indonesia						
Intermediate demand	52.89387	98.84951	70.33884	100.00000	71.44672	42.86744
Final demand	47.10613	1.15049	29.66116	0.00000	28.55328	57.13256
Malaysia						
Intermediate demand	98.64712	98.55768	92.43757	100.00000	87.46476	79.70475
Final demand	1.35288	1.44232	7.56243	0.00000	12.53524	20.29525
Philippines						
Intermediate demand	68.68292	85.93702	64.96833	100.00000	64.89095	43.91432
Final demand	31.31708	14.06298	35.03167	0.00000	35.10905	56.08568
Singapore						
Intermediate demand	54.86015	66.93923	100.77464	100.00000	68.43469	68.69883
Final demand	45.13985	33.06077	-0.77464	0.00000	31.56531	31.30117
Thailand						
Intermediate demand	88.73807	79.45046	77.15571	100.00000	61.66327	46.94945
Final demand	11.26193	20.54954	22.84429	0.00000	38.33673	53.05055
China						
Intermediate demand	57.90841	93.46840	69.44203	100.00000	84.24872	60.48096
Final demand	42.09159	6.53160	30.55797	0.00000	15.75128	39.51904
Taiwan						
Intermediate demand	73.30598	70.24787	83.85729	100.00000	56.35174	54.56567
Final demand	26.69402	29.75213	16.14271	0.00000	43.64826	45.43433
South Korea						
Intermediate demand	85.33403	71.73378	82.70121	100.00000	64.16649	57.26620
Final demand	14.66597	28.26622	17.29879	0.00000	35.83351	42.73380
Japan						
Intermediate demand	116.12490	99.72571	218.15966	100.00000	77.71391	68.97947
Final demand	-16.12490	0.27429	-118.15966	0.00000	22.28609	31.02053
United States						
Intermediate demand	99.86806	76.80478	80.29549	100.00000	67.56946	55.42526
Final demand	0.13194	23.19522	19.70451	0.00000	32.43054	44.57474

Table 13. Economy-specific contribution to changes in intermediate demand for the products of Japan (%)

Sector	Indonesia	Malaysia	Philippines	Singapore	Thailand	China	Taiwan	South Korea	Japan	United States
1	-0.00124	-0.01630	-0.04347	-0.00574	-0.00538	-0.02251	-0.03231	0.00195	102.60883	-2.48383
2	-0.01235	-0.00507	-0.01384	-0.00176	-0.00757	-0.02799	-0.01838	-0.06974	100.18127	-0.02458
3	-0.39015	-1.51095	-0.28741	-0.24256	-1.40610	-3.79671	-2.93076	-4.61486	167.68074	-52.50123
4	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	100.00000	0.00000
5	-0.00689	-0.01612	-0.01146	-0.00717	-0.01598	-0.01698	-0.10855	-0.06626	101.59516	-1.34577
6	-0.00021	0.01066	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	100.07036	-0.08082

Table 14. Percent deviations of price competitiveness for Japan and the United States from the baseline: manufacturing sector

	In the Japanese market		In the U.S. market	
Sector	Japan	United States	Japan	United States
1	0.04415	-6.13812	-1.16028	0.00793
2	0.04649	-6.96841	-0.53101	0.02300
3	0.14046	-7.62954	-1.22780	0.02270
4	0.02084	-5.11115	-1.86088	0.00666
5	0.01451	-0.87064	-0.79474	0.01553
6	0.06965	-5.88248	-1.07250	0.01677

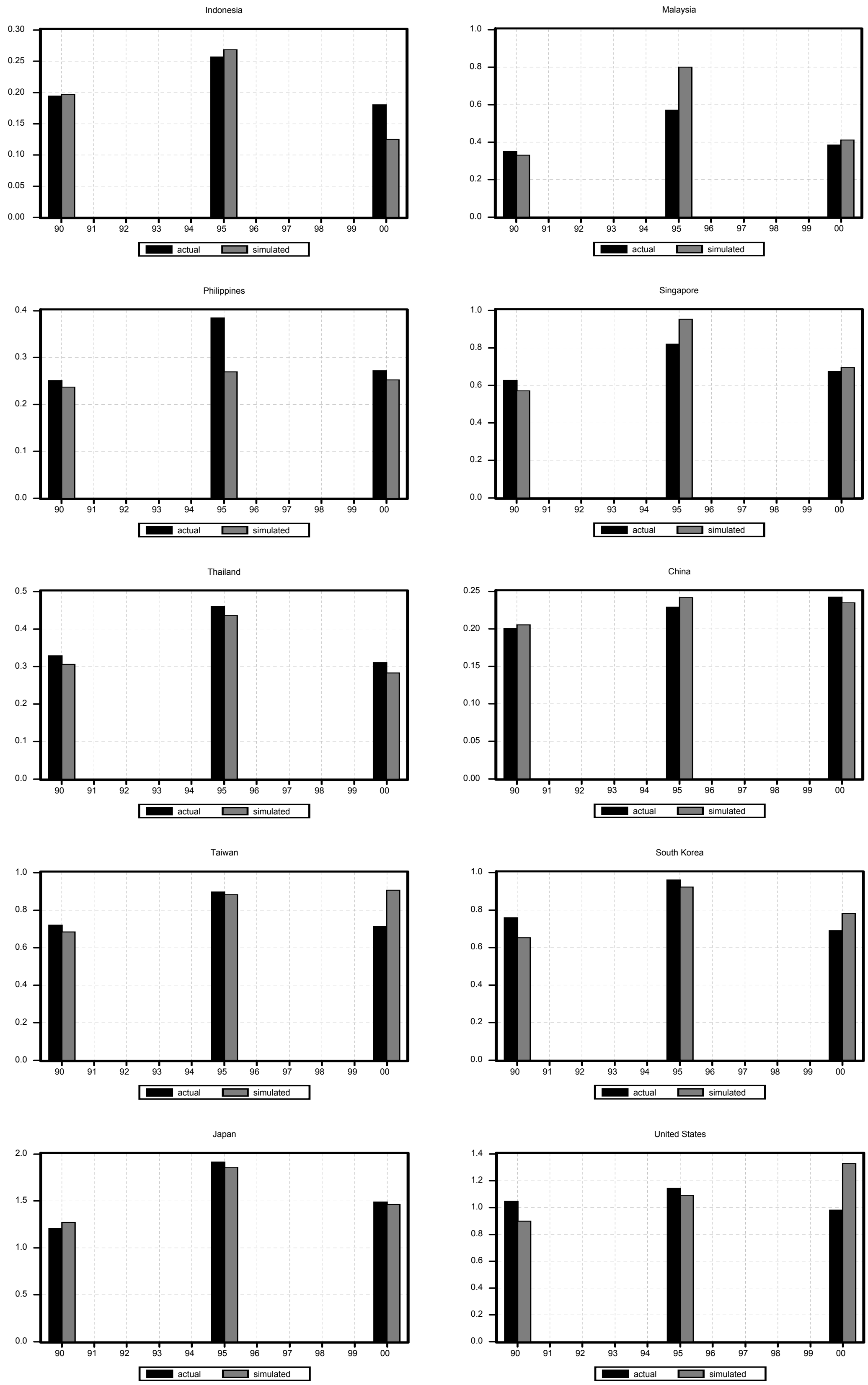

Figure 1. Final test of price in sector 1

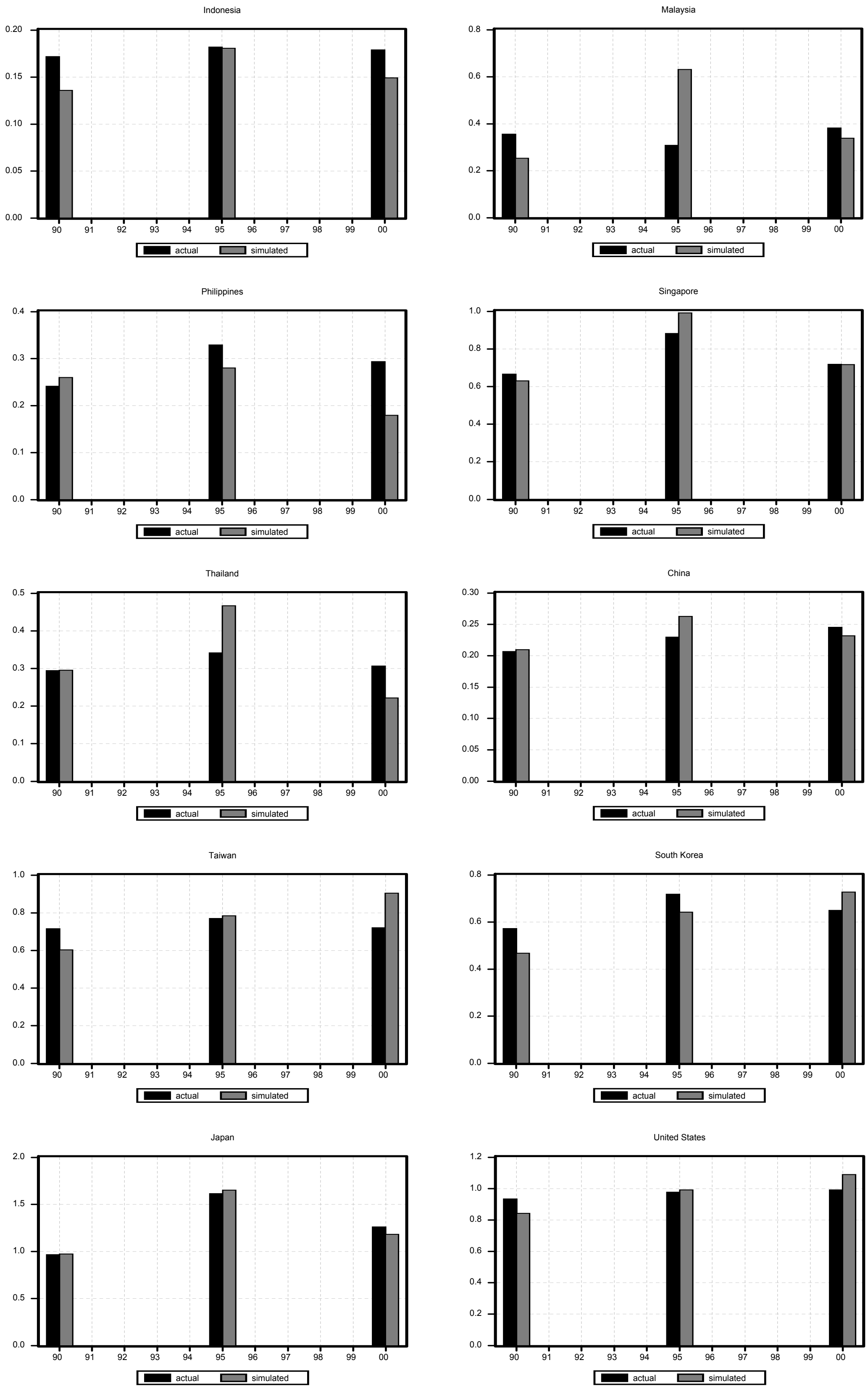

Figure 2. Final test of price in sector 2

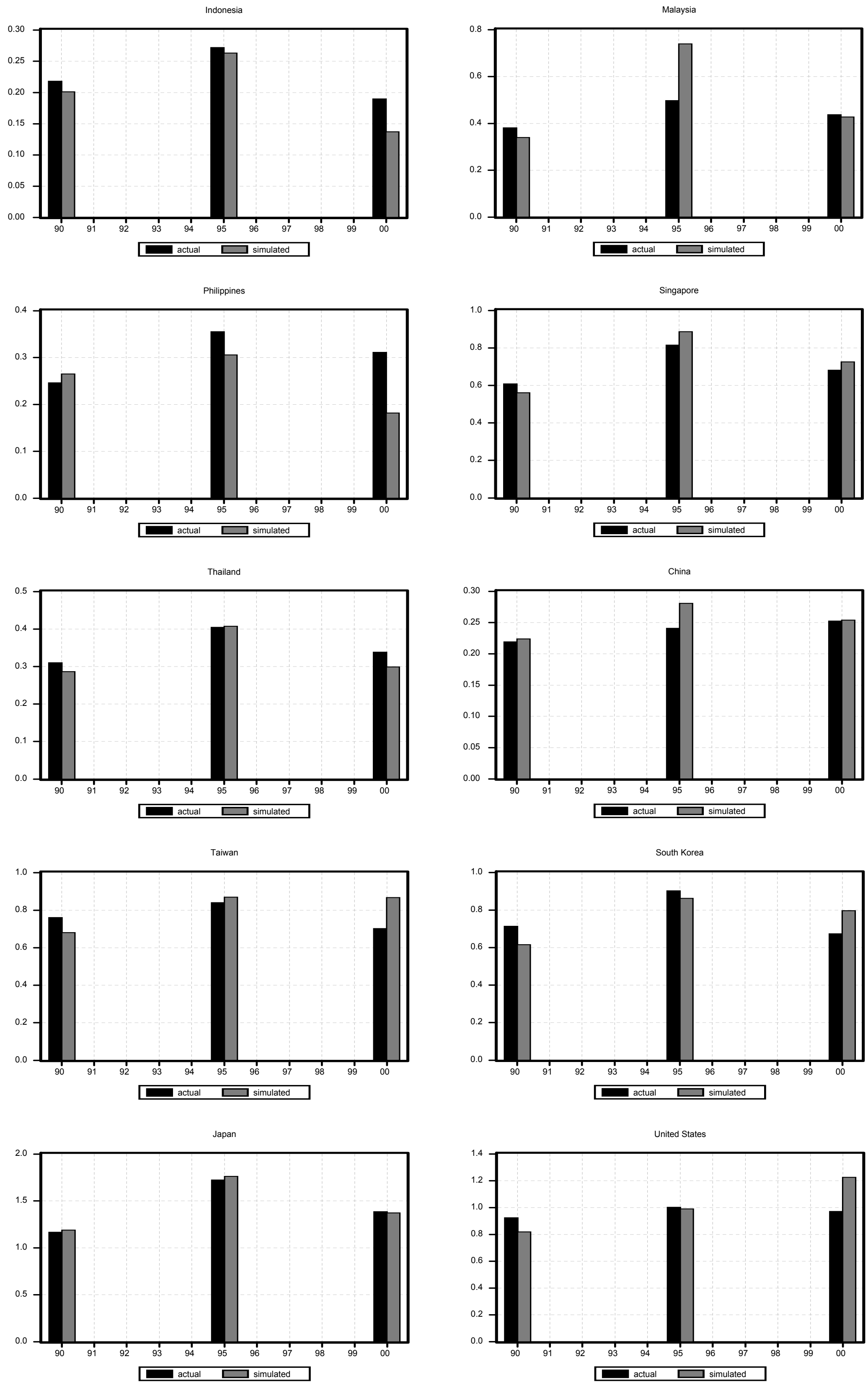

Figure 3. Final test of price in sector 3

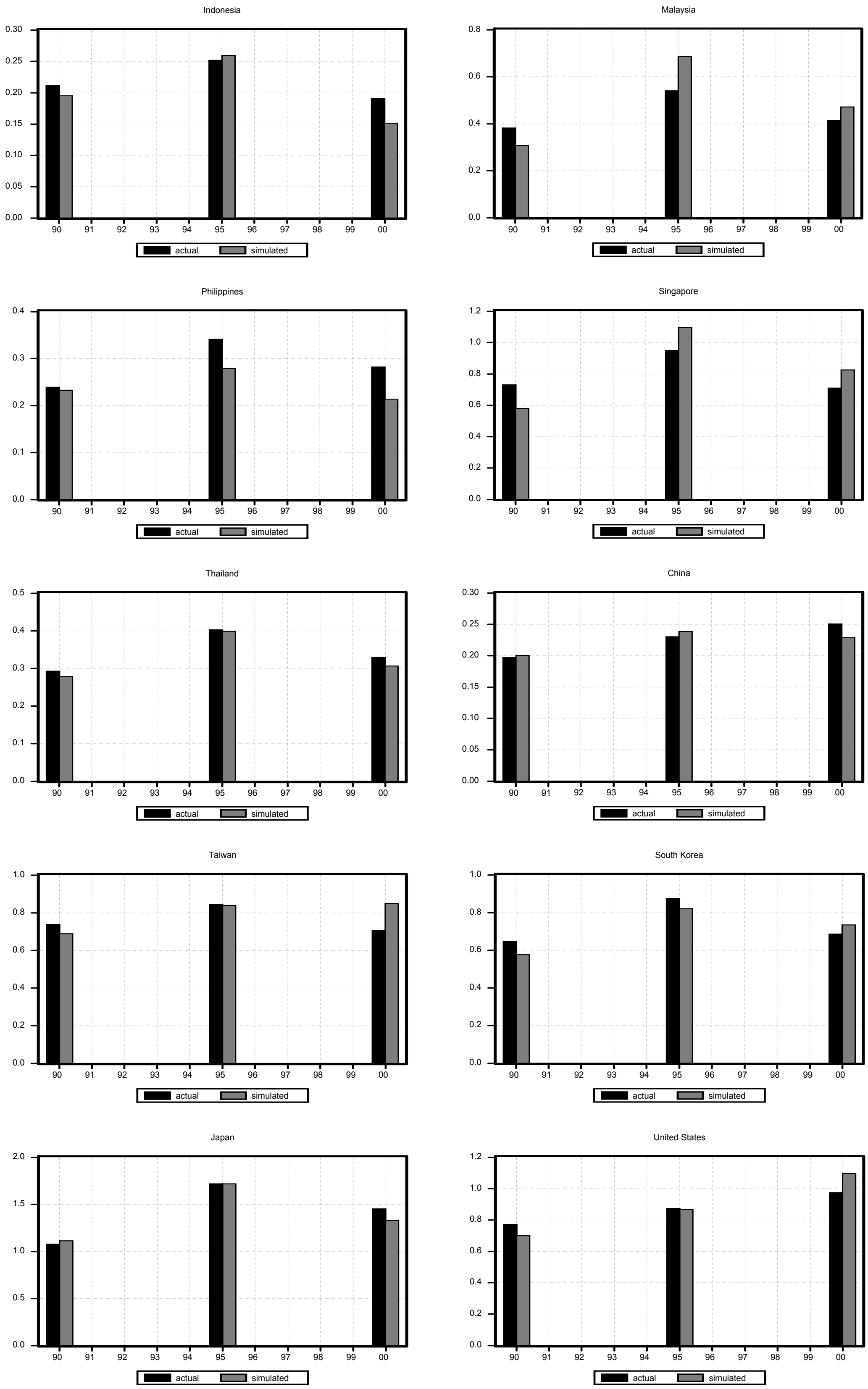

Figure 4. Final test of price in sector 4

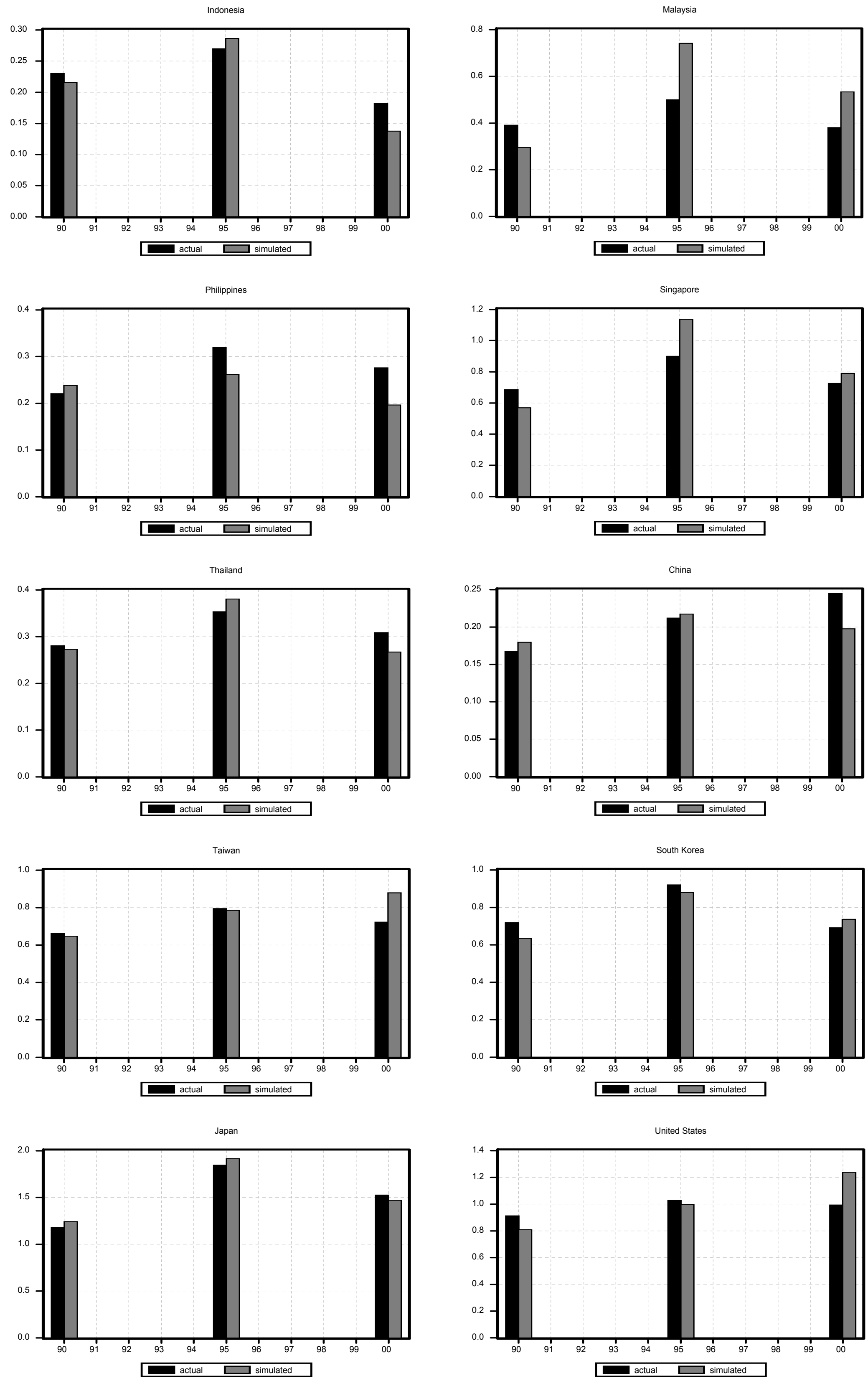

Figure 5. Final test of price in sector 5

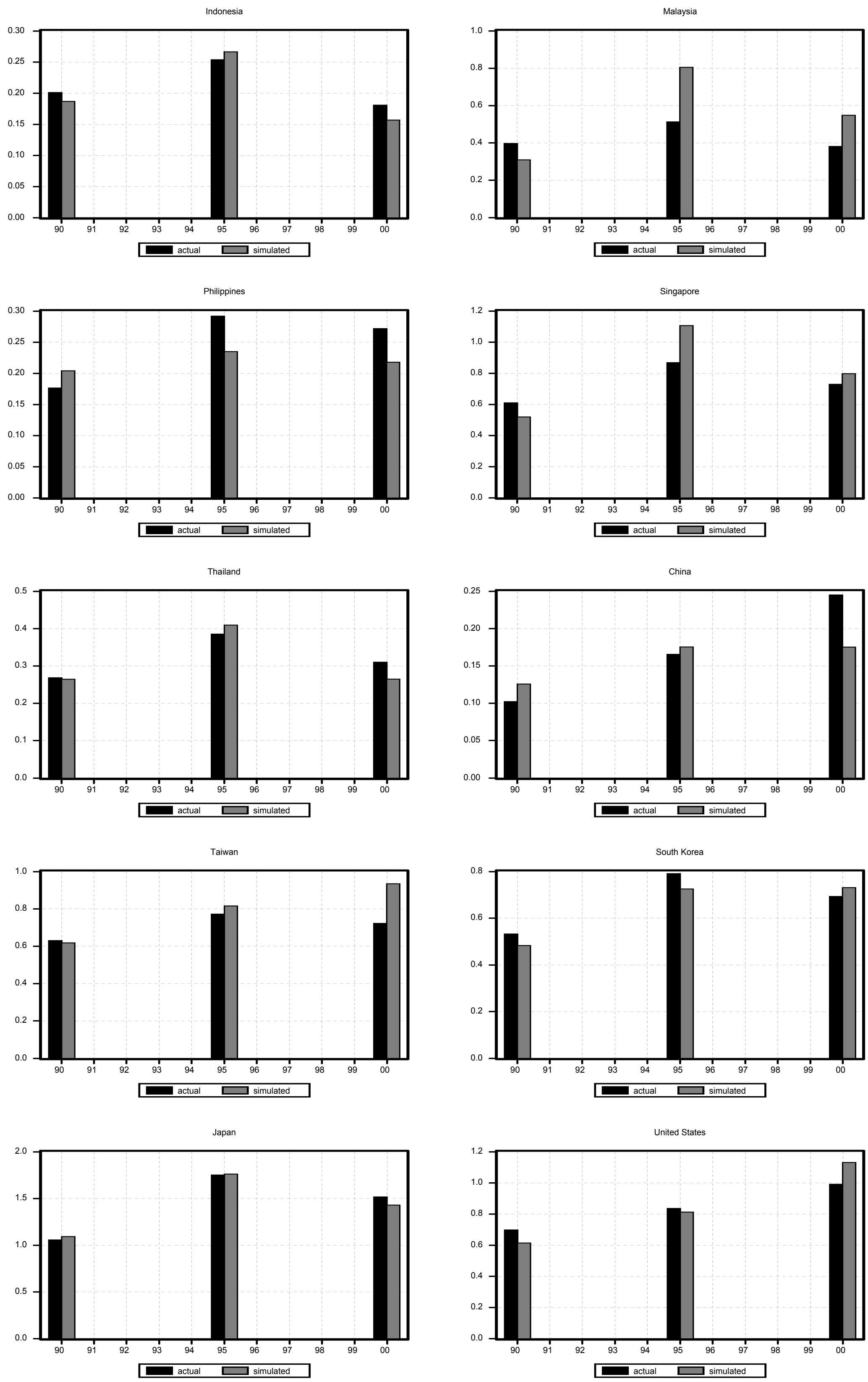

Figure 6. Final test of price in sector 6

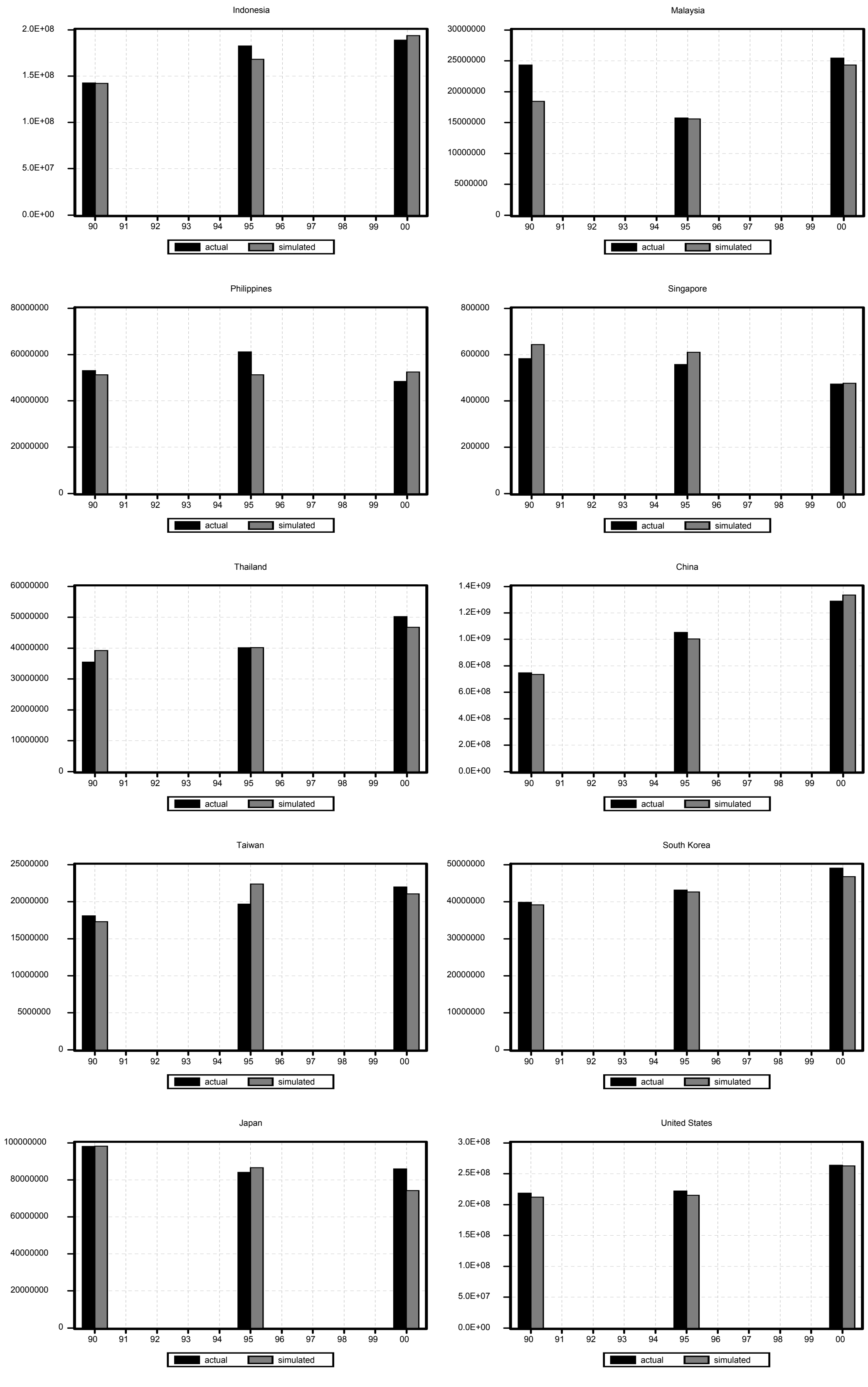

Figure 7. Final test of output in sector 1

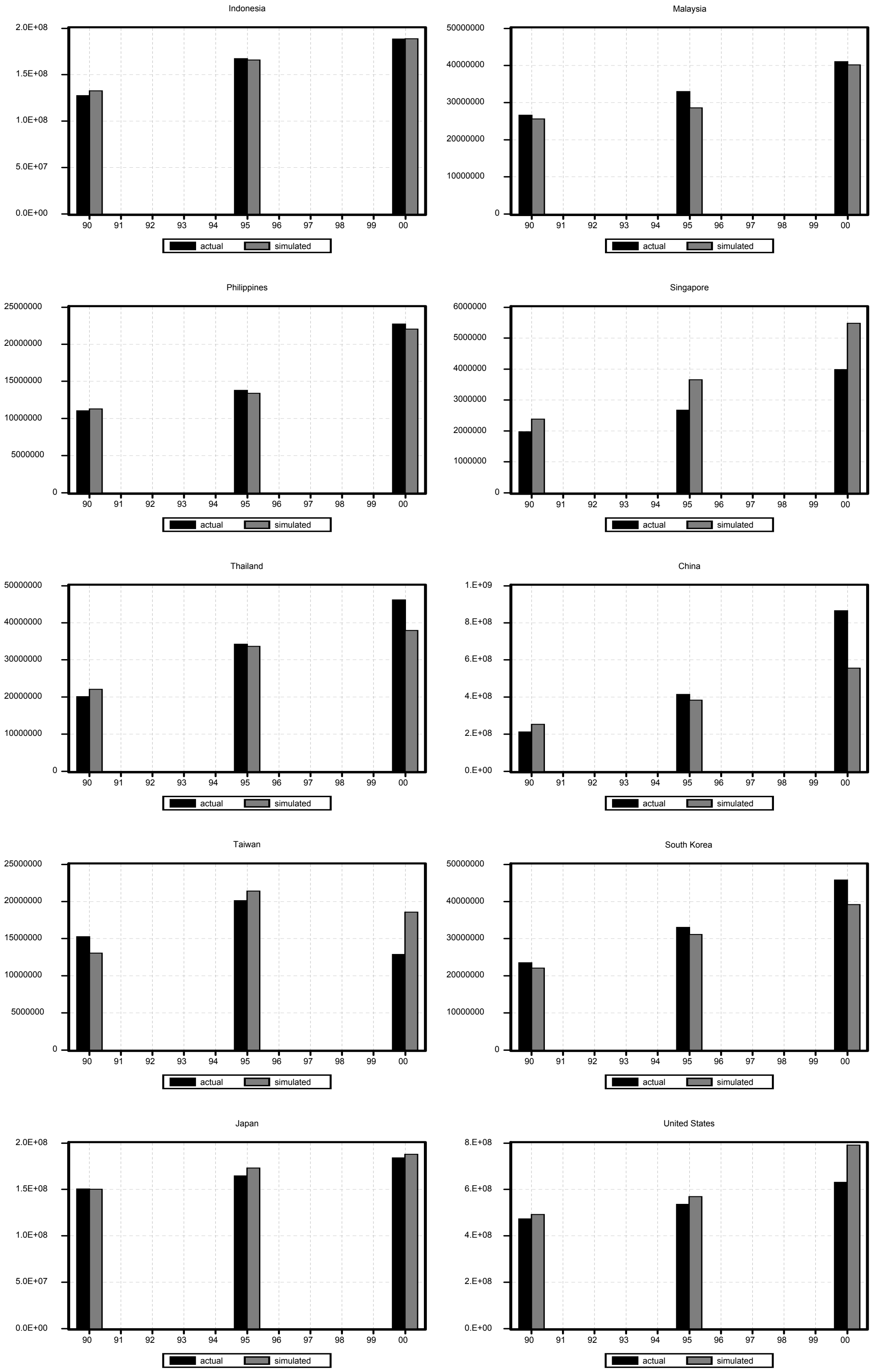

Figure 8. Final test of output in sector 2

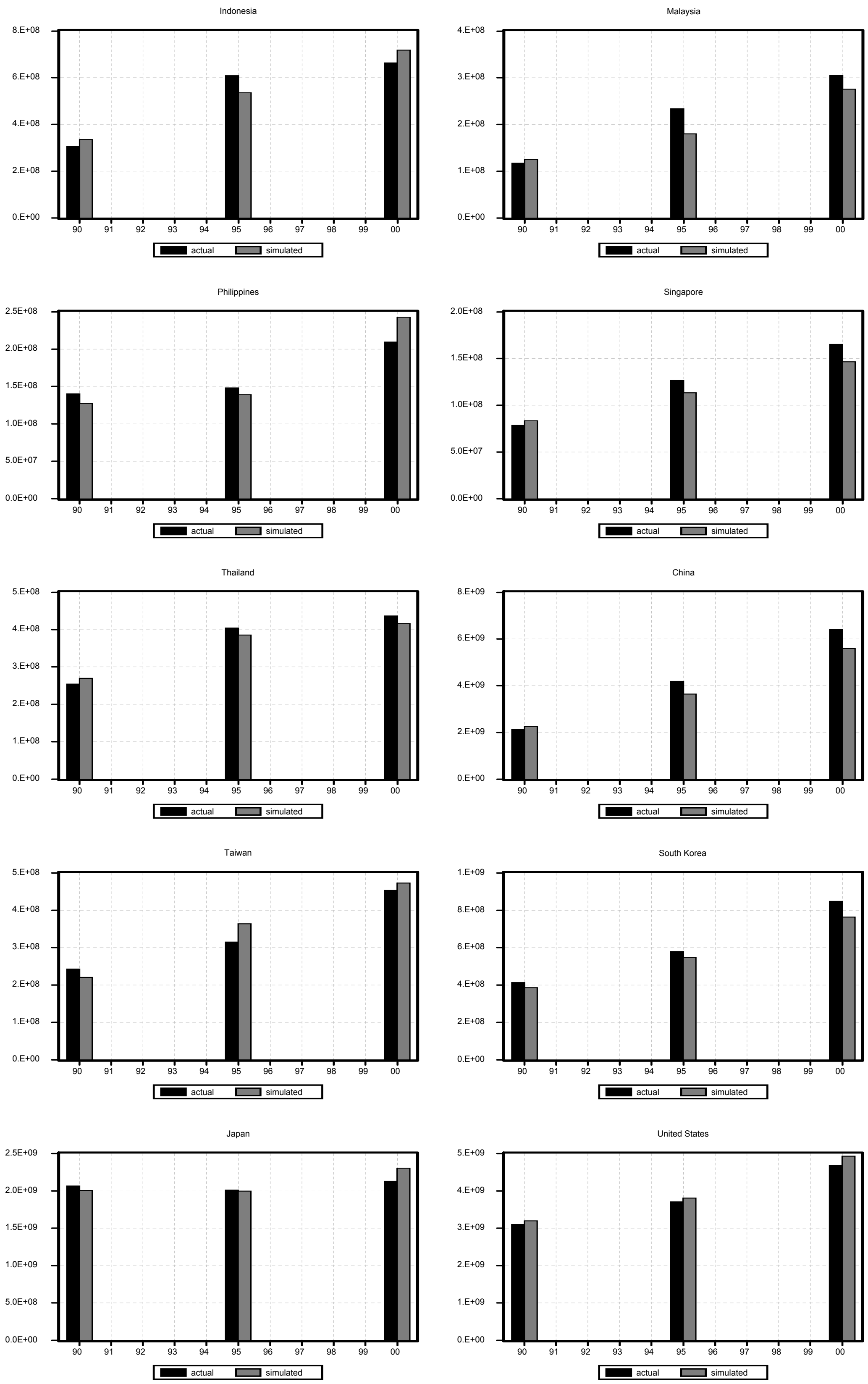

Figure 9. Final test of output in sector 3

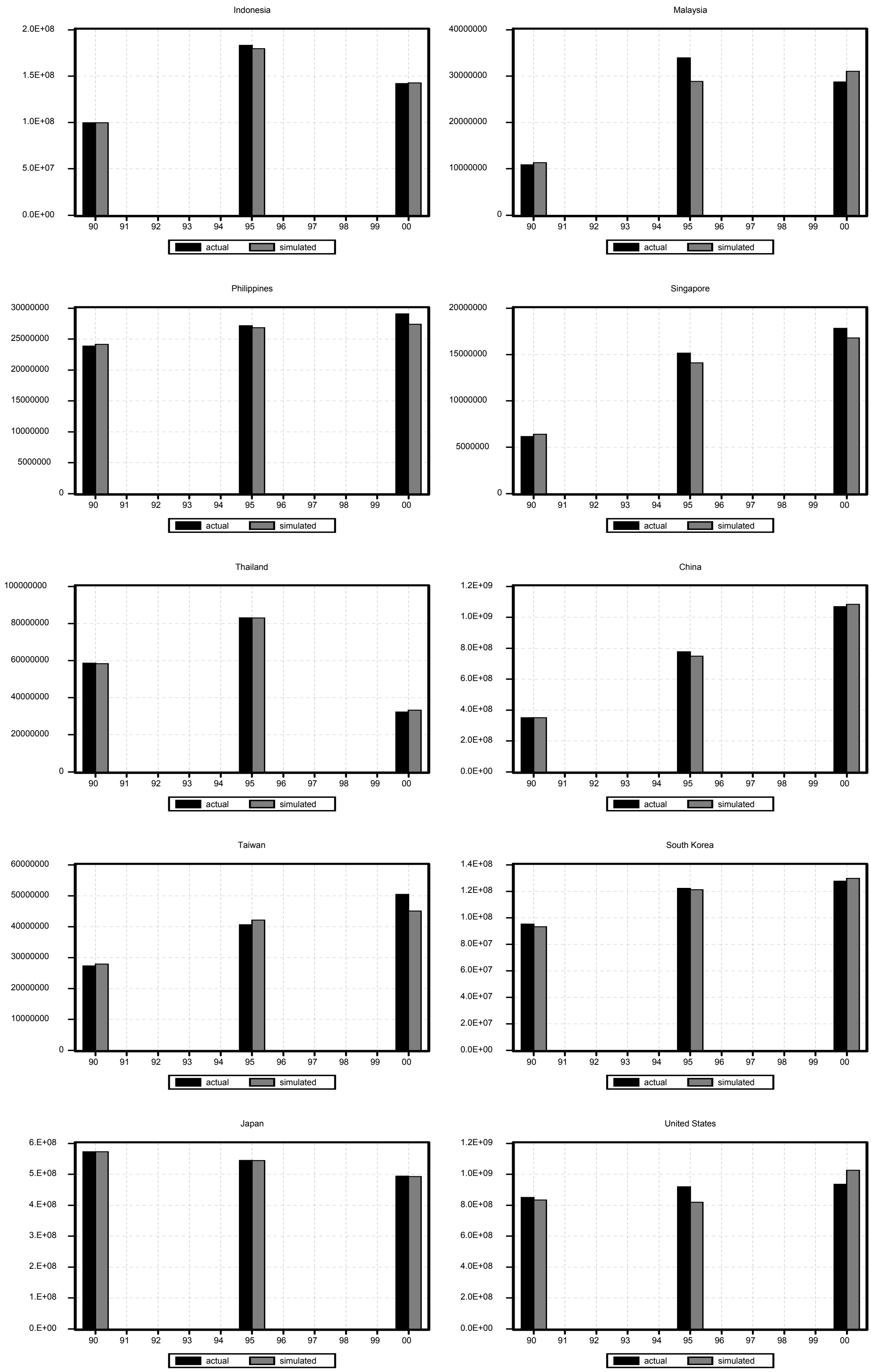

Figure 10. Final test of output in sector 4

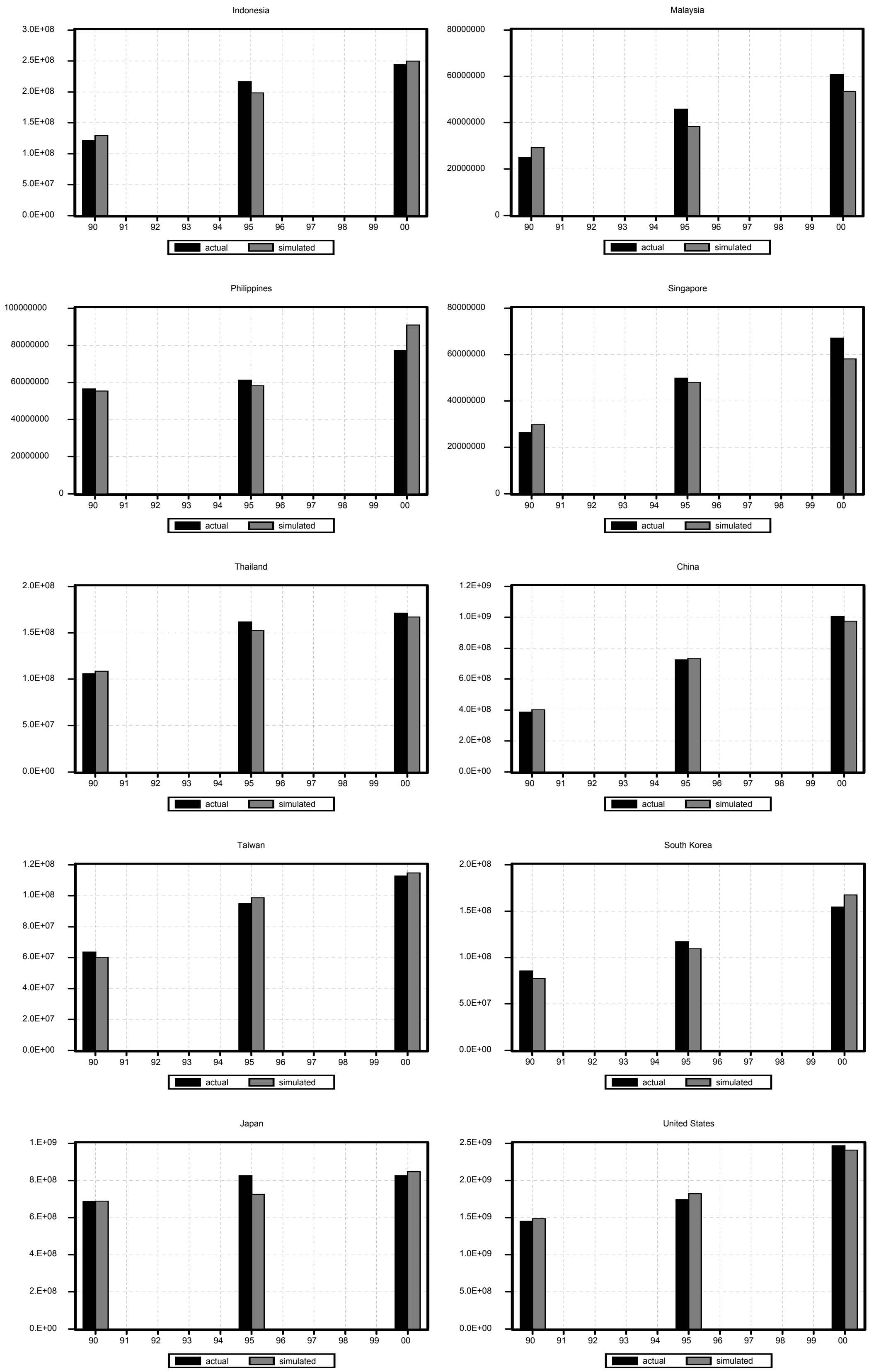

Figure 11. Final test of output in sector 5

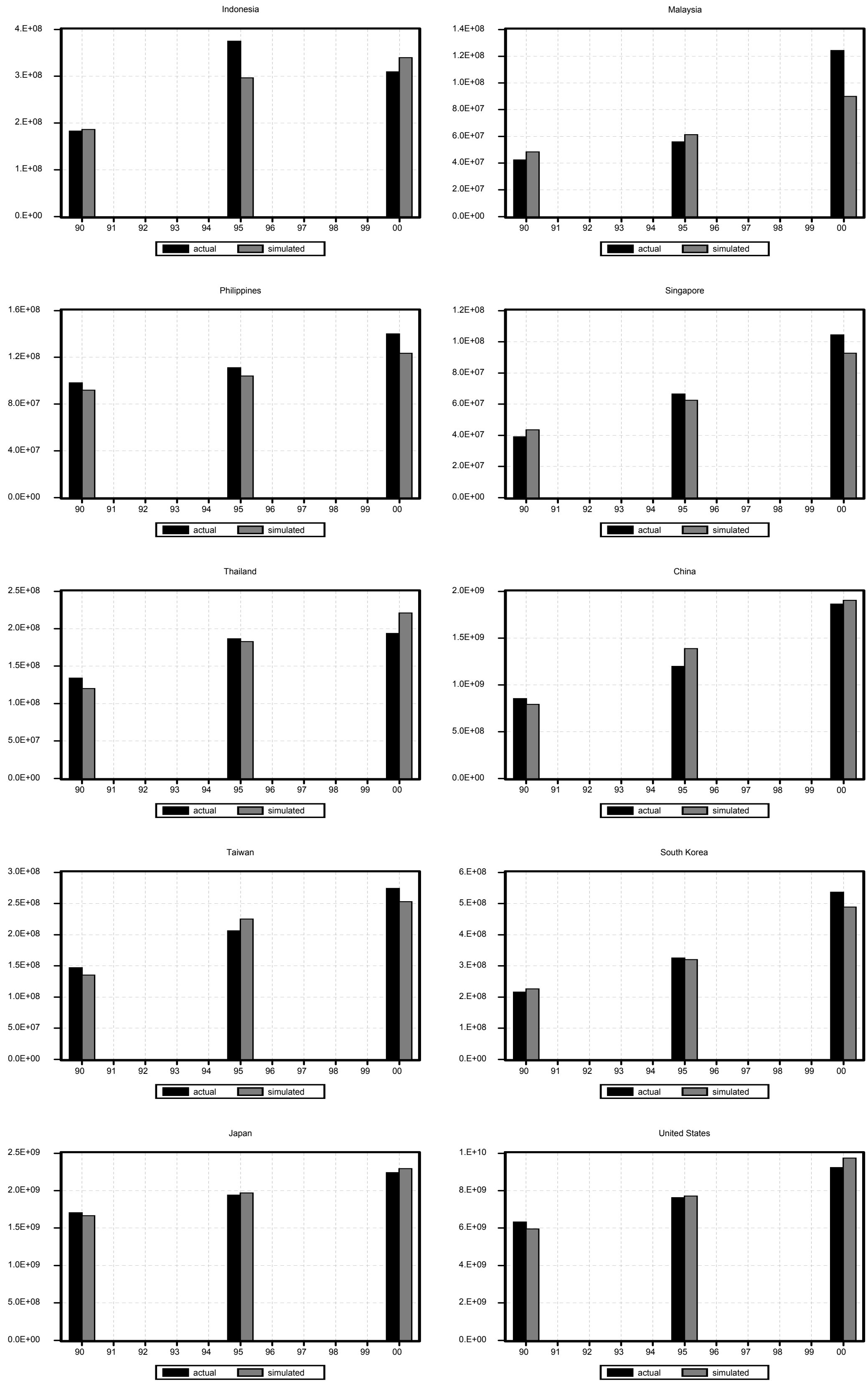

Figure 12. Final test of output in sector 6