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Keywords: Productivity Growth, Multi-Factor CES, Elasticity of Substitution,
General Equilibrium, Linked Input-Output Tables

JEL classification: D24, D57, D58

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Multifactor CES Elasticity and Productivity Growth: A Cross-Sectional Approach

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Abstract

Sector-wise productivity growth is measured, along with the sectoral elasticity of substitution, under the multifactor CES framework by regressing the growth of factor-wise cost shares against the growth of relative factor prices. We use linked input–output tables for Japan and Korea as the data sources for factor price and cost shares in two temporally distant states. We then construct a multisectoral general equilibrium model using the system of estimated CES unit cost functions and evaluate the economy-wide distribution of exogenous productivity gains in terms of welfare. Further, we examine the differences between models based on a priori elasticities such as the Leontief and the Cobb–Douglas systems.

Keywords: Productivity Growth, Multifactor CES, Elasticity of Substitution, General Equilibrium, Linked Input–Output Tables

1. Introduction

In this study, we measure productivity growth of multiple industrial sectors, in conjunction with the multifactor constant elasticity of substitution (CES), by way of two temporally distant cross-sectional data sets (i.e., linked input–output tables). As we learn about the multifactor CES unit cost function, we discover that an industry-specific elasticity can be estimated by regressing the growth of factor-wise cost shares against the growth of factor-wise relative prices. We also discover that the industry-specific productivity growth can be measured via the intercept of the regression line. Consequently, we use linked input–output tables to observe the cost shares and relative prices for two periods for multiple industrial sectors.

The two-input CES function was first introduced by Arrow et al. (1961), and Uzawa (1962) and McFadden (1963) later showed that elasticities were still unique for cases with more than two input factors. Subsequent empirical analyses concerning the measurement of CES elasticities (e.g., van der Werf, 2008; Koesler and Schymura, 2015) have been undertaken to handle elasticities between more than two factors of production by way of time-series observations while embedding nest structures into the two-input CES framework that conforms to the work by Sato (1967). The number of factors and, thus, estimable elasticities can nevertheless be narrowed depending on the availability of time-series data. Since we are interested in constructing a multisector gen-

eral equilibrium model that calls for multifactor production functions, we can take advantage of an alternative approach.

When a multisectoral general equilibrium model is established, assessments can be made, in terms of welfare, of the arbitrary productivity shock that results from technological innovation. Previous studies on this topic have assumed a constant and unanimous unit elasticity (Klein, 1952–1953) or have used empirically estimated elasticities in translog or multistage (nested) CES functions with a highly aggregated and, thus, limited number of substitutable factors. Examples include works by Kuroda et al. (1984), Saito and Tokutsu (1989), and Tokutsu (1994), and a significant amount of work concerning CGE models, such as Böhringer et al. (2015). In contrast, our approach allows us to construct an empirical model of multifactor production with different elasticities of substitution among many (over 350) industrial sectors. Moreover, our approach allows us to prospectively portray the ex post technological structure following any given exogenous productivity shocks and to account for welfare in terms of economy-wide input–output performances.

The remainder of this paper is organized as follows. In the Section 2, we introduce the basics of the multifactor CES elasticity and productivity growth estimation and apply the protocol to linked input-output tables for Japan and Korea that have sufficient capacity as far as the degrees of freedom of the regressions are concerned. In Section 3, we replicate the current technological structure as the general equilibrium state of a system of empirically estimated multifactor CES functions; further, we trace how that structure is transformed by exogenous productivity stimuli. Section 4 provides concluding remarks.

2. The Model

2.1. Multifactor CES Functions

A constant-return multifactor CES production function of an industrial sector (index j omitted) has the following form:

$$y = \theta f\left(\mathbf{x}\right) = \theta \left(\sum_{i=0}^{n} \delta_i^{\frac{1}{\sigma}} x_i^{\frac{\sigma-1}{\sigma}} \right)^{\frac{\sigma}{\sigma-1}}$$

where y is the output and x_i is the ith factor input. Here, the share parameters are assumed to maintain $\delta_i > 0$ and $\sum_i \delta_i = 1$, while the elasticity of substitution $\sigma \geq 0$ is subject to estimation. Also, we are interested in measuring the growth of productivity, i.e., $\Delta \ln z$, where Δ represents temporally distant differences.

The expression below shows the unit cost function compatible with the multifactor CES production function:

$$c = \theta^{-1} h\left(\boldsymbol{w}\right) = \frac{1}{\theta} \left(\sum_{i=0}^{n} \delta_i w_i^{\rho} \right)^{\frac{1}{\rho}}$$

where c denotes the unit cost of the output and w_i denotes the ith factor price. Here, we use $\rho = 1 - \sigma$ for convenience. The cost share of the ith input, a_i, can be determined, with regard to

Shephards lemma, by differentiating the unit cost function:

$$a_i = \frac{\partial c}{\partial w_i}\frac{w_i}{c} = \delta_i \left(\theta c / w_i\right)^{-\rho} \tag{1}$$

By taking the log of both the sides, we have

$$\ln a_i = \ln \delta_i - \rho \ln \theta + \rho \ln \left(w_i / c\right)$$

We observe two temporally distant values for cost shares (a_i^0 and a_i^1), factor prices (w_i^0 and w_i^1), and unit costs of outputs as prices ($c^0 = w^0$ and $c^1 = w^1$) reflecting perfect competition, and, we find two identities regarding the data:

$$\ln a_i^0 = \ln \delta_i - \rho \ln \theta^0 + \rho \ln \left(w_i^0 / w^0\right) + \epsilon_i^0$$
$$\ln a_i^1 = \ln \delta_i - \rho \ln \theta^1 + \rho \ln \left(w_i^1 / w^1\right) + \epsilon_i^1$$

where we assume that ϵ_i^0 and ϵ_i^1 are identically and normally distributed disturbance terms. Subtraction results in the main regression equation as follows:

$$\Delta \ln a_i = -\rho \Delta \ln \theta + \rho \Delta \ln \left(w_i / w\right) + \epsilon_i \tag{2}$$

Here, the disturbance term $\epsilon_i = \epsilon_i^0 - \epsilon_i^1$ is identically and normally distributed so that one can estimate ρ and $\Delta \ln \theta$ via the simple linear regression shown in equation (2). That is, by regressing the growth of factor-wise cost shares (i.e, $\Delta \ln a_i$) on the growth of relative prices (i.e., $\Delta \ln \left(w_i / w\right)$), the slope obtained gives the estimate of ρ and the intercept gives the estimate of $-\rho \Delta \ln \theta$. Also, note that δ_i can be calibrated via equation (1) as long as we have the estimate for ρ.

2.2. The Data and Estimations

A set of linked input–output tables includes sectoral transactions in both nominal and real terms. Since real value is adjusted for inflation in order to enable a comparison of quantities as if the prices had not changed, and since the nominal value is not adjusted, we use a price index to convert nominal into real values. That is, if we standardize the value of a commodity at the reference state as real, its nominal (unadjusted) value at the target state relative to the reference state equals the price index called a deflator. Naturally, the 1995–2000–2005 linked input–output tables for both Japan (MIAC, 2011) and Korea (BOK, 2015) include factor-wise deflators (395 factors for Japan and 350 factors for Korea) spanning the fiscal years recorded. These linked input–output tables, however, do not include deflators for primary factors (i.e., labor and capital); and therefore, we used the quality-adjusted price indexes compiled by the JIP (2015) for Japan and by the KIP (2015) for Korea in order to inflate the nominal values of primary inputs.

Hence, observations for both the dependent variable (cost shares as input–output coefficients a_{ij}) and the independent variable (price ratios w_j / w_i) for estimating equation (2) become available with sufficient capacity in terms of degrees of freedom as we verify that there are $n + 1$ inputs, namely, $i = 0, 1, \cdots, n$ and n outputs, namely, $j = 1, \cdots, n$, for an input–output table. In particular, we use the 2000 and 2005 input–output coefficient matrices from the three-period linked

input–output tables as the data for the cost share growth (i.e., $\Delta \ln a_{ij}$). As we set the reference state at year 2000, the five-year growth of output-relative factor prices simply becomes the log difference between deflators:

$$\Delta \ln w_i/w_j = \ln p_i/p_j$$

where p_i denotes the deflator for commodity i in year 2005 with respect to year 2000.

Figure 1 displays the estimated CES elasticity (i.e., $\sigma_j = 1 - \rho_j$ for all j) with respect to the statistical significance of ρ_j, i.e., the slope of the regression in equation (2) in terms of standard error, for Japan. Figure 2 displays the same for Korea. Note that the CES elasticities are statistically significant (p-value < 0.1) for 176 out of 395 sectors for Japan and 166 out of 350 sectors for Korea. The estimation results are summarized in Tables 3 and 4 for Japan and Korea, respectively. These tables include sectors whose slopes ($\rho_j = 1 - \sigma_j$) of the regression equation (2) are statistically significant; and we indicate the level of significance by *** (0.01 level), **(0.05 level), and *(0.1 level), along with the estimated elasticities. In the third column of Tables 3 and 4, we display the productivity growth, $\Delta \ln \theta$, labeled as TFPg (Total Factor Productivity growth). These numbers are the estimated constant terms of equation (2) divided by the negative of the corresponding slope that is estimated at the same time. Here, the indicated statistical significances are the constant terms of equation (2). Also, note that these tables are sorted by the level of estimated TFPg.

Let us now assess the estimated TFPg with regard to other possible productivity measurements. Below is the log of the Törnqvist index, the exactness of which Diewert (1976) demonstrated by measuring the productivity growth of translog functions. Thus, we know that equation (3) is equal to the productivity growth of the underlying translog function, with or without knowing its parameters.

$$\text{TFPg (translog)} = -\ln p + \sum_{i=0}^{n} \left(\frac{a_i^0 + a_i^1}{2} \right) \ln p_i \tag{3}$$

Note that although it is almost impossible to estimate the parameters of a translog function with one hundred factor inputs, its productivity growth can be measured using the same data (cost shares and price changes) as those used in estimating the productivity for a multifactor CES function.

In Figures 3 and 4, we plot the estimated TFP as index numbers, i.e., θ_j^1/θ_j^0, for a multifactor CES function, tagged as TFP (CES), for all sectors listed in Tables 3 and 4 against the log of the Törnqvist indexes, tagged as TFP (translog). Blue dots indicate sectors whose slope and regression constant for equation (2) are both statistically significant (p-value < 0.1), whereas red dots indicate sectors whose slope is significant but constant is not. In both cases, we observe correlations between the two TFP measurements; therefore, we evaluate them objectively, as summarized in Table 1. Here, "Correlation" designates Pearson's correlation coefficient, whereas "Concordance" designates Lin's concordance correlation coefficient (Lin, 2000). In other words, by way of a multifactor CES function, we obtain TFP estimates similar to those based on translog functions that are very general in terms of their elasticities of substitution, set aside their estimability; yet, a multifactoral elasticity of substitution can be estimated for many factor inputs. Note, however, that the null hypothesis has to be accepted (i.e., $\rho_j = 1 - \sigma_j = 0$) for sectors where the slope of the

Table 1: Concordances and correlations between Translog and multifactor CES TFP gain estimates.

Dots	Concordance	Correlation	Obs.
Red & Blue (JPN)	0.655	0.669	176
Red (JPN)	0.625	0.759	100
Blue (JPN)	0.668	0.816	76
Red & Blue (KOR)	0.356	0.419	166
Red (KOR)	0.312	0.333	97
Blue (KOR)	0.276	0.405	69

regression (2) is not statistically significant and, in that event, we assume that the function follows Cobb–Douglas and that TFP is unmeasurable.

3. Prospective Analysis

3.1. Projected Prices

In this section, we construct a multisectoral general equilibrium model that reflects all measured elasticities and observed current cost shares; further, we exogenously impose some productivity change onto the model and simulate the multisectoral distribution that can potentially take place. For the sake of simplicity, let us normalize all current prices at unity. In that event, we recall equation (1):

$$a_{ij} = \delta_{ij}, \qquad \sum_{i=0}^{n} a_{ij} = 1, \quad j = 1, 2, \cdots, n$$

Then, the system of CES unit cost functions in equilibrium, under some exogenously given productivity change; i.e., $\boldsymbol{\theta} = (\theta_1, \theta_2, \cdots, \theta_n) \neq \mathbf{1}$, must be in the following state:

$$\begin{aligned}
\pi_1 &= \theta_1^{-1} \left(a_{01}\pi_0^{\rho_1} + a_{11}\pi_1^{\rho_1} + \cdots a_{n1}\pi_n^{\rho_1} \right)^{\frac{1}{\rho_1}} \\
\pi_2 &= \theta_2^{-1} \left(a_{02}\pi_0^{\rho_2} + a_{12}\pi_1^{\rho_2} + \cdots a_{n2}\pi_n^{\rho_2} \right)^{\frac{1}{\rho_2}} \\
&\vdots \\
\pi_n &= \theta_n^{-1} \left(a_{0n}\pi_0^{\rho_n} + a_{1n}\pi_1^{\rho_n} + \cdots a_{nn}\pi_n^{\rho_n} \right)^{\frac{1}{\rho_n}}
\end{aligned} \tag{4}$$

where the projected (ex post) general equilibrium price for factor i is denoted by π_i. Note that the current state (i.e., $\boldsymbol{\theta} = \mathbf{1}$) can be reproduced by setting all prices at the current state (i.e., $\boldsymbol{\pi} = \mathbf{1}$) and vice versa.[1]

The projected price after the exogenous productivity change can be obtained by solving equation

[1] This may not be so obvious when $\boldsymbol{\rho} = \mathbf{0}$, until we see (7).

(4) for $\boldsymbol{\pi}$. By rearranging, we obtain the following:

$$\begin{aligned}
\theta_1^{\rho_1}\pi_1^{\rho_1} &= a_{01}\pi_0^{\rho_1} + a_{11}\pi_1^{\rho_1} + \cdots a_{n1}\pi_n^{\rho_1} \\
\theta_2^{\rho_2}\pi_2^{\rho_2} &= a_{02}\pi_0^{\rho_2} + a_{12}\pi_1^{\rho_2} + \cdots a_{n2}\pi_n^{\rho_2} \\
&\vdots \\
\theta_n^{\rho_n}\pi_n^{\rho_n} &= a_{0n}\pi_0^{\rho_n} + a_{1n}\pi_1^{\rho_n} + \cdots a_{nn}\pi_n^{\rho_n}
\end{aligned}$$

or by way of row vectors and matrices:

$$\boldsymbol{\pi}^{\boldsymbol{\rho}} \langle \boldsymbol{\theta}^{\boldsymbol{\rho}} \rangle = \mathbf{a}_0 + \boldsymbol{\pi}^{\boldsymbol{\rho}} \mathbf{A}$$

where $\boldsymbol{\pi}^{\boldsymbol{\rho}} = \left(\pi_1^{\rho_1}, \cdots, \pi_n^{\rho_n}\right)$ and $\boldsymbol{\theta}^{\boldsymbol{\rho}} = \left(\theta_1^{\rho_1}, \cdots, \theta_n^{\rho_n}\right)$, while we set the price of a primary input as a numéraire (i.e., $\pi_0 = 1$). Angle brackets indicate diagonalization. Note that $\mathbf{A}$ and $\mathbf{a}_0$ are the current input–output coefficients matrix and the value added coefficients vector, respectively. Now, the projected equilibrium price $\boldsymbol{\pi}$ can be obtained:

$$\boldsymbol{\pi} = \left(\mathbf{a}_0 \left[\langle \boldsymbol{\theta}^{\boldsymbol{\rho}} \rangle - \mathbf{A}\right]^{-1}\right)^{\frac{1}{\boldsymbol{\rho}}} \tag{5}$$

Besides CES, we may use equation (5) to obtain the projected price for the cases of Leontief ($\boldsymbol{\rho} = \mathbf{1}$) and Cobb–Douglas ($\boldsymbol{\rho} = \mathbf{0}$) cases. The Leontief case is straightforward:

$$\boldsymbol{\pi} = \mathbf{a}_0 \left[\langle \boldsymbol{\theta} \rangle - \mathbf{A}\right]^{-1} \tag{6}$$

For the Cobb–Douglas case, we first take the log of equation (4) and then let $\boldsymbol{\rho} \to \mathbf{0}$. As shown below, we determine the unit cost function of any industrial sector j while omitting the subscript:

$$\ln \pi + \ln \theta = \frac{\ln\left(a_0 + \sum_{i=1}^{n} a_i \pi_i^{\rho}\right)}{\rho} \to \sum_{i=1}^{n} a_i \ln \pi_i$$

Here, we applied l'Hospital's rule when we let $\rho \to 0$ since, in that event the numerator and denominator both approach zero. By way of row vectors and matrices, this can be written concisely in the following manner:

$$\ln \boldsymbol{\pi} = -\ln \boldsymbol{\theta} + (\ln \boldsymbol{\pi})\, \mathbf{A} \tag{7}$$

where the log operators are applied by element. The Cobb–Douglas version of the projected price will thus be expressed as follows:

$$\boldsymbol{\pi} = \exp\left(-(\ln \boldsymbol{\theta})\left[\mathbf{I} - \mathbf{A}\right]^{-1}\right) \tag{8}$$

3.2. Projected Structures

Since we set the current price to unity, the final demand in monetary terms will be the same as the physical quantity demanded. Let the current (nominal) final demand be denoted by a column

vector $\mathbf{d} = (d_1, \cdots, d_n)^{\intercal} \geq \mathbf{0}$. Note that the sum of product-wise final demand and that of sector-wise value added (the social cost) equals the GDP. If we have the projected price is attributable to some exogenous productivity change, we can evaluate the corresponding welfare change in terms of the social cost saved (SCS, hereafter); that is,

$$\text{SCS} = \sum_{j=1}^{n} v_j - v'_j = (\mathbf{1} - \boldsymbol{\pi})\,\mathbf{d} \tag{9}$$

The sector-wise distribution of the SCS, however, requires more examination of the projected structure of the economy.

According to equation (1), the projected cost shares, which we denote b_{ij}, the ex post the exogenous productivity change z_j for sector j, can be evaluated using the following:

$$b_{ij} = a_{ij}\left(\theta_j \pi_j / \pi_i\right)^{-\rho_j} \qquad i = 0, 1, \cdots, n \tag{10}$$

Hence, under CES, the projected primary factor input (or value added) distribution $\mathbf{v}' = \left(v'_1, \cdots, v'_n\right)$ including all sectors for a given fixed final demand $\mathbf{d}$ (in physical quantity), can be evaluated as follows:

$$\mathbf{v}' = \mathbf{b}_0 \left\langle [\mathbf{I} - \mathbf{B}]^{-1} \langle \boldsymbol{\pi} \rangle \, \mathbf{d} \right\rangle \tag{11}$$

where the entries for $\mathbf{b}_0$ and $\mathbf{B}$ are specified by equation (10). Conversely, the current distribution of primary factor inputs (or value added) $\mathbf{v} = (v_1, \cdots, v_n)$ is specified by the current observed cost shares as follows:

$$\mathbf{v} = \mathbf{a}_0 \left\langle [\mathbf{I} - \mathbf{A}]^{-1} \mathbf{d} \right\rangle \tag{12}$$

Since equations (11) and (12) are row vectors, one can evaluate the SCS in terms of sector-wise distribution.

Let us now consider the Cobb–Douglas case. By taking the log of equation (10) and then letting $\rho_j \to 0$ for all j, we obtain the following:

$$\ln b_{ij} = \ln a_{ij} - \rho_j \ln\left(\theta_j \pi_j / \pi_i\right) \to \ln a_{ij}$$

Thus, the projected primary factor inputs distribution for the Cobb–Douglas case is as follows:

$$\mathbf{v}' = \mathbf{a}_0 \left\langle [\mathbf{I} - \mathbf{A}]^{-1} \langle \boldsymbol{\pi} \rangle \, \mathbf{d} \right\rangle \tag{13}$$

As for the Leontief case, by plugging equation (10), with $\rho_j = 1$ for all sector j into equation (11), we obtain the following formula:

$$\begin{aligned} \mathbf{v}' &= \mathbf{a}_0 \langle \boldsymbol{\pi} \rangle^{-1} \langle \boldsymbol{\theta} \rangle^{-1} \left\langle \left[\mathbf{I} - \langle \boldsymbol{\pi} \rangle \, \mathbf{A} \, \langle \boldsymbol{\pi} \rangle^{-1} \langle \boldsymbol{\theta} \rangle^{-1}\right]^{-1} \langle \boldsymbol{\pi} \rangle \, \mathbf{d} \right\rangle \\ &= \mathbf{a}_0 \left[\langle \boldsymbol{\theta} \rangle - \mathbf{A}\right]^{-1} \langle \mathbf{d} \rangle \end{aligned} \tag{14}$$

Finally, one can verify that when $\mathbf{A} \geq \mathbf{0}$ and $\boldsymbol{\theta} > \mathbf{0}$, the following must be true:

$$\begin{aligned} [\langle\boldsymbol{\theta}\rangle - \mathbf{A}]^{-1} &= \langle\boldsymbol{\theta}\rangle^{-1} + \mathbf{A}\langle\boldsymbol{\theta}\rangle^{-2} + \mathbf{A}^2\langle\boldsymbol{\theta}\rangle^{-3} + \cdots > \mathbf{0} \\ [\mathbf{I} - \mathbf{A}]^{-1} &= \mathbf{I} + \mathbf{A} + \mathbf{A}^2 + \cdots > \mathbf{I} \end{aligned} \tag{15}$$

Thus, we see that

$$\begin{aligned} [\langle\boldsymbol{\theta}\rangle - \mathbf{A}]^{-1} &\leq [\mathbf{I} - \mathbf{A}]^{-1} \qquad \text{if } \boldsymbol{\theta} \geq \mathbf{1} \\ [\langle\boldsymbol{\theta}\rangle - \mathbf{A}]^{-1} &\geq [\mathbf{I} - \mathbf{A}]^{-1} \qquad \text{if } \mathbf{0} < \boldsymbol{\theta} \leq \mathbf{1} \end{aligned}$$

Hence, according to euqations (12) and (14), we find that $\mathbf{v} - \mathbf{v}' \geq \mathbf{0}$, if $\boldsymbol{\theta} \geq \mathbf{1}$, and $\mathbf{v} - \mathbf{v}' \leq \mathbf{0}$, if $\mathbf{0} < \boldsymbol{\theta} \leq \mathbf{1}$, for the Leontief system. Moreover, because $[\mathbf{I} - \mathbf{A}]^{-1} > \mathbf{I}$, we find that $\boldsymbol{\pi} \leq \mathbf{1}$ if $\boldsymbol{\theta} \geq \mathbf{1}$ and $\boldsymbol{\pi} \geq \mathbf{1}$ if $\mathbf{0} < \boldsymbol{\theta} \leq \mathbf{1}$ by equation (8) for the Cobb–Douglas system. Hence, from equations (12) and (13), we find that $\mathbf{v} - \mathbf{v}' \geq \mathbf{0}$, if $\boldsymbol{\theta} \geq \mathbf{1}$, and $\mathbf{v} - \mathbf{v}' \leq \mathbf{0}$, if $\mathbf{0} < \boldsymbol{\theta} \leq \mathbf{1}$ for the Cobb–Douglas system as well.

To summarize, the following must be true for both the Leontief and Cobb–Douglas systems:

$$\begin{aligned} \mathbf{v} - \mathbf{v}' &\geq \mathbf{0} \qquad \text{if } \boldsymbol{\theta} \geq \mathbf{1} \\ \mathbf{v} - \mathbf{v}' &\leq \mathbf{0} \qquad \text{if } \mathbf{0} < \boldsymbol{\theta} \leq \mathbf{1} \end{aligned} \tag{16}$$

In other words, the SCS will be positive for all sectors if the exogenous productivity change is increasing, and negative for all sectors if the exogenous productivity change is decreasing. THis is applicable to systems with unanimous elasticity, such as Leontief and Cobb–Douglas. In contrast, we find nothing definitive about the CES system, in general.

3.3. Simulations

Let us now apply the framework discussed in the previous sections. First, we calibrate the multisectoral models with different elasticities, namely the Leontief, the Cobb–Douglas, and the multifactor CES models, as of 2005. Thus, the cost shares of the current state (i.e., $\mathbf{a}_0$ and $\mathbf{A}$) are as of 2005. For the multifactor CES system, we make use of the elasticities that are statistically significant, i.e., the sectors displayed in Tables 3 and 4; we assume unit elasticity (or the null hypothesis) for the remainder of the sectors.

As for the exogenous productivity change ($\boldsymbol{\theta}$), we examine the productivity doubling of the Ready Mixed Concrete sector (RMC, hereafter), which is 150th sector in Japan, and the 159th in Korea. Thus,

$$\begin{aligned} \text{Japan:} \quad & z_{j=150} = 2, \quad z_{j\neq 150} = 1 \quad (n = 395) \\ \text{Korea:} \quad & z_{j=159} = 2, \quad z_{j\neq 159} = 1 \quad (n = 350) \end{aligned} \tag{17}$$

There are a couple of reasons for choosing this sector. One reason is its stimulus is more influential than not throughout the economy. In other words, upstream industrial sectors are preferable because they are able to influence all downstream sectors, whereas downstream sectors hardly have any influence on upstream sectors. Based on the work by Chenery and Watanabe (1958), we performed

triangulation[2] on the 2005 input–output coefficient matrices for both Japan and Korea. We found that the RMC sector was placed in the upper stream of the supply chain in both economies (137th out of 395 for Japan, and 65th out of 350 for Korea). Another criterion for selecting is that the output of the sector be completely domestic (not imported) as the current study precludes international trade. Most importantly, we required the equivalence of the sector to be examined for both countries. The RMC sector meets all of these criteria.

In Table 2, we summarize the results of our SCS calculations via equation (9) for the three systems, namely, Leontief, Cobb–Douglas, and CES in Japan and Korea. The projected equilibrium price $\boldsymbol{\pi}$ for given $\boldsymbol{\theta}$ as in equation (17), is calculated using equation (6) for the Leontief system, equation (8) for the Cobb–Douglas system, and equation (5) for the CES system. Along with the SCS, we Show the output of the RMC sector of the 2005 input–output table. Notably, the SCS of

Table 2: SCS (social cost saved) by productivity doubling of RMC (ready mixed concrete) sector. Values in parentheses are the kurtosis of the SCS distribution.

	Japan [BJPY]		Korea [BKRW]	
Output	1,347		6,398	
SCS Leontief	674	(315)	3,203	(162)
SCS Cobb–Douglas	926	(52)	4,349	(84)
SCS CES	944	(45)	4,550	(102)

the Leontief system is very slightly larger than one-half the output of the RMC sector, reflecting the double productivity of the RMC sector. Regarding equation (15), this is legitimate as we consider the following:

$$[\mathbf{I} - \mathbf{A}]^{-1} - [\langle\boldsymbol{\theta}\rangle - \mathbf{A}]^{-1} \approx \mathbf{I} - \langle\boldsymbol{\theta}\rangle^{-1} = 1/2$$

Conversely, the SCS of the Cobb–Douglas and CES systems is larger than that of the Leontief system, reflecting further transmissions across sectors that have greater elasticity. Note that the average of all elasticities i.e., $\sum_{j=1}^{n} \sigma_j / n$ of the CES system was 1.32 for Japan and 1.39 for Korea.

Let us now look at the sectoral distribution of the SCS. Figures 5, 6, and 7 show the projected sector-wise SCS from productivity doubling of the RMC sector in Japan under the Leontief, Cobb–Douglas, and CES systems, respectively. Corresponding figures for Korea are shown in Figures 8, 9, and 10. As anticipated with regard to equation (16), the SCS for the Leontief and Cobb–Douglas systems is positively distributed overall.[3]

Basically, when there is productivity doubling in one sector, its price will be cut in half. The intersectoral propagation of that price change will nevertheless be different, depending on the elasticity of factor substitution among the interacting sectors. As for the Leontief system, because factor substitution will not exist with any other sector, the price change of RMC to half its former level will have no effect upon its intermediate demand. Thus, in this case, all the factor inputs

[2]Stages of production leading to final goods are investigated through permutation of sectors. See, e.g., Chaovalitwongse et al. (2011) for recent methodological progress.

[3]However, due to the negative entries for $\mathbf{d}$, slightly negative values are observed.

(including the primary factor) for the RMC sector will be reduced by half. This is the main reason why the primary factor for the RMC sector (as SCS) is reduced rather significantly for the Leontief system. Consequently, the intermediate demand for the factors (including the primary factor) will be respectively reduced by as much as half the amount that used to go into the RMC sector. Such a reduction in intermediate demand and thus, supply, will accumulated with convergence. In other words, at least half of the primary factor will be directly reduced in the RMC sector and indirectly reduced in any other sector. Figures 5 and 8 reflect the results of productivity doubling in the RMC sector on the primary factor demand under a system of zero elasticity of substitution.

In contrast, for the Cobb–Douglas system, the intermediate demand for RMC, when its price is reduced to half, must double, which is the very definition of the unit elasticity of substitution. Thus, in this case, the monetary output and factor inputs (including the primary factor) of the RMC sector will not change. As for an elastic CES system, where the elasticity of substitution is greater than unity, the factor demand for RMC increases by more than double when the price of RMC is reduced by half. And in this case, the factor inputs of the RMC sector can be increased.[4] Since the unit cost functions are strictly concave in both systems, the price of all factors except that of the primary factor, which will stay constant, will converge in a strictly descending manner. Hence, in equilibrium, the primary factor will be reduced for the sectors where the primary factor becomes relatively more expensive as compared with the other factor inputs.

Notably, Figures 6 and 7 indicate that the primary factor is reduced rather prominently (as SCS) for some sectors in Japan, namely, Public construction of roads (279th), Public construction of rivers, drainages, and others (280th), and Residential construction (non-wooden) (275th). Figures 9 and 10 indicate that Residential building construction (289th), Road construction (272nd), and Non-residential building construction (270th) are the prominent sectors where the primary factor is reduced rather prominently (as SCS) for Korea. These sectors obviously utilize RMC extensively for production. In other words, the primary factor in these sectors will be substituted by RMC because of its reduced price.

Moreover, these figures show that not only is the magnitude of propagation (in terms of SCS) of the productivity stimuli magnified by larger elasticities of substitution but the distribution of the SCS becomes more even. We measured the polarity of the distribution of SCS among the sectors via kurtosis, as displayed in the parentheses in Table 2. The primary factor is largely reduced in the RMC sector, where the productivity is enhanced for the Leontief system, whereas the reduction of the primary factor is spread among the sectors for the Cobb–Douglas and CES systems. Put differently, the welfare gain of enhanced productivity in one industry is mainly attained as the curtailment of factor inputs of that particular industry while keeping the output level constant in the Leontief system. In contrast, in the Cobb–Douglas and CES systems, the reduced price is appreciated by other industries, so their primary factors are reduced by substitution.

4. Concluding Remarks

To date, input–output analysis has been a one-of-a-kind framework that considers industrywide impacts when assessing the costs and benefits of new goods and innovations. Nonetheless, input–

[4]This is the main reason why we observe, in Figures 7 and 10, negative SCS (increased primary factor input) in the RMC sector.

output theory has also been used to analyze the non-substitution theorem, which allows researchers to apply a fixed technological structure while restricting the subject of analysis to transformations within final demand. Substitution of technology will always take place in any industry when new technology is introduced into any component (industry and sector) of the economy. Larger influences are typically foreseeable for intermediate industries, as they have much greater and wider feedback on economy-wide systems of production.

In order to consider all technology substitution possibilities, we have proposed a methodology to measure the sector-wise elasticity of substitution for the CES production function, rather than using uniform a priori elasticities of substitution (such as zeros and ones) when modeling economy-wide, multisector, and multifactor production systems. A dual analytical method (i.e., unit cost functions) was used to evaluate the influences on general equilibrium technological substitutions and, eventually, on the social costs and benefits initiated by the introduction of innovations, which we treat as gains in productivity. We have found that the more elastic production functions (Cobb–Douglas and CES) have more significant and wider transmission effects, whereas inelastic production functions (Leontief) have relatively less effects that are polarized. Applications and extensions of this framework could be substantial, including international, dynamic, and quality considerations that remain open for future investigations.

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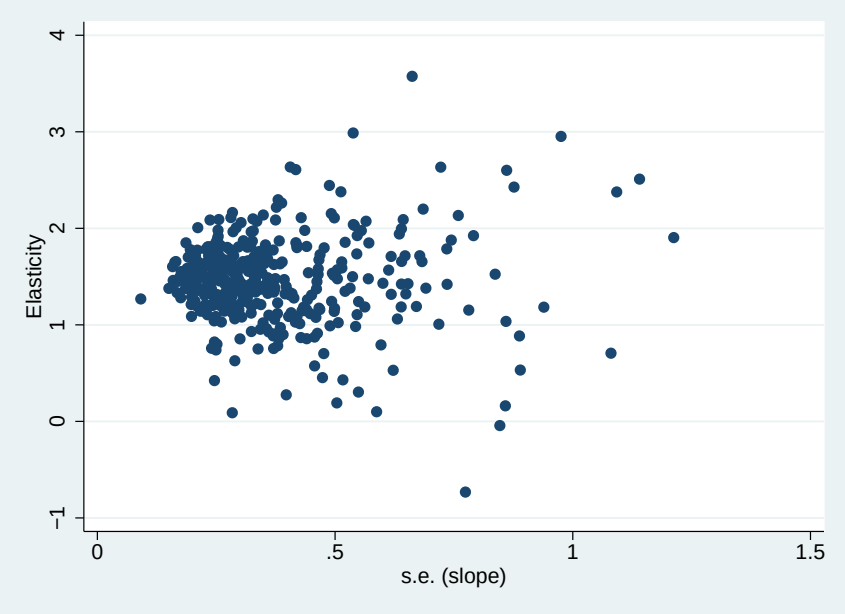

Figure 1: CES elasticity vs significance (Japan)

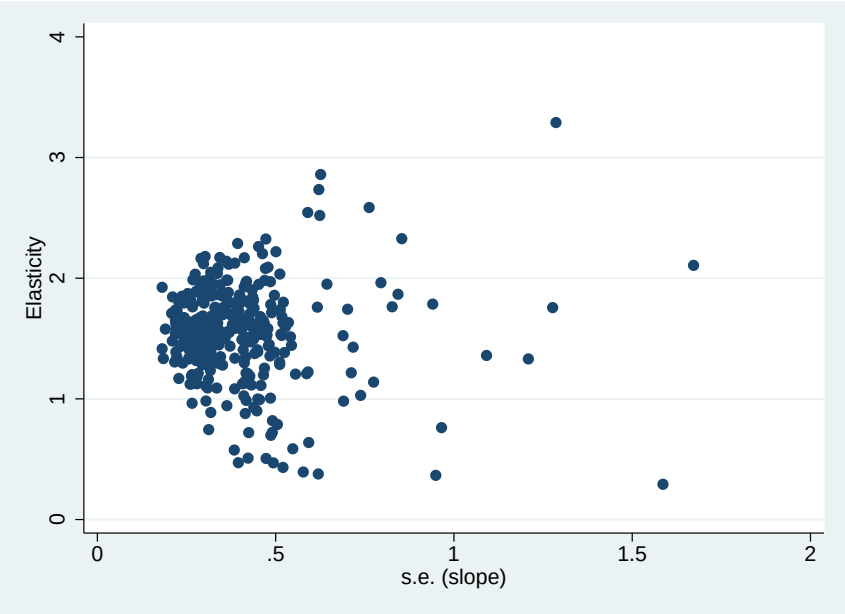

Figure 2: CES elasticity vs significance (Korea)

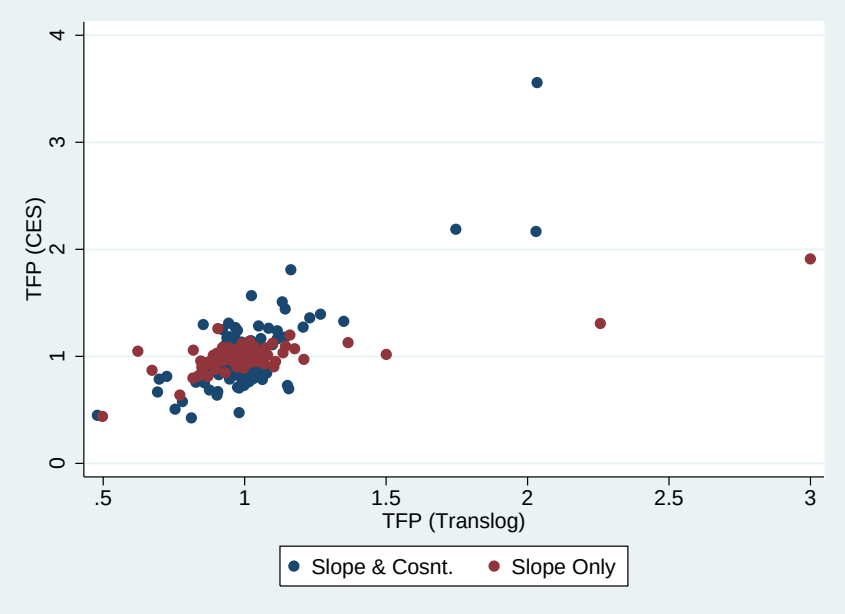

Figure 3: TFP (index) of different measurements. (Japan)

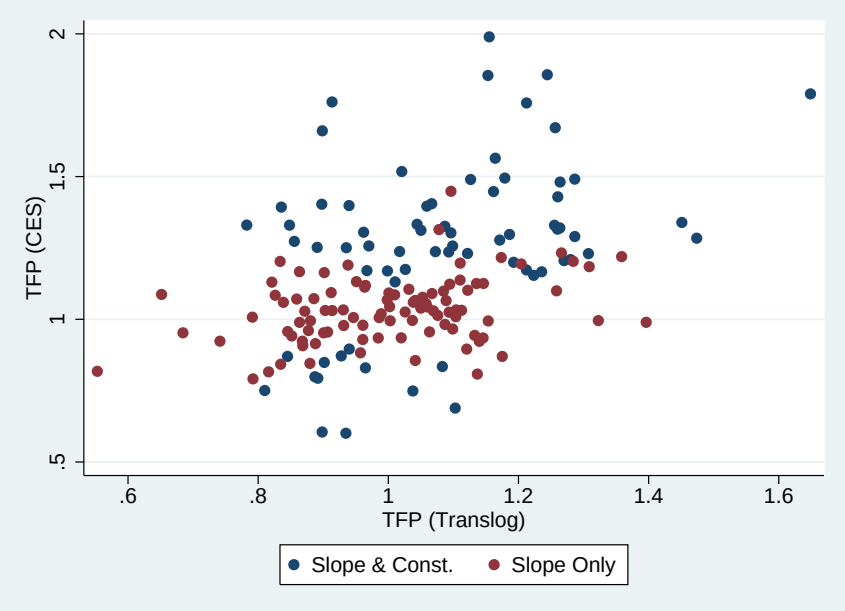

Figure 4: TFP (index) of different measurements. (Korea)

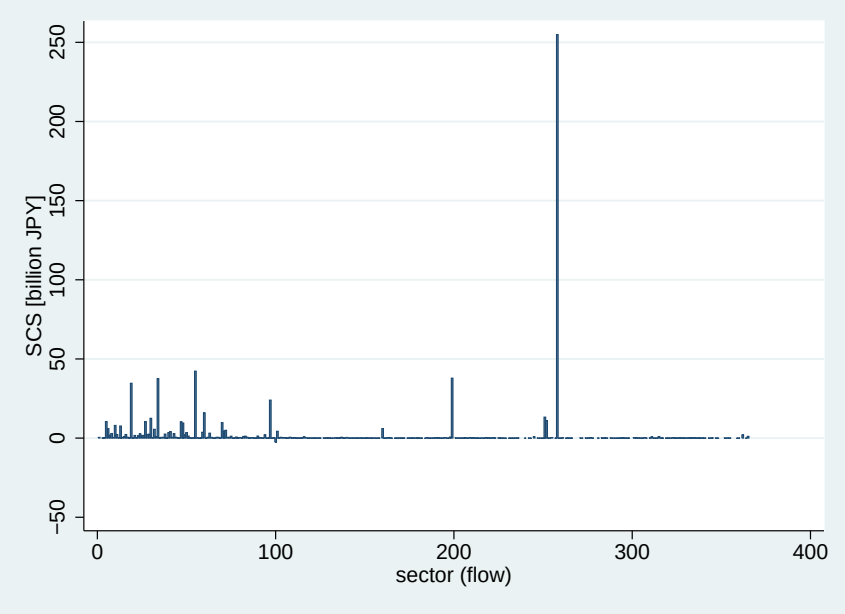

Figure 5: Sectoral distribution of SCS for productivity doubling of the RMC sector (150th) for Leontief system. (Japan)

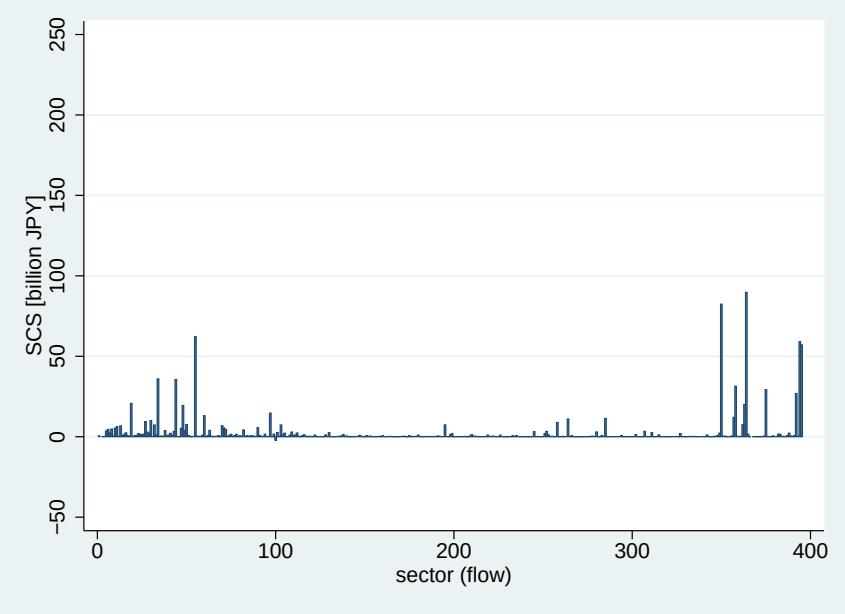

Figure 6: Sectoral distribution of SCS for productivity doubling of RMC sector (150th) for Cobb–Douglas system. (Japan)

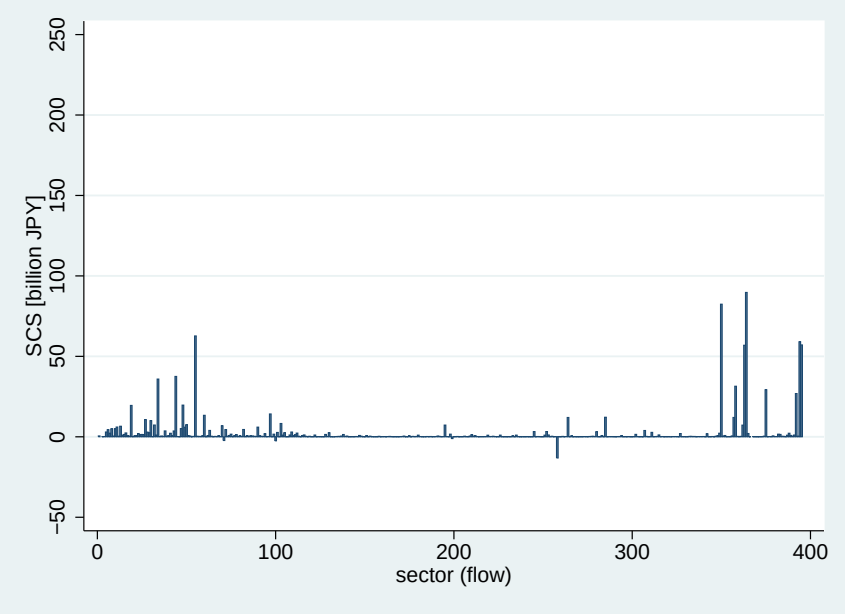

Figure 7: Sectoral distribution of SCS for productivity doubling of RMC sector (150th) for multifactor CES system. (Japan)

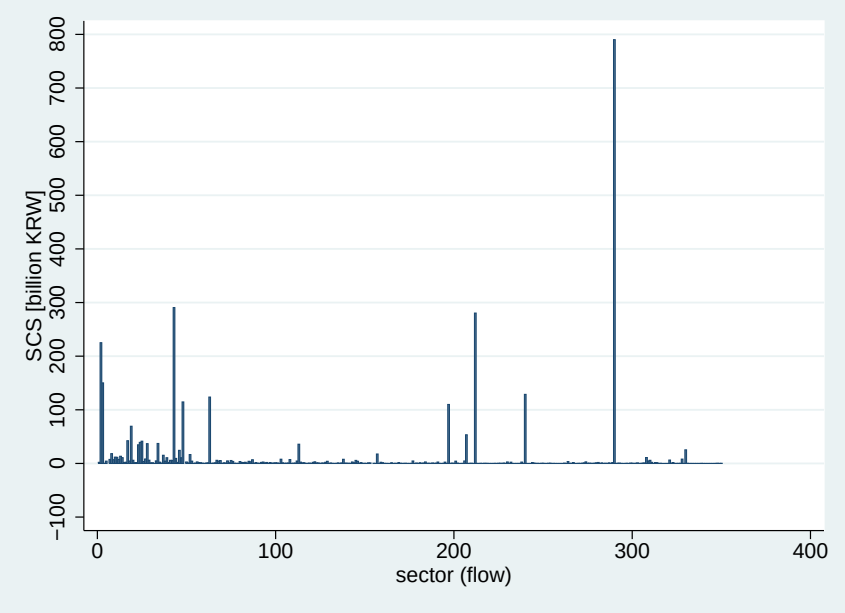

Figure 8: Sectoral distribution of SCS for productivity doubling of RMC sector (159th) for Leontief system. (Korea)

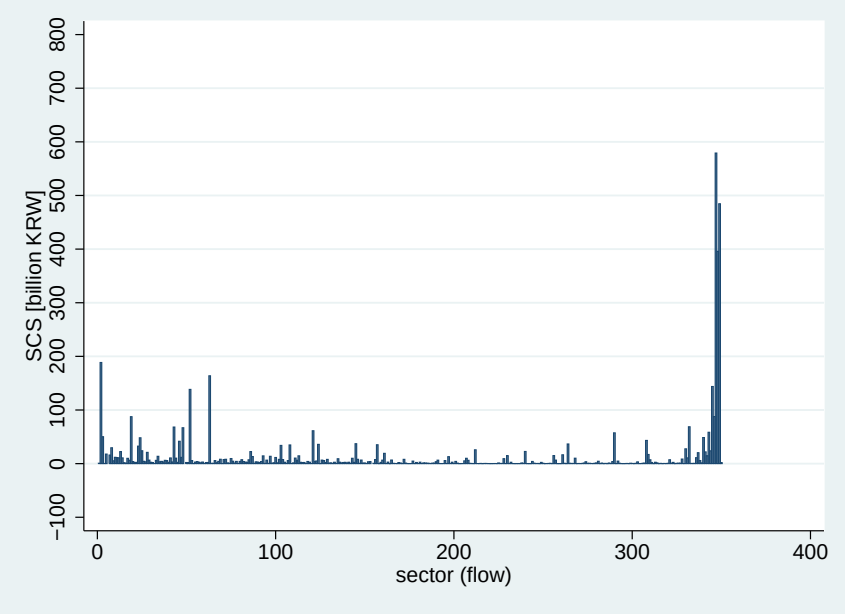

Figure 9: Sectoral distribution of SCS for productivity doubling of RMC sector (159th) for Cobb–Douglas system. (Korea)

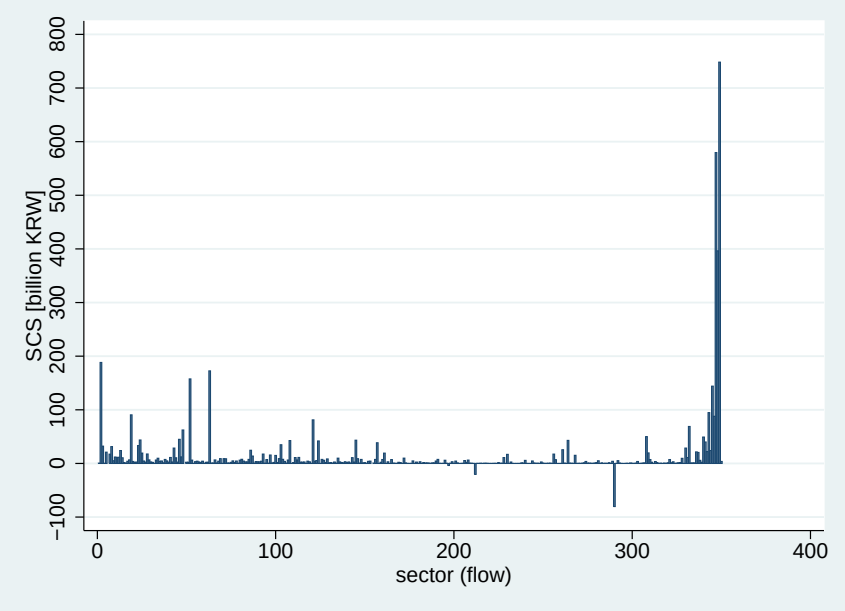

Figure 10: Sectoral distribution of SCS for productivity doubling of RMC sector (159th) for CES system. (Korea)

Table 3: CES Elasticities and Productivity Growths (Japan 2000–2005)

sector	Elasticity	TFPg	Obs.
Rice	1.709	0.097	70
Wheat, barley and the like	2.952 *	0.081	58
Potatoes and sweet potatoes	1.590	−0.003	61
Pulses	1.904	−0.153	53
Vegitables	1.715	0.136	76
Fruits	1.488	−0.224	70
Sugar crops	2.133	−0.116	55
Crops for beverages	1.140	−1.153	47
Other edible crops	1.878	−0.005	46
Crops for feed and forage	2.988 ***	−0.207 ***	56
Seeds and seedlings	1.655	−0.024	73
Flowers and plants	1.036	−2.183	73
Other inedible crops	1.371	−0.067	66
Dairy cattle farming	1.787	0.248 *	76
Hen eggs	2.377	0.192 **	58
Fowls and broilers	2.199 *	0.332 ***	55
Hogs	0.706	−0.772	69
Beef cattle	2.428	−0.025	71
Other livestock	1.855	0.126 *	70
Veterinary service	1.238	−0.179	77
Agricultural services (except veterinary service)	1.199	−0.200	96
Silviculture	−0.043	−0.183 **	88
Logs	0.532	0.521	71
Special forest products (inc. hunting)	1.420	0.446	63
Fisheries	1.648 ***	−0.011	90
Marine culture	1.717 **	0.092	90
Inland water Culture	1.373	0.049	82
Metallic ores	1.634 ***	−0.799 ***	80
Materials for ceramics	0.913	1.372 **	96
Gravel and quarrying	1.409	−0.046	96
Crushed stones	1.041	−2.373 **	93
Other non-metallic ores	1.299	0.975 ***	73
Coal mining , crude petroleum and natural gas	1.850 ***	−0.277 ***	87
Slaughtering and meat processing	1.148	0.177	74
Processed meat products	1.358	−0.021	95
Bottled or canned meat products	1.106	0.739	87
Dairy farm products	1.530	0.206 **	100
Frozen fish and shellfish	2.074 *	0.449 ***	78
Salted, dried or smoked seafood	1.348	0.278	90
Bottled or canned seafood	1.243	0.145	83
Fish paste	1.536	−0.006	101
Other processed seafood	1.435	0.371 **	100
Grain milling	1.190	0.136	70
Flour and other grain milled products	1.413	0.459 ***	82
Noodles	1.669 **	0.151 *	106
Bread	1.664 **	−0.015	109
Confectionery	1.807 ***	0.080	119
Bottled or canned vegetables and fruits	1.227	−0.288	86
Preserved agricultural foodstuffs (other than bottled or canned)	1.370	0.305 **	96
Sugar	1.492 **	−0.044	81
Starch	1.417	0.339 *	73
Dextrose, syrup and isomerized sugar	1.405 **	0.133 **	76
Vegetable oils and meal	1.200	0.668 ***	105
Animal oils and fats	1.421	−0.136	75
Condiments and seasonings	1.310	0.067	112
Prepared frozen foods	1.535	0.209	100
Retort foods	1.543 *	0.012	90
Dishes, sushi and lunch boxes	1.761 **	0.165 ***	114
School lunch (public) **	1.153	0.094	73
School lunch (private) *	1.426	−0.551 **	42
Other foods	1.278	0.375 *	109

Continued.

sector	Elasticity	TFPg	Obs.
Refined sake	1.028	−2.946	89
Beer	1.477	−0.002	89
Whiskey and brandy	2.601 *	−0.071	86
Other liquors	1.942	−0.085	95
Tea and roasted coffee	1.373	0.653 ***	89
Soft drinks	1.653	0.181	95
Manufactured ice	0.984	−1.444	61
Feeds	1.171	1.984 ***	105
Organic fertilizers, n.e.c.	0.454	−0.521 ***	79
Tobacco	1.567	0.404 **	99
Fiber yarns	1.851 **	−0.094	92
Cotton and staple fiber fabrics (inc. fabrics of synthetic spun fibers)	1.159	−0.805 **	78
Silk and artificial silk fabrics (inc. fabrics of synthetic filament fibers)	1.261	−0.699 ***	79
Woolen fabrics, hemp fabrics and other fabrics	0.792	−0.585	77
Knitting fabrics	0.906	0.912 *	86
Yarn and fabric dyeing and finishing (processing on commission only)	0.954	1.141	107
Ropes and nets	1.454	−0.152	92
Carpets and floor mats	0.702	0.651 ***	83
Fabricated textiles for medical use	1.414	−0.107	66
Other fabricated textile products	1.426	0.206 **	116
Woven fabric apparel	1.577 *	−0.065	99
Knitted apparel	2.031 *	−0.084	105
Other wearing apparel and clothing accessories	1.800 *	−0.270 ***	107
Bedding	1.478	−0.199	89
Other ready-made textile products	1.390	−0.005	99
Timber	1.241	0.348	77
Plywood	1.713 **	−0.126	84
Wooden chips	1.626 *	−0.350 ***	62
Other wooden products	1.716 ***	−0.035	158
Wooden furniture and fixtures	2.086 ***	0.004	143
Wooden fixtures	1.223	0.218	112
Metallic furniture and fixture	1.775 **	0.103	122
Pulp	2.634 **	−0.028	102
Paper	1.340	0.016	114
Paperboard	1.341	−0.079	108
Corrugated cardboard	1.324	−0.413	82
Coated paper and building (construction) paper	1.197	−0.063	108
Corrugated card board boxes	1.234	−0.271	89
Other paper containers	1.122	−0.136	96
Paper textile for medical use	1.428	−0.105	104
Other pulp, paper and processed paper products	1.517 **	0.035	123
Printing, plate making and book binding	1.581	0.086	125
Chemical fertilizer	1.608 *	0.012	111
Industrial soda chemicals	1.147	0.475	94
Inorganic pigment	1.581 **	0.233 ***	102
Compressed gas and liquefied gas	1.593 *	0.041	79
Salt	0.885	−1.737	73
Other industrial inorganic chemicals	1.643 **	0.026	114
Petrochemical basic products	1.798 *	−0.200	87
Petrochemical aromatic products (except synthetic resin)	1.326	0.356	83
Aliphatic intermediates	1.461 *	0.214 **	107
Cyclic intermediates	1.784 ***	0.367 ***	103
Synthetic rubber	1.465	0.192	98
Methane derivatives	1.210	0.085	82
Oil and fat industrial chemicals	1.555 *	0.047	89
Plasticizers	2.262 ***	−0.153 ***	82
Synthetic dyes	1.868 ***	0.165 ***	95
Other industrial organic chemicals	1.687 *	0.115	116
Thermo-setting resins	1.058	2.743 ***	104
Thermoplastics resins	1.190	0.945 ***	99
High function resins	0.905	−0.217	96
Other resins	0.961	−2.054	94

Continued.

sector	Elasticity	TFPg	Obs.
Rayon and acetate	0.990	14.826 **	86
Synthetic fibers	1.636 *	−0.065	97
Medicaments	1.976 *	0.132	133
Soap, synthetic detergents and surface active agents	1.086	−0.678	111
Cosmetics, toilet preparations and dentifrices	1.576 *	0.074	103
Paint and varnishes	1.703 ***	0.047	123
Printing ink	1.348	0.242 *	100
Photographic sensitive materials	1.581 **	0.283 **	104
Agricultural chemicals	1.307	−0.007	92
Gelatin and adhesives	1.364	0.114	119
Other final chemical products	1.782 ***	0.048	148
Petroleum refinery products (inc. greases)	1.353	1.768 ***	98
Coal products	1.979 **	0.593 ***	89
Paving materials	1.183	−0.204	89
Plastic products	1.431	−0.090	167
Tires and inner tubes	1.517 *	0.072	100
Rubber footwear	1.513	−0.267	105
Plastic footwear	1.965 ***	−0.095 **	106
Other rubber products	1.740 ***	0.052	123
Leather footwear	0.886	0.567	95
Leather and fur skins	0.874	0.373	87
Miscellaneous leather products	1.397	−0.250 **	119
Sheet glass and safety glass	1.021	0.246	107
Glass fiber and glass fiber products, n.e.c.	1.774 ***	−0.002	104
Other glass products	2.006 ***	−0.060	105
Cement	1.577 **	0.000	101
Ready mixed concrete	0.869	0.679 *	88
Cement products	1.223	−0.121	116
Pottery, china and earthenware	2.073 ***	−0.089 *	117
Clay refractories	1.656 ***	−0.022	107
Other structural clay products	1.485 **	0.010	105
Carbon and graphite products	1.308	−0.050	104
Abrasive	1.363 *	0.025	124
Miscellaneous ceramic, stone and clay products	1.455 ***	0.004	145
Pig iron	1.600 **	−0.680 *	167
Ferro alloys	1.652 *	−0.823	83
Crude steel (converters)	2.635 ***	−0.377 ***	97
Crude steel (electric furnaces)	1.870 **	−0.226	94
Hot rolled steel	2.138 ***	−0.207	95
Steel pipes and tubes	0.973	−11.035 *	96
Cold-finished steel	1.422	0.315	95
Coated steel	1.981 ***	0.004	98
Cast and forged steel	1.013	22.002 ***	83
Cast iron pipes and tubes	1.805 **	−0.102	88
Cast and forged materials (iron)	2.091 ***	−0.026	131
Iron and steel shearing and slitting	2.379 ***	−0.265 *	81
Other iron or steel products	1.345 *	0.231	79
Copper	2.110 **	−0.448	75
Lead and zinc (inc. regenerated lead)	1.340	0.659 *	83
Aluminum (inc. regenerated aluminum)	1.061	−3.066	80
Other non-ferrous metals	0.192	−0.529	149
Electric wires and cables	1.566 ***	0.051	119
Optical fiber cables	1.634 **	−0.360 ***	113
Rolled and drawn copper and copper alloys	1.829 **	−0.166	81
Rolled and drawn aluminum	1.824 *	−0.063	84
Non-ferrous metal castings and forgings	1.615 **	−0.034	121
Nuclear fuels	1.085	1.572 **	51
Other non-ferrous metal products	2.152 **	−0.549 **	86
Metal products for construction	1.497 **	0.040	134
Metal products for architecture	1.142	0.195	122
Gas and oil appliances and heating and cooking apparatus	1.568 ***	0.069	131
Bolts, nuts, rivets and springs	1.763 ***	−0.060	130

Continued.

sector	Elasticity	TFPg	Obs.
Metal containers, fabricated plate and sheet metal	1.780 ***	0.104 **	132
Plumber's supplies, powder metallurgy products and tools	1.596 ***	0.057	126
Other metal products	1.774 ***	0.087 *	143
Boilers	1.646 **	0.217 ***	118
Turbines	1.689 ***	0.783 ***	117
Engines	1.859 ***	−0.026	127
Conveyors	1.408 **	−0.005	136
Refrigerators and air conditioning apparatus	1.375	0.410 ***	140
Pumps and compressors	2.111 ***	0.085 **	127
Machinists' precision tools	1.285	0.452 ***	126
Other general industrial machinery and equipment	1.386 *	0.116	138
Machinery and equipment for construction and mining	1.308	−0.220	129
Chemical machinery	1.528 **	−0.176 **	130
Industrial robots	1.520 **	−0.117	122
Metal machine tools	1.469	−0.234 *	127
Metal processing machinery	1.654 ***	−0.192 ***	126
Machinery for agricultural use	1.576 **	0.030	140
Textile machinery	2.218 ***	−0.169 ***	136
Food processing machinery and equipment	1.562 **	−0.116 *	122
Semiconductor making equipment	1.453 **	0.099	140
Other special machinery for industrial use	1.646 **	0.026	144
Metal molds	1.894 ***	0.035	125
Bearings	1.627 ***	0.086	112
Other general machines and parts	1.644 ***	−0.013	141
Copy machine	1.210	−0.609 ***	130
Other office machines	1.154	0.473	131
Machinery for service industry	1.378 **	−0.233 **	127
Rotating electrical equipment	1.457 **	−0.172 **	125
Transformers and reactors	1.600 **	−0.102	122
Relay switches and switchboards	1.270	−0.072	139
Wiring devices and supplies	1.784 ***	−0.019	126
Electrical equipment for internal combustion engines	1.483 **	−0.021	128
Other electrical devices and parts	1.388 **	−0.246 ***	140
Applied electronic equipment	1.455 **	0.160 *	131
Electric measuring instruments	1.362 *	−0.399 ***	126
Electric bulbs	1.570 **	0.125 *	101
Electric lighting fixtures and apparatus	0.755	0.224	123
Batteries	1.640 **	−0.317 ***	127
Other electrical devices and parts	2.059 ***	0.121	123
Household air-conditioners	1.246	0.509 **	148
Household electric appliances (except air-conditioners)	1.333 **	0.182	151
Video recording and playback equipment	2.007 ***	0.773 ***	134
Electric audio equipment	1.376	0.411 ***	144
Radio and television sets	0.900	−4.189 **	123
Wired communication equipment	2.164 ***	−0.243 ***	148
Cellular phones	1.143	3.108	145
Radio communication equipment (except cellular phones)	1.367	−0.265 **	147
Other communication equipment	0.758	−0.323 *	139
Personal Computers	1.455 *	0.647	124
Electronic computing equipment (except personal computers)	1.668 ***	0.268	124
Electronic computing equipment (accessory equipment)	1.871 ***	0.412 ***	130
Semiconductor devices	1.476	0.013	122
Integrated circuits	1.269	−0.693	124
Electron tubes	1.825 ***	0.018	114
Liquid crystal element	2.296 ***	1.269 ***	114
Magnetic tapes and discs	1.479	0.348	119
Other electronic components	1.746 ***	−0.049	150
Passenger motor cars	1.703 **	−0.135 *	121
Trucks, buses and other cars	1.488	0.277 ***	123
Two-wheel motor vehicles	1.088	−0.187	97
Motor vehicle bodies	1.592 *	−0.139	123
Internal combustion engines for motor vehicles and parts	1.803 ***	0.010	129

Continued.

sector	Elasticity	TFPg	Obs.
Motor vehicle parts and accessories	1.701 ***	0.137 **	150
Steel ships	1.451 ***	0.307 ***	155
Ships (except steel ships)	1.081	2.768	140
Internal combustion engines for vessels	1.808 **	0.057	113
Repair of ships	1.378 **	0.239 ***	140
Rolling stock	1.808 ***	−0.284 ***	136
Repair of rolling stock	1.712 ***	−0.052	115
Aircrafts	1.684 **	−0.103	119
Repair of aircrafts	1.657	−0.308 **	60
Bicycles	1.728	−0.233 **	111
Other transport equipment	1.973 ***	−0.089	138
Camera	0.628	−0.212	113
Other photographic and optical instruments	0.423 **	−0.014	125
Watches and clocks	1.471 ***	−0.339 ***	119
Professional and scientific instruments	1.289	−0.010	118
Analytical instruments, testing machine, measuring instruments	0.823	0.003	149
Medical instruments	0.090 ***	−0.052	149
Toys and games	1.123	0.895 *	133
Sporting and athletic goods	1.578 **	0.077	133
Musical instruments	1.237	0.137	112
Audio and video records, other information recording media	1.488 *	−0.135 *	93
Stationery	1.030	−0.796	125
Jewelry and adornments	1.142	0.559 **	172
”Tatami” (straw matting) and straw products	1.525	−0.390 *	67
Ordnance	1.358	0.235	122
Miscellaneous manufacturing products	1.622 ***	0.071	178
Residential construction (wooden)	1.445	0.132	153
Residential construction (non-wooden)	1.202	0.231	157
Non-residential construction (wooden)	1.183	0.109	149
Non-residential construction (non-wooden)	1.316	0.124	159
Repair of construction	1.212	0.190	144
Public construction of roads	0.855	−0.437	153
Public construction of rivers, drainages and others	1.063	0.363	153
Agricultural public construction	2.039 *	0.062	142
Railway construction	0.740	−0.488 ***	146
Electric power facilities construction	0.800	−0.029	148
Telecommunication facilities construction	1.309	0.115	138
Other civil engineering and construction	0.931	−0.922	150
Electricity	1.476 *	−0.052	96
Private power generation	1.007	−32.744	78
Gas supply	1.674	0.126	91
Steam and hot water supply	0.100	0.178	53
Water supply	1.315	−0.033	96
Industrial water supply	1.117	1.011 *	62
Sewage disposal **	1.734 ***	−0.013	84
Waste management services (public) **	1.522	−0.610 ***	87
Waste management services (private)	1.421	0.231 **	87
Wholesale trade	1.334	−0.183 *	119
Retail trade	1.413	−0.483 ***	114
Financial service	0.275 *	0.260 ***	99
Life insurance	1.023	2.589	86
Non-life insurance	0.855	−1.897 ***	79
Real estate agencies and managers	0.927	−0.236	81
Real estate rental service	0.304	−0.210 *	84
House rent	0.857	−0.062	87
Railway transport (passengers)	2.086 ***	−0.040	110
Railway transport (freight)	1.918 ***	0.154 ***	99
Bus transport service	0.784	0.613 **	86
Hired car and taxi transport	0.430	0.118	84
Road freight transport(exceptSelf-transport by private cars)	1.159	−0.699 **	91
Ocean transport	1.173	0.974	101
Coastal and inland water transport	1.247	−0.630 ***	103

Continued.

sector	Elasticity	TFPg	Obs.
Harbor transport service	1.105	−0.759 ***	94
Air transport	1.534	0.248 **	103
Consigned freight forwarding	−0.732 **	−0.239 *	91
Storage facility service	1.602 **	−0.404 ***	103
Packing service	1.299	−0.141	101
Facility service for road transport	1.088	−0.161	85
Port and water traffic control **	1.078	−0.604	83
Services relating to water transport	1.540	−0.258 **	84
Airport and air traffic control (public) **	1.412	−0.099	86
Airport and air traffic control (industrial)	1.143	−0.572 **	82
Services relating to air transport	1.195	−0.057	108
Travel agency and other services relating to transport	0.161	−0.014	73
Postal service and mail delivery	1.423	0.394 *	90
Fixed telecommunication	0.750	0.573 **	101
Mobile telecommunication	1.924	−0.144	73
Other services relating to communication	2.444 ***	0.019	63
Public broadcasting	1.188	−0.402 *	88
Private broadcasting	1.101	−1.329 ***	91
Cable broadcasting	1.116	−1.439 ***	81
Information services	1.459	0.032	98
Internet based services			-2
Image information production and distribution industry	1.678 **	−0.201 **	117
Newspaper	1.529 **	0.007	97
Publication	1.470 *	0.029	103
News syndicates and private detective agencies	1.434 *	−0.045	72
Public administration (central) **	1.603 ***	0.223 ***	217
Public administration (local) **	1.228	−0.301 **	124
School education (public) **	1.849	−0.013	106
School education (private) *	1.716	−0.563 ***	107
Social education (public) **	1.812 *	−0.238 ***	91
Social education (private, non-profit) *	1.321	−0.464	76
Other educational and training institutions (public) **	1.418	−1.458 ***	90
Other educational and training institutions (profit-making)	1.748 **	0.079	72
Research institutes for natural science (pubic) **	2.090 *	−0.745 ***	88
Research institutes for cultural and social science (public) **	1.995	−0.968 ***	62
Research institutes for natural sciences (private, non-profit) *	1.380	−2.144 ***	59
Research institutes for cultural and social science (private,non-profit) *	1.183	−5.944 ***	47
Research institutes for natural sciences (profit-making)	2.108 **	−0.855 ***	91
Research institutes for cultural and social science (profit-making)	2.510	−0.211 **	50
Research and development (intra-enterprise)	1.461 **	−0.317 ***	124
Medical service (public)	1.808 ***	−0.087 **	151
Medical service (non-profit foundations, etc.)	1.812 ***	−0.021	152
Medical service (medical corporations, etc.)	1.622 **	0.168 **	154
Health and hygiene (public) **	1.496 ***	0.033	89
Health and hygiene (profit-making)	1.509 **	0.059	92
Social insurance (public) **	1.292	−0.274 **	68
Social insurance (private, non-profit) *	1.370	−0.190 **	68
Social welfare (public) **	1.479 **	−0.201 ***	140
Social welfare (private, non-profit) *	1.460 ***	−0.072	141
Social welfare (profit-making)	1.268 ***	0.251 ***	141
Nursing care (In-home)	1.552 ***	−0.095 **	151
Nursing care (In-facility)	1.585 ***	0.101 **	157
Private non-profit institutions serving enterprises	1.586 *	−0.450 ***	89
Private non-profit institutions serving households, n.e.c. *	1.391 *	0.242 ***	103
Advertising services	1.964 ***	0.018	101
Goods rental and leasing (except car rental)	1.126	−1.000	111
Car rental and leasing	1.448	0.201	76
Repair of motor vehicles	1.442 *	−0.052	112
Repair of machine	1.622 **	−0.153 *	143
Building maintenance services	1.260	−0.264	80
Judicial, financial and accounting services	1.316	0.290	78
Civil engineering and construction services	1.632	−0.145	90

Continued.

sector	Elasticity	TFPg	Obs.
Worker dispatching services	1.469	0.400 ***	79
Other business services	2.098 ***	0.270 ***	120
Movie theaters	0.530	−0.129	74
Performances (except otherwise claasified), theatrical comranies	1.321	0.129	106
Amusement and recreation facilities	1.380	−0.107	100
Stadiums and companies of bicycle, horse, motorcar and motorboat races	1.735	−0.313 ***	103
Sport facility service, public gardens and amusement parks	1.571	−0.220 *	114
Other amusement and recreation services	1.185	−0.975 **	103
General eating and drinking places (except coffee shops)	1.211	−0.119	146
Coffee shops	1.183	−0.326 *	137
Eating and drinking places for pleasures	1.281	−0.098	145
Accommodations	1.825 ***	−0.084 **	159
Cleaning	1.655 **	−0.103 *	86
Barber shops	1.657 ***	−0.148 ***	84
Beauty shops	1.459 *	−0.126	89
Public baths	1.544 *	−0.188 **	92
Other cleaning, barber shops, beauty shops and public baths	1.186	−1.225 **	88
Photographic studios	1.499	−0.399 ***	96
Ceremonial occasions	1.087	1.733 ***	152
Miscellaneous repairs, n.e.c.	0.575	0.099	114
Supplementary tutorial schools, instruction services for arts, culture and technical skills	1.431	−0.101	110
Other personal services	1.925 *	−0.155 **	111
Office supplies	2.608 ***	−0.015	27
Activities not elsewhere classified	3.575 ***	0.047	177

Table 4: CES Elasticities and Productivity Growths (Korea 2000–2005)

sector	Elasticity	TFPg	Obs.
Unmilled rice	0.378	0.178	78
Barley	1.763	0.284	59
Wheat	1.786	0.643 **	25
Misc. cereals	0.367	−0.312	46
Vegetables	1.216	−0.383	101
Fruits	1.029	−11.848 **	90
Pulses	1.867	0.276 *	49
Potatoes	1.139	−0.725	46
Oleaginous crops	1.760	−0.376 **	46
Cultivated medicinal herbs	0.762	1.712 **	58
Other edible crops	2.586 **	−0.139	54
Cotton and hemp	0.981	−1.223	22
Horticultural specialities	1.963	0.063	101
Natural rubber			
Seeds and seedlings	0.638	−0.549 *	95
Other Inedible crops	0.292	1.230 *	16
Dairy farming	0.471	−0.360 **	117
Beef cattle	0.506	−0.941 **	119
Pigs	0.509	−0.788 **	120
Poultry and birds	0.987	−16.635 **	122
Other animals	0.723	−0.836	102
Operation of timber tracts	0.470	0.004	92
Raw timber	0.587	0.178	46
Edible forest products	0.698	0.308	74
Misc. forest products	1.214	−0.617	68
Fishing	1.289	0.246	160
Aquaculture	1.160	1.010 ***	126
Agriculture, forestry and fishing related services	1.681	−0.770 ***	131
Anthracite	2.325 ***	0.122	128
Bituminous coal			
Crude petroleum and Natural gas			
Iron ores	1.801	−0.060	78
Copper ores			
Lead and zinc ores	2.107	−0.210	7
Misc. non-ferrous metal ores	2.328	0.421 ***	48
Sand and gravel	2.520 **	−0.201	109
Crushed and broken stone abd Other bulk stones	1.787 *	−0.044	116
Limestone	1.648	0.067	122
Materials for ceramics	1.494	−0.003	113
Crude salt	1.782	0.312 ***	91
Misc. non-metallic minerals	2.262 ***	0.185	104
Slaughtering and meat processing	1.255	0.280	101
Poultry slaughtering and processing	1.428	0.189	91
Prepared meat products	1.650	0.274 **	138
Dairy products	1.971 **	0.157 *	140
Canned seafoods	1.331	1.047 *	106
Frozen fish and seafoods	1.756	−1.440 ***	98
Salted, dried and smoked seafoods	3.290 *	0.084	94
Misc. processed seafoods	1.360	1.289 ***	109
Polished rice	1.285	0.473	92
Polished barley	1.209	−0.250	69
Flour and cereal preparations	1.743	−0.519 **	98
Raw sugar			
Refined sugar	1.533	−0.253	97
Starches	2.220 **	−0.137 *	98
Glucose, glucose syrup and maltose	1.611	0.118	106
Bakery and confectionery products	1.819 *	0.213 **	170
Noodles	1.294	0.512 *	131
Seasonings	1.636	0.037	149
Soy sauce ad bean paste	1.750 *	0.008	123
Animal and marine fats and oils	1.188	0.951 *	103

Continued.

sector	Elasticity	TFPg	Obs.
Vegetable fats and oils, and processed edible refined oil	1.514	0.106	123
Canned or cured fruits and vegetables	1.761 *	−0.034	135
Coffee and tea	1.550	−0.324 **	125
Ginseng products	1.686 *	0.089	100
Malt and yeast	1.629	−0.116	86
Bean curd and Misc. foodstuffs	1.572	0.192	158
Ethyl alcohol for beverages	1.666	0.070	104
Blended and distilled sojoo	1.631	−0.035	117
Beer	0.993	−38.630 ***	106
Other liquors	1.740	0.018	124
Soft drinks and Manufactured ice	1.205	0.562	137
Prepared livestock feeds	1.713 *	0.069	150
Tobacco products	1.950	−0.538 **	98
Woolen yarn	1.347	0.712 ***	109
Cotton yarn	0.999	37.363	123
Silk and hempen yarn	1.006	2.922	82
Regenerated fiber yarn	1.472	1.128 ***	82
Synthetic fiber yarn	1.903 **	−0.067	120
Thread and other fiber yarns	1.915 ***	−0.004	110
Woolen fabrics	1.407	−0.031	110
Cotton fabrics	1.083	−1.519 *	123
Silk and hempen fabrics	1.982 **	0.196	106
Regenerated fiber fabrics	1.527	0.282	100
Synthetic fiber fabrics	1.852 **	0.097	124
Other fiber fabrics	1.384	−0.132	116
Knitted fabrics	1.928 **	0.064	107
Fiber bleaching and dyeing	1.949 **	0.058	115
Knitted wearing apparels	1.199	−0.706	124
Knitted clothing accessories	2.204 **	0.100	112
Textile wearing apparels and Clothing accessories	0.930	1.066	137
Leather wearing apparels	1.845 *	0.116	104
Fur and Fur wearing apparels	1.318	0.509 ***	121
Textile products and Misc. textile products	1.613	−0.249	154
Cordage, rope, and fishing nets	1.386	0.057	111
Leather	1.831 **	0.260 **	125
Luggage and handbags	2.172 ***	0.161 ***	114
Footwear	1.836 ***	−0.139 *	127
Other leather products	1.858 *	0.028	87
Lumber	2.081 **	−0.080	101
Plywood	1.769 *	−0.067	118
Reconstituted and densified wood	1.597	−0.409 **	113
Wooden products for construction	1.953 ***	−0.164 **	110
Wooden containers and Other wooden products	2.034 **	0.224 **	120
Pulp	1.526 *	0.273	108
Newsprint	1.708	−0.108	115
Printing paper	1.613	−0.122	138
Other raw paper and paperboard	1.808 ***	0.043	146
Corrugated paper and solid fiber boxes	1.662 **	−0.040	115
Paper containers	1.927 ***	0.107	128
Stationery paper and office paper	1.497 *	0.032	121
Other paper products	1.597 *	0.054	156
Printing	1.579 ***	0.081	139
Reproduction of recorded media	1.987 ***	0.123 **	132
Coal briquettes	1.524	0.706	74
Coke and other coal products	1.340	0.017	119
Naphtha	1.612	−0.697 **	117
Gasoline and Jet oil	1.698 **	−0.234	123
Kerosene	1.633	−0.283	122
Light oil	1.349	−0.213	122
Heavy oil	1.626	−0.359	121
Liquefied petroleum gas	1.390	−0.038	121
Lubricants	1.736 *	0.180	127

Continued.

sector	Elasticity	TFPg	Obs.
Misc. petroleum refinery products	1.793 *	−0.011	123
Petrochemical basic products	1.305	0.883	121
Petrochemical intermediate products and Other basic organic chemicals	1.876 **	0.042	159
Coal chemicals	0.394	−0.521	105
Industrial gases	1.714	−0.042	120
Basic inorganic chemicals	1.280	0.301	157
Synthetic resins	1.534	0.587 ***	151
Synthetic rubber	1.450	0.646 **	116
Regenerated cellulose fibers	1.330	0.124	95
Synthetic fibers	1.701 *	−0.073	124
Nitrogen compounds	1.759 **	0.025	110
Fertilizers	1.664	0.187	138
Pesticides and other agricultural chemicals	1.510	0.195	130
Medicaments	1.998 ***	0.207 **	171
Cosmetics and dentifrices	1.974 **	0.255 **	161
Soap and detergents	1.499	0.257 *	147
Dyes, pigments, and tanning materials	1.390	0.544 **	141
Paints, varnishes, and allied products	1.700 **	0.118	151
Printing ink	2.049 ***	0.190 ***	123
Adhesives, gelatin and sealants	1.882 **	−0.021	139
Explosives and fireworks products	1.637 **	−0.156	135
Recording media and Photographic chemical products	1.853 ***	0.031	138
Misc. chemical products	1.589 **	0.245 **	168
Primary plastic products	1.625	0.251 *	151
Industrial plastic products	1.674 **	0.014	163
Household articles of plastic material	1.721 **	0.032	120
Tires and tubes	1.477	−0.189	140
Rubber products	1.763 ***	−0.022	150
Sheet glass and primary glass products	1.985 ***	0.088	125
Industrial glass products	2.121 ***	0.292 **	165
Household glass products and others	1.940 ***	0.143 *	132
Pottery	1.560 *	0.177	151
Refractory ceramic products	1.332	−0.102	142
Clay products for construction	1.800 **	0.285 **	136
Cement	2.086 ***	0.070	150
Ready mixed concrete	2.040 ***	0.030	128
Concrete blocks, bricks, and other concrete products	1.891 ***	0.182 ***	140
Lime, gypsum, and plaster products	1.813 *	0.282 ***	130
Cut stone & stone products	1.376	0.195	130
Asbestos and mineral wool products	1.754 **	0.212 **	141
Abrasives	1.710 **	0.074	138
Asphalts	1.582	0.164	121
Misc. nonmetallic minerals products	1.680 *	0.152	136
Pig iron	1.922 ***	−0.171	134
Ferroalloys	0.819	−1.402	108
Steel ingots and semifinished products	0.887	−2.770 **	140
Steel rods and bars	1.616	0.160	124
Section steel	1.520 **	0.340 *	117
Rails and wires	1.115	1.781	127
Hot rolled steel plates and sheets	0.576	−0.661 *	135
Steel pipe and tubes, except foundry iron pipe and tubes	1.025	9.495	138
Cold rolled steel sheet, strip, and bars	0.720	−0.294	143
Iron foundries and foundry iron pipe and tubes	1.840 ***	−0.006	148
Forgings	2.125 ***	−0.289 **	118
Coated steel plates	1.210	0.032	140
Misc. primary iron and steel products	1.681	0.186	113
Copper ingots	1.526	0.312	120
Aluminium ingots	0.788	−0.232	120
Lead and zinc ingots	1.125	2.700 ***	132
Gold and silver ingots	2.860 ***	−0.186 *	108
Other nonferrous metal ingots	1.697 *	−0.097	117
Primary copper products	1.537	−0.080	130

Continued.

sector	Elasticity	TFPg	Obs.
Primary aluminium products	1.437	0.288 *	140
Other nonferrous metal casting and forgings, and primary nonferrous metals	1.560	0.175	125
Metal products for construction	1.828 **	0.019	130
Metal products for structure	1.518	0.191	146
Metal tanks and reservoirs for equipment	1.331	−0.012	125
Metal cans, barrels, and drums	1.616	0.146	128
Handtools	1.125	−0.099	141
Bolts, nuts, screws, rivets, and washers	1.688 **	−0.168	135
Fabricated wire products	1.485	−0.426 **	144
Fastening metal products	1.661 **	0.038	133
Treatment and coating of metals and Misc. fabricated metal products	1.722 **	−0.060	167
Internal combustion engines and turbines	1.649 ***	0.063	152
Parts of general-purposed machinery and equipment	1.401	0.234	154
Conveyors and conveying equipment	1.649 **	−0.110	161
Air-conditioning equipment and industrial refrigeration equipment	1.524 **	0.209	159
Boiler, Heating apparatus and cooking appliances	1.610 *	0.274 **	160
Pumps and compressors	1.601 **	−0.018	154
Misc. machinery and equipment of general purpose	1.441	0.146	171
Metal cutting type machine tools	1.201	−0.419	157
Metal forming machine tools	1.296	−0.212	153
Agricultural implements and machinery	1.620 ***	0.129	151
Construction and mining machinery	1.577 **	0.025	152
Food processing machinery	1.592 **	0.278 ***	139
Textile machinery	1.468 *	0.199	161
Metal molds and industrial patterns	1.662 **	0.169	148
Misc. machinery and equipment of special purpose	0.745	0.348	178
Motors and generators	1.731 ***	0.187 **	157
Electric transformers	1.851 ***	0.087	146
Capacitors and rectifiers, Electric transmission and distribution equipment	1.583 ***	−0.005	163
Insulated wires and cables	1.777 ***	−0.089	165
Batteries	1.404	0.275	147
Electric lamps and electric lighting fixtures	1.575 **	−0.068	156
Misc. electric equipment and supplies	1.503 *	0.082	151
Electron tubes	1.709 ***	0.393 **	155
Digital display	1.090	0.693	155
Semiconductor devices	1.542 **	0.371	158
Integrated circuits	1.181	0.331	163
Electric resistors and storage batteries	2.033 ***	0.582 ***	152
Electric coils, transformers	1.348	0.439 ***	138
Printed circuit boards	1.550 **	0.357 *	156
Misc. electronic components	1.416	0.499 *	166
Television	1.448	0.865 **	146
Electric household audio equipment	2.141 ***	0.564 ***	147
Other audio and visual equipment	1.614 *	0.402 *	160
Line telecommunication apparatuses	1.636 **	0.118	157
Wireless telecommunication and broadcasting apparatuses	1.485	0.933	159
Computer and peripheral equipment	1.660 **	0.619 *	162
Office machines and devices	1.536 *	0.332 **	150
Household refrigerators	1.795 ***	0.213 ***	148
Household laundry equipment	1.480 **	0.399 ***	141
Other household electrical appliances	1.436	0.057	156
Medical instruments and supplies	1.793 ***	0.271 **	163
Regulators and Measuring and analytical instruments	1.603 **	0.266 **	163
Photographic and optical instruments	2.116 ***	0.688 ***	161
Watches and clocks	1.615 **	0.618 ***	143
Passenger automobiles	1.674 ***	0.334 ***	151
Buses and vans	1.736 ***	0.208 ***	148
Trucks and Motor vehicles with special equipment	1.845 ***	0.229 ***	150
Motor vehicle engines, chassis, bodies and parts	1.235	0.302	184
Trailers and containers	1.391	0.407 **	131
Steel ships	1.549 **	−0.203	177
Other ships	1.888 ***	−0.287 ***	162

Continued.

sector	Elasticity	TFPg	Obs.
Ship repairing and ship parts	1.799 ***	0.154 **	147
Railroad vehicles and parts	1.537 **	0.174	153
Aircraft and parts	1.283	−0.043	155
Motorcycles and parts	1.687 **	0.095	144
Bicycles and parts and misc. transportation equipment	1.860 ***	0.400 ***	128
Wood furniture	1.495 *	0.447 ***	161
Metal furniture	1.565 **	0.006	142
Other furniture	1.090	−0.221	162
Toys and games	1.189	−0.038	157
Sporting and athletic goods	1.720 *	−0.058	155
Musical instruments	1.506 **	−0.005	151
Pens, pencils, and other artists' materials	1.794 ***	0.160 *	141
Jewelry and plated ware	1.524	0.456 **	120
Misc. manufacturing products	1.448	0.131	192
Hydroelectric power generation	1.447	0.371 *	109
Fire power generation	0.944	−3.262 *	119
Nuclear power generation	0.901	5.375 ***	122
Other generation	1.491	0.378	94
Manufactured gas supply	1.142	5.584 ***	109
Steam and hot water supply	1.472	0.413 ***	101
Water supply	1.675 **	0.285 **	120
Residential building construction	0.964	−3.307 **	174
Non-residential building construction	1.169	−0.187	178
Building repairs	1.123	0.316	164
Road construction	1.389 *	0.023	175
Railroad construction	1.432 *	−0.045	166
Breakwater, pier, and harbor construction	1.122	−0.061	156
Airport construction	1.212	−0.177	154
Dam, levee, and flood control project construction	1.371	0.172	158
Water main line and drainage project construction	1.306	−0.018	165
Land clearing and reclamation, and irrigation project construction	1.539 **	0.009	163
Land leveling and athletic field construction	1.348	−0.101	169
Electric power plant construction	1.334 *	−0.125	167
Communications line construction	1.585 **	0.006	155
Misc. construction	1.111	−3.552 ***	170
Wholesale and Retail trade	0.879	1.296 *	145
Restaurants	1.131	0.719	177
Accommodation	1.657 **	0.094	128
Railroad passenger transport	2.544 ***	−0.181 *	131
Railroad freight transport	1.452	0.602 ***	117
Road passenger transport	1.983 ***	0.285 **	127
Road freight transport	1.961 **	0.370 ***	127
Coastal and inland water transport	1.552 **	0.265 ***	130
Oceangoing transport	1.439	1.656 ***	136
Air transport	1.458	0.681 ***	153
Supporting land transport activities	1.555 **	0.507 ***	122
Supporting water transport activities	1.637 **	0.029	121
Supporting air transport activities	2.164 ***	0.339 ***	104
Cargo handling	1.861 **	−0.373 ***	118
Warehousing and storage	1.529	−0.133	126
Other services incidental to transportation	1.407	−0.540 **	117
Postal services	1.444	−1.093 ***	112
Telecommunications	1.623 *	−0.213	119
Broadcasting	0.983	−5.878	119
Central bank and banking institutions, Non-bank depository institutions	1.864 **	0.287 ***	116
Other financial brokerage institutions	1.663	0.401 ***	104
Life insurance	1.627 *	−0.005	102
Non-life insurance	1.586 *	0.250 *	103
Services auxiliary to finance and insurance	1.585	0.000	105
Owner-occupied housing	−3.798	0.119	5
Renting and subdividing of real estate	1.557	−0.235 *	119
Services related to real estate	2.091 **	−0.080	87

Continued.

sector	Elasticity	TFPg	Obs.
Research institutes(public)	1.611 **	−0.080	178
Research institutes(private, non-profit, commercial)	1.498 *	0.566 ***	148
Research and experiment in enterprise	1.415 **	−0.502 ***	221
Legal and accounting services	1.355	0.152	83
Market research and management consultancy	1.339	0.225	91
Advertising services	1.109	4.591 ***	121
Architectural engineering services	1.606 **	−0.048	139
Computer softwares development and supply	1.299	0.197	111
Computer related services	1.310	1.045 ***	107
Renting of machinery and goods	1.355	−0.678 ***	129
Cleaning and disinfection services	1.552 *	0.058	100
Misc. business services	1.337	−0.619 **	125
Public government	0.432	−0.647 ***	201
Local government	1.223	1.315 **	210
Education (public)	1.936 ***	−0.231 **	165
Education (private, non-profit)	1.525 *	−0.509 ***	144
Education (commercial)	1.682 **	0.417 ***	123
Medical and health services(public)	2.180 ***	−0.011	134
Medical and health services(Private, non-profit)	1.946 ***	−0.046	137
Medical and health services (commercial)	2.288 ***	0.030	156
Social work activities(public)	2.169 ***	0.124	117
Social work activities(other)	1.757 **	0.229 **	133
Sanitary services(public)	1.701 **	0.185	126
Sanitary services(commercial)	1.398	0.056	125
Newspapers	1.873 ***	−0.049	114
Publishing	1.473 *	0.154	120
Library, museum and similar recreation related services(public)	1.843 ***	0.112	129
Library, museum and similar recreation related services(other)	1.578 *	0.066	131
Motion picture, Theatrical producers, bands, and entertainers	1.619 ***	0.158 *	147
Sports organizations and sports facility operation	1.635 ***	0.241 **	140
Misc. amusement and recreation services	1.817 ***	0.514 ***	149
Business and professional organizations	2.735 ***	0.335 ***	91
Other membership organizations	1.855 **	0.225 **	110
Motor repair services	1.339	0.440 ***	140
Other personal repair services	1.925 ***	−0.225 ***	143
Laundry and cleaning services	1.585	0.336 **	87
Barber and beauty shops	1.559	−0.028	89
Personal services	1.977 ***	−0.110 *	120
Office supplies			
Business consumption expenditures			
Nonclassifiable activities			