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Abstract

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Keywords: CES Production Function, Linked Input–Output Tables, Information and Communication Technology, Armington Elasticities, General Equilibrium Modeling

JEL classification: C67, D57, D83, F19

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The Role of ICT Productivity in Korea–Japan Multifactor CES Productions and Trades

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Abstract

In this paper, we examine the economic impact of information and communication technology (ICT) innovation, under the general equilibrium framework, with empirically estimated constant elasticity of substitution (CES) production frontiers. Innovation can generate not only productivity growth and price changes but also changes in the economic structure of production and trade patterns, eventually increasing social welfare. To study such impact of ICT innovation, we construct a bilateral general equilibrium model, spanning 350 commodities and sectors with trades between Japan and the Republic of Korea (South Korea). We estimate all CES parameters from published statistics such as the linked input–output tables and Comtrade databases. A small exogenous productivity shock in ICT is examined in terms of potential price reduction in all commodities in both countries.

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1. Introduction

The ICT sector has become the leading sector of the global economy. According to OECD (2017), value added for the ICT sector and sub-sectors accounted for 5.4% of OECD countries total in 2015. Among 31 countries, the Republic of Korea ranked first with 10.3%. Specifically, the ICT manufacturing accounted for 7.2%, telecommunications for 1.3%, and information technology (IT) and other information services for 1.9%. Japan ranked sixth with 6.0%, of which 1.7% came from ICT manufacturing, 1.8% from telecommunications, and 2.4% from IT and other information services. Moreover, OECD (2017) demonstrated a constant rise in the spread of ICT infrastructure and a growing demand for ICT goods on trade.

Some empirical studies have shown ICT's importance in economic growth. Farhadi et al. (2012) found that ICT use had a significant effect on economic growth by using panel data of 159 sample countries. Despite numerous studies showing the important role played by the ICT sector, evidence of its contribution to economic growth in developing countries is absent. For example, the empirical results of Lee et al. (2005) indicate that ICT investments have been contributing to an improvement in economic growth in many developed and newly industrialized economies while it was insignificant in developing countries, such as China. Zuhdi et al. (2012) showed that the ICT sector played an important role in changing the structure of Japan's economy, but did not have a significant effect in Indonesia.

Although evidence of the ICT sector's importance in growth for developing countries is limited, some studies have shown its importance in Japan and South Korea (Jorgenson and Motohashi, 2005; Kanamori and Motohisa, 2007; Zuhdi et al., 2012; Jung et al., 2013; Ju, 2014). This paper attempts to bridge this research gap, using a bilateral general equilibrium model including multicommodity productions and trades between Japan and South Korea. Our model is different from the ones in previous studies in that all elasticities are estimated from published statistics, such

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as the linked input–output tables for Japan and for South Korea, and the UN Comtrade database. We thus modify the general equilibrium frameworks with Linear (Engelbrecht, 1988) and Cobb-Douglas (Martínez et al., 2010) production frontiers, by empirically estimating multifactor CES production frontiers.

Furthermore, we integrate the empirically estimated general equilibrium models of the two countries, spanning more than 350 sectors and commodities, by two-stage nested trade models that connect the commodities of the two countries. Then, we apply some small productivity shocks into the ICT sector in either or both of the two countries and monitor the commodity-wide equilibrium price changes. The ex-post structure can then be retrieved from the meta structure installed in the set of empirically estimated CES production functions. The economic impact analysis will be conducted upon this ex-post equilibrium structure.

The paper is organized as follows. In the next section, we use regression to estimate the CES elasticity. In Section 3, we explain how we can evaluate the ex-post general equilibrium prices and the corresponding structure of production (i.e., input–output coefficients). We summarize the results pertaining to small exogenous ICT productivity shocks in Section 4. Section 5 provides the concluding remarks.

2. Methodology

2.1. CES Parameters Estimation

A CES production function with $n + 1$ factor inputs is of the following form:

$$y = \theta \left(\sum_{i=0}^{n} (\lambda_i)^{\frac{1}{\sigma}} (x_i)^{\frac{\sigma-1}{\sigma}} \right)^{\frac{\sigma}{\sigma-1}} \tag{1}$$

where y denotes the output and x_i denotes the ith factor input of production. Here, $\sigma = 1 - \gamma$ is the (constant) elasticity of substitution (CES) between any two-factor inputs of production, and θ is the (total factor) productivity (TFP). The share parameters are assumed to maintain that $\sum_{i=0}^{n} \lambda_i = 1$ with $\lambda_i > 0$. The production function is assumed to have constant returns to scale. Below is the dual (unit cost) function of the production function (1):

$$c = \theta^{-1} \left(\sum_{i=0}^{n} \lambda_i (p_i)^{\gamma} \right)^{\frac{1}{\gamma}} \tag{2}$$

where p_i denotes the ith factor price and c denotes the output price, which equals the unit cost of production.

By virtue of (2), the cost share of ith factor s_i can be evaluated by the following formula:

$$s_i = \frac{p_i x_i}{cy} = \frac{\partial c}{\partial p_i} \frac{p_i}{c} = \frac{\partial \ln c}{\partial \ln p_i} = \lambda_i \left(\frac{p_i}{\theta c} \right)^{\gamma} \tag{3}$$

Note that the second equal sign is due to Shephard's lemma under constant returns to scale (homogeneous of degree one) production. By taking natural log on both sides, equation (3) can be expanded, as regards the observed data (indexed by t), as follows:

$$\ln s_{it} = \ln \lambda_i - \gamma \ln \theta_t c_t + \gamma \ln p_{it} + u_{it} \tag{4}$$

where u_{it} denote error terms. We may then estimate γ by fixed effects (within-group) regression. Here we have two temporally distant observations ($t = 0, 1$). As we indicate temporally difference by Δ, we have the following simple (fixed effects) regression.

$$\Delta \ln s_i = -\gamma \Delta \ln \theta c + \gamma \Delta \ln p_i + \Delta u_i \tag{5}$$

assuming that error terms Δu_i are IID. In other words, CES $\sigma = 1 - \gamma$ can be estimated by the slope of the regression line between the growth of cost shares $\Delta \ln s_i$ and the growth of factor prices $\Delta \ln p_i$. Moreover, the intercept of the regression line provides an estimate of productivity growth $\Delta \ln \theta$, given the growth of output price $\Delta \ln c$ and the estimate of its slope γ.

More specifically, the slope of the regression line (5) can be evaluated by:

$$\gamma = \frac{\mathrm{Cov}\,(\Delta \ln s_i, \Delta \ln p_i)}{\mathrm{Var}\,(\Delta \ln p_i)} \tag{6}$$

Also, using the estimate of the intercept of the regression line, the productivity growth $\Delta \ln \theta$ can be evaluated by:

$$-\gamma \Delta \ln \theta c = \overline{\Delta \ln s_i} - \gamma \overline{\Delta \ln p_i} \tag{7}$$

where overbar indicates arithmetic mean.

As is obvious from (5), the sample size of regression depends on the number of factor inputs n. The minimum number of factor inputs is 2 or $n = 1$, and in that case, (5) becomes a two-point regression line with $i = 0, 1$. Below we write (6-7) down for this two-factor case:

$$\gamma = \frac{\Delta \ln s_0 - \Delta \ln s_1}{\Delta \ln p_0 - \Delta \ln p_1} \tag{8}$$

$$-\gamma \Delta \ln \theta c = -\frac{\Delta \ln s_0 \Delta \ln p_1 - \Delta \ln s_1 \Delta \ln p_0}{\Delta \ln p_0 - \Delta \ln p_1} \tag{9}$$

Moreover, (2) becomes a CES aggregator function when (1) does not involve production i.e., θ = constant, or $\Delta \ln \theta = 0$. In such cases, c becomes a CES aggregator price whose growth can be evaluated by using (9) for the two-factor case, such that:

$$\Delta \ln c = \frac{\Delta \ln s_0 \Delta \ln p_1 - \Delta \ln s_1 \Delta \ln p_0}{\Delta \ln s_0 - \Delta \ln s_1} \tag{10}$$

Furthermore, one of the two-factor prices (or its growth of the second input i.e., $\Delta \ln p_1$) can be calculated back from the growth of the aggregator price $\Delta \ln c$ by:

$$\Delta \ln p_1 = \Delta \ln c - (\Delta \ln c - \Delta \ln p_0) \frac{\Delta \ln s_1}{\Delta \ln s_0} \tag{11}$$

so that γ can be obtained by plugging (11) into (8).

Finally, the share parameter λ_i can be calibrated to satisfy (3) at either of the two periods. Suppose that all prices are standardized at the current period $t = 1$ so that $p_1 = p_{i1} = 1$ for all i. Then, $\theta_1 = 1$ must hold by virtue of (2), and thus, λ_i can be calibrated according to (4), as follows:

$$\lambda_i = s_{i1} \tag{12}$$

2.2. Measurement

In this study, we construct a multi-sector and multifactor bilateral (South Korea–Japan) general equilibrium model. The substitution structure of the model is illustrated in Figure 1. We estimate the multifactor CES elasticity by using the factor-wise shares of cost (i.e., input–output coefficients) available in the 1995–, 2000–2005 linked input–output tables for both Japan (MIAC, 2011) and South Korea (BOK, 2009), choosing 2000 as the reference and 2005 as the current period.

For the estimation of substitution elasticities between domestic and imported commodities (i.e., Armington elasticities), we apply two-stage nested two-factor CES aggregator functions. We call the elasticity between domestic and foreign commodities as between group. We estimate the between-group elasticity for each input factor through two-point regression, since domestic and foreign commodity prices and value shares are available for the two periods in the linked input–output tables. Moreover, the elasticity between the commodities imported from the counterpart country and the rest of the world (ROW) is referred to as within group.[1]

[1]These terminologies of classification are adopted from Saito (2004) while Feenstra et al. (2014) use different terms.

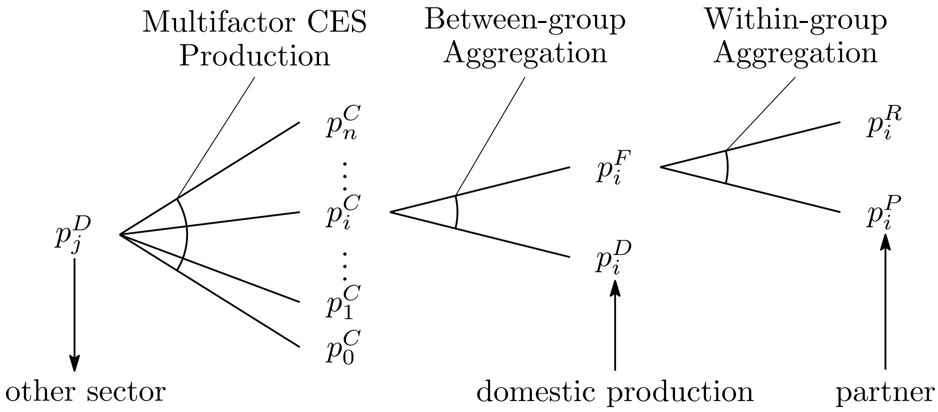

Figure 1: Substitution structure for productions and trades.

We also estimate the within-group elasticity for each input factor through two-point regression; however, in this case, we use the counterpart's domestic commodity price for one of the two-factor prices and use the foreign price as the aggregated output price for between-group elasticity estimation. The counterpart countrys money share in imports for each commodity can be calculated by the imported yens available in a set of linked input–output tables; and the imported dollars from the country are available from the UN Comtrade database (Comtrade, 2017). The database covers 6,376 commodities that we convert into the linked input–output sector classification.

2.2.1. Between-group Armington Elasticities

The between-group aggregator is the two-factor CES function that compounds the foreign (imported) and domestically produced commodities. For each commodity j (index omitted), the dual aggregator function can be written as follows:

$$\begin{aligned} p^C &= \left(\alpha \left(p^D\right)^\varepsilon + (1-\alpha) \left(p^F\right)^\varepsilon\right)^{\frac{1}{\varepsilon}} \\ &\equiv U\left(p^D, p^F\right) \end{aligned} \tag{13}$$

where p^C, p^D, and p^F denote the prices of the compound, domestic, and foreign commodity, respectively. The elasticity parameter ε is estimated by two-point calibration through (8), using the observed values of prices p^D, p^F and shares s^D, s^F for the two periods. The share parameter α is calibrated through (12) as we standardize prices at the current period. In Figure 2, we display the histogram of the between-group elasticities, in log-absolute values with base of 10, for 395 commodities for Japan (average = 1.68) and 350 commodities for Korea (average = 0.531).

2.2.2. Within-group Armington Elasticities

The within-group aggregator is a two-factor CES function that compounds one kind of commodity imported from the counterpart country and another from the ROW. For each commodity j (index omitted), the dual aggregator function can be written as follows:

$$\begin{aligned} p^F &= \left(\beta \left(p^P\right)^\eta + (1-\beta) \left(p^R\right)^\eta\right)^{\frac{1}{\eta}} \\ &\equiv V\left(p^P, p^R\right) \end{aligned} \tag{14}$$

where, p^F, p^P, and p^R denote prices of foreign, counterpart, and ROW commodity, respectively. The elasticity parameter η is estimated by two-point regression through (8) and (11) using the observed values of prices p^F, p^P and shares s^P, s^R for the two periods. The share parameter β is estimated using (12) as we standardize the prices at the current period. In Figure 2, we display the histogram of the within-group elasticities, in log-absolute values with a base of 10, for 395 commodities for Japan (average = 5.54) and 350 commodities for South Korea (average = 0.446).

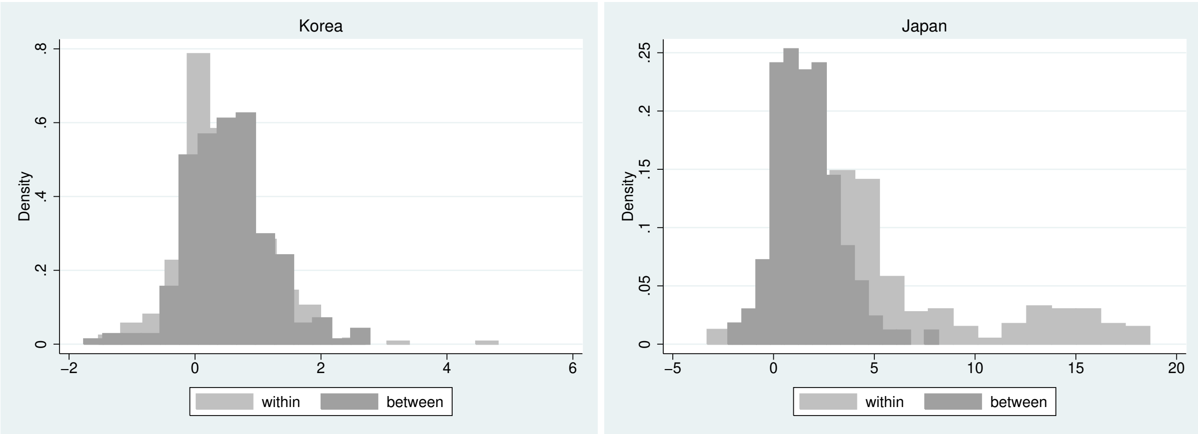

Figure 2: Histogram of empirically estimated between- and within- group Armington elasticities in log-absolute values. These two-factor elasticities are estimated by two-point regression.

2.3. CES Production Elasticities

We estimate CES elasticities for all production sectors by using the regression equation (5). We use the growth of compound factor prices $\Delta \ln p^C$ as the explanatory variable, which we obtain using the between-group aggregator (13), for each commodity. In Figure 3, we display the estimated CES elasticities for both South Korea (350 sectors) and Japan (395 sectors).

Figure 4 shows the productivity growth $\Delta \ln \theta_j$ (TFP growth) for all j sectors, which we estimate from the intercept of the regression line of (5).

Below, we display the CES unit cost function for each industrial sector j (index omitted):

$$\begin{aligned} p^D &= \theta^{-1} \left(\sum_{i=0}^{n} \lambda_i (p_i^C)^\gamma \right)^{\frac{1}{\gamma}} \\ &\equiv H\left(p_0^C, p_1^C, \cdots p_n^C; \theta\right) \end{aligned} \tag{15}$$

Note that the elasticity parameter γ_H is obtained from the slope of the regression line (5), while the share parameters are standardized at the current period so that $\lambda_{Hi} = s_i^1$ for $i = 0, 1, \cdots, n$, i.e., the current period input–output coefficients of the jth sector. Further, the current TFP level must be $\theta = 1$ in the event that we standardize all prices at the current period, so that $p^D = p_i^C = 1$. Hence, (15) is the sectoral unit cost function inclusive of *exogenous* productivity shock θ in the current period.

3. Bilateral General Equilibrium

3.1. Model Integration

Here, we construct a general equilibrium model that reflects all the estimated elasticities for the two countries. First, we will review a single country's general equilibrium state of multisectoral production. We standardize the share parameters at the current state to examine various exogenous shocks (such as productivity shocks). Below we display the system of unit cost functions (15) for the two countries, namely, Japan (labeled J) and South Korea (labeled K):

$$\mathbf{p}_J^D = H_J\left(\mathbf{p}_J^C, p_0^C; \boldsymbol{\theta}_J\right) \qquad \mathbf{p}_K^D = H_K\left(\mathbf{p}_K^C, p_0^C; \boldsymbol{\theta}_K\right) \tag{16}$$

Note that $(\theta_1, \cdots, \theta_n)$ denotes the set of exogenous productivity shocks under investigation, where $\theta = 1$ indicates a no shock condition. Moreover, the price of primary factor p_0^C is kept constant.

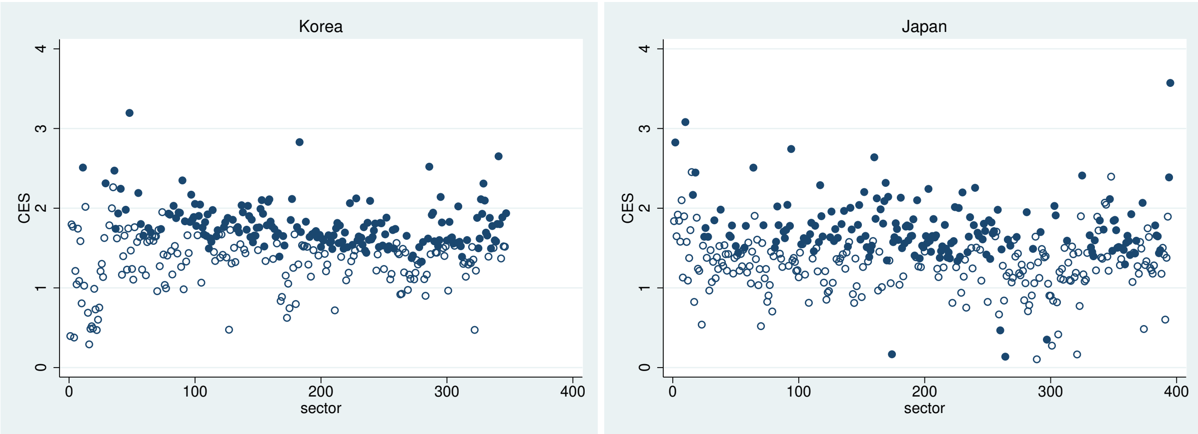

Figure 3: Empirically estimated CES i.e., $\sigma = 1 - \gamma$ for each sector. Solid dot indicates that the estimate is statistically significant at the 10% significance level. Open dot indicates that we cannot reject the null hypothesis that $\sigma = 1$ (i.e., Cobb-Douglas). The empirical model is constructed using all estimated elasticities regardless of the significance.

Below, we display the Armington aggregation functions, that is, within-group aggregation (14) and between-group aggregation (13), in a concise form:

$$\mathbf{p}_J^C = U_J\left(\mathbf{p}_J^D, \mathbf{p}_J^F\right) \qquad \mathbf{p}_K^C = U_K\left(\mathbf{p}_K^D, \mathbf{p}_K^F\right) \tag{17}$$

$$\mathbf{p}_J^F = V_J\left(\mathbf{p}_J^P; \mathbf{p}_J^R\right) \qquad \mathbf{p}_K^F = V_K\left(\mathbf{p}_K^P; \mathbf{p}_K^R\right) \tag{18}$$

where the prices of the ROW, that is, $\mathbf{p}^R$ are kept constant (under the small-country assumption). Finally, to close the model, we introduce the following identities:

$$\mathbf{p}_J^P = \mathbf{p}_K^D \qquad \mathbf{p}_K^P = \mathbf{p}_J^D \tag{19}$$

The integrated general equilibrium model comprises the equations (16-19), mapping the prices $\mathbf{p}$ i.e.,

$$\mathbf{p} = \left(\mathbf{p}_J^D, \mathbf{p}_J^C, \mathbf{p}_J^F, \mathbf{p}_J^P, \mathbf{p}_K^D, \mathbf{p}_K^C, \mathbf{p}_K^F, \mathbf{p}_K^P\right)$$

onto itself, under given productivity shock $\boldsymbol{\theta} = (\boldsymbol{\theta}_J, \boldsymbol{\theta}_K)$. Write this mapping by $G_{\boldsymbol{\theta}} : \mathbb{R}^{4(n_J+n_K)} \to \mathbb{R}^{4(n_J+n_K)}$. The fixed point of $G_{\boldsymbol{\theta}}$ can be obtained through recursion, starting from an arbitrary initial guess such as $\mathbf{1}$ for any set of exogenous productivity shock $\boldsymbol{\theta}$, since $G_{\boldsymbol{\theta}}$ is a contraction mapping. In other words, the equilibrium price $\bar{\mathbf{p}}$ can be obtained by the following procedure:

$$\bar{\mathbf{p}} = G_{\boldsymbol{\theta}}\left(\cdots G_{\boldsymbol{\theta}}\left(G_{\boldsymbol{\theta}}\left(\mathbf{1}\right)\right)\cdots\right) \tag{20}$$

3.2. Structure of Production

Let us recall from (3) that the cost share of an input i of a sector j can be obtained by the unit cost function H_j as follows:

$$s_{ij} = \frac{\partial H_j}{\partial p_i^C}\frac{p_i^C}{p_j^D} = \lambda_{ij}\left(\frac{p_i^C}{p_j^D}\right)^{\gamma_j}$$

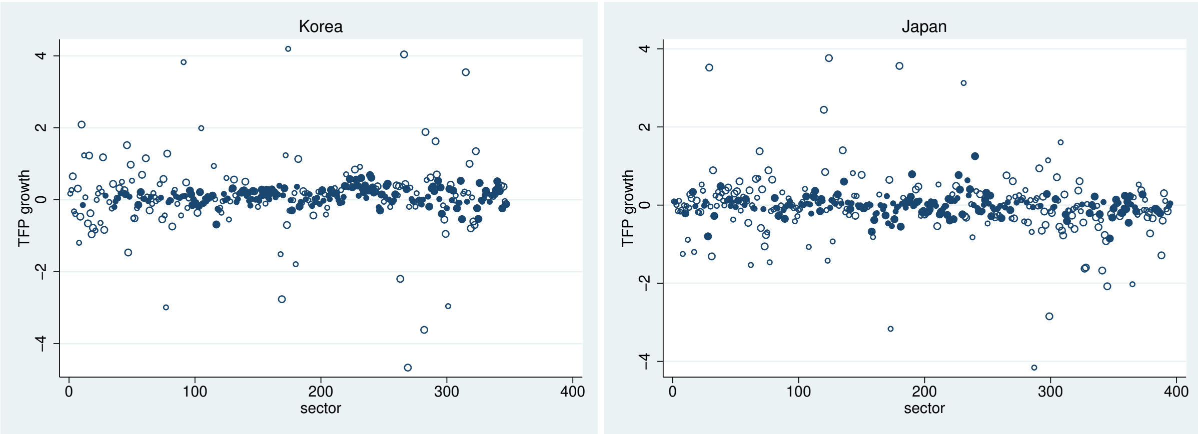

Figure 4: Empirically estimated TFP growth, i.e., $\Delta \ln \theta$ for each sector. Solid dot indicates that the slope and intercept estimators of (5) are both statistically significant at the 10% significance level. Small solid dot indicates that the intercept is significant but the slope is not. Open dot indicates that the slope is significant but the intercept is not. Small open dot indicates that neither the slope nor the intercept is significant.

In other words, we may derive the input–output coefficient matrix from the sectoral unit cost function, that is, H, by the following calculation:

$$\left\langle \mathbf{p}^C \right\rangle \nabla_n H \left\langle \mathbf{p}^D \right\rangle^{-1} = \mathbf{A} \tag{21}$$

$$\left\langle \mathbf{p}^C \right\rangle \nabla_0 H \left\langle \mathbf{p}^D \right\rangle^{-1} = \mathbf{v} \tag{22}$$

where, $\mathbf{A} = \{s_{ij}\}$ denotes an $n \times n$ monetary input–output coefficient matrix and $\mathbf{v} = \{s_{0j}\}$ denotes a $1 \times n$ primary input (or, value added) coefficient vector. Here, we use ∇_n to represent a gradient with respect to $p_1^C, \cdots, and p_n^C$ whereas ∇_0 with respect to p_0^C only. Angle brackets indicate diagonalization. We know, by (3), that (21-22) are true for the current state where the prices are standardized at $\mathbf{p}^1 = \mathbf{1}$.

Given below is the commodity balance of a single country in monetary terms:

$$\mathbf{y} = \mathbf{A}\mathbf{y} + \mathbf{f} + \mathbf{e} - \mathbf{m} \tag{23}$$

where $\mathbf{y}$ denotes domestic output, $\mathbf{f}$ denotes domestic final demand, $\mathbf{e}$ denotes export, and $\mathbf{m}$ denotes import, all in column vectors. $\mathbf{Ay}$ is the intermediate demand. We define foreign import coefficient vector $\mathbf{r}$ as follows:

$$\mathbf{m} = \langle \mathbf{r} \rangle [\mathbf{A}\mathbf{y} + \mathbf{f}] \tag{24}$$

Since $\mathbf{r}$ is the share of import in the total domestic demand, it has the following characteristics, under the CES between-group aggregator:

$$r_i = \frac{\partial p_i^C}{\partial p_i^F} \frac{p_i^F}{p_i^C} = (1 - \alpha_i) \left(\frac{p_i^F}{p_i^C} \right)^{\varepsilon} \tag{25}$$

Note that (23-24) form the following import endogenized (competitive import or Chenery–Moses type) model to assess the outputs $\mathbf{y}$ from the given final demand $\mathbf{f}$ and exports $\mathbf{e}$ while endogenizing imports $\mathbf{m}$.

$$\mathbf{y} = [\mathbf{I} - [\mathbf{I} - \langle \mathbf{r} \rangle] \mathbf{A}]^{-1} [[\mathbf{I} - \langle \mathbf{r} \rangle] \mathbf{f} + \mathbf{e}] \tag{26}$$

Further, we define the counterpart countrys import coefficient $\mathbf{r}^P$ by the following equation:

$$\mathbf{m}^P = \left\langle \mathbf{r}^P \right\rangle \mathbf{m} \tag{27}$$

where, $\mathbf{m}^P$ denotes the import from the counterpart country. Since $\mathbf{r}^P$ is the share of import from the counterpart country within foreign import, it has the following characteristics, under the CES within-group aggregator.

$$r_i^P = \frac{\partial p_i^F}{\partial p_i^P} \frac{p_i^P}{p_i^F} = \beta_i \left(\frac{p_i^P}{p_i^F} \right)^\eta \tag{28}$$

In this study, we partly endogenize exports: the export to the counterpart country is driven by the partner countrys import from its counterpart, and vice versa. In other words, we suppose that

$$\mathbf{e} = \mathbf{e}^W + \mathbf{m}^{P\prime} \tag{29}$$

where, $\mathbf{m}^{P\prime}$ denotes the import of the counterpart country from its partner country. Here, we keep $\mathbf{e}^W$, the export to the ROW, as exogenous.

Given the equilibrium price $\bar{\mathbf{p}}$ post productivity shock upon the current state through (20), all the coefficients, that is, $\bar{\mathbf{A}}$, $\bar{\mathbf{v}}$, $\bar{\mathbf{r}}$, and $\bar{\mathbf{r}}^P$ for both countries become known. Then, the ex-post net input–output space $(\boldsymbol{\ell}, \mathbf{f})$, where $\boldsymbol{\ell}$ denotes primary input row vector and $\mathbf{f}$ denotes the final demand column vector, are determined by (24, 26, 27, and 29) for the two countries, respectively. Let us write the formulas down for a single country:

$$\mathbf{y} = \left[\mathbf{I} - [\mathbf{I} - \langle \bar{\mathbf{r}} \rangle] \bar{\mathbf{A}}\right]^{-1} \left[[\mathbf{I} - \langle \bar{\mathbf{r}} \rangle] \mathbf{f} + \mathbf{e}^W - \mathbf{m}^{P\prime}\right] \tag{30}$$

$$\boldsymbol{\ell} = \mathbf{y}^\intercal \langle \bar{\mathbf{v}} \rangle \tag{31}$$

$$\mathbf{m}^P = \left\langle \bar{\mathbf{r}}^P \right\rangle \langle \bar{\mathbf{r}} \rangle \left[\bar{\mathbf{A}}\mathbf{y} + \mathbf{f}\right] \tag{32}$$

Note that a single country's net input–output difference is dependent upon its counterpart's net input–output difference

In this study, we measure welfare of a single country by the gain of linear (fixed proportion) output attainable under the given total amount of primary input based on the current state, that is, $\boldsymbol{\ell}^1$. More specifically, we measure the scalar δ of the following problem:

$$\max_{\delta} \ \mathbf{f} = \delta \mathbf{f}^1 \text{ s.t. (30), (31), } \boldsymbol{\ell}\mathbf{1} \leq \boldsymbol{\ell}^1\mathbf{1} \tag{33}$$

where $\mathbf{1} = (1, \cdots, 1)^\intercal$ denotes an n column vector of ones. Note that (33) in a single country is performed under $\mathbf{m}^{P\prime}$ given by (32) of the counterpart country. On the other hand, the counterpart country's (32) is given by the country's (33), which in turn is solved under (32) of the counterpart's partner country. In this study, we settle this mutuality by recursion, using the current state equilibrium as an initial condition for $\mathbf{m}^P$ in both countries.[2]

4. Analysis

4.1. ICT and ICT-related sectors

The effect of ICT in national economies has been examined in different ways. While some studies have used the input–output tables to examine the role of ICT (Mattioli and Lamonica (2013), Xing et al. (2011), Kecek et al. (2016), Jung et al. (2013), Jung (2012), and Vu (2013)), they do not reflect changes in international trade due to increased productivity by ICT. We build a bilateral multifactor CES general equilibrium model using 2000–2005 linked input–output tables for Japan and South Korea. The linked input–output tables contain data for 395 industries in Japan and 350 industries in South Korea. However, the Bank of Korea (BOK), which compiles the input–output tables of South Korea, does not set classification standards for the ICT industries. Jung (2012) suggested 16 industries in manufacturing and four in services as ICT industries among 350 industries in the linked input–output tables of South Korea. Kwak (2014) identified 11 manufacturing and seven service industries among 161 industries from the (small sized) input–output tables of South Korea. On the other hand, Jung et al. (2013) followed the OECD standards and reclassified the input–output tables of South Korea into ICT-producing and ICT-using industries. OECD

[2]Note that $\delta = 1$ is the solution to (33) for both countries at current state equilibrium.

(2011) conducted the classification of ICT products. According to this classification, the ICT goods and services have four manufacturing sectors (e.g., computers and peripheral equipment, communication equipment, consumer electronic equipment, and miscellaneous ICT components and goods) and six service sectors (e.g., manufacturing services for ICT equipment, business and productivity software and licensing services, IT consultancy and services, telecommunications services, leasing or rental services for ICT equipment, and other ICT services). Some studies adopted the OECD standards to classify ICT industries in national input–output tables (Xing et al. (2011), Jung et al. (2013)). Meanwhile, MIAC (2017) published ICT input–output tables for Japan, which comprises ICT and non-ICT industries. In this table, ICT is composed of ICT industries, ICT-related industries, and R&D industries. Similarly, Kim et al. (2016) constructed ICT input–output tables of South Korea, which comprises ICT manufacturing and ICT service industries. We adopt the classification of MIAC (2017) and select 45 ICT industries for Japan. Referring to Kim et al. (2016), we choose 39 industries for South Korea, corresponding to the ICT industries in Japan. Tables 1 and 2 show the ICT industries of the linked input–output tables for Japan and South Korea.

4.2. CES elasticity and productivity growth of ICT

Tables 3 and 4 show the CES elasticities and productivity growths of ICT industries in Japan and South Korea. CES elasticities of most ICT industries are estimated to be greater than 1. Furthermore, half of the industries' coefficients are significant. In Japan, $j = 325$ (other services related to communication 2.410) has the biggest CES elasticity, whereas $j = 228$ (household electrical audio equipment, 2.123) for South Korea. Compared to 2000, the productivity of ICT industries in Japan declined in 2005. Productivity growths (TFPg) of 23 ICT industries show negative signs in Table 3. Furthermore, negative coefficients for 18 industries are significant, such as in communication equipment, broadcasting, and R&D. The biggest productivity improvement is seen in $j = 240$ (liquid crystal element, 1.252) in Japan. In contrast, the ICT industries of South Korea showed productivity improvement in 2005. In Table 4, only two industries, $j = 300$ (telecommunications) and $j = 312$ (research and experiment in enterprise, 0.540), have significant negative values. Among all ICT industries, the greatest productivity growth is seen in $j = 315$ (advertising services, 3.545), whose coefficient has a significant positive value. In addition, $j = 318$ (computer-related services, 0.999) is in the second place.

4.3. Simulations

We first calculate the equilibrium price when productivity increases in the ICT sectors of Japan and South Korea. For this, we use the 2000–2005 linked input–output tables of Japan and South Korea. Since the linked input–output tables do not provide price indexes for the primary inputs (i.e., labor and capital), we aggregate them as a single input in this paper. To address this, we adopt the quality-adjusted price indexes of labor and capital which are compiled by JIP (2015) for Japan and by KIP (2015) for South Korea, during the corresponding periods with inflation adjusted. To construct a bilateral general equilibrium model, we use the UN Comtrade database. Domestic and trade models are integrated into this bilateral model.

First, we look at what happens when the productivity of every ICT sector increases by 10% exogenously in Japan and South Korea. Using the bilateral general equilibrium model, we summarize the total effects in Table 5. We explain changes in the final demand, and in the export and import of the two countries, in three kinds of scenarios. The first indicates that productivity has increased in both countries. The second case shows that productivity has increased only in Japan, while the last shows an increase only in South Korea. Note that BJPY stands for billion Japanese yen and BKRW for billion South Korean won.

The increase in the gross domestic product (ΔGDP) from both countries' ICT improvement is 4,343 BJPY for Japan and 77,284 BKRW for South Korea. The net benefit (in terms of gain in the final demand Δy) is 8,582 BJPY for Japan (about 1.70% of the current GDP) and 54,303 BKRW for South Korea (about 6.49% of the current GDP). When one country's ICT productivity increases, its GDP and final demand may also increase. Japan gets an additional of 8,292 BJPY of GDP and 9,792 BJPY of final demand because of Japan's ICT betterment. Meanwhile, South Korea gains an additional of 40,090 BKRW of GDP and 35,042 BKRW of final demand through South Korea's ICT productivity growth. Meanwhile, one country's ICT development has different effects on its partner country. Japan's improved ICT raises South Korea's GDP by 11,452 BKRW and final demand by 5,117 BKRW, since South Korea has huge imports from Japan (53,842 BKRW). Productivity growth knocks the price down. Thus, South Korea imports more of the relatively inexpensive Japanese goods. However, South Korea's ICT productivity enhancement curtails Japan's GDP (1,142 BJPY) and final demand (232 BJPY).

Table 1: ICT sectors in Japan

		id	sector
ICT sectors			
	Communication	284	Telecommunication facilities construction
		323	Fixed telecommunication
		324	Mobile telecommunication
		325	Other services relating to communication
	Broadcasting	326	Public broadcasting
		327	Private broadcasting
		328	Cable broadcasting
	Information services	329	Information services
		330	Internet based services
	Information production	331	Image information production and distribution industry
		332	Newspaper
		333	Publication
		334	News syndicates and private detective agencies
ICT-related sectors			
	Manufacturing	103	Printing, plate making and book binding
		175	Electric wires and cables
		176	Optical fiber cables
		210	Copy machine
		211	Other office machines
		227	Video recording and playback equipment
		228	Electric audio equipment
		229	Radio and television sets
		230	Wired communication equipment
		231	Cellular phones
		232	Radio communication equipment (except cellular phones)
		233	Other communication equipment
		234	Personal Computers
		235	Electronic computing equipment (except personal computers)
		236	Electronic computing equipment (accessory equipment)
		237	Semiconductor devices
		238	Integrated circuits
		239	Electron tubes
		240	Liquid crystal element
		241	Magnetic tapes and discs
		242	Other electronic components
		268	Audio and video records, other information recording media
	ICT related services	364	Advertising services
		374	Movie theaters
		375	Performances (except otherwise classified), theatrical companies
R & D			
		343	Research institutes for natural science (pubic) **
		344	Research institutes for cultural and social science (public) **
		345	Research institutes for natural sciences (private, non-profit) *
		346	Research institutes for cultural and social science (private, non-profit) *
		347	Research institutes for natural sciences (profit-making)
		348	Research institutes for cultural and social science (profit-making)
		349	Research and development (intra-enterprise)

The changes in bilateral trades, that is, exports and imports between the two countries, show positive signs in Table 5. Exports from South Korea to Japan (74,856 BKRW) are greater than imports from Japan (58,667 BKRW) in the first simulation, when ICT improves in both countries. Thus, South Korea has a positive net export (16,189 BKRW). On the other hand, Japan has had negative net exports (1,742 BJPY). However, if the ICT productivity of only one country is enhanced, South Korea's exports decline sharply. The net exports of South Korea are 15,425 BKRW in scenario 2 and 16,299 BKRW in scenario 3. South Korea's bilateral imports show equivalent amounts in the three scenarios, as seen in Table 5. In other words, South Korea's economy depends greatly on Japan. Meanwhile, Japan's bilateral imports in the second and third scenarios are less than half of that in the first scenario. Japan responds flexibly to price changes in bilateral trade.

Table 2: ICT sectors in Korea

		id	sector
ICT sectors			
	Communication	281	Communications line construction
		300	Telecommunications
	Broadcasting	301	Broadcasting
	Information services	314	Market research and management consultancy
		317	Computer softwares development and supply
		318	Computer related services
	Information production	334	Newspapers
		335	Publishing
ICT-related sectors			
	Manufacturing	113	Printing
		114	Reproduction of recorded media
		212	Motors and generators
		213	Electric transformers
		214	Capacitors and rectifiers, electric transmission and distribution equipment
		215	Insulated wires and cables
		216	Batteries
		217	Electric lamps and electric lighting fixtures
		218	Misc. electric equipment and supplies
		219	Electron tubes
		220	Digital display
		221	Semiconductor devices
		222	Integrated circuits
		223	Electric resistors and storage batteries
		224	Electric coils, transformers
		225	Printed circuit boards
		226	Misc. electronic components
		227	Television
		228	Electric household audio equipment
		229	Other audio and visual equipment
		230	Line telecommunication apparatuses
		231	Wireless telecommunication and broadcasting apparatuses
		232	Computer and peripheral equipment
		233	Office machines and devices
	ICT-related services	315	Advertising services
		336	Library, museum and similar recreation related services (public)
		337	Library, museum and similar recreation related services (other)
		338	Motion picture, theatrical producers, bands, and entertainers
R & D			
		310	Research institutes (public)
		311	Research institutes (private, non-profit, commercial)
		312	Research and experiment in enterprise

4.3.1. Sectoral price changes

When there is a 10% productivity increase in one sector, prices fall by 10%. However, the intersectoral propagation of that price change will differ depending on the elasticity of factor substitution among the interacting sectors. All ICT sectors show more than 9% price reductions in Figure 5 for Japan and Figure 6 for South Korea. In these figures, most of the ICT sectors show a greater than 10% price reduction.

The top six ICT sectors in Japan as shown in Figure 5 are $j = 364$ (advertising services, 14.66%), $j = 374$ (movie theaters, 13.91%), $j = 229$ (radio and television sets, 13.41%), $j = 234$ (personal computers, 12.57%), $j = 236$ (electronic computing equipment (accessory equipment), 12.43%), and $j = 327$ (private broadcasting 12.14%). Meanwhile, the top six in Korea as shown in Figure 6 are $j = 315$ (advertising services, 18.72%), $j = 227$ (television, 15.48%), $j = 231$ (wireless telecommunication and broadcasting apparatuses, 14.75%), $j = 301$ (broadcasting, 14.20%), $j = 232$ (computer and peripheral equipment, 13.69%), and $j = 229$ (other audio and visual equipment, 13.55%). Interestingly, advertising services took the first place in both countries. Intuitively, we can understand the huge direct and indirect effects of the advertising industry on the entire economy; similarly, television, audio, and broadcasting also rank high in the two countries. It is obvious that the advertising and broadcasting industries have deep interactions in the economy. Conversely, computer equipment, the representative ICT industry, ranked fourth in Japan and fifth in

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

id	sector	Elasticity		TFPg		Obs.
103	Printing, plate making and book binding	1.548		0.084		125
175	Electric wires and cables	1.575	***	0.044		119
176	Optical fiber cables	1.636	**	−0.361	***	113
210	Copy machine	1.240		−0.539	***	130
211	Other office machines	1.136		0.528		131
227	Video recording and playback equipment	2.003	***	0.769	***	134
228	Electric audio equipment	1.391	*	0.397	***	144
229	Radio and television sets	0.939		−7.175	**	123
230	Wired communication equipment	2.198	***	−0.237	***	148
231	Cellular phones	1.141		3.126		145
232	Radio communication equipment (except cellular phones)	1.354		−0.283	**	147
233	Other communication equipment	0.752		−0.322	*	139
234	Personal Computers	1.448	*	0.634		124
235	Electronic computing equipment (except personal computers)	1.643	***	0.249		124
236	Electronic computing equipment (accessory equipment)	1.887	***	0.406	***	130
237	Semiconductor devices	1.501		0.024		122
238	Integrated circuits	1.245		−0.824		124
239	Electron tubes	1.787	***	0.000		114
240	Liquid crystal element	2.256	***	1.252	**	114
241	Magnetic tapes and discs	1.506		0.357		119
242	Other electronic components	1.692	***	−0.078		150
268	Audio and video records, other information recording media	1.530	**	-0.127	*	93
284	Telecommunication facilities construction	1.279		0.129		138
323	Fixed telecommunication	0.773		0.613	**	101
324	Mobile telecommunication	1.899		−0.156		73
325	Other services relating to communication	2.410	***	0.016		63
326	Public broadcasting	1.170		−0.445	*	88
327	Private broadcasting	1.082		−1.626	***	91
328	Cable broadcasting	1.104		−1.598	***	81
329	Information services	1.439		0.028		98
330	Internet based services					
331	Image information production and distribution industry	1.660	**	-0.206	**	117
332	Newspaper	1.508	**	0.006		97
333	Publication	1.450	*	0.027		103
334	News syndicates and private detective agencies	1.397	*	−0.052		72
343	Research institutes for natural science (pubic) **	2.069		−0.765	***	88
344	Research institutes for cultural and social science (public) **	2.044		−0.923	***	62
345	Research institutes for natural sciences (private, non-profit) *	1.393		−2.078	***	59
346	Research institutes for cultural and social science (private, non-profit) *	1.215		−5.071	***	47
347	Research institutes for natural sciences (profit-making)	2.114	**	−0.854	***	91
348	Research institutes for cultural and social science (profit-making)	2.396		−0.227	**	50
349	Research and development (intra-enterprise)	1.465	**	−0.318	***	124
364	Advertising services	1.925	***	0.017		101
374	Movie theaters	0.484		−0.122		74
375	Performances (except otherwise classified), theatrical companies	1.287		0.137		106

South Korea.

Moreover, both ICT and non-ICT industries response with lower prices to ICT innovation, as seen in Figures 5 and 6. For examples, the top six non-ICT industries in Japan, as seen in Figure 5, are j =128 (cosmetics, toiletries, and dentifrices, 3.14%), j =219 (applied electronic equipment, 3.09%), j =259 (cameras, 2.90%), j =264 (medical instruments, 2.03%), j =220 (electrical measuring instruments, 2.02%), and j =127 (soap, synthetic detergents, and surface active agents, 1.89%). Whereas, the top six in Korea, as seen in Figure 6 are j =238 (regulators and measuring and analytical instruments, 3.04%), j =348 (office supplies, 2.54%), j =235 (household laundry equipment, 2.40%), j =236 (other household electrical appliances, 2.38%), j =280 (electric power plant construction, 2.32%), and j =237 (medical instruments and supplies, 2.13%). Thus, ICT innovation induces price reduction for itself and other industries. For example, the two biggest inputs in j =128 (cosmetics, toiletries, and dentifrices) in Japan are the ICT industries, that is, j = 364 (advertising services) and j = 349 (research and development [intra-enterprise]). There is one more point we should consider.

Figures 5 and 6 show that South Korea has had greater price reductions than Japan. The price reduction in the

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

id	sector	Elasticity		TFPg		Obs.
113	Printing	1.579	***	0.072		139
114	Reproduction of recorded media	1.977	***	0.115	*	132
212	Motors and generators	1.747	***	0.177	**	157
213	Electric transformers	1.815	***	0.079		146
214	Capacitors and rectifiers, electric transmission and distribution equipment	1.562	**	−0.013		163
215	Insulated wires and cables	1.784	***	−0.098		165
216	Batteries	1.389		0.269		147
217	Electric lamps and electric lighting fixtures	1.582	**	−0.074		156
218	Misc. electric equipment and supplies	1.492	*	0.075		151
219	Electron tubes	1.695	***	0.382	**	155
220	Digital display	1.095		0.708		155
221	Semiconductor devices	1.511	**	0.359		158
222	Integrated circuits	1.190		0.343		163
223	Electric resistors and storage batteries	2.063	***	0.576	***	152
224	Electric coils, transformers	1.334		0.448	***	138
225	Printed circuit boards	1.540	**	0.347		156
226	Misc. electronic components	1.402		0.497	*	166
227	Television	1.470		0.840	**	146
228	Electric household audio equipment	2.123	***	0.559	***	147
229	Other audio and visual equipment	1.596	*	0.396	*	160
230	Line telecommunication apparatuses	1.645	**	0.111		157
231	Wireless telecommunication and broadcasting apparatuses	1.501		0.915		159
232	Computer and peripheral equipment	1.630	**	0.605		162
233	Office machines and devices	1.543	*	0.320	**	150
281	Communications line construction	1.576	**	0.002		155
300	Telecommunications	1.596	*	−0.237	*	119
301	Broadcasting	0.965		−2.958		119
310	Research institutes (public)	1.578	**	−0.086		178
311	Research institutes (private, non-profit, commercial)	1.523	**	0.527	***	148
312	Research and experiment in enterprise	1.390	**	−0.540	***	221
314	Market research and management consultancy	1.324		0.228		91
315	Advertising services	1.141		3.545	***	121
317	Computer softwares development and supply	1.293		0.194		111
318	Computer related services	1.322		0.999	***	107
334	Newspapers	1.878	***	−0.056		114
335	Publishing	1.494	**	0.131		120
336	Library, museum and similar recreation related services (public)	1.777	***	0.123		129
337	Library, museum and similar recreation related services (other)	1.501		0.082		131
338	Motion picture, theatrical producers, bands, and entertainers	1.597	***	0.156	*	147

ICT industry of Japan is 10.92% on average, whereas in South Korea, it is 12.29%. Figures 7) and 10) show that price changes are only influenced by domestic ICT improvements. The ICT industries' average is 10.52% for Japan and 11.96% for South Korea. The price reduction caused by a partner country's ICT improvement is 0.14% for Japan and 0.29% for South Korea, as seen in Figures 9 and 8. In Figure 9, it shows that Japans ICT industries are ranked high, such as $j = 229$ (radio and television sets, 1.32%), $j = 234$ (personal computers, 0.72%), $j = 236$ (electronic computing equipment (accessory equipment), 0.61%), and $j = 231$ (cellular phones, 0.60%). Similarly, in Figure 8, South Koreas ICT industries are also ranked high, such as $j = 221$ (semiconductor devices, 1.13%), $j = 228$ (household electrical audio equipment, 0.89%), $j = 227$ (television, 0.71%), $j = 231$ (wireless telecommunication and broadcasting apparatuses, 0.70%), and $j = 232$ (computer and peripheral equipment, 0.67%). Ultimately, a countrys domestic ICT growth influences its partner country's prices of ICT products. Furthermore, South Korea suffers from a bigger downturn than Japan, as it is strongly affected by its partner's economic climate.

4.3.2. Sectoral changes of outputs and bilateral trade values

To observe industrial changes specifically, we classify sectors into seven categories, including the ICT industries. Here, non-ICT industries are aggregated into six sectors such as agriculture, processed food, mining, energy, non-ICT manufacturing, non-ICT services, and others. The changes of total bilateral trade values by the three scenarios are mentioned in 4.3. Tables 6 and 7 demonstrate changes of (domestic) outputs and bilateral trade values (net) in eight groups between Japan and South Korea. Overall, Table 7 shows a larger number of positive values than Table 6. It

Table 5: Prospective analysis of productivity improvement in ICT sectors between Japan and Korea

	Japan		Korea	
	BJPY	(BKRW)	BKRW	(BJPY)
Current GDP	505,269		851,982	
Scenario 1: 10% productivity increase in Japan and Korea				
ΔGDP	4,343	40,362	77,284	8,316
ΔFinal demand Δf	8,582	79,759	54,303	5,843
ΔExport to partner Δe^p	6,313	58,667	74,856	8,054
ΔImport from partner Δm^p	8,054	74,856	58,667	6,313
Δe^p-Δm^p	−1,742		16,189	
Scenario 2: 10% productivity increase in Japan				
ΔGDP	8,292	77,065	11,452	1,232
Δ Final demand Δf	9,792	91,007	5,117	551
Δ Export to partner Δe^p	5,686	52,842	37,417	4,026
Δ Import from partner Δm^p	4,026	37,417	52,842	5,686
Δe^p-Δm^p	1,660		−15,425	
Scenario 3: 10% productivity increase in Korea				
ΔGDP	−1,142	−10,618	40,090	4,314
ΔFinal demand Δf	−232	−2,160	35,042	3,771
ΔExport to partner Δe^p	5,593	51,981	35,681	3,839
ΔImport from partner Δm^p	3,839	35,681	51,981	5,593
Δe^p-Δm^p	1,754		−16,299	

suggests that South Korea gains more than Japan in terms of output.

In 4.3.1, we find that chain reactions to price changes in South Korea are more sensitive than that in Japan. If the price of intermediate inputs drops because of any exogenous ICT productivity improvement, South Korea gains because it is more sensitive to price changes of intermediate inputs. Thus, South Korea produces more with less expensive intermediate inputs. In South Korea, all scenarios show an increase in output, whereas Japan has negative values under scenarios 1 and 3.

This means that if there is no ICT innovation in Japan but only betterment in South Korea, the output of Japan shrinks. In other words, Japan's domestic intermediate inputs are substituted for imported goods from South Korea since they become less expensive. Simultaneously, net bilateral trade values of the ICT industries in Japan show negative values in all cases. On the other hand, Korea has negative net trade values for non-ICT manufacturing in all scenarios (and additional negative net trade values for non-ICT services and others in scenarios 1 and 3), since Japan's non-ICT goods become less expensive because of ICT improvement. Thus, South Korea imports more non-ICT goods from Japan. This leads to negative values in net bilateral trade in non-ICT industries of South Korea.

5. Concluding Remarks

The ICT is widely recognized as a key factor in economic growth. We go by the definition used in some previous studies such as OECD (2011) to select 45 industries of Japan and 39 of South Korea in the 2000–2005 linked input–output tables to represent the ICT sector. We examine the impacts of the ICT sector on economic growth by using a bilateral multifactor CES general equilibrium model of Japan and South Korea. The main findings of this study are as follows. First, estimating the elasticities of substitution and productivity growths of the ICT sector shows that South Korea shows greater positive ICT productivity growth than Japan. Some ICT industries of Japan show negative productivity growth. Second, we simulate three types of exogenous ICT productivity growth at 10%. We describe the effects of ICT productivity growth as changes in price, GDP, final demand, outputs, and (net) bilateral trade values. Regarding price changes, we find that the advertising services sector responds rapidly to ICT innovation. Thus, the advertising industry reduces its price substantially in both countries. As a result, television, broadcasting, and computer-related industries also react sensitively to ICT innovation in both countries. On average, South Korea has bigger cost reductions than Japan since South Korea's price reductions are larger. Third, the net bilateral trade values indicate that South Korea gains more than Japan. Since South Korea reacts quickly to price changes, it can achieve larger cost reductions. Thus, South Korea benefits more from the bilateral trade.

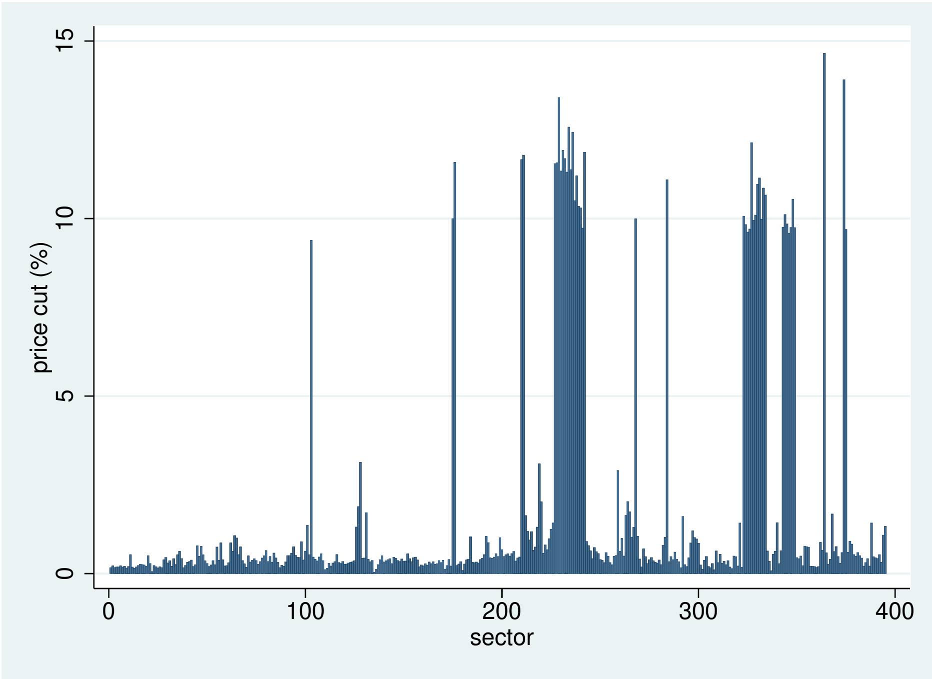

Figure 5: Sectoral distribution of price cut of Japan (10% of ICT productivity increments in Japan and Korea)

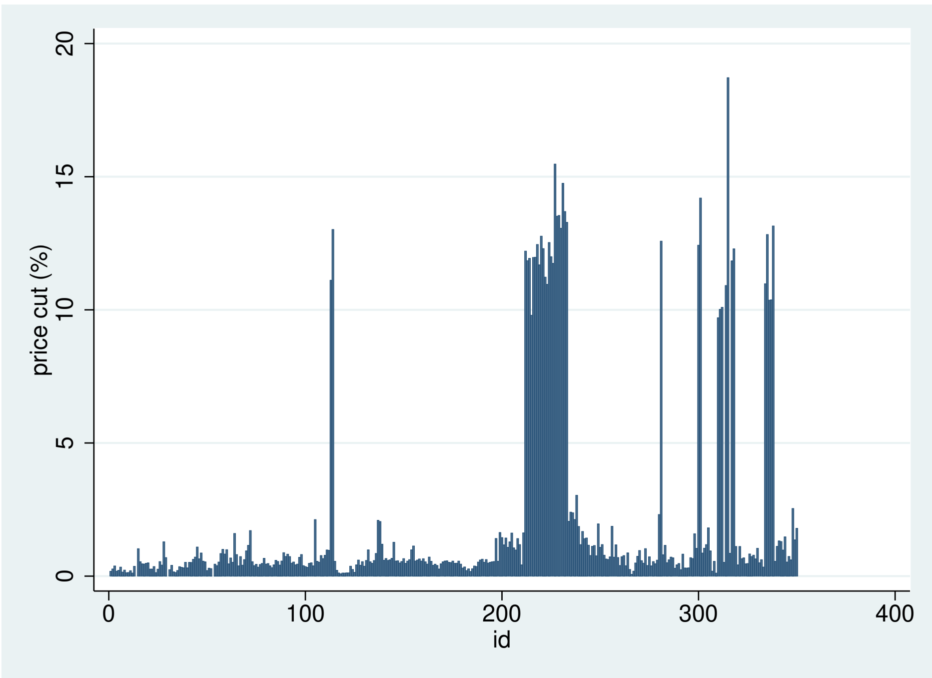

Figure 6: Sectoral distribution of price cut of Korea (10% of ICT productivity increments in Japan and Korea)

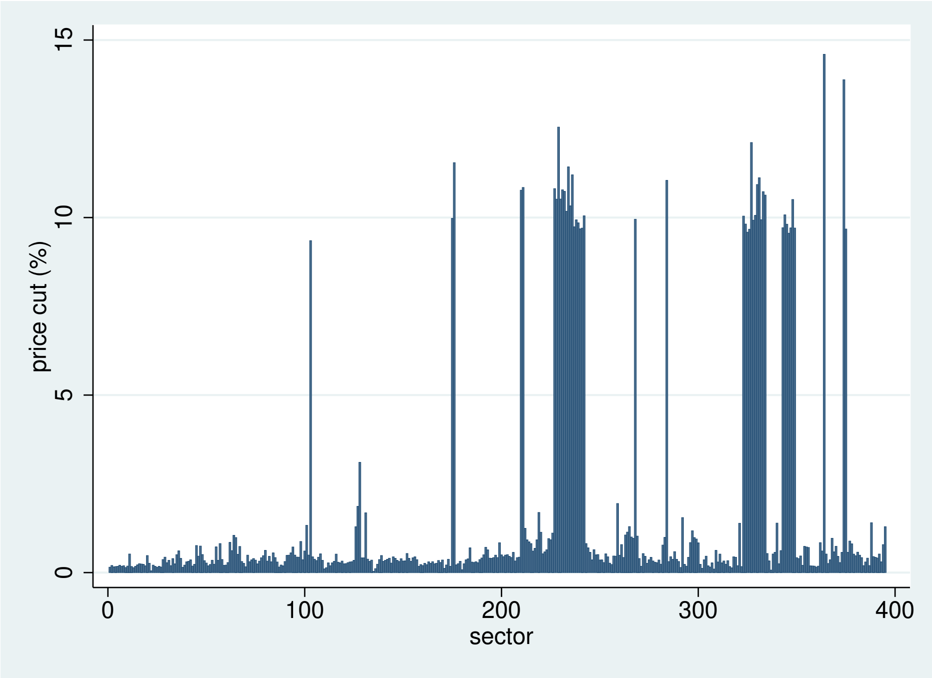

Figure 7: Sectoral distribution of price cut of Japan (10% of ICT productivity increments only in Japan)

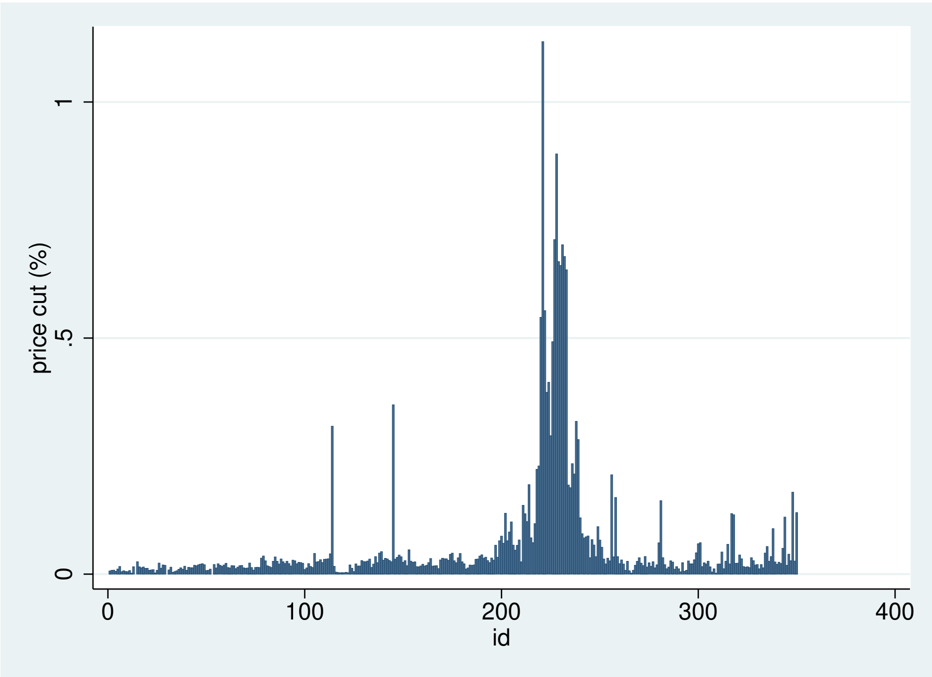

Figure 8: Sectoral distribution of price cut of Korea (10% of ICT productivity increments only in Japan)

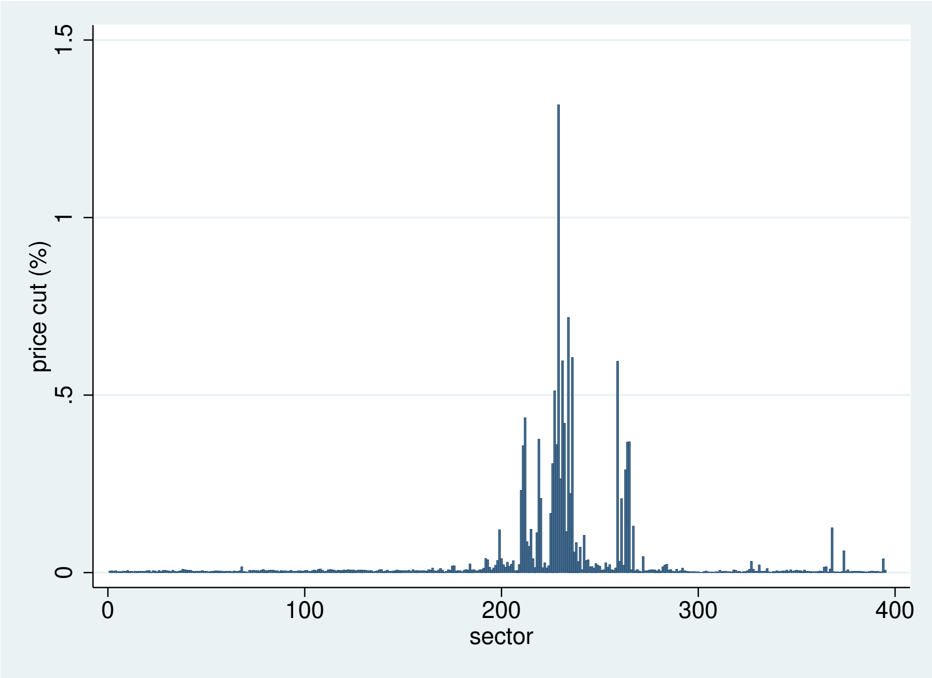

Figure 9: Sectoral distribution of price cut of Japan (10% of ICT productivity increments only in Korea)

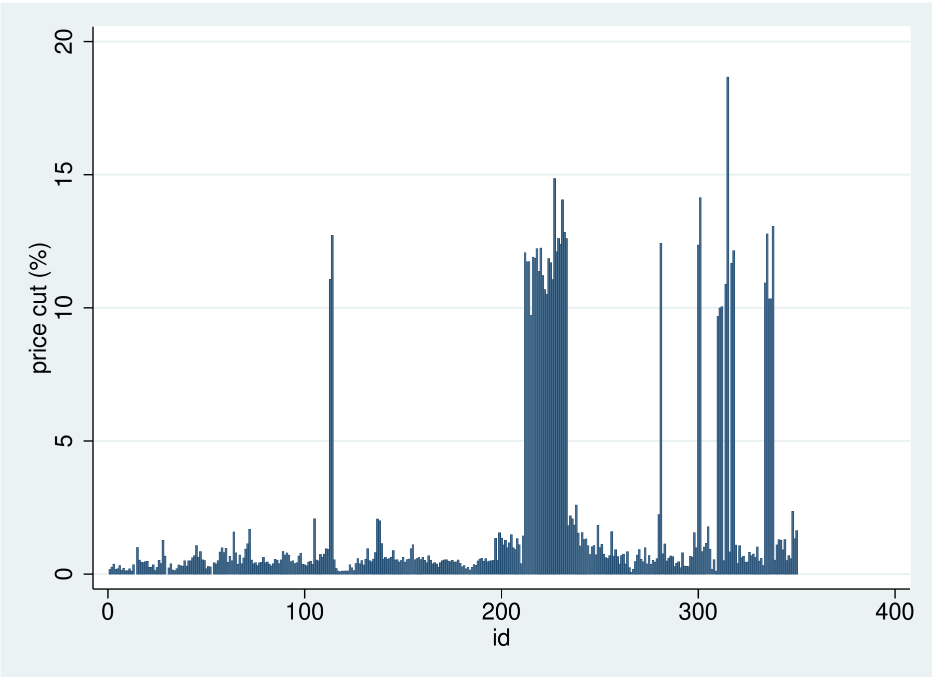

Figure 10: Sectoral distribution of price cut of Korea (10% of ICT productivity increments only in Korea)

Table 6: Changes of sectoral outputs and bilateral net trade values (Japan). Unit: Billion JPY.

scenario	sector	Δ Trades	Δ Outputs
Scenario 1: 10% productivity increase in Japan and Korea	Agriculture	−48	166
	Processed food	−75	564
	Mining	−124	−5
	Energy	0	−104
	Non-ICT manufacturing	2,889	−635
	Non-ICT Services and the others	−88	5,230
	ICT sectors	−4,296	−2,096
Scenario 2: 10% productivity increase in Japan	Agriculture	−42	204
	Processed food	−93	632
	Mining	−121	4
	Energy	0	58
	Non-ICT manufacturing	2,710	256
	Non-ICT Services and the others	−384	6,969
	ICT sectors	−410	3,711
Scenario 3: 10% productivity increase in Korea	Agriculture	−47	−13
	Processed food	−58	−6
	Mining	−124	−5
	Energy	0	−104
	Non-ICT manufacturing	2,755	−622
	Non-ICT Services and the others	23	−522
	ICT sectors	−799	−1,293

Table 7: Changes of sectoral outputs and bilateral net trade values (Korea). Unit: Billion KRW.

scenario	sector	Δ Trades	Δ Outputs
Scenario 1: 10% productivity increase in Japan and Korea	Agriculture	334	2,507
	Processed food	828	4,465
	Mining	1,472	211
	Energy	0	1,508
	Non-ICT manufacturing	-20,123	39,039
	Non-ICT Services and the others	-469	56,724
	ICT sectors	34,147	82,844
Scenario 2: 10% productivity increase in Japan	Agriculture	340	354
	Processed food	940	795
	Mining	1,417	61
	Energy	0	449
	Non-ICT manufacturing	-22,419	13,984
	Non-ICT Services and the others	160	9,260
	ICT sectors	4,138	14,059
Scenario 3: 10% productivity increase in Korea	Agriculture	324	1,437
	Processed food	680	2,506
	Mining	1,479	128
	Energy	0	519
	Non-ICT manufacturing	−24,085	12,536
	Non-ICT Services and the others	−481	29,375
	ICT sectors	5,784	29,150

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