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Keywords: Linked Input–Output Tables, Information and Communications Technology, Tracing Elasticities

JEL classification: C67, D57, D83, F19

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Multi-Sectoral Value Chain in a Bilateral General Equilibrium

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Abstract

The information and communication technology (ICT) is a key engine of economic growth. In this paper, we examine the impact of ICT innovation using a multifactor constant elasticity of substitution (CES) general equilibrium model. Innovation not only leads to productivity growth and thus influence prices, it also changes output and trade patterns, and welfare. To examine trade values, we construct a bilateral multifactor CES general equilibrium model between Japan and the Republic of Korea using linked input–output tables. We estimate elasticities of substitution and productivity growths of the ICT sectors, to assess the effects of ICT improvement on the two countries.

Keywords: Linked Input–Output Tables, Information and Communications Technology, Tracing Elasticities

1. Introduction

Recently, Kim et al. (2017) developed a bilateral multifactor constant elasticity of substitution (CES) general equilibrium model with state-replicating Armington elasticities; each elasticity of substitution between foreign and domestic commodities is measured by a two-point calibration, such that the Armington aggregator can replicate the two temporally distant observations of market shares and prices. This study integrates the domestic production of two countries, Japan and the Republic of Korea, with bilateral trade models and constructs a bilateral general equilibrium model.

In this paper, we examine the effect of the information and communication technology (ICT) sector on economic growth using a bilateral multifactor CES general equilibrium model. The ICT sector has become the leading sector of the global economy. According to

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OECD (2017), value added for the ICT sector and sub-sectors stood at 5.4% of all OECD countries in 2015. Among 31 countries, the Republic of Korea ranked first with 10.3%. More specifically, 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 lacking. 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. However, it was not significant in developing countries, such as China. Zuhdi et al. (2012) showed the ICT sector played an important role in changing the structure of Japan's economy, but did not have a significant effect in Indonesia.

We build a bilateral multifactor CES general equilibrium model between Japan and the Republic of Korea to bridge this research gap. Although evidence of the ICT sector's importance in growth for developing countries is still scarce, some studies have been able to show this in Japan and Korea. (Jorgenson and Motohashi (2005), Kanamori and Motohisa (2007), Zuhdi et al. (2012), Jung et al. (2013), Ju (2014)).

2. Methodology

2.1. Two-point calibration of the CES function

Let us begin with a two-input production function with constant CES, as follows:

$$z = F(x, y) = \theta \left(\alpha^{1/\sigma} x^{1-1/\sigma} + \beta^{1/\sigma} y^{1-1/\sigma} \right)^{1/(1-1/\sigma)} \tag{1}$$

where x and y denote the physical level of the two inputs and z denotes the output in physical units. As for the parameters, $\sigma > 0$ denotes the elasticity of substitution, whereas $\alpha > 0$ and $\beta > 0$ denote the share parameters where $\alpha + \beta = 1$. The level of productivity is denoted by θ.

Notice that the following function represents the (dual) unit cost that corresponds to the production function (1):

$$r = G(p, q) = \theta^{-1} \left(\alpha p^{1-\sigma} + \beta q^{1-\sigma} \right)^{1/(1-\sigma)} \tag{2}$$

where p and q denote the prices for the first and second factor, respectively, while r denotes the output price (or, the unit cost of the output). We can verify that (2) and (1) are dual as follows:

First, the isoquant of (1) must be tangent to the price ratio, that is:

$$\left(\frac{\partial y}{\partial x} \right)_z = -\frac{\partial z}{\partial x} / \frac{\partial z}{\partial y} = -\left(\frac{\alpha}{\beta} \frac{y}{x} \right)^{1/\sigma} = -\frac{p}{q}$$

Thus, the cost share ratio b/a (i.e., the cost share of the second input $b = \frac{qy}{px+qy}$ with respect to the first input $a = \frac{px}{px+qy}$) would be

$$\frac{b}{a} = \frac{qy}{px} = \frac{\beta}{\alpha} \left(\frac{q}{p} \right)^{1-\sigma} \tag{3}$$

Alternatively, since (2) is homogeneous in degree one, Euler's rule implies that

$$r = \frac{\partial G}{\partial p} p + \frac{\partial G}{\partial q} q = xp + yq = \theta^{-1} \alpha \left(\frac{r}{p} \right)^{\sigma} p + \theta^{-1} \beta \left(\frac{r}{q} \right)^{\sigma} q$$

and we can obtain the cost share ratio that is identical to (3) through (2) as well.

Now, let us look at the cost shares of the inputs $(a^0, b^0; a^1, b^1)$, and the prices of inputs and outputs $(p^0, q^0, r^0; p^1, q^1, r^1)$ for two different periods, where we indicate periods by subscript 0 (reference) and 1 (current). One can verify, with reference to (3), that the following parameters can be obtained from the observables, i.e.,

$$1 - \sigma = \frac{\ln a^1/a^0 - \ln b^1/b^0}{\ln p^1/p^0 - \ln q^1/q^0} \tag{4}$$

$$\ln \alpha = \ln a^0 - (1-\sigma) \ln p^0/r^0 = \ln a^1 - (1-\sigma) \ln p^1/r^1 \tag{5}$$

$$\ln \beta = \ln b^0 - (1-\sigma) \ln q^0/r^0 = \ln b^1 - (1-\sigma) \ln q^1/r^1 \tag{6}$$

$$\theta^0 = \alpha \left(p^0/r^0 \right)^{1-\sigma} + \beta \left(q^0/r^0 \right)^{1-\sigma} \tag{7}$$

$$\theta^1 = \alpha \left(p^1/r^1 \right)^{1-\sigma} + \beta \left(q^1/r^1 \right)^{1-\sigma} \tag{8}$$

satisfy the inputs and outputs of the CES unit cost function (2) for the two periods,

$$r^0 = (\theta^0)^{-1} \left(\alpha(p^0)^{1-\sigma} + \beta(q^0)^{1-\sigma}\right)^{1/(1-\sigma)} \tag{9}$$

$$r^1 = (\theta^1)^{-1} \left(\alpha(p^1)^{1-\sigma} + \beta(q^1)^{1-\sigma}\right)^{1/(1-\sigma)} \tag{10}$$

Thus, we call the parameters obtained through (4–8) as state replicating and the procedure, two-point calibration.

Notice that (1) becomes an aggregator function if θ is constant. In that case, the state-replicating aggregator function can be two-point calibrated by (4–6) using the observed cost shares and prices of the inputs for two periods, i.e., $(a^0, b^0; a^1, b^1)$ and $(p^0, q^0; p^1, q^1)$, while the two output (aggregated) prices (r^0, r^1) are evaluated using the following formulae:

$$r^0 = \left(\alpha(p^0)^{1-\sigma} + \beta(q^0)^{1-\sigma}\right)^{1/(1-\sigma)} \tag{11}$$

$$r^1 = \left(\alpha(p^1)^{1-\sigma} + \beta(q^1)^{1-\sigma}\right)^{1/(1-\sigma)} \tag{12}$$

Alternatively, when the output price is observed but one of the input prices (say, for the second input) is not observed, we may still calibrate the parameters as follows:

$$1 - \sigma = \frac{\ln a^1/a^0}{\ln p^1/p^0 - \ln r^1/r^0} \tag{13}$$

$$\ln \alpha = \ln a^0 - (1-\sigma)\ln p^0/r^0 = \ln a^1 - (1-\sigma)\ln p^1/r^1 \tag{14}$$

$$\ln \beta = \ln(1-\alpha) \tag{15}$$

Note that in this case, the price of the second factor (q_0, q_1) can be evaluated as follows:

$$q^0 = \left(\frac{(r^0)^{1-\sigma} - \alpha(p^0)^{1-\sigma}}{\beta}\right)^{1/(1-\sigma)}, \qquad q^1 = \left(\frac{(r^1)^{1-\sigma} - \alpha(p^1)^{1-\sigma}}{\beta}\right)^{1/(1-\sigma)}$$

2.2. Multifactor CES elasticity of substitution

A multifactor CES unit cost function is of the form

$$p = \theta^{-1}\left(\lambda_0(p_0)^{1-\sigma} + \lambda_1(p_1)^{1-\sigma} + \cdots + \lambda_N(p_N)^{1-\sigma}\right)^{1/(1-\sigma)} \tag{16}$$

where $p_0, p_1, \cdots, p_N$ denote the input prices, p denotes the output price, and $\lambda_0, \lambda_1, \cdots, \lambda_N$ are the share parameters where $\sum_{i=0}^{N} \lambda_i = 1$. The multifactor CES elasticity of substitution is denoted by σ. The parameters σ and θ cannot be calibrated in a state-replicating fashion, but we can estimate them using regression, as follows:

Applying Shepard's lemma for (16) yields the following:

$$s_i = \frac{\partial p}{\partial p_i}\frac{p_i}{p} = \lambda_i \left(\frac{p_i}{\theta p}\right)^{1-\sigma} \tag{17}$$

By taking the log on both sides we have:

$$\ln s_i = \ln \lambda_i - (1-\sigma)\ln\theta + (1-\sigma)\ln p_i/p \tag{18}$$

Since factor cost shares are observable for two periods (s_i^0, s_i^1) for all inputs $i = 0, 1, \cdots, N$ in a set of linked input–output tables, the following two equations must hold:

$$\begin{aligned}\ln s_i^0 &= \ln \lambda_i - (1-\sigma)\ln\theta^0 + (1-\sigma)\ln p_i^0/p^0\\ \ln s_i^1 &= \ln \lambda_i - (1-\sigma)\ln\theta^1 + (1-\sigma)\ln p_i^1/p^1\end{aligned}$$

Subtracting, we have:

$$\begin{aligned}\ln s_i^1/s_i^0 &= -(1-\sigma)\left(\ln\theta^1/\theta^0 + \ln p^1/p^0\right) + (1-\sigma)\left(\ln p_i^1/p_i^0\right)\\ \Delta\ln s_i &= -(1-\sigma)\left(\Delta\ln\theta + \Delta\ln p\right) + (1-\sigma)\Delta\ln p_i \end{aligned} \tag{19}$$

That is, the multifactor CES elasticity of substitution σ can be estimated by the slope of the simple regression line between the growth of cost shares and the growth of factor prices. Moreover, the intercept of the regression line provides an estimate of productivity growth $\ln\theta^1/\theta^0$, given the estimate of its slope $(1-\sigma)$.

3. Measurement

The substitution structure of the bilateral general equilibrium model is illustrated in Figure 1. We measure multifactor (intermediate) CES elasticity of substitution by using the 1995–2000–2005 linked input–output tables for both Japan (MIAC, 2011) and Korea (BOK, 2009), choosing 2000 as the reference and 2005 as the current period. For the measurement of Athe rmington elasticities, we use the six-digit HS trade data of the UN Comtrade database (Comtrade, 2017) that covers 6,376 goods converted into the linked input–output sector classification, to obtain the market share of the partner country with respect to the rest of the world (ROW) for the corresponding two periods. In this study, the state-replicating Armington elasticities are measured in a two-stage nested structure.

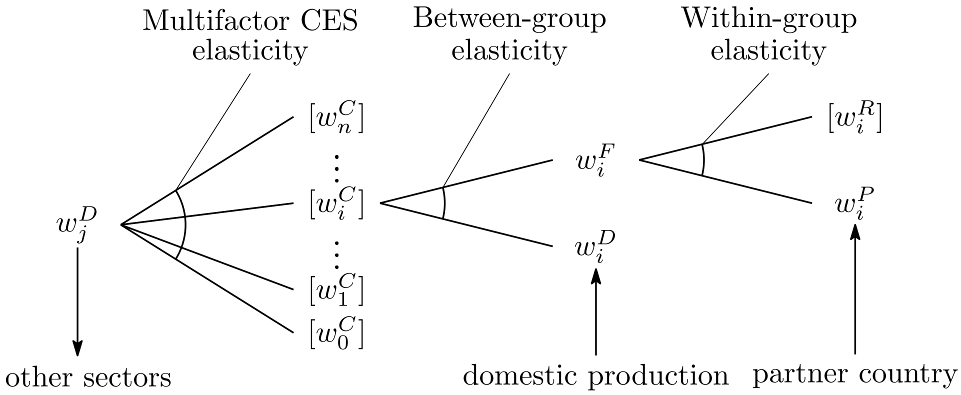

Figure 1: Substitution structure of the bilateral general equilibrium model.

For each traded good, we first calibrate the within-group elasticity that replicates the observed partner–ROW market shares with regard to price changes of the partner country-made commodity, and that of the compound commodity (i.e., compound of the partner's and the ROW's commodities) which we monitor as the *foreign* commodity, for the two periods concerned. We then calibrate the between-group elasticity that replicates the observed domestic–foreign market shares with regard to price changes of the corresponding factor prices for the two periods. Finally, we measure the multifactor CES elasticity of substitution through ia regression.

3.1. Armington Elasticities

3.1.1. Within-group Elasticities

The within-group aggregator is the two-input CES function that compounds the commodity of one kind imported from the partner country and that from the ROW. For each commodity j, the dual aggregator function can be written as follows:

$$w_j^F = \left(\alpha_j (w_j^P)^{1-\sigma_j} + \beta_j (w_j^R)^{(1-\sigma_j)}\right)^{1/(1-\sigma_j)} \equiv V_j\left(w_j^P, w_j^R\right) \tag{20}$$

where, w_j^F, w_j^P, w_j^R denote prices of foreign, partner, and ROW commodity j, respectively. The parameters are calibrated by (13–15) using the observed values of w_j^F, w_j^P and market shares s_j^P, s_j^R for the two periods. In Figure 2 we display the histogram of the calibrated within-group elasticities of 395 commodities for Japan and 350 commodities for Korea. Overall, the calibrated within-group elasticities are very large, which means that the partner's and the ROW's commodities are (almost complete) substitutes. Note that the log-absolute values (with base of 10) are used to display the elasticities.

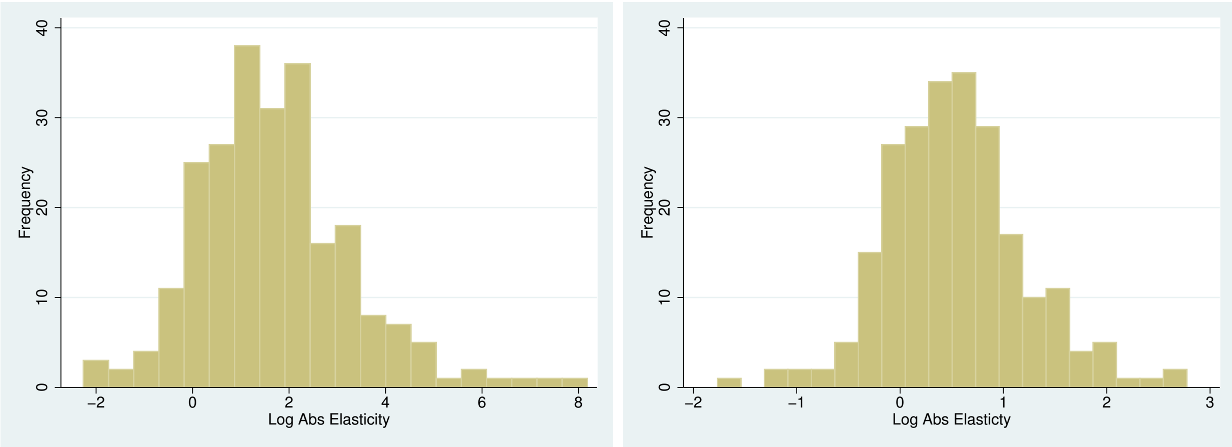

Figure 2: Histogram of calibrated between-group elasticities in log-absolute values for Japan (left) and Korea (right).

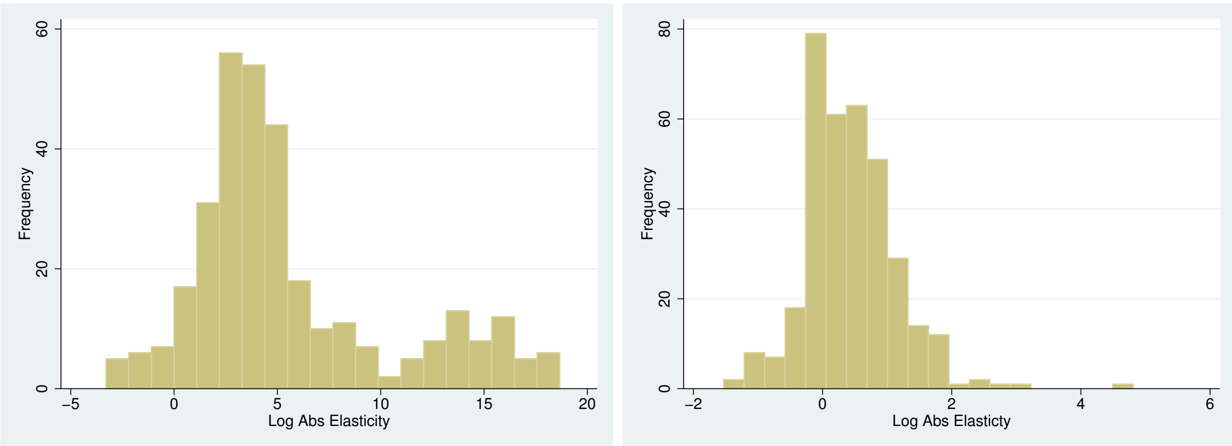

Figure 3: Histogram of calibrated within-group elasticities in log-absolute values for Japan (left) and Korea (right).

3.1.2. Between-group Elasticities

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

$$w_j^C = \left(\alpha_j (w_j^D)^{1-\sigma} + \beta_j (w_j^F)^{(1-\sigma_j)}\right)^{1/(1-\sigma_j)} \equiv U_j \left(w_j^D, w_j^F\right) \tag{21}$$

where w_j^C, w_j^D, w_j^F denote the prices of the compound, domestic, and foreign commodity j, respectively. The parameters are calibrated by (4–6) using the observed values of w_j^D, w_j^F and market shares s_j^D, s_j^F for the two periods. In Figure 2, we display the histogram of the

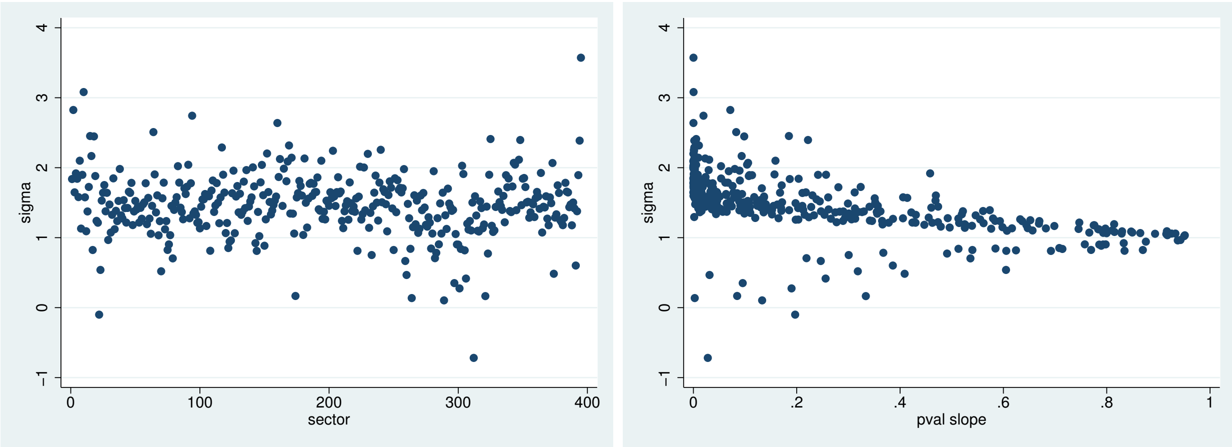

Figure 4: Estimated multifactor CES elasticities and their statistical significance, for Japan.

calibrated between-group elasticities of 395 commodities for Japan and 350 commodities for Korea. Overall, the calibrated within-group elasticities are very large, which means that the domestic and foreign commodities are (almost complete) substitutes. Note that the log-absolute values (with base of 10) are used to display the elasticities.

3.2. Multifactor CES Elasticities

We estimate the multifactor CES elasticities for all production sectors according to the regression equation (19). For the explanatory variables in the regression, we use the growth of compound factor prices i.e., $\Delta \ln w_i^C$ which we calculate by using the between-group aggregator (21) for each commodity. In Figure 4, we display the estimated multifactor CES elasticity of substitution for Japan (395 sectors). The corresponding statistical significances are indicated in the right-hand side figure. In Figure 5, we display the estimated multifactor CES elasticity of substitution for Korea (380 sectors). The corresponding statistical significances are indicated in the right-hand side figure.

Figure 6 shows the productivity growth $\Delta \ln \theta_j$ (or, total factor productivity growth TFPg) for all j sectors, which can be estimated from the intercept of the regression line of (19), for Japan. On the right-hand side of the figure, we display the corresponding statistical significances of the intercept and the slope of the regression line. Similarly, in Figure 7 we display the productivity growth $\Delta \ln \theta_j$ (or, total factor productivity growth TFPg) for all j sectors for Korea.

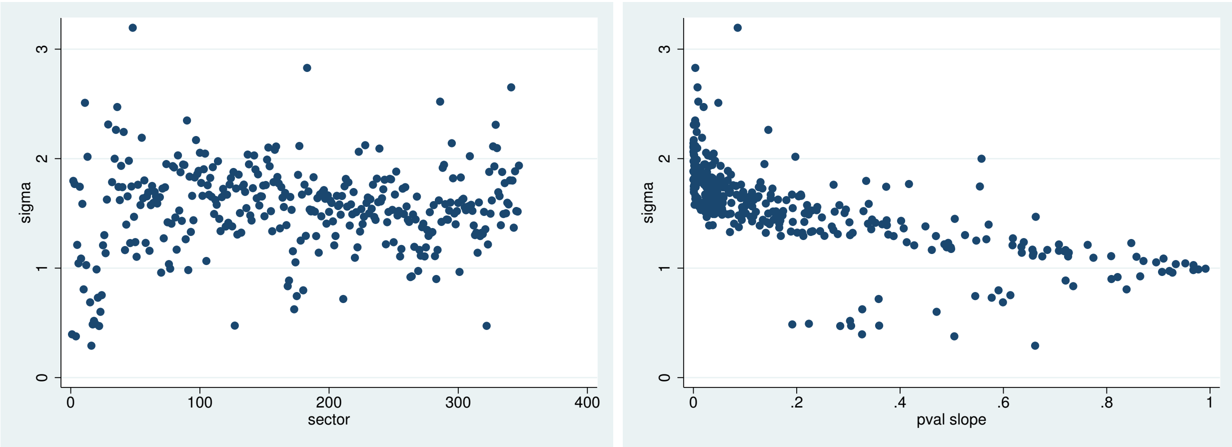

Figure 5: Estimated multifactor CES elasticities and their statistical significance, for Korea.

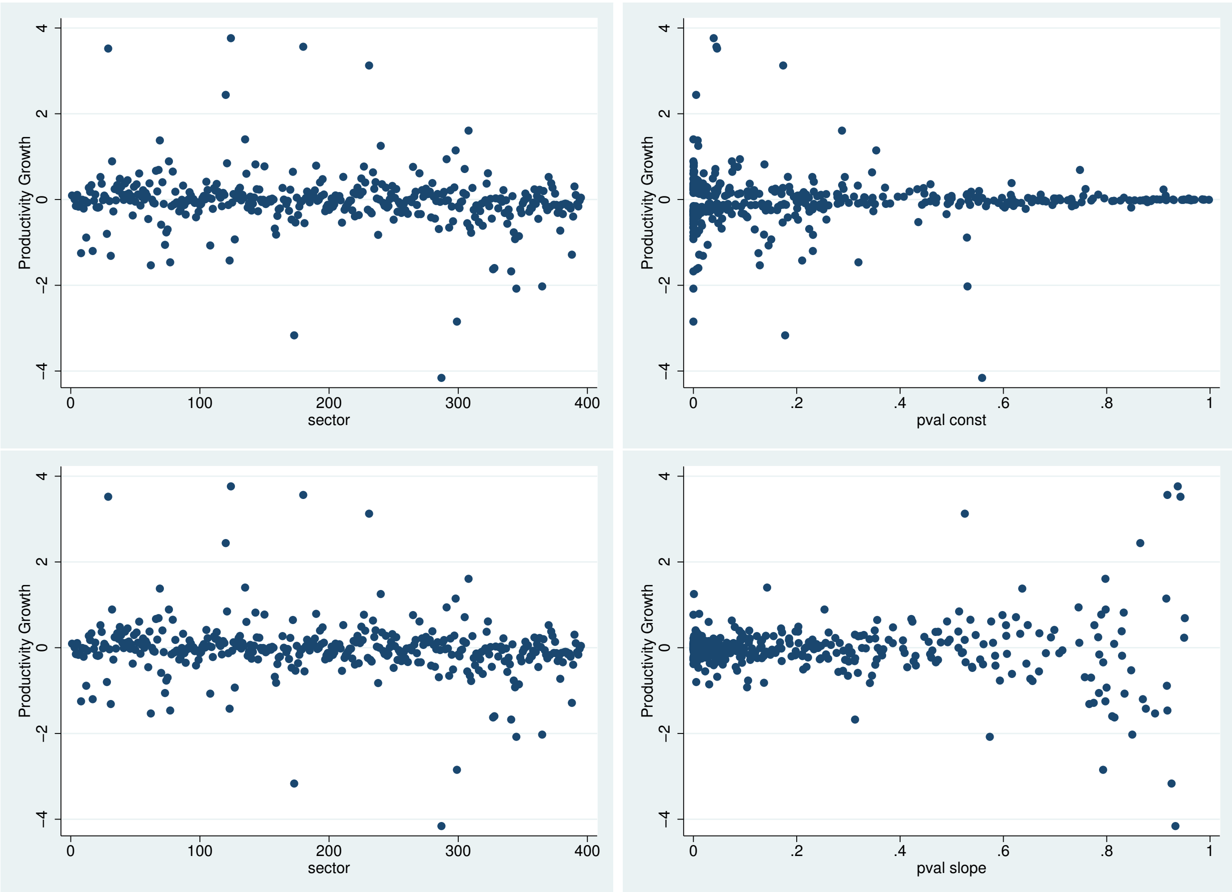

Figure 6: Estimated multifactor CES productivity growth and their statistical significances, for Japan.

Below, we display the multifactor CES unit cost function for the j sector:

$$w_j^D = \theta_j^{-1} \left(\lambda_{0j} (w_0^C)^{1-\sigma_j} + \lambda_{1j} (w_1^C)^{1-\sigma_j} + \cdots + \lambda_{Nj} (w_N^C)^{1-\sigma_j} \right)^{1/(1-\sigma_j)} \tag{22}$$

$$\equiv H_j \left(w_0^C, w_1^C, \cdots w_N^C; \theta_j \right) \tag{23}$$

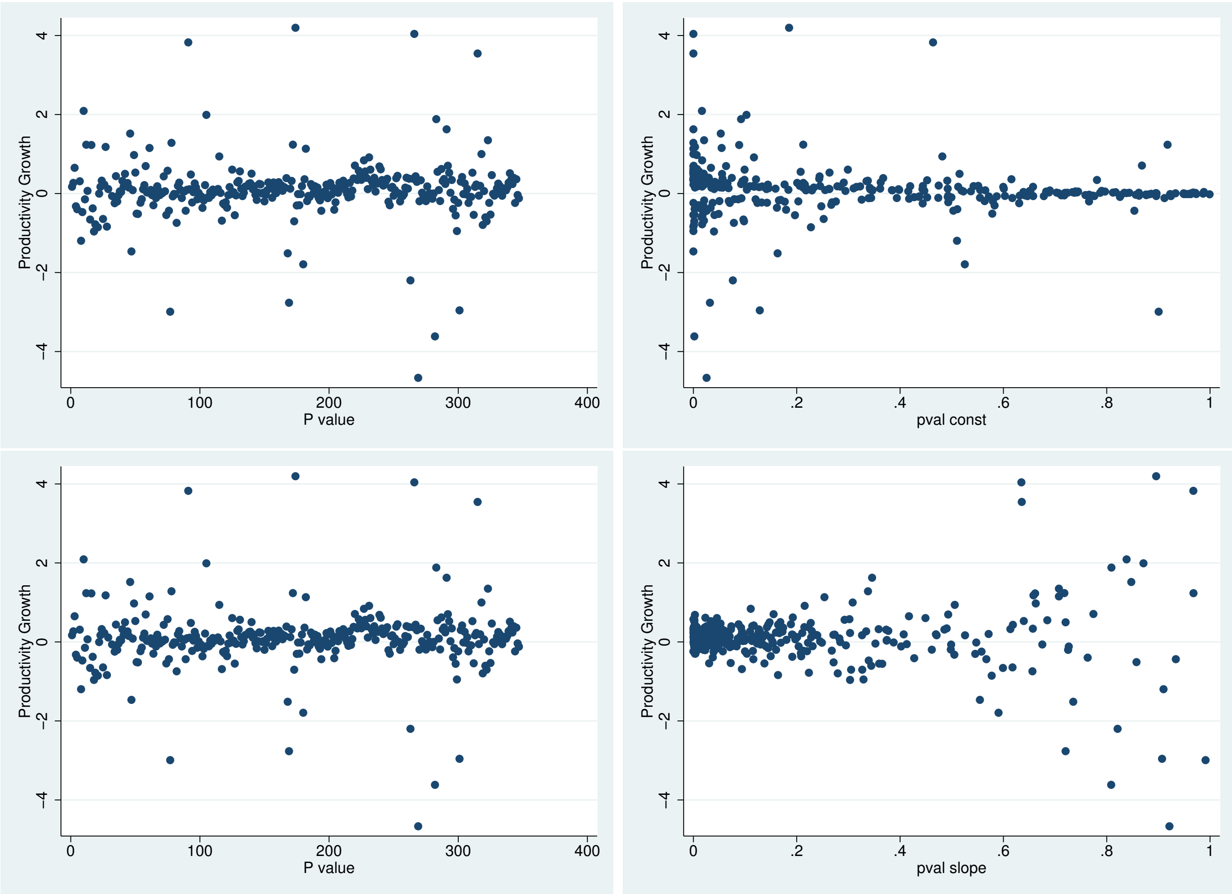

Figure 7: Estimated multifactor CES productivity growth and their statistical significances for Korea.

Note that the elasticity parameters (i.e., σ_j in (22)) are obtained from the slope of the regression line (19), while the share parameters (i.e., λ_{ij} in (22) are calibrated at the current cost shares i.e., $\lambda_{ij} = s_{ij}^1$ which is observable as the input–output coefficient.

4. Bilateral General Equilibrium

4.1. Model Integration

Here, we construct a bilateral multisectoral general equilibrium model that reflects all the measured elasticities for the two countries. First, we will look at one country's general equilibrium state of multisectoral production. We calibrate the share parameters at the current state to examine various exogenous shocks (such as productivity shocks), based on the current state. Below we display the system of unit cost functions (23) in a concise form for the two countries, namely, Japan (labeled J) and Korea (labeled K):

$$\mathbf{w}_J^D = H_J\left(\mathbf{w}_J^C, w_0^C; \boldsymbol{\theta}_J\right), \qquad \mathbf{w}_K^D = H_K\left(\mathbf{w}_K^C, w_0^C; \boldsymbol{\theta}_K\right) \tag{24}$$

Note that $(\theta_1, \cdots, \theta_N)$ denotes the set of exogenous productivity shocks for investigation, where $\theta = 1$ indicates a flat (i.e., no shock) condition. Moreover, w_0^C is kept constant.

We then display the Armington aggregator functions, i.e., within-group aggregator (20) and between-group aggregator (21), in a concise form:

$$\mathbf{w}_J^C = U_J\left(\mathbf{w}_J^D, \mathbf{w}_J^F\right) \qquad \mathbf{w}_K^C = U_K\left(\mathbf{w}_K^D, \mathbf{w}_K^F\right) \tag{25}$$

$$\mathbf{w}_J^F = V_J\left(\mathbf{w}_J^P; \mathbf{w}_J^R\right) \qquad \mathbf{w}_K^F = V_K\left(\mathbf{w}_K^P; \mathbf{w}_K^R\right) \tag{26}$$

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

$$\mathbf{w}_J^P = \mathbf{w}_K^D \qquad \mathbf{w}_K^P = \mathbf{w}_J^D \tag{27}$$

The integrated general equilibrium model comprises the equations (24–27), mapping the prices $\mathbf{w} = \left(\mathbf{w}_J^D, \mathbf{w}_J^C, \mathbf{w}_J^F, \mathbf{w}_J^P, \mathbf{w}_K^D, \mathbf{w}_K^C, \mathbf{w}_K^F, \mathbf{w}_K^P\right)$ onto itself, under certain productivity shock $\boldsymbol{\theta} = (\boldsymbol{\theta}_J, \boldsymbol{\theta}_K)$. Let us specify this mapping as $G^* : \mathbb{R}^{4(n_J+n_K)} \to \mathbb{R}^{4(n_J+n_K)}$. The fixed point of G^* can be obtained through recursion, starting from arbitrary initial guess such as $\mathbf{1}$ (Krasnosel'skiĭ, 1964), for any set of exogenous productivity shock $\boldsymbol{\theta}$:

$$\boldsymbol{w}^* = \lim_{k\to\infty} G^{*k}\left(\mathbf{1}\right) = G^*\left(\cdots G^*\left(G^*\left(\mathbf{1}\right)\right)\cdots\right)$$

For the sake of empirical analysis, we calibrate all parameters under current-state standardized prices. Thus, the current-state prices, under flat exogenous productivity shocks $\boldsymbol{\theta} = \mathbf{1}$ are all unity i.e., $\mathbf{w} = \mathbf{1}$.

4.2. Prospective Structures

Since we know by Shephard's lemma that the factor input can be obtained by differentiating the unit cost function, inputs in physical units per physical unit output for all sectors, or the physical input–output coefficient matrix, can be obtained as the gradient of (24), i.e.,

$$\nabla \mathbf{w}^{*D} = \begin{bmatrix} \frac{\partial H_1(\mathbf{w}^C, w_0^C; \boldsymbol{\theta})}{\partial w_0^C} & \frac{\partial H_2(\mathbf{w}^C, w_0^C; \boldsymbol{\theta})}{\partial w_0^C} & \cdots & \frac{\partial H_n(\mathbf{w}^C, w_0^C; \boldsymbol{\theta})}{\partial w_0^C} \\ \frac{\partial H_1(\mathbf{w}^C, w_0^C; \boldsymbol{\theta})}{\partial w_1^C} & \frac{\partial H_2(\mathbf{w}^C, w_0^C; \boldsymbol{\theta})}{\partial w_1^C} & \cdots & \frac{\partial H_n(\mathbf{w}^C, w_0^C; \boldsymbol{\theta})}{\partial w_1^C} \\ \vdots & \vdots & \ddots & \vdots \\ \frac{\partial H_1(\mathbf{w}^C, w_0^C; \boldsymbol{\theta})}{\partial w_n^C} & \frac{\partial H_2(\mathbf{w}^C, w_0^C; \boldsymbol{\theta})}{\partial w_n^C} & \cdots & \frac{\partial H_n(\mathbf{w}^C, w_0^C; \boldsymbol{\theta})}{\partial w_n^C} \end{bmatrix} = \begin{bmatrix} \nabla_0 H\left(\mathbf{w}^C, w_0^C; \boldsymbol{\theta}\right) \\ \nabla H\left(\mathbf{w}^C, w_0^C; \boldsymbol{\theta}\right) \end{bmatrix}$$

where $\nabla_0 H$ is a n row vector, while ∇H is a $n \times n$ matrix. For convenience, we will use the following terms to indicate the monetary input–output coefficient matrices for current and posterior states (with $\boldsymbol{\theta} \neq \mathbf{1}$).

$$\begin{aligned} 1\nabla_0 H\left(\mathbf{1}, 1; \mathbf{1}\right)\langle\mathbf{1}\rangle^{-1} &\equiv \mathbf{a} & \qquad 1\nabla_0 H\left(\boldsymbol{w}^C, 1; \boldsymbol{\theta}\right)\left\langle\boldsymbol{w}^C\right\rangle^{-1} &\equiv \mathbf{a}^* \\ \langle\mathbf{1}\rangle \nabla H\left(\mathbf{1}, 1; \mathbf{1}\right)\langle\mathbf{1}\rangle^{-1} &\equiv \mathbf{A} & \qquad \left\langle\boldsymbol{w}_{\boldsymbol{\theta}}^C\right\rangle \nabla H\left(\boldsymbol{w}_{\boldsymbol{\theta}}^C, 1; \boldsymbol{\theta}\right)\left\langle\boldsymbol{w}_{\boldsymbol{\theta}}^C\right\rangle^{-1} &\equiv \mathbf{A}^* \end{aligned}$$

Here, $\mathbf{a}$ and $\mathbf{A}$ are the current state (observed) value-added and input–output coefficients, respectively. Angle brackets indicate diagonalization.

Given below is the current-state commodity balance in monetary terms:

$$\mathbf{x} = \mathbf{A}\mathbf{x} + \mathbf{y} + \mathbf{e} - \mathbf{m} \tag{28}$$

where $\mathbf{x}$ denotes domestic output, $\mathbf{y}$ denotes domestic final demand, $\mathbf{e}$ denotes export, $\mathbf{m}$ denotes import, all in column vectors of monetary terms, and $\mathbf{Ax}$ represents intermediate demand. As we monitor $\mathbf{m}$, we have the import coefficient $\mathbf{s}$ that satisfies the following equation:

$$\mathbf{m} = \langle\mathbf{s}\rangle\left[\mathbf{A}\mathbf{x} + \mathbf{y}\right]$$

Further, let us define $\mathbf{s}^P$, the partner-country import coefficient, which is obtained from the partner country import $\mathbf{m}^P$, by using the following equation:

$$\mathbf{m}^P = \left\langle\mathbf{s}^P\right\rangle\mathbf{m} = \left\langle\mathbf{s}^P\right\rangle\langle\mathbf{s}\rangle\left[\mathbf{A}\mathbf{x} + \mathbf{y}\right]$$

Given below is the commodity balance of the posterior state:

$$\mathbf{x}^* = \mathbf{A}^*\mathbf{x}^* + \mathbf{y}^* + \left(\mathbf{e}^R + \mathbf{e}^{*P}\right) - \left(\mathbf{m}^{*R} + \mathbf{m}^{*P}\right) \tag{29}$$

The posterior state values are distinguished by $\boldsymbol{\theta}$. Note that we assume that exports to the ROW are fixed. We assume that imports and exports are subject to change because of $\boldsymbol{\theta} \neq \mathbf{1}$. Note that imports from the partner and the ROW are assumed to be proportional to total domestic demand, as given below:

$$\mathbf{m}^{*P} \left\langle \mathbf{s}^{*P} \right\rangle \left\langle \mathbf{s}^{*} \right\rangle \left[\mathbf{A}^{*}\mathbf{x}^{*} + \mathbf{y}^{*}\right] = \mathbf{e}^{*P\prime} \qquad \mathbf{m}^{*R} = \left[\mathbf{I} - \left\langle \mathbf{s}^{*P} \right\rangle\right] \left\langle \mathbf{s}^{*} \right\rangle \left[\mathbf{A}^{*}\mathbf{x}^{*} + \mathbf{y}^{*}\right] \tag{30}$$

where $\mathbf{y}^*$, the posterior final demand, will be discussed later. As indicated above, exports to the partner country are determined by imports from the partner's partner country.[1] The posterior import coefficients $\mathbf{s}^*$ and $\mathbf{s}^{*\mathbf{P}}$ are calculated according to (5) and (14).

The posterior value-added (external inputs) total can be evaluated by the import endogenized model with regard to the posterior commodity balance equation (29) and (30):[2]

$$\mathbf{a}^{*}\mathbf{x}^{*} = \mathbf{a}^{*} \left[\mathbf{I} - \left[\mathbf{I} - \left\langle \mathbf{s}^{*} \right\rangle\right] \mathbf{A}^{*}\right]^{-1} \left[\left[\mathbf{I} - \left\langle \mathbf{s}^{*} \right\rangle\right] \mathbf{y}^{*} + \mathbf{e}^{*P} + \mathbf{e}^{R}\right] \tag{31}$$

We assume that an economy maximizes its final demand $\mathbf{y}^*$ given the total of external inputs, and to this end the compensation for increased exports to the partner country can be spent for whatever commodity is demanded. We incorporate such external inputs into the domestic production in such a way that the external inputs (value-added) total is fortified.[3] In particular, we must find a scalar δ of the following problem that maximizes the total ex ante value of the current-proportioned final demand i.e., $\mathbf{y}^* = \left\langle \boldsymbol{w}_{\boldsymbol{\theta}}^{D} \right\rangle \mathbf{y}\delta$, given the ex ante total value-added (31), which is limited to the sum of the locally existing primary factor ℓ ($= \mathbf{a}_0\mathbf{x}$) and the compensation for net exports to the partner country, i.e.,

$$\max_{\delta} \ \mathbf{1}\mathbf{y}^{*} = \mathbf{1} \left\langle \boldsymbol{w}_{\boldsymbol{\theta}}^{D} \right\rangle \mathbf{y}\delta \quad \text{s.t.} \qquad \mathbf{a}^{*}\mathbf{x}^{*} \leq \ell + \mathbf{1}\left(\mathbf{e}^{*P} - \mathbf{e}^{P}\right) - \mathbf{1}\left(\mathbf{m}^{*P} - \mathbf{m}^{P}\right) \tag{32}$$

Note that the solution to (32) determines the posterior total domestic demand and thus imports from the partner country which, in turn, determines the compensation for exports against the partner's partner country through (30) that must enter into the constraint of the partner country's problem. In other words, (32) must be solved recursively for both countries under the condition given by the partner country.

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[1] Here, a prime is used to indicate the partner country's export to its partner country.

[2] This model is otherwise called the Chenery–Moses type or the competitive import model.

[3] It may be more natural to incorporate export compensation into imports; however, this option was not exercised on the grounds that imports are endogenized with respect to domestic final demand alone, as specified in (30).

5. Analysis

5.1. 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 observe the role of ICT (Mattioli and Lamonica (2013), Xing et al. (2011), Kecek et al. (2016), Jung et al. (2013), Jung (2012), Vu (2013)), they do not reflect changes in international trade caused by productivity enhancement of ICT. We build a bilateral multifactor CES general equilibrium model using 2000–2005 linked input–output tables for Japan and Korea. The linked input–output tables are composed of 395 industries for Japan and 350 industries for Korea. However, the Bank of Korea (BOK), which compiles the input–output tables of Korea, does not give the standard of classification for ICT industries. Jung (2012) suggested 16 industries in manufacturing and four in services as ICT industries among 350 industries of the linked input–output tables of Korea. Kwak (2014) selected 11 manufacturing and seven service industries among 161 industries of the (small sized) input–output tables of Korea. On the other hand, Jung et al. (2013) followed the OECD and reclassified the input–output tables of Korea into ICT-producing and ICT-using industries. OECD (2011) shows the classification of the ICT products. According to this definition, ICT goods/services are classified into four manufacturing sectors, e.g., computers and peripheral equipment, communication equipment, consumer electronic equipment, miscellaneous ICT components and goods, and six service sectors, e.g., manufacturing services for ICT equipment, business and productivity software and licensing services, information technology consultancy and services, telecommunications services, leasing or rental services for ICT equipment, and other ICT services. Some studies adopt the OECD definition to choose ICT industries in national input–output tables (Xing et al. (2011), Jung et al. (2013)). Meanwhile, MIAC (2017) publishes ICT input–output tables for Japan which consists of ICT and non-ICT industries. In this table, ICT is made up of ICT industries, ICT-related industries, and R & D industries. Likewise, Kim et al. (2016) has constructed ICT input–output tables of Korea which comprises ICT manufacturing and ICT service industries. We adopt the classification of MIAC (2017) and select 45 industries as ICT for Japan. Referring to Kim et al. (2016), we choose 39 industries for Korea which correspond to the ICT industries of Japan. Tables 1 and 2 show the ICT industries of the linked input–output tables for Japan and Korea.

5.2. CES elasticity and productivity growth of ICT

Tables 3 and 4 show the CES elasticities and productivity growths of ICT industries for Japan and Korea. CES elasticities of most ICT industries are estimated to be greater than

1. Furthermore, half 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 Korea. Compared with 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 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 ICT industries, the greatest productivity growth is seen $j = 315$ (advertising services, 3.545), whose coefficient has a significant positive value. And $j = 318$ (computer-related services, 0.999) is in second place.

5.3. Simulations

5.3.1. Overall

We first calculate the equilibrium price when productivity increases in the ICT sectors of Japan and Korea. For this, we use the 2000–2005 linked input–output tables of Japan and Korea. Since 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 Korea, for the corresponding periods to inflate the value-added observed in normal values. 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 is increased by 10% exogenously in Japan and Korea. Using the bilateral general equilibrium model, we summarize the total effects in Table 5. We explain changes in final demand, and in the export and import of the two countries, in three kinds of scenarios. The first indicates that productivity improved in both countries. The second case shows that productivity increased only in Japan, while the last shows an increment only in Korea. Notice that BJPY stands for billion Japanese yen and BKRW for billion 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 Korea. The net benefit (in terms of gain in final demand Δy) is 8,582 BJPY for Japan (about 1.70% of the current GDP) and 54,303 BKRW for Korea (about 6.49% of the current GDP). When only one country's ICT productivity grows, GDP and final demand may increase. Japan gets additional 8,292 BJPY of GDP and

9,792 BJPY of final demand because of Japan's ICT betterment. Meanwhile, Korea gains 40,090 BKRW of GDP and 35,042 BKRW of final demand through Korea's ICT productivity growth. Meanwhile, the partner's ICT development has different effects. Japan's improved ICT raises Korea's GDP (11,452 BKRW) and final demand (5,117 BKRW), since Korea has huge imports from Japan (53,842 BKRW). Productivity growth knocks the price down. Thus, Korea imports more of the relatively cheaper Japanese goods. However, Korea's ICT productivity enhancement curtails Japan's GDP (−1,142 BJPY) and final demand (−232 BJPY). The changes in bilateral trades, i.e., exports and imports between the two countries, show positive signs in Table 5. Exports from 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, Korea has a positive net export (16,189 BKRW). On the other hand, Japan shows negative net exports (−1,742 BJPY). However, if ICT productivity of only one side is enhanced, Korea's exports decline sharply. Net exports of Korea in scenario 2 record −15,425 BKRW and −16,299 BKRW in scenario 3. Korea's bilateral imports shows equivalent amounts in the three scenarios, as seen in Table 5. In other words, Korea's economy depends deeply on Japan. Meanwhile, Japan's bilateral imports in the second and third scenarios are less than half of those in the first scenario. Japan responds flexibly to price changes in bilateral trade.

5.3.2. Sectoral price changes

Basically, when there is a 10% productivity improvement 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 8 for Japan and Figure 9 for Korea. In these figures, most of the ICT sectors show a greater than 10% price reduction.

The top six ICT sectors in Figure 8 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%) for Japan. Meanwhile, $j = 315$ (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%) are the top six for Korea in Figure 9. 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 huge interaction in the economy. Meanwhile, computer equipment, the representative ICT indstry, ranked fourth and fifth in Japan and fifth in Korea. Moreover, not only ICT industries, but also non-ICT industries showed lower prices in response to ICT innovation, as seen in Figures 8 and 9. For examples, 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%) are the top six non-ICT industries for Japan, as seen in Figure 8, whereas 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%) are the top six for Korea, as seen in Figure 9. Thus, ICT innovation induces price reductions for itself and other industries. To take a concrete example, the two biggest inputs of j =128 (cosmetics, toiletries, and dentifrices) industry of Japan are ICT industries such as $j = 364$ (advertising services) and $j = 349$ (research and development (intra-enterprise)). There is one more point we should consider. Figures 8 and 9 explain that Korea saw greater price reductions than Japan. The price cut in the ICT industry of Japan is 10.92%, on average, whereas in Korea it is 12.29%. Figures 10) and 13) show that price changes were only influenced by domestic ICT improvement. The ICT industries' average was 10.52% for Japan and 11.96% for Korea. The price reduction caused by only the partner country's ICT uplift was 0.14% for Japan and 0.29% for Korea, as seen in Figures 12 and 11. In Figure 12, ICT industries 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%) are ranked high. Similarly, high ranked sectors for Korea are ICT industries 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%) in Figure 11. Ultimately, domestic ICT growth influences the partner country's price of ICT industries. Furthermore, Korea suffers a bigger downturn than Japan, as it is strongly affected by the partner's economic climate.

5.3.3. Sectoral changes of outputs and bilateral trade values

To observe industrial changes specifically, we classify sectors into seven categories, including 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 the others. The changes of total bilateral trade values by the three scenarios are mentioned in 5.3.1. Tables 6 and 7 demonstrate changes of (domestic) outputs and bilateral trade values (net) of eight groups between Japan and Korea. Overall, Table 7 shows a larger number of positive values than Table 6. It suggests Korea gains more than Japan in terms of output. In 5.3.2, we found that chain reactions to price changes in Korea are more sensitive than in Japan. If the price of intermediate inputs drops because of any exogenous ICT productivity improvement, Korea benefits as it is more sensitive to price changes of intermediate inputs. Thus, Korea produces more with cheaper intermediate inputs. In 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 Korea, the output of Japan shrinks. In other words, Japan's domestic intermediate inputs are substituted for imported goods from Korea since they become cheap. Simultaneously, net bilateral trade values of the ICT industries of Japan show negative values for all cases. On the other hand, Korea has negative net trade values for non-ICT manufacturing for all scenarios (and additional negative net trade values for non-ICT services and the others for scenarios 1 and 3), since Japan's non-ICT goods become cheaper because of an improvement in ICT. Thus, Korea imports more non-ICT goods from Japan. This then leads to negative values in net bilateral trade values of Korea's non-ICT industries.

6. Concluding Remarks

ICT is widely recognized as a key factor in economic growth. We go by the definition used in OECD (2011) and in some previous studies, to select 45 industries of Japan and 39 of Korea in 2000–2005 linked input–output tables as constituting the ICT sector. We examine the impact of the ICT sector on economic growth by using a bilateral multifactor CES general equilibrium model of Japan and 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 Korea shows greater and positive ICT productivity growth than Japan. Some ICT industries of Japan show negative productivity. Second, we examine three types of simulations of exogenous 10% ICT productivity improvement. We describe the effects of ICT productivity growth as changes in price, GDP, final demand, outputs, and (net) bilateral trade values. In terms of 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

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)

also react sensitively to ICT innovation in both countries. On average, Korea has bigger cost reductions than Japan since Korea's price reductions are large. Third, net bilateral trade values indicate that Korea gains more than Japan. Since Korea reacts quickly to price changes, it can achieve bigger cost reductions. Thus, Korea benefits more from 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

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

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

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

	Japan		Korea	
	BJPY	(BKRW)	BKRW	(BJPY)
Current Gross domestic product (GDP)	505,269		851,982	
Scenario 1: 10% productivity increase of ICT sectors in Japan and Korea				
ΔGDP	4,343	40,362	77,284	8,316
ΔFinal demand Δy	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 of ICT sectors in Japan				
ΔGDP	8,292	77,065	11,452	1,232
Δ Final demand Δy	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 of ICT sectors in Korea				
ΔGDP	-1,142	-10,618	40,090	4,314
ΔFinal demand Δy	-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	

Table 6: Changes of Sectoral Outputs and Bilateral Trade Values (Japan)

scenario	sector	Δ(Net) Bilateral trade values (BJPY)	Δ Outputs (BJPY)
Scenario 1: 10% productivity increase of ICT sectors 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 of ICT sectors 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 of ICT sectors 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 Trade Values (Korea)

scenario	sector	Δ(Net) Bilateral trade values (BKRW)	Δ Outputs (BKRW)
Scenario 1: 10% productivity increase of ICT sectors 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 of ICT sectors 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 of ICT sectors 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

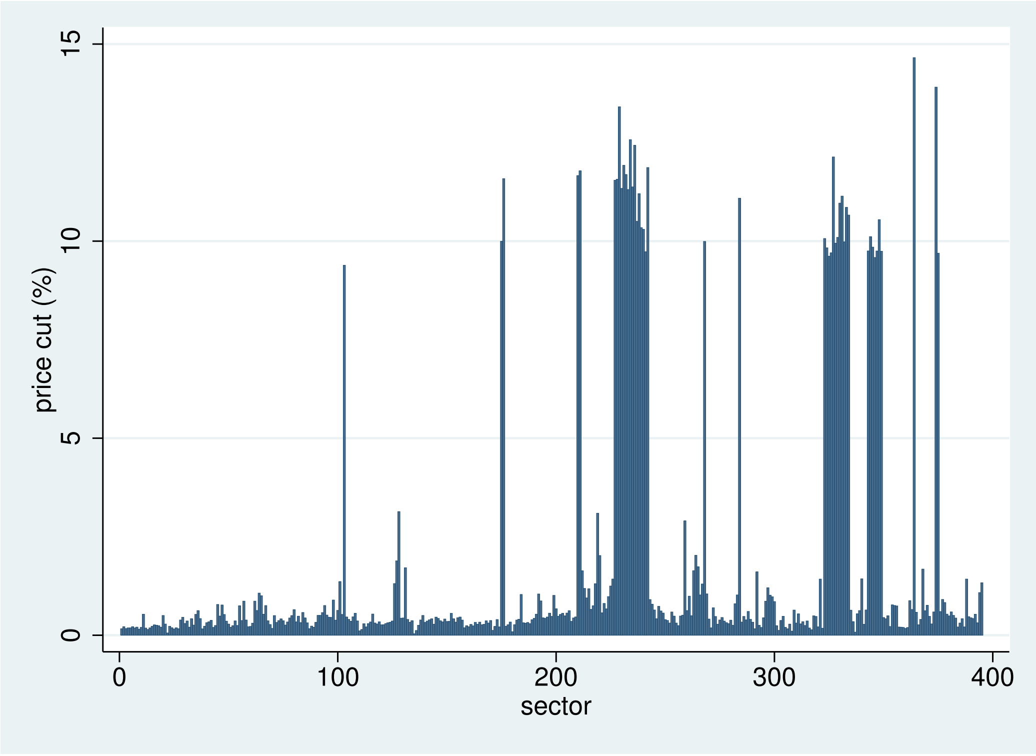

Figure 8: Sectoral distribution of price cut of Japan (10% of ICT productivity increments in Japan and Korea)

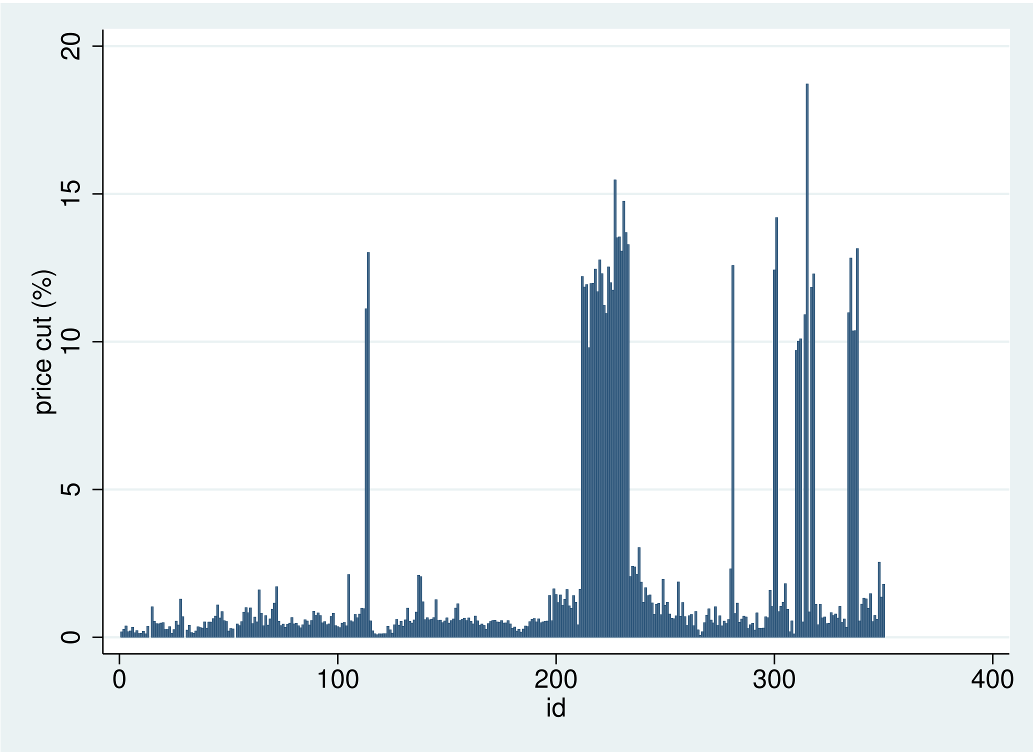

Figure 9: Sectoral distribution of price cut of Korea (10% of ICT productivity increments in Japan and Korea)

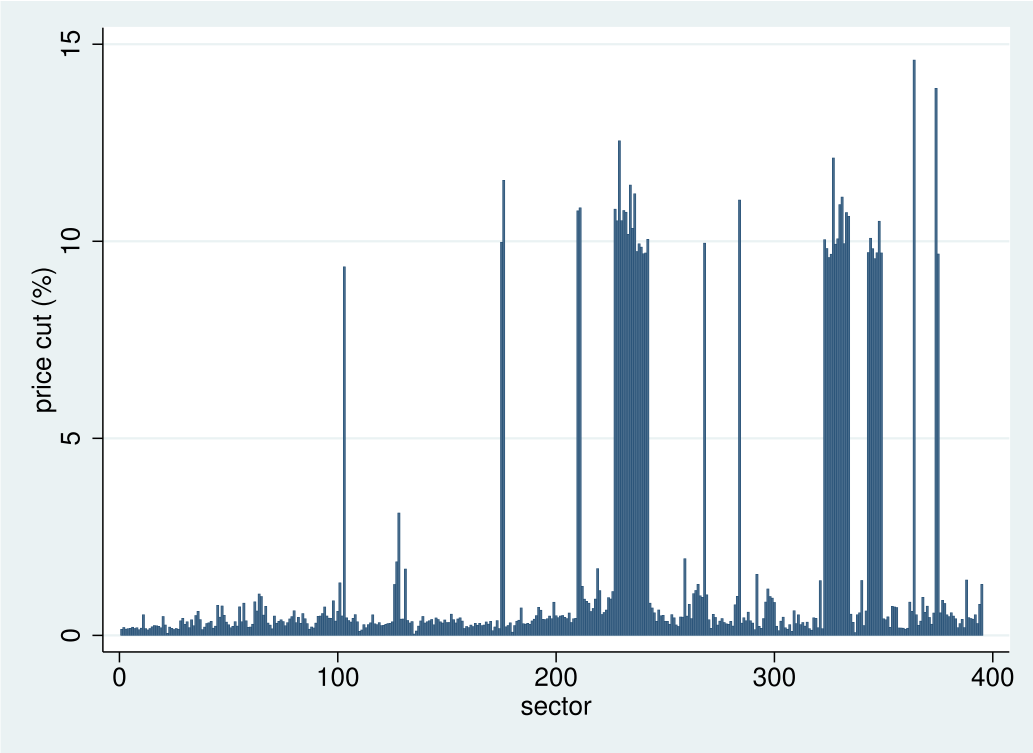

Figure 10: Sectoral distribution of price cut of Japan (10% of ICT productivity increments only in Japan)

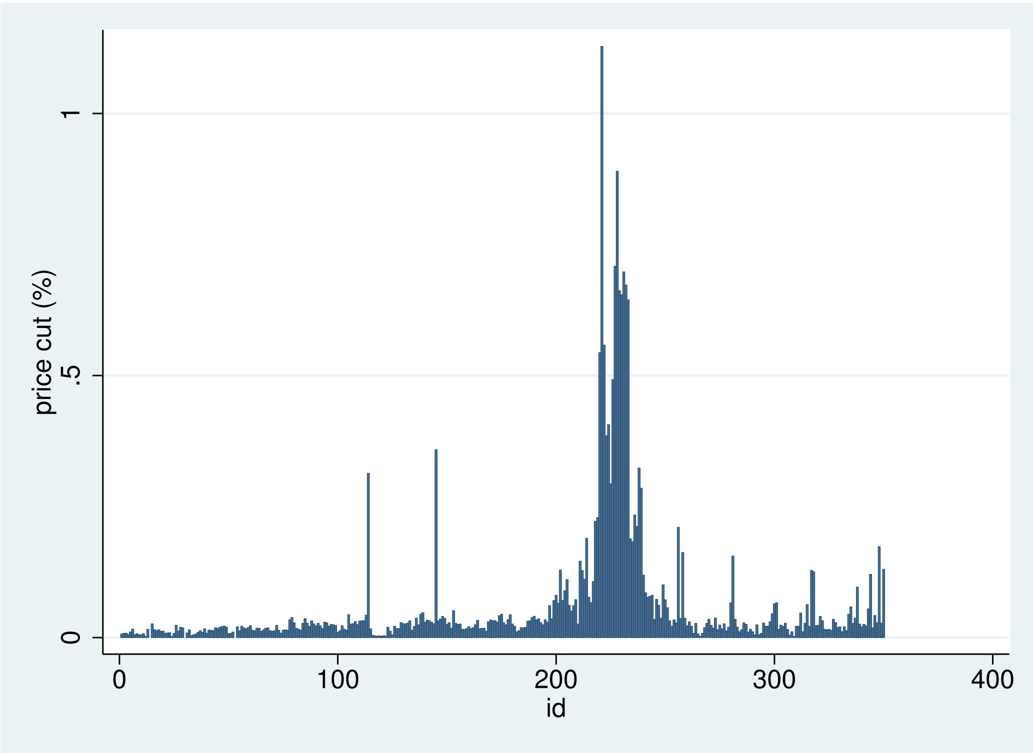

Figure 11: Sectoral distribution of price cut of Korea (10% of ICT productivity increments only in Japan)

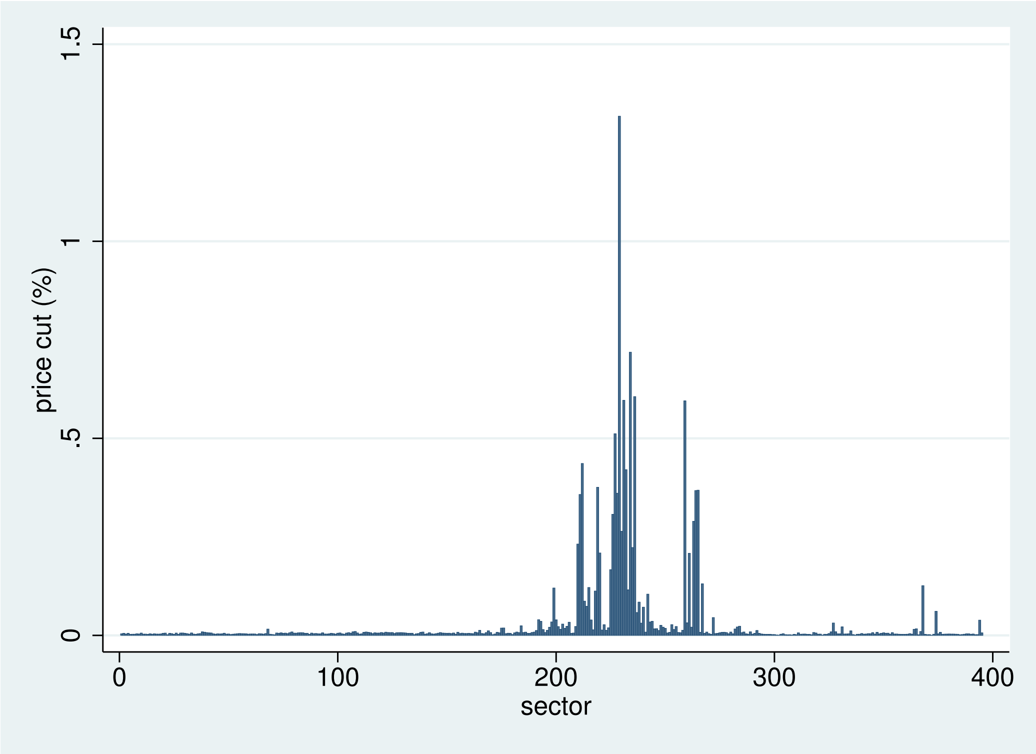

Figure 12: Sectoral distribution of price cut of Japan (10% of ICT productivity increments only in Korea)

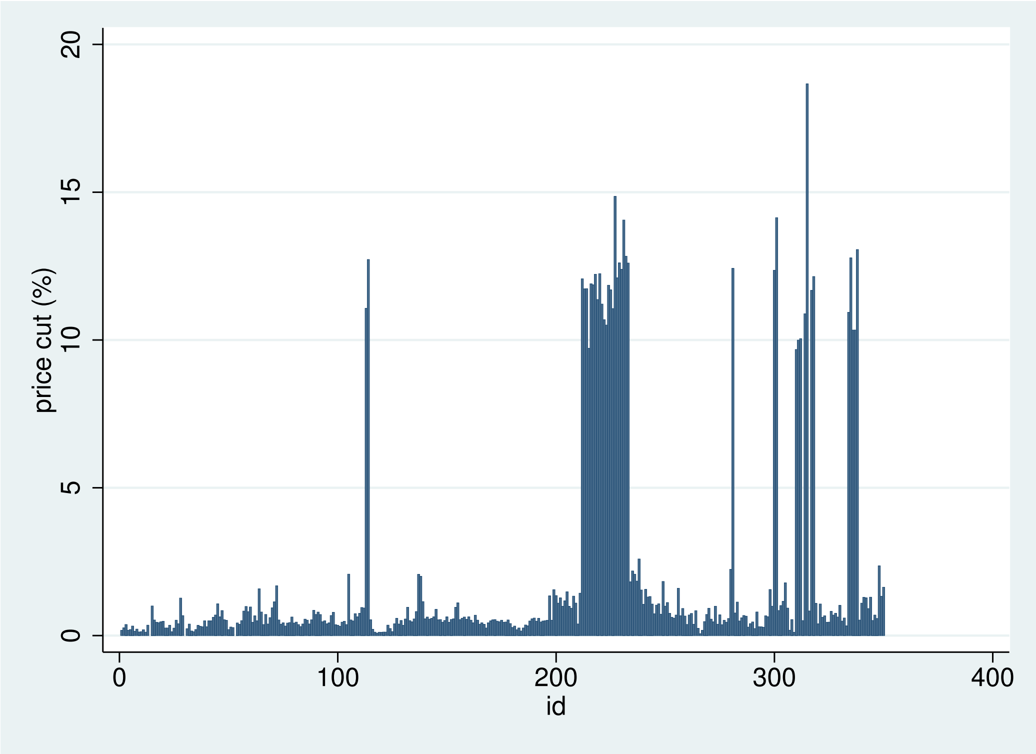

Figure 13: Sectoral distribution of price cut of Korea (10% of ICT productivity increments only in Korea)

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