

International Competitiveness: A Comparison of the Manufacturing Sector in Korea and Japan

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Using firm-level data covering most firms in the manufacturing sectors of Korea and Japan, we compiled a new dataset of TFP and factor costs by firm size and industry. Employing this dataset, we quantitatively examine changes in the two countries' relative competitiveness. Following Dekle, and Fukao's (2011) approach based on production cost functions, we decompose intertemporal changes in the relative competitiveness of Korean firms vis-à-vis Japanese firms into four factors: (1) differences in TFP growth (catching up of Korean firms); (2) changes in relative factor prices; (3) changes in relative intermediate input prices; and (4) changes in real exchange rates. Using our new dataset, we also compare changes in the two

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countries' competitiveness by different firm-size groups. We find that during the period of 1994-2010, the real wage rate of Korean workers doubled in most industries. Nevertheless, the competitiveness of Korean firms relative to their Japanese counterparts did not deteriorate. The main factors canceling out the impact of real wage increases were Korea's higher TFP growth in many industries such as motor vehicles and the sharp decline in Korean intermediate input prices in some industries such as electrical and electronic machinery. We also find that in many industries the competitiveness of Korean small and medium-sized firms vis-à-vis their Japanese counterparts increased by more than that of large firms. Two important developments can be observed which likely contributed to the improved competitiveness of small and medium-sized firms in Korea vis-à-vis their rivals in Japan. First, in Korea, small and medium-sized firms registered higher TFP growth rates than large firms during 1994-2010. And second, wage gaps across firm-size groups narrowed in Japan, while they widened in Korea.

Keywords: Competitiveness, Average production costs, TFP

JEL Classification: D24, O47, O57

I. Introduction

During the two lost decades, Japan's manufacturing sector suffered from a deterioration of its international competitiveness caused by currency appreciation and a slowdown of TFP growth (Dekle, and Fukao 2011; Jorgenson, Nomura, and Samuels 2015). In some important industries, such as electrical and electronic machinery and motor vehicles, Korean firms such as Samsung Electronics and Hyundai Motors have captured markets from Japanese firms. Because the two countries share a similar level of economic development and similar factor endowments (abundant skilled labor and technical knowledge, scarce natural resources, etc.), have limited mutual foreign direct investment, and are located in close proximity, firms from the two countries frequently produce close substitutes and stand in fierce competition in world markets. The relative competitiveness of firms from the two countries has important implications for the two countries' trade balance and final demand in the economy. Against this background, the purpose of the present study is to compare the manufacturing-sector competitiveness of the two countries using firm-level data covering the period from 1994 to 2010.

Our approach has two distinguishing characteristics. First, we quantitatively analyze changes in the relative competitiveness of the two

countries from the perspective of average production costs. Following Dekle, and Fukao's (2011) approach based on production cost functions, we decompose intertemporal changes in the relative competitiveness of Korean firms vis-à-vis Japanese firms into four factors: (1) differences in TFP growth (catching up of Korean firms); (2) changes in relative factor prices; (3) changes in relative intermediate input prices; and (4) changes in real exchange rates. As Dekle, and Fukao (2011) and Demian, and di Mauro (2015) have shown, changes in relative competitiveness can differ substantially across subsectors. We therefore examine competitiveness at a subsector level.

The second distinguishing characteristic of our analysis is that we take account of the possibility that changes in international competitiveness may differ across different firm-size groups. To do so, we compare the competitiveness of the two countries across different firm-size groups. In many manufacturing subsectors, firms of different size compete in different markets. For example, in the motor vehicle and electrical and electronic machinery industries, most large firms are assemblers and compete in final goods markets. In contrast, most smaller firms are parts and components suppliers and compete in intermediate goods markets. Probably because of such differences, the manufacturing sector in both countries is characterized by a dual structure: large firms tend to be more human- and physical capital-intensive and offer substantially higher wages than smaller firms.¹ In addition, TFP growth may also differ across firms of different size. As shown by Kim, Fukao, and Makino (2010), the productivity gap between large and small factories has widened in Japan.² In the two lost decades, when productivity growth in Japan overall was very sluggish, it was primarily small and medium-sized enterprises (SMEs) that suffered a slowdown in TFP growth, while most large manufacturing firms in Japan continued to experience substantial TFP growth. This means that if no such widening in productivity gaps occurred in Korea, the competitiveness of small firms in Korea may have improved vis-à-vis their Japanese counterparts.

In order to examine manufacturing-sector competitiveness in the two countries from these two perspectives — average production costs and potential productivity differences across firms of different size — we compiled a new dataset of TFP and factor costs by firm size and

¹ For more on this issue, see Okazaki, and Okuno-Fujiwara (1999); Lim (2013).

² On this issue, also see Fukao, and Kwon (2006).

industry, using firm-level data. The dataset covers most firms in Korea's and Japan's manufacturing sector and spans the period from 1994 to 2010. One of the authors of this paper has measured the absolute level of TFP of the firms in Korea and Japan, and studied about TFP catch-up in Jung, Lee, and Fukao (2008). The current paper is different from that work in four aspects. First, this paper measures not the absolute level of TFP but its change over time. Second, it considers the changes in the values of such determinants of average production costs as factor prices and exchange rates. Third, this paper covers small and medium sized firms as well as large sized firms. Fourth, this paper covers more recent years, compared to the period of 1984-2005 in Jung, Lee, and Fukao (2008), and utilizes Bank of Korea's new data on prices in Korea.

The remainder of this study is organized as follows. In the next section, we explain our analytical framework and data. Next, in Section III, we report the results of our empirical analysis, while in Section IV we summarize our main findings and discuss issues left for future research.

II. Analytical Framework and Data

Our approach to compare the competitiveness of Korea's and Japan's manufacturing sectors follows that presented in Dekle, and Fukao (2011). Specifically, we measure changes in the competitiveness of Korean firms by estimating changes in their average production costs relative to the average production costs of Japanese firms.

The structure of this section is as follows. First, we explain how we decompose changes in firms' average production costs. Next, we explain how we aggregate firm-level data into averages for firm groups (firms are grouped by country, by industry, and by firm size) and how we convert the data for the two countries into a comparable unit. Finally, we describe our data sources.

We assume constant returns to scale and the following production function for a representative firm f in industry i in country κ at time t :

$$Y_{f,i,\kappa}(t) = F_{i,\kappa}(L_{f,i,\kappa}(t), K_{f,i,\kappa}(t), X_{f,i,\kappa}(t), T_{f,i,\kappa}(t)) \quad (1)$$

where $Y_{f,i,\kappa}(t)$ denotes the real gross output of firm f , $L_{f,i,\kappa}(t)$ is the labor input, $K_{f,i,\kappa}(t)$ the capital service input, $X_{f,i,\kappa}(t)$ the input of intermediate

goods, and $T_{f,i,\kappa}(t)$ the technology level.

The average production cost of firm f , $C_{f,i,\kappa}$, is given by

$$C_{f,i,\kappa}(t) = \frac{\tau_{f,i,\kappa}(t)}{Y_{f,i,\kappa}(t)} = \frac{w_{f,i,\kappa}(t)L_{f,i,\kappa}(t) + r_{i,\kappa}(t)K_{f,i,\kappa}(t) + q_{i,\kappa}(t)X_{f,i,\kappa}(t)}{Y_{f,i,\kappa}(t)} \quad (2)$$

where $\tau_{f,i,\kappa}(t)$ denotes the total cost, $w_{f,i,\kappa}(t)$ denotes the wage rate for workers at firm f , $r_{i,\kappa}(t)$ is the price of capital services, and $q_{i,\kappa}(t)$ the price of intermediate inputs.³ We measure all three factor prices in real terms. In the case of Korean firms, we deflate the three nominal factor prices in won by Korea's consumer price index (CPI). Therefore, the unit of Korea's average production costs, $C_{f,i,Korea}$, is Korea's consumption basket. Similarly, for Japanese firms, we deflated factor prices in yen by Japan's CPI. The unit of Japan's average production costs, $C_{f,i,Japan}$, is Japan's consumption basket.

For the Korea Japan comparison of average production costs, we need to measure the two countries' production costs in terms of an identical unit. For this purpose, we divide our average costs data on Japanese firms, $C_{f,i,Japan}$, by the real exchange rate, $\pi = (\Pi \times \text{Korea's CPI}/\text{Japan's CPI})$, where Π denotes the nominal yen-won rate (the value of the Korean won in terms of the Japanese yen). The derived value, $C_{f,i,Japan}/\pi$, denotes Japan's average costs in terms of Korea's consumption basket.

Differentiating Equation (2) over time and using cost minimization conditions, we obtain

$$\hat{C}_{f,i,\kappa}(t) = s_{f,i,\kappa}^L(t)\hat{w}_{f,i,\kappa}(t) + s_{f,i,\kappa}^K(t)\hat{r}_{i,\kappa}(t) + s_{f,i,\kappa}^X(t)\hat{q}_{i,\kappa}(t) - \hat{A}_{f,i,\kappa}(t) \quad (3)$$

where the circumflex denotes the growth rate of a variable. $s_{f,i,\kappa}^L(t)$, $s_{f,i,\kappa}^K(t)$, and $s_{f,i,\kappa}^X(t)$ denote the cost share of each production factor. The cost shares are defined as follows:

$$s_{f,i,\kappa}^L(t) = \frac{w_{f,i,\kappa}(t)L_{f,i,\kappa}(t)}{w_{f,i,\kappa}(t)L_{f,i,\kappa}(t) + r_{i,\kappa}(t)K_{f,i,\kappa}(t) + q_{i,\kappa}(t)X_{f,i,\kappa}(t)}$$

³ We calculate firm-level wage rates by dividing total direct labor costs by the number of employees. As for the price of capital services, $r_{i,\kappa}$ and the price of intermediate inputs, $q_{i,\kappa}$, we do not have information at the firm level, so that we assume that these are identical across firms in a particular industry.

$$\begin{aligned}s_{f,i,\kappa}^K(t) &= \frac{r_{i,\kappa}(t)K_{f,i,\kappa}(t)}{w_{f,i,\kappa}(t)L_{f,i,\kappa}(t) + r_{i,\kappa}(t)K_{f,i,\kappa}(t) + q_{i,\kappa}(t)X_{f,i,\kappa}(t)} \\ s_{f,i,\kappa}^X(t) &= \frac{q_{i,\kappa}(t)X_{f,i,\kappa}(t)}{w_{f,i,\kappa}(t)L_{f,i,\kappa}(t) + r_{i,\kappa}(t)K_{f,i,\kappa}(t) + q_{i,\kappa}(t)X_{f,i,\kappa}(t)}\end{aligned}$$

In Equation (3), $\hat{A}_{f,i,\kappa}(t)$ denotes total factor productivity (TFP) growth on a gross output basis, which is defined by

$$\hat{A}_{f,i,\kappa}(t) = \frac{T_{f,i,\kappa}(t)}{Y_{f,i,\kappa}(t)} \frac{\partial F_{i,\kappa}(\dots)}{\partial T_{f,i,\kappa}(t)} \hat{T}_{f,i,\kappa}(t)$$

In order to apply Equation (3) to discrete time-series data, we use the following Törnqvist approximation of this equation:

$$\begin{aligned}\hat{C}_{f,i,\kappa}^{t-1,t} &\equiv \ln(C_{f,i,\kappa}(t)) - \ln(C_{f,i,\kappa}(t-1)) \\ &= \frac{s_{f,i,\kappa}^L(t) + s_{f,i,\kappa}^L(t-1)}{2} \{(\ln(w_{f,i,\kappa}(t)) - \ln(w_{f,i,\kappa}(t-1))) \\ &\quad + \frac{s_{f,i,\kappa}^K(t) + s_{f,i,\kappa}^K(t-1)}{2} \{(\ln(r_{i,\kappa}(t)) - \ln(r_{i,\kappa}(t-1))) \\ &\quad + \frac{s_{f,i,\kappa}^X(t) + s_{f,i,\kappa}^X(t-1)}{2} \{(\ln(q_{i,\kappa}(t)) - \ln(q_{i,\kappa}(t-1))) \\ &\quad - \{(\ln(A_{f,i,\kappa}(t)) - \ln(A_{f,i,\kappa}(t-1)))\}\}\}\}\end{aligned}\tag{4}$$

Using Equation (4), we can decompose changes in average costs into changes in capital services prices, changes in wage rates, changes in intermediate input prices, and changes in TFP. We use the following variables to represent the different terms on the right-hand side of Equation (4):

$$\begin{aligned}\hat{W}_{f,i,\kappa}^{t-1,t} &\equiv \frac{s_{f,i,\kappa}^L(t) + s_{f,i,\kappa}^L(t-1)}{2} \left\{ \ln(w_{f,i,\kappa}(t)) - \ln(w_{f,i,\kappa}(t-1)) \right\}, \\ \hat{R}_{i,\kappa}^{t-1,t} &\equiv \frac{s_{f,i,\kappa}^K(t) + s_{f,i,\kappa}^K(t-1)}{2} \left\{ \ln(r_{i,\kappa}(t)) - \ln(r_{i,\kappa}(t-1)) \right\}, \text{ and}\end{aligned}$$

$$\hat{Q}_{f,i,\kappa}^{t-1,t} \equiv \frac{s_{f,i,\kappa}^X(t) + s_{f,i,\kappa}^X(t-1)}{2} \left\{ \ln(q_{i,\kappa}(t)) - \ln(q_{i,\kappa}(t-1)) \right\}.$$

Differentiating Equation (1) over time and applying the Törnqvist approximation, we can derive the following growth accounting relationship:

$$\begin{aligned} \hat{A}_{f,i,\kappa}^{t-1,t} &\equiv \ln(A_{f,i,\kappa}(t)) - \ln(A_{f,i,\kappa}(t-1)) \\ &= \ln(Y_{f,i,\kappa}(t)) - \ln(Y_{f,i,\kappa}(t-1)) \\ &\quad - \frac{s_{f,i,\kappa}^L(t) + s_{f,i,\kappa}^L(t-1)}{2} \left\{ \ln(L_{f,i,\kappa}(t)) - \ln(L_{f,i,\kappa}(t-1)) \right\} \\ &\quad - \frac{s_{f,i,\kappa}^K(t) + s_{f,i,\kappa}^K(t-1)}{2} \left\{ \ln(K_{f,i,\kappa}(t)) - \ln(K_{i,\kappa}(t-1)) \right\} \\ &\quad - \frac{s_{f,i,\kappa}^X(t) + s_{f,i,\kappa}^X(t-1)}{2} \left\{ \ln(X_{i,\kappa}(t)) - \ln(X_{i,\kappa}(t-1)) \right\} \end{aligned}$$

Using this relationship, we estimate the TFP growth rate of firm f in industry i in country κ from $t-1$ to t , $\hat{A}_{f,i,\kappa}^{t-1,t}$, in Equation (4).

Next, we turn to how we aggregate the variables in Equation (4) over all firms in industry i in country κ . As weights for the aggregation, we use the total costs of each firm f . We then aggregate the variables on both sides of Equation (4) as follows:

$$\hat{C}_{i,\kappa}^{t-1,t} = \sum_{f \in i} \left[\theta_{f,i,\kappa}^{t-1,t} \times \hat{C}_{f,i,\kappa}^{t-1,t} \right],$$

$$\hat{W}_{i,\kappa}^{t-1,t} = \sum_{f \in i} \left[\theta_{f,i,\kappa}^{t-1,t} \times \hat{W}_{f,i,\kappa}^{t-1,t} \right],$$

$$\hat{R}_{i,\kappa}^{t-1,t} = \sum_{f \in i} \left[\theta_{f,i,\kappa}^{t-1,t} \times \hat{R}_{f,i,\kappa}^{t-1,t} \right],$$

$$\hat{Q}_{i,\kappa}^{t-1,t} = \sum_{f \in i} \left[\theta_{f,i,\kappa}^{t-1,t} \times \hat{Q}_{f,i,\kappa}^{t-1,t} \right], \text{ and}$$

$$\hat{A}_{i,\kappa}^{t-1,t} = \sum_{f \in i} \left[\theta_{f,i,\kappa}^{t-1,t} \times \hat{A}_{f,i,\kappa}^{t-1,t} \right],$$

where

$$\theta_{f,i,\kappa}^{t-1,t} = \frac{1}{2} \left\{ \frac{\tau_{f,i,\kappa}(t-1)}{\sum_{g \in i} \tau_{g,i,\kappa}(t-1)} + \frac{\tau_{f,i,\kappa}(t)}{\sum_{g \in i} \tau_{g,i,\kappa}(t)} \right\}.$$

This aggregation yields the following relationship:

$$\hat{C}_{i,\kappa}^{t-1,t} = \hat{W}_{i,\kappa}^{t-1,t} + \hat{K}_{i,\kappa}^{t-1,t} + \hat{Q}_{i,\kappa}^{t-1,t} - \hat{A}_{i,\kappa}^{t-1,t} \quad (5)$$

We use 1994 as the benchmark year and set $C_{i,\kappa}(1994)=1$. We, then, calculate $C_{i,\kappa}(t)$ for $t > 1994$ iteratively using $C_{i,\kappa}(t) = C_{i,\kappa}(t-1) \cdot \exp(\hat{C}_{i,\kappa}^{t-1,t})$.

We can then examine the sources of changes in the relative competitiveness of the two countries in a particular industry by calculating the difference between the two countries in each of the terms on both sides of Equation (5) and taking account of changes in the real exchange rate:

$$\begin{aligned} \hat{C}_{i,Korea}^{t-1,t} - \hat{C}_{i,Japan}^{t-1,t} + \hat{\pi}^{t-1,t} &= \hat{W}_{i,Korea}^{t-1,t} - \hat{W}_{i,Japan}^{t-1,t} + \hat{K}_{i,Korea}^{t-1,t} - \hat{K}_{i,Japan}^{t-1,t} \\ &\quad + \hat{Q}_{i,Korea}^{t-1,t} - \hat{Q}_{i,Japan}^{t-1,t} - \hat{A}_{i,Korea}^{t-1,t} + \hat{A}_{i,Japan}^{t-1,t} + \hat{\pi}^{t-1,t} \end{aligned} \quad (6)$$

When we compare competitiveness across firm-size groups, we aggregate the variables for each firm-size group.

Next, let us explain our data sources and describe the key variables of our analysis. The main source for Japanese firm-level data is the *Basic Survey on Business Structure and Activities (BSBSA)* published by the Ministry of Economy, Trade and Industry (METI). The BSBSA consists of a survey of all firms with 50 or more employees and capital of 30 million yen or more in the manufacturing, retail, and wholesale sectors as well as some service sectors (including software services). Data for most of the key variables for Japanese firms are taken from this survey.

To deflate most of the input and output variables we employ industry-level deflators from the Japan Industrial Productivity Database 2014 (JIP 2014). CPI data are obtained from the Statistics Bureau, Ministry of Internal Affairs and Communications.

Specifically, our variables are measured as follows. Output is measured

by deflating firms' annual sales data from the *BSBSA* by the gross output deflators taken from JIP 2014. Labor input is firms' number of employees taken from the *BSBSA*. Capital input is calculated as firms' nominal fixed tangible assets (excluding land) from the *BSBSA* deflated by industry-level investment good deflators from JIP 2014. Intermediate input is calculated as nominal intermediate inputs from the *BSBSA* deflated by the intermediate input deflator from JIP 2014. Nominal intermediate inputs are the sum of the cost of sales and sales and general administration expenses minus total direct labor costs and depreciation.

Wage rate $w_{i,k}$ in Equation (2) is calculated by dividing total direct labor costs by the number of employees. The price of capital services, $r_{i,k}$, is the sum of the interest rate and the depreciation rate minus the rate of change in investment goods prices (capital gains). We calculate depreciation rates at the industry level using capital data from JIP 2014.⁴ For the interest rate, we use the rate on newly issued 10-year bonds, obtained from the Ministry of Finance. Finally, we employ the intermediate input deflator, $q_{i,k}$, to deflate nominal intermediate input to obtain real values.

Our main source for data on Korean firms is the firm-level dataset compiled by NICE GROUP (formerly National Information and Credit Evaluation, Inc., NICE). The dataset covers firms subject to statutory audit as well as firms listed on the Korea Stock Exchange. Firms are subject to statutory audit if they have assets of more than 7 billion Korean won.

Industry-level deflators are compiled from two data sets. Output and intermediate input deflators are taken from the Korea Industrial Productivity Database 2012 (KIP 2012) provided by the Korea Productivity Center.⁵ As the deflator for capital we use the investment goods deflator provided by the Bank of Korea (BOK). The depreciation rate for capital is also taken from the BOK. Meanwhile, CPI data are taken from the Korean Statistical Information Service (KOSIS).

Next, wage rates, $w_{f,i,Korea}$, the price of capital services, $r_{i,Korea}$, and the price of intermediate inputs, $q_{i,Korea}$, for Korean firms are calculated in

⁴ Industry-level depreciation rates are calculated as the ratio of economic depreciation over the capital stock in a particular industry and year. Industry-level economic depreciation is the total sum of the economic depreciation of capital assets in the industry. JIP 2014 provides capital stock data for each industry and year.

⁵ KIP 2012 was the most recent version available in January 2016.

the same manner as for Japanese firms. For the price of capital services we use the interest rate on 5-year housing bonds, which is taken from KOSIS.

When calculating wage rates, we had to estimate the total direct labor costs for Korean firms due to the lack of labor cost data in the NICE Database for many firms after 2004. As reporting of labor costs became voluntary in 2004, many firms have not reported labor costs since then. In order to estimate the total labor costs per worker for firms for which such data are not available in the NICE Database we calculate the average of the total labor costs per worker using the available data for the latest three years and extrapolated these using the industry average growth rate of average labor costs per worker. For the industry average labor costs per worker, we use the direct labor costs published by KOSIS, which are available for six different firm-size categories.

III. Empirical Results

This section reports the results of our empirical analysis. Figure 1 shows developments in average production costs and the constituent components over time in the motor vehicle industry in the two countries. All nominal values are deflated by the respective national CPI. For example, Figure 1(a) shows Japan's real average production costs (Japan's nominal costs in yen terms/Japan's CPI), $C_{i,Japan}$, Korea's real average production costs (Korea's nominal costs in won terms/Korea's CPI), $C_{i,Korea}$, and Japan's average costs converted into won (in real terms) using the real exchange rate, $C_{i,Japan}/\pi$. All three variables are normalized to equal one in the base year, 1994. Since the values for Korea's real average production costs and for Japan's average costs converted into won (in real terms) using the real exchange rate measure production costs in the two countries in terms of the same unit, namely, Korea's consumption basket, the two series allow us to examine how the relative competitiveness of the motor vehicle industry in the two countries evolved over time.

In a similar manner, Figures 1(b) to (d) show how factor prices — wage rates, the rental price of capital, and intermediate input prices — evolved over time in real terms.⁶ Finally, Figure 1(e) shows developments

⁶ Note that the series for the industry-level wage rate, $w_{i,k}(t)$, is derived as follows:

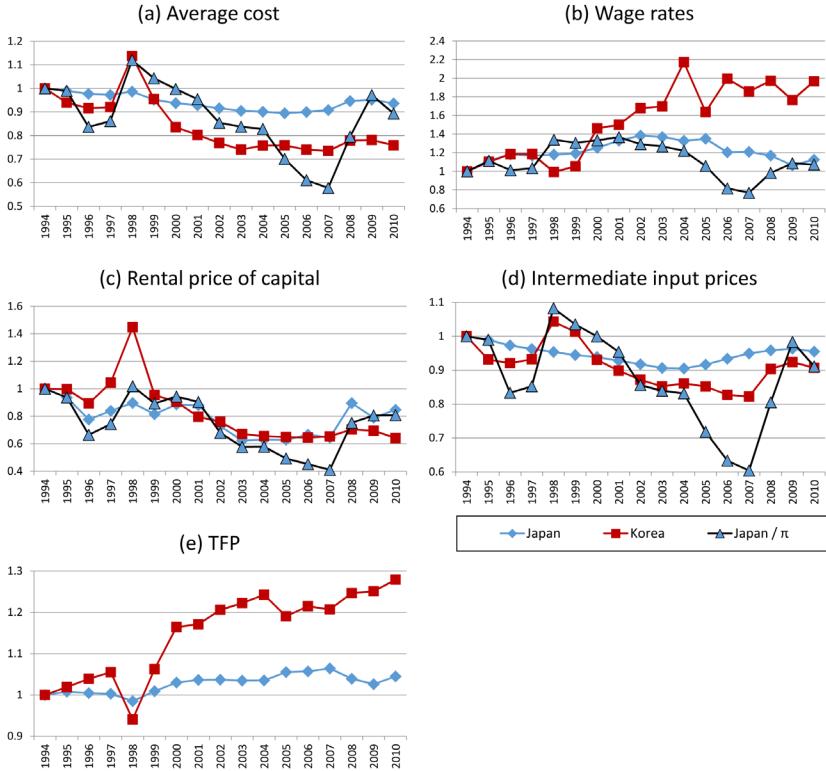


FIGURE 1
AVERAGE PRODUCTION COSTS AND CONSTITUENT COMPONENTS, MOTOR VEHICLE INDUSTRY: KOREA-JAPAN COMPARISON

in TFP over time in the motor vehicle industry in the two countries. As explained in Section II, under our assumptions, changes in the average production costs in each country are equal to the weighted average of changes in the prices of the three factor minus changes in that

$$w_{i,k}(t) = w_{i,k}(t-1) \cdot \exp(\hat{w}_{i,k}^{t-1,t}), \text{ and } \hat{w}_{i,k}^{t-1,t} = \sum_{f \in I} \left[\theta_{f,i,k}^{t-1,t} \times \left\{ \ln(w_{f,i,k}(t)) - \ln(w_{f,i,k}(t-1)) \right\} \right]$$

where $\theta_{f,i,k}^{t-1,t}$ is the weight that we already used for the aggregation of Equation (4) across firms. However, here we do not multiply values by the cost share of labor. Therefore, the series $w_{i,k}(t)$ differs from $W_{i,k}(t)$. The rental price of capital, $r_{i,k}(t)$, and intermediate input prices, $q_{i,k}(t)$, take the same value for all firms within the same industry, so that these series require no aggregation.

country's TFP. Moreover, the weights are equal to the cost share of each factor of production. In the case of machinery industries, the cost share of intermediate inputs is typically much higher than the labor and capital cost shares. In the case of the motor vehicle industry, for example, the cost share of intermediate inputs is around 80-85%, while that of labor is about 10-15% and that of capital about 5-10%.⁷ Moreover, probably reflecting increasing modularization and the growing international division of labor, the cost share of intermediate inputs is on a rising trend.

Figure 1 suggests that Korean firms' competitiveness vis-à-vis their Japanese counterparts, measured in terms of their average production costs, improved by about 5% during the period 1994-2010. The main engine for this gain in competitiveness was the higher TFP growth of Korean firms. Over the 16-year period, Korean firms' TFP growth was 20 percentage points higher than that of their Japanese counterparts.⁸ On the other hand, real wage rates in Korea doubled during this period, reducing the competitiveness of Korean firms. In contrast, real wage rates in Japan hardly increased at all. In sum, our findings regarding long-run trends indicate that Korean workers in the motor vehicle industry enjoyed a doubling of real wage rates without this resulting in a loss of Korean firms' competitiveness, which was made possible by the higher TFP growth in Korea.

Next, looking at annual fluctuations in the relative average production costs of the two countries, these are dominated by changes in the real exchange rate. As Figure 2 shows, during the period 1994-2010, there were two big swings in the yen-won real exchange rate: the Korean won appreciated substantially before the Asian currency crisis of 1997 and the global financial crisis of 2008 and depreciated sharply after the two crises. Reflecting these exchange rate movements, Korean firms' competitiveness vis-à-vis Japanese firms deteriorated gradually before the two crises and improved rapidly after the crises.

It has been frequently argued that Korean manufacturing firms to a considerable extent rely on imported inputs, especially from Japan, and

⁷ Cost shares also depend on firm size. For example, smaller firms in the machinery industries tend to have lower intermediate input cost shares than larger firms.

⁸ Nevertheless, according to the East Asian Listed Company Database (EALC) based on purchasing power parity (PPP) data, the average TFP level of Korean firms in the motor vehicle industry in 2010 was still lower than that of Japanese firms. For more details, see Jung, Lee, and Fukao (2008).



Note: The monthly average nominal yen-won rate (obtained from the Bank of Korea) is converted into real terms using the consumer price indexes of the two countries.

FIGURE 2
YEN-WON REAL EXCHANGE RATE (MONTHLY, 1994=1)

that a depreciation of the won leads to higher prices for foreign inputs, so that a depreciation of the won does not necessarily lead to a substantial improvement in Korean firms' competitiveness.⁹ As Figure 1 indicates, it is true that intermediate input prices (deflated by Korea's CPI) for Korean firms increased substantially during the periods of currency depreciation after the two crises; however, as panel Figure 1 (a) shows, the overall effect of the sharp currency depreciations was an improvement in Korean firms' competitiveness vis-à-vis Japanese firms. Thus, even though it raises imported intermediate import prices, currency depreciation appears to increase Korean firms' competitiveness.

Figure 1 also shows that most of the increase in real wages and TFP in Korea occurred between 1998 and 2004. It seems that both real wage rate and TFP improvements lost steam after 2004. Meanwhile, in the case of capital costs, taking also account of the relatively small cost share of capital inputs, it appears that movements in the rental price of capital did not play a decisive role in determining the relative competitiveness of firms from the two countries, with the exception of the period of Korea's credit crunch in 1998.

Next, let us examine the case of the electrical and electronic

⁹ See, for example, Pyun, and Choi (2015).

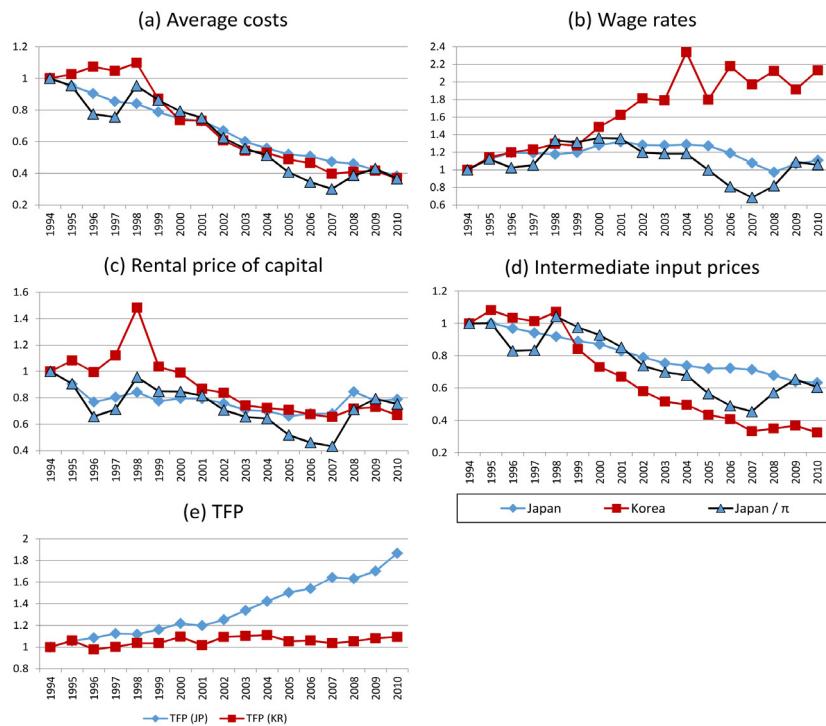


FIGURE 3

AVERAGE PRODUCTION COSTS AND CONSTITUENT COMPONENTS, ELECTRICAL AND ELECTRONIC MACHINERY INDUSTRY: KOREA-JAPAN COMPARISON

machinery industry. As shown in Figure 3, Korean workers enjoyed a doubling of the real wage rate almost without a loss in Korean firms' competitiveness, as in the case of the motor vehicle industry. However, the main factor canceling out the impact of the real wage increases was not high TFP growth: as panel Figure 3 (e) shows, according to our estimation, TFP growth in Korea's electrical and electronic machinery industry was much lower than that in Japan. The main factor underpinning Korean firms' competitiveness in this sector was the very sharp decline in intermediate input prices. Specifically, as can be seen in Figure 3, the decline in intermediate input prices (in terms of Korea's consumption basket) for Korean firms between 1994 and 2010 was 30 percentage points greater than the decline in intermediate input prices converted into won (in real terms) for Japanese firms.

What explains the very low TFP growth and the sharp decline in intermediate input prices of Korean firms in the electrical and electronic machinery? There are two plausible explanations.

The first explanation is as follows. From the end of the 1990s to the present, Korean electrical and electronic machinery firms increased their procurement of inexpensive intermediate inputs from developing economies such as China. Firms achieved such an increase not only by switching from expensive suppliers in developed economies such as Japan to new, inexpensive suppliers in developing economies, but also by splitting production processes into multiple tasks and relocating most of the tasks to developing economies by setting up affiliates abroad (Choi 2014). Although Japanese electrical and electronic machinery firms made similar efforts from the beginning of the 1990s, Korean firms probably have made larger strides in this direction. This may be partly because Korean firms are more specialized in consumer electronics such as mobile phones and household appliances, the production processes of which can be relatively easily modularized and split. According to this explanation, the main source of Korean electrical and electronic machinery firms' competitiveness is not their efficient domestic production but their ability to procure cheap high-quality intermediate inputs from abroad through the smooth operation of worldwide supply chains and their highly productive affiliates abroad.

The second explanation is offshoring bias.¹⁰ Suppose that imported intermediate inputs, say a certain type of ready-made semiconductors, are much cheaper than domestically produced inputs but their quality is not inferior. Moreover, electrical and electronic machinery firms are much more advanced in terms of increasing procurement of imported intermediate inputs than firms in other industries. Therefore, the share of imported inputs of semiconductors in total semiconductor inputs increases much more rapidly in the case of electrical and electronic machinery firms than firms in other industries (Fukao, and Arai 2015, have shown that this is the case in Japan). Also suppose that no separate deflators for imported and domestically produced semiconductors are available and the only available deflator is for the average of the two. Under these circumstances, if semiconductor input in the electrical and electronic machinery industry is measured by dividing the value of semiconductor inputs by the deflator comprising both imported and

¹⁰ For more on the offshoring bias problem, see Diewert, and Nakamura (2011); Houseman *et al.* (2011).

domestically produced semiconductors, this will result in an underestimation of the increase in semiconductor inputs in this industry and therefore overestimate TFP growth.

Using METI's *Survey on Foreign and Domestic Price Differentials for Industrial Intermediate Input* and other statistics, Fukao, and Arai (2015) have shown that in the case of Japan's electrical and electronic machinery industry, increases in intermediate inputs are underestimated and TFP growth is overestimated in the JIP Database due to such offshoring bias. Therefore, part of the high TFP growth of Japanese firms and the relatively slow decline in intermediate input prices in Figure 3 may be caused by offshoring bias. However, we cannot judge whether the data on Korean firms also suffer from such bias or not.

To determine what the actual reason for the low TFP growth and sharp decline in intermediate input prices of Korean firms in the electrical and electronic machinery is further research is required. What we can say, however, is that if the first explanation is correct, the results presented in Figure 3 can be considered to be a more or less accurate description of actual developments. Moreover, if the second explanation is correct, then—since the upward bias of TFP growth and the upward bias of intermediate input prices cancel each other out in the calculation of competitiveness—our conclusion that Korean workers enjoyed a doubling of their real wage rate almost without a loss in Korean firms' competitiveness also remains unaffected.

Next, let us have a look at our results on long-run trends in the relative competitiveness of all manufacturing subsectors. These are presented in Figure 4, which compares relative changes in average production costs and constituent components between the two countries by sector for the period 1994-2010.¹¹ In the figure, industries are ordered from left to right in terms of the size of the net increase in the ratio of average production costs of Korean firms over average production costs of Japanese firms. The stacked columns depict the contribution of changes in the five components to changes in relative production costs, that is, the contribution of changes in relative prices of the three production factors, changes in TFP, and changes in the real yen-won rate. The figure indicates that during this period Korean

¹¹ Figure 4 shows the results for all manufacturing subsectors except leather products (we did not have observations on Korean firms), printing publishing and allied products (there does not seem to be much competition between the two countries in this subsector), and miscellaneous manufacturing.

firms' competitiveness as measured by average production costs improved considerably in eight sectors. What is more, in six of these sectors— instruments; stone, clay and glass products; apparel; lumber and wood products; motor vehicles; and furniture and fixtures—the ratio of Korea's average production costs to Japan's average production costs declined by more than 10%. At the same time, the ratio of Korea's average production costs to Japan's average production costs increased by more than 10% in only three sectors: fabricated metal, petroleum and coal products, and textile mill products.

The main sources of the improvement in the competitiveness of Korean firms were higher TFP growth and a larger decline in intermediate input prices. Specifically, in eight sectors— transportation equipment and ordnance, motor vehicles, lumber and wood products, non-electrical machinery, petroleum and coal products, paper and allied products, chemicals, and food and kindred products—the industry average TFP growth of Korean firms was more than 5% higher than that of Japanese firms. On the other hand, in four sectors— electrical and electronic machinery; fabricated metal; stone, clay and glass products, rubber and miscellaneous plastics—the average TFP growth of Korean firms was more than 5% lower than that of Japanese firms. Turning to intermediate input prices, the decline of the ratio of Korean firms' intermediate input prices to Japanese firms' intermediate input price reduced Korea's relative average production costs by more than 10 percentage points in six sectors: electrical and electronic machinery, stone, clay and glass products, instruments, apparel, furniture and fixtures, rubber and miscellaneous plastics, and lumber and wood products. Moreover, in only two industries— fabricated metal and petroleum and coal products— did the increase in the ratio raise Korea's relative average production costs by more than 10 percentage points.

Real wages in Korea increased relative to those in Japan in all 17 sectors. In four sectors— transportation equipment and ordnance, non-electrical machinery, fabricated metal, and furniture and fixtures—the large wage increases in Korea raised the ratio of Korea's average production costs to Japan's average production costs by more than 8 percentage points. In addition, the real exchange rate appreciated by 5% during the period 1994-2010. However, these two factors were canceled out by the higher TFP growth and larger decline in intermediate input prices of Korean firms in most sectors, as we saw in detail in the case of the motor vehicle and electrical and electronic machinery industries.

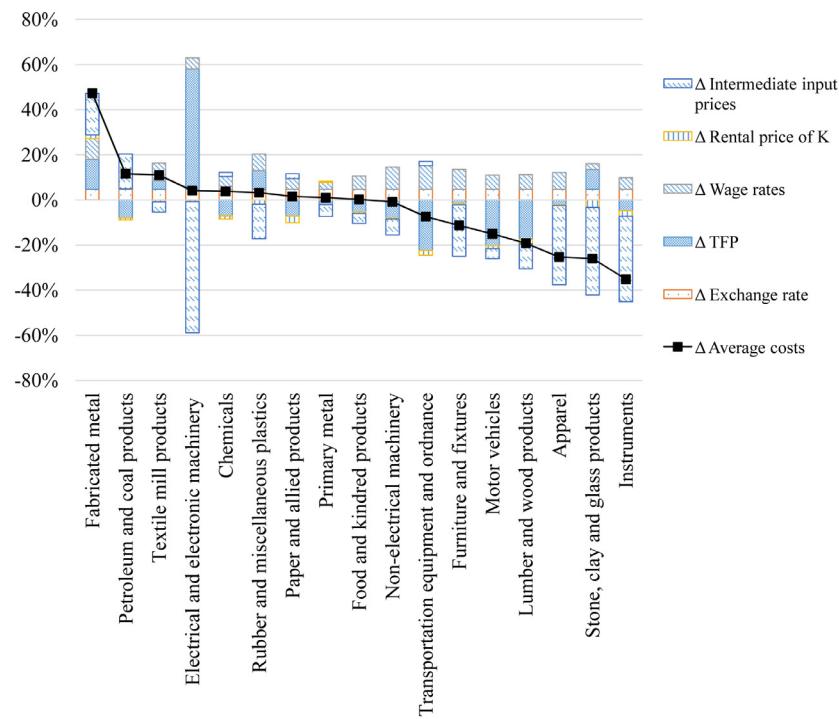


FIGURE 4
CHANGES IN AVERAGE PRODUCTION COSTS AND CONSTITUENT COMPONENTS
BY SECTOR: KOREA-JAPAN COMPARISON, 1994-2010

Next, let us compare changes in the two countries' competitiveness by different firm-size groups. Within each industry in each country and for each year, we divide all firms into three groups in terms of their size, namely, large firms, medium-sized firms, and small firms. Firm size is measured in terms of the number of workers, and we divide firms into these three firm groups such that each group has about the same number of workers within each industry in each country and in each year. We then compare changes in the competitiveness of Korean firms relative to their Japanese counterparts in each firm-size group. For example, we compare changes in the competitiveness of large Korean firms in the chemical industry relative to large Japanese firms in the same industry. We should note that the set of firms included in each group of firms changes over time because of the entry and exit of

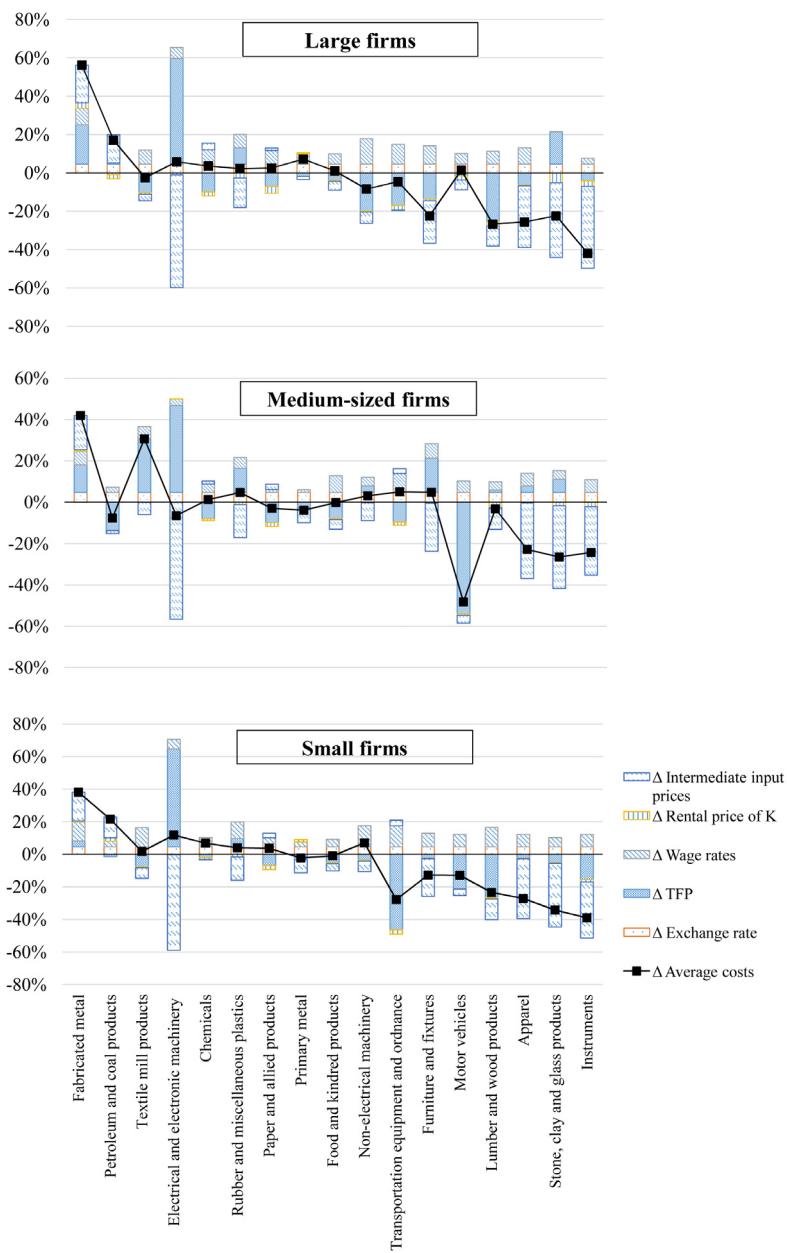
firms as well as changes in firms' size.¹²

The results are reported in Figure 5. As in Figure 4, industries are ordered from left to right in terms of the size of the net increase in the ratio of the average production costs of all Korean firms over the average production cost of all Japanese firms. Figure 5 shows that the industry ranking of industries is quite similar across the different firm-size groups. It appears that there exist common factors such as changes in wage rates or innovation that affect firms of all size groups within a particular industry and country in a similar fashion.

However, it is also interesting to note that there are some differences in changes in relative competitiveness across different firm-size groups. In the case of the motor vehicle industry, small and medium-sized Korean firms experienced an improvement in their relative competitiveness against Japanese firms, with the main factor being improvements in TFP. On the other hand, the competitiveness of large Korean firms did not improve at all vis-à-vis their Japanese counterparts. Thus, the improvement in Korean firms' competitiveness in the motor vehicle industry seen in Figure 1 was driven by small and medium-sized firms. Similarly, in the case of transportation equipment and ordnance, the competitiveness of Korean medium-sized firms improved substantially compared to their Japanese rivals. In the case of primary metal, the relative competitiveness of Korean small and medium-sized firms also improved substantially—by 4% and 2% respectively—whereas the competitiveness of large Korean firms deteriorated by 7%. On the other hand, in instruments and non-electrical machinery, the competitiveness of large Korean firms vis-à-vis their Japanese counterparts improved much more than in the case of small and medium-sized firms.

In about half of the 17 industries, the improvement in small Korean firms' competitiveness vis-à-vis their Japanese counterparts is greater

¹² We should also note that the average size of firms in the same firm-size group in a particular industry may differ between the two countries. For the manufacturing sector overall and the observation period from 1994 to 2010 overall, the average number of workers per firm in the large, medium, and small firm group in Japan is 5,980, 965, and 170, respectively, compared to 3,117, 604, and 129 in Korea. In the case of the motor vehicle industry, the corresponding numbers are 30,363, 4,691, and 310 for Japan, and 40,542, 1,181, and 157 for Korea. In the electrical and electronic machinery industry, the numbers are 24,220, 1,999, and 226 for Japan, and 27,022, 1,361, and 146 for Korea. These figures suggest that small and medium-sized firms in Korea tend to be smaller than their Japanese counterparts in the same firm-size group.

**FIGURE 5**

CHANGES IN AVERAGE PRODUCTION COSTS AND CONSTITUENT COMPONENTS BY SECTOR AND FIRM SIZE: KOREA-JAPAN COMPARISON, 1994-2010

TABLE 1
TFP GROWTH BY FIRM SIZE AND PERIOD: KOREA-JAPAN COMPARISON

Year	Korea			Japan		
	Large Firms	Medium-sized Firms	Small Firms	Large firms	Medium-sized Firms	Small Firms
1994-2000	6.7%	4.0%	7.0%	3.6%	2.3%	2.6%
2000-2005	-0.4%	4.6%	1.0%	4.1%	3.1%	2.7%
2005-2010	3.0%	1.8%	2.6%	-4.2%	-0.5%	-1.1%
1994-2010	3.3%	3.5%	3.8%	1.3%	1.7%	1.5%

Note: Firms in the electrical and electronic machinery industry are not included.

than the improvement in large Korean firms' relative competitiveness. One reason for this probably is that the productivity of small and medium-sized firms in Japan did not improve very much — *i.e.*, they fell behind large firms in terms of their productivity growth (Fukao, and Kwon 2006; Kim, Fukao, and Makino 2010). This raises the question what happened in Korea's manufacturing sector. Did small and medium-sized firms in Korea register higher TFP growth than large firms? Or do the results primarily reflect the disappointing TFP performance of small and medium-sized firms in Japan?

To examine this issue, Table 1 compares the TFP growth of all manufacturing firms by firm-size group and country.¹³ Starting with the results for the observation period overall from 1994 to 2010, we find that in Korea, small and medium-sized firms enjoyed higher TFP growth than large firms. In Japan's case, too, small and medium-sized firms registered higher TFP growth than large firms when looking at the

¹³ As for Figure 5, we divide all firms in each industry in each country by firm size and split them into groups such that the total employment of each firm-size group in each industry in each country is more or less the same. However, for the calculation for Figure 5, we exclude data of electric machinery firms. The reason is that the TFP growth rates of the electrical and electronic machinery industry (especially in Japan) are extremely high, so that this industry would dominate the results for Figure 5 if it were included in the calculation. We also calculated TFP growth of electric machinery firms by firm size group and by country. We found that, as in Figure 5, over the 1994-2010 period the TFP growth rates of small and medium-sized firms in Korea were higher than that of large firms. However in the case of Japan, TFP growth of large-sized firms for the period of 1994-2010 was higher than those of small and medium-sized firms.

observation period as a whole. The finding that in Japan smaller firms registered faster TFP growth than larger firms contrasts from the results obtained by Kim, Fukao, and Makino (2010). The reason for this difference probably is differences in the period covered in the two analyses. The study by Kim, Fukao, and Makino (2010) does not include the period after the global financial crisis of 2008. This crisis delivered a hard blow to large Japanese exporters such as Toyota through the appreciation of the yen and the decline in demand in the United States and Europe. It is likely that this is a major reason for the sharp decline in large firms' TFP between 2005 and 2010 shown in Table 1. Thus, looking at the results in Table 1 in detail to reconcile the various findings shows that patterns in TFP growth by firm size differ considerably by period. Over the observation period as a whole, small and medium-sized firms in Korea did indeed register higher TFP growth than large firms, partly contributing to the fact that small and medium-sized firms caught up more with their Japanese counterparts than did large firms. Partly, however, the greater catch-up of small and medium-sized firms in Korea also reflects the slow TFP growth of their Japanese counterparts, although the results are partly obscured by the impact of the global financial crisis on the TFP of large firms in Japan.

Next, Figure 6 compares wage rates — another important component of average production costs — by firm size and country. We can see that wage rate gaps across firm-size groups moved in opposite directions in the two countries. In Japan, wage gaps narrowed, while in Korea, wage gaps widened. These developments likely also contributed to improvements in the competitiveness of small and medium-sized Korean firms vis-à-vis their Japanese counterparts.

Our findings on changes in the competitiveness of small and medium-sized firms in Korea have important implications for Korea's manufacturing sector.

First, as already discussed in Section I, smaller firms tend to mainly produce intermediate inputs. The increase in the competitiveness of these Korean suppliers is good news for large assemblers, since this enables them to find good suppliers nearby. The improvements in the competitiveness of Korean electric machinery firms through the decline of intermediate input prices (as seen in Figure 3) may be partly caused by this structural change in Korea.

Second, most smaller firms do not export their products. They compete with foreign firms mainly within the domestic market. Since Korea still imposes relatively high tariffs on imports from Japan,

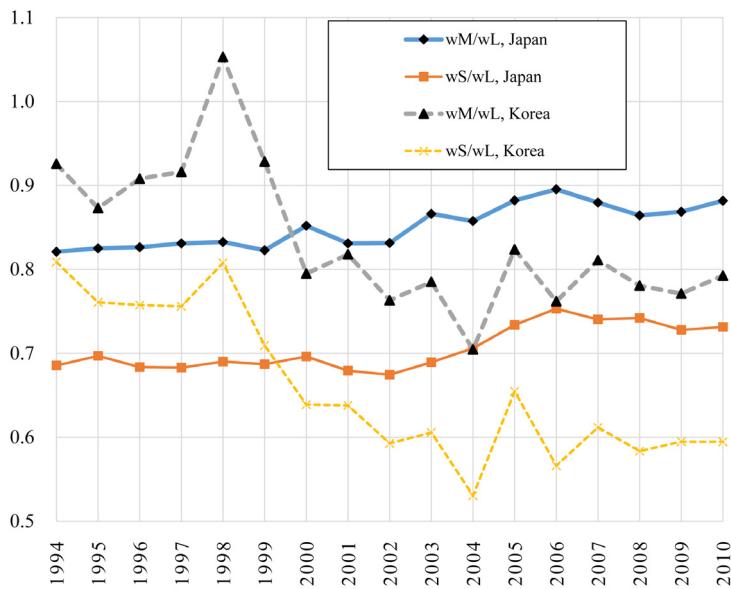


FIGURE 6
WAGE RATE GAPS BETWEEN FIRM-SIZE GROUPS: KOREA-JAPAN
COMPARISON

Korea's domestic market is protected from Japanese firms. If Korea wants to join the Trans-Pacific Partnership (TPP), it will have to cut such import tariff rates substantially. Our findings regarding the improvement in smaller firms' competitiveness, however, suggest that Korea probably does not to be too concerned about future tariff reductions.

IV. Conclusion

We compiled a new dataset of TFP and factor costs by firm size and industry, using firm-level data covering most firms in the manufacturing sectors of Korea and Japan. Using this dataset, we quantitatively analyzed changes in the two countries' relative competitiveness. Following Dekle, and Fukao's (2011) approach based on production cost functions, we decomposed intertemporal changes in the relative competitiveness of Korean firms vis-à-vis Japanese firms into four factors: (1) differences in TFP growth (catching up of Korean firms); (2) changes in relative

factor prices; (3) changes in relative intermediate input prices; and (4) changes in real exchange rates. Using our new dataset we also compared changes in the two countries' competitiveness by firm-size group.

We found that during the period 1994-2010, Korean workers enjoyed a doubling of real wage rates in most industries. However, the competitiveness of Korean firms relative to Japanese firms did not deteriorate. The main factors canceling out the impact of real wage increases were Korea's higher TFP growth in many industries such as motor vehicles and the sharp decline in Korean intermediate input prices in some industries such as electrical and electronic machinery. We also found that in many industries the competitiveness of Korean small and medium-sized firms vis-à-vis their Japanese counterparts increased by more than that of large firms. Two important developments can be observed which likely contributed to the improved competitiveness of small and medium-sized firms in Korea vis-à-vis their Japanese counterparts. First, in Korea, small and medium-sized firms registered higher TFP growth rates than large firms during 1994-2010; and second, wage gaps across firm-size groups narrowed in Japan, while they widened in Korea.

We hope that our approach provides a new framework for the analysis of international competitiveness by sector and firm size. Moreover, we already obtained some interesting results, as summarized above. However, the analysis of this paper also raises new questions for research.

First, according to OECD (2015), Ito and Lechevalier (2009), and Syverson (2004), productivity differences among firms are widening in many OECD countries. Why was this not the case in Korea, so that small and medium-sized firms were able to catch up with larger firms?

Second, in this age of global division of labor and offshoring, how to procure cheap but high-quality intermediate inputs is becoming more and more important for firms' competitiveness. Why do Korean firms in the electrical and electronic machinery sector seem to have been so successful in this regard? For a rigorous analysis of this issue, we need to examine input price data and the issue of offshoring bias.

Third, we should note that a large exchange rate appreciation might immediately wipe out all the gains in international competitiveness brought about by TFP growth achieved over many years. As shown in Figure 2, since the start of Abenomics in 2013, the Korean won has appreciated more than 50% against the yen in real terms, so that the real exchange rate now is almost at the same level as just before the global financial crisis. Although our average cost data do not cover this

period, it likely that Korean firms' competitiveness has deteriorated substantially as a result. We therefore need to update our data to cover the period after 2013 before making policy recommendations on this issue, but it seems that in order to maintain the competitiveness of its firms, Korea may need a large currency depreciation against the yen in the near future.

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