Global Outsourcing and Wage Inequality in Middle-Income Countries*

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Abstract

A substantial number of studies have suggested that global outsourcing can induce wage inequality. As Feenstra and Hanson (1996a) argued, global outsourcing is comparable to skill-biased technological change (SBTC) in that global outsourcing is more likely to increase the wage of skilled workers than that of unskilled ones. The present paper examines the effects of outsourcing on wage of skilled and unskilled workers in Korea's manufacturing sector. In particular, this study determines whether outsourcing to developed countries (DCs) and less developed countries (LDCs) has *opposite* effects on relative wage in Korean labor market. The results of system and difference GMM estimation based on manufacturing data from 1992 to 2006 indicate that outsourcing to DCs and LDCs have opposite (and significant) effects on relative wage, that is, outsourcing to DCs (LDCs) reduces the wage of skilled (unskilled) workers.

Keywords: Global Outsourcing, Wage Inequality, Middle Income country

JEL Classification: F23, F31

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1. Introduction

Recent years have witnessed the rapid globalization of the world economy as a result of the development of IT technology, the improvement of transportation systems, and the expansion of regionalism. In response, an increasing number of firms have expanded their worldwide production networks. As a result, multinational corporations (MNCs) have increasingly focused on diversifying their production strategies regardless of the location. In other words, MNCs have increasingly emphasized *global outsourcing*, searching for optimal production locations across borders. Because of this growing interest in global outsourcing, the trade of intermediate inputs has received increasing attention from both scholars and practitioners. This is because global outsourcing reflects the sharing of production resources based on the trade of intermediate goods. As Yeats (2001) argued, the trade of parts and components is expanding faster than total trade and accounts for approximately 30% of total OECD trade.

This expansion of global outsourcing, together with the increase in the trade of intermediate inputs, is likely to have considerable influence on employment and wage. Because global outsourcing basically exploits foreign labor and capital to produce goods, it can directly influence domestic labor demand. Hence, if a certain production activity is outsourced abroad, then workers' wage may decrease through a decrease in labor demand. In addition, if outsourced production is labor-intensive, then unskilled workers are more likely to get lower wage than skilled ones. This argument provides the springboard for theories suggesting that global outsourcing induces *wage inequality*.

Actually, Unemployment and income polarization are serious issues for most countries, and global outsourcing is considered as one of the most important causes. Surely, Korea is not an exception. [Figure 1] shows the share of intermediate inputs in total trade in Korea over time. In 2009, intermediate inputs accounted for approximately 48% of total trade, even though they did not peak that year. In fact, Athukorala (2006), Ernst (2003), and Wakasugi et al. (2008) pointed out that production networks in East Asia, including those in Korea, are tied closer together than those in any other region. This implies that outsourcing activity is widespread in Korea.

This widespread outsourcing may be closely related to unemployment. In particular, high unemployment rates for less educated individuals pose serious challenges to governments. [Figure 2] shows the unemployment rate for Korea by education level.

Individuals with only a high school degree have more difficulty in getting jobs than those with a college degree. This employment gap implies that income polarization is a serious problem as well.

Insert [Figure 1] here

Insert [Figure 2] here

This paper provides an empirical analysis of the relationship between unemployment/income polarization and global outsourcing. Specifically, the paper focuses on the effects of global outsourcing on the wage inequality between skilled and unskilled workers in Korea.

An important factor to consider in analyzing Korea's global outsourcing is that Korea is a *middle-income country*. Previous studies of global outsourcing have typically focused on the case of developed countries (DCs) and considered *least skilled outsourcing*, implying that production activities requiring the least amount of skill are typically outsourced abroad. However, in middle-income countries such as Korea, not all global outsourcing reflects less skill-intensive production. In particular, it is not plausible to consider the trade of intermediate inputs with DCs as the least-skilled outsourcing. It is a waste of resources to outsource low-skilled production to advanced countries, that is, such production should be outsourced to less developed countries (LDCs). In this regard, global outsourcing from middle-income countries can be classified into the following two categories: outsourcing to DCs and that to LDCs. Thus, this paper investigates two different kinds of outsourcings in the context of middle-income countries.

As we define two types of outsourcing strategies, their effects on relative wage will be different. For instance, the effect of outsourcing to Vietnam will be substantially different from that of outsourcing to Japan. Precisely, these effects will be opposite to each other. Outsourcing to Vietnam typically occurs in low-tech industries, whereas outsourcing to Japan is typically found in high-tech ones. Hence, outsourcing to Vietnam may reduce the relative demand for unskilled workers and reduce their wage. This is consistent with the findings of previous empirical studies. On the other hand, outsourcing to Japan may reduce the wage of skilled workers. Previous studies have typically overlooked this effect because they have only focused on analyzing outsourcing from DCs. Therefore, the present paper contributes to the

literature by scrutinizing the differential effects of global outsourcing based on outsourcing destinations.

In fact, previous studies have suggested various theoretical approaches to explain the widening wage gap from international trade. Some early studies in the 1980s argued that trade competition can reduce relative employment and wage for unskilled workers (Ravenga, 1992; Borjas et al., 1992). On the other hand, a number of studies have been skeptical about the effect of trade on relative wage. Several studies have explained the increasing wage inequality by *Skill-Biased Technological Change* (SBTC), not by international trade (Berman et al., 1994; Lawrence and Slaughter, 1993). Although some studies have criticized the SBTC hypothesis (Card and DiNardo, 2002; Leamer, 1995), the reason why SBTC has been popular is that this growing inequality cannot be explained by traditional theories of international trade. For instance, Wood (1997) demonstrated increases in relative wage of skilled workers in developing countries. This is a serious violation of the traditional Stolper-Samuelson theorem because countries exporting less-skill intensive goods face a drop in relative wage if the theorem is correct, but in reality, it does not.

Phenomena that contradict the standard Heckscher-Ohlin model could be explained by the theories pertaining to trade of intermediate inputs appeared. Especially, the relationship between global outsourcing and wage inequality has received considerable theoretical attention. A representative study verifying the effects of global outsourcing on relative wage is Feenstra and Hanson (1996a), who claimed that approximately 15% to 33% of increases in relative wage of skilled workers can be explained by global outsourcing. Later, Feenstra and Hanson (1996b) employed a different data set based on NBER data and demonstrated the robustness of their argument. Moreover, they noted that the effects of global outsourcing on relative wage vary over time.

With such theories explaining the effect of global outsourcing on wage inequality, a number of studies have compared SBTC with outsourcing in terms of their effects on relative wage. Feenstra and Hanson (1999) examined the effects of outsourcing and technological process on relative wage by using *computer share* as a proxy for technological process for each industry and concluded that not only international trade, but SBTC can also explain wage inequality. However, they concluded that it is difficult to determine which factor is more likely to influence the rising wage inequality. A number of studies have replicated their study by using data from other industrialized countries, including Anderton and Breton (1999) for the U.K., Geishecker (2002) for Germany, and Hsieh and Woo (2005) for Hong Kong.

Recent studies have noted that global outsourcing can be classified into two or more categories and that they have differential effects on the labor market**.** Hence, unlike SBTC, not all types of outsourcing strategies may increase the relative wage of skilled workers, that is, some may reduce it. Ahn et al. (2007) analyzed the effects of outsourcing in Asia on Korean and Japanese labor markets and found that outsourcing had negative effects on the employment of less skilled workers in Japan but no significant effect on Korean workers. The reason why outsourcing did not have a significant effect on the Korean labor market is probably because intermediate inputs imported from Japan accounted for a substantial portion of Korea's total imported intermediate inputs. The authors claim that since the effect of outsourcing to Japan is opposite to that of outsourcing to China, the two effects cancel each other out, and the effect of outsourcing is not significant. Chongvilivan et al. (2009) classified global outsourcing into upstream and downstream outsourcing. Upstream outsourcing involves the production of intermediate inputs such as high-tech components and product designs, whereas downstream outsourcing entails the production/assembly of final goods. They suggest that upstream outsourcing has negative effects on skilled workers, whereas downstream outsourcing has negative effects on unskilled workers.

This paper is in the same tradition as recent studies above and considers global outsourcing from Korea (a middle-income country) to DCs and LDCs. We demonstrate that these two outsourcing strategies have opposite effects on relative wage. Ahn et al. (2007), who examined the effects of outsourcing in East Asia, is most relevant to the present study. They distinguish outsourcing to Japan from outsourcing to China to determine their separate effects on the Korean labor market. However, they consider outsourcing only in East Asia, and Japan is the only country which is more advanced than Korea. Thus, it is difficult to generalize their findings to other cases. This study employs worldwide data from a large number of countries to provide a general conclusion.

The rest of this paper is organized as follows: Section 2 provides a theoretical model for outsourcing from middle-income countries, and Section 3 introduces the empirical model. Section 4 describes the data, and suggests descriptive statistics. Section 5 presents the empirical results, and Section 6 concludes with a summary.

2. Global Outsourcing from Middle-Income Countries

We now establish a model specifying the relationship between global outsourcing and relative wage. We revise the model in Feenstra and Hanson (1996a) from the perspective of middle-income countries. Hence, we suppose that there are three countries: the north (N), south (S), and middle (M) country. Assuming that single manufactured goods are assembled from a continuum of intermediate inputs, the production function of each intermediate input *x(z)* can be written as follows.

$$x(z) = A_i \left[m\dot{n} \left\{ \frac{L(z)}{a_L(z)}, \frac{H(z)}{a_H(z)} \right\} \right]^{\theta} [K(z)]^{1-\theta} \quad , \qquad z \in [0,1]. \tag{1}$$

The continuum of intermediate inputs is indexed by $z \in [0,1]$, which denotes various production activities. A_i denotes technologies that vary across north, south, and middle country (i = N, S, M). Producing one unit of input $x(z)$ requires $a_L(z)$ units of unskilled labor and $a_H(z)$ units of skilled labor. In addition, $L(z)$ and $H(z)$ denote, respectively, the total amount of unskilled labor and that of skilled labor used to produce $x(z)$, and $K(z)$ is total amount of capital required to produce $x(z)$. Skilled and unskilled labors are combined with the framework of Leontief technology and then Cobb-Douglas function is adapted to total labor and capital. Finally, θ denotes the amount of labor required for producing $x(z)$.

Given these inputs, the production function to produce final good Y follows a Cobb-Douglas function, and we assume that Y is *costlessly* assembled.

$$\ln Y = \int_0^1 \alpha(z) \ln x(z)\, dz \, , \qquad \text{where} \quad \int_0^1 \alpha(z)\, dz = 1. \tag{2}$$

Here, $\alpha(z)$ is the share of input $x(z)$ required to produce Y, and each input $x(z)$ receives its share $\alpha(z)$, depending on activity z (where $z \in [0,1]$). In addition, $\int_0^1 \alpha(z)\, dz = 1$ indicates that the production function of Y follows the Cobb-Douglas function.

We assume that factor prices are not equal across countries and that capital earnings, denoted by r_i, is not an exception. Here, r_i is highest for the south, followed by middle and north, in that order, and relative wage of skilled workers follows the same order:

$$\text{i) } r_N < r_M < r_S,$$
$$\text{ii)} q_N/w_N < q_M/w_M < q_S/w_S, \quad (3)$$

where w_i, q_i, and r_i denote the factor prices of L_i, H_i, and K_i, respectively.

Since the production function has a dual relationship with the minimum-cost function, (1) can be written as a unit-cost function. It is convenient to work with a unit-cost function because (1) has rather complex structure. Based on the production function (1), we can express the unit-cost function of $x(z)$ for country i as follows.

$$c(w_i, q_i, r_i; z) = B_i[w_i a_L(z) + q_i a_H(z)]^{\theta} r_i^{1-\theta}, \quad (4)$$

where $w_i a_L(z) + q_i a_H(z)$ denotes the cost spending on overall labor to produce one unit of input $x(z)$ and r_i is the cost spending on capital to produce one unit of $x(z)$. As discussed earlier, θ is the cost share of labor, and B_i is a term corresponding to A_i in (1).[1]

We assume that the minimum cost $c(w_i, q_i, r_i; z)$ is a continuous and linear function of z for fixed wage. The locus of unit-cost function for $x(z)$ in each country is graphed in [Figure 3], where $C_N C_N$, $C_S C_S$, and $C_M C_M$ indicate unit-cost line for north, south, and middle countries, respectively. The upward sloping curves $C_i C_i$ have two intersections z_1 and z_2, whereas there is one intersection in Feenstra and Hanson (1996a), who considered only the case of the north and south countries. For $0 < z < z_1$, in the area requiring more low-skilled labor, the south countries have cost advantage because we assume that q_S/w_S exceeds q_N/w_N and q_M/w_M in (3) which implies the factor price of unskilled labor is relatively cheaper than that of other countries. For $z_2 < z < 1$, on the other hand, the north countries have the cost advantage. Accordingly, the middle countries have the cost advantage in the center of area, (z_1, z_2). Based on their cost advantages, each country specializes their production activity by determining z.

Insert [Figure 3] here

In order to understand how the intersection points z_1 and z_2 are determined, we need to exploit the full-employment conditions for skilled and unskilled labor. The total

[1] Precisely, $B_i \equiv \theta^{-\theta}(1-\theta)^{-(1-\theta)} A_i^{-1}$.

demand for each factor is derived by differentiating the unit-cost function in (4) with respect to each factor price, combining it with each input $x(z)$ and integrating over z. Without loss of generality, we now focus on the case of the middle countries. The full-employment conditions for skilled and unskilled labor are,

$$L_M\left(\frac{q_M}{w_M}\right) = \int_{z_1}^{z_2} \frac{\partial c_M}{\partial w_M} x_M(z)dz = \int_{z_1}^{z_2} B_M\theta \left[\frac{r_M}{w_M a_L(z) + q_M a_H(z)}\right]^{1-\theta} a_L(z)x_M(z)dz\,, \qquad (5)$$

$$H_M\left(\frac{q_M}{w_M}\right) = \int_{z_1}^{z_2} \frac{\partial c_M}{\partial q_M} x_M(z)dz = \int_{z_1}^{z_2} B_M\theta \left[\frac{r_M}{w_M a_L(z) + q_M a_H(z)}\right]^{1-\theta} a_H(z)x_M(z)dz\,. \qquad (6)$$

Here $\partial c/\partial w$ is unskilled labor requirement to produce one unit of $x(z)$, and $(\partial c/\partial w) \times x(z)$ is the total demand for unskilled labor for each input. Hence, by integrating $(\partial c/\partial w) \times x(z)$ over z, we obtain the total demand for unskilled labor. The total demand for skilled labor can be derived in the same way.

The total cost of labor in the middle countries is $w_M L_M + q_M H_M$. If this term is divided by the fraction of the total cost of labor θ, then the term $[w_M L_M + q_M H_M]/\theta$ is the total cost of capital and labor. Then, multiplying it by $1-\theta$ yields the cost share of capital.

$$r_M K_M = [w_M L_M + q_M H_M]\,\frac{1-\theta}{\theta}\,. \qquad (7)$$

In the Cobb-Douglas function in (2), each input z has its own share $\alpha(z)$ to produce the final good Y. Let E denote the world expenditure on Y, then $\alpha(z)E$ represents the total spending on the input $x(z)$. If the total expenditure on $x(z)$ is multiplied by the inverse of unit cost, then it is the amount of $x(z)$ itself. Thus,

$$x_M(z) = \frac{\alpha(z)E}{c_M(z)}\,, \quad z \in [z_1\ z_2]. \qquad (8)$$

Replacing $x_M(z)$ in (5) and (6) with (8), we can derive a simpler version of demand for unskilled and skilled worker,[2] which no longer contains r_M.

$$L_M\left(\frac{q_M}{w_M}\right) = \int_{z_1}^{z_2} B_M\theta \left[\frac{a_H(z)\alpha(Z)E}{w_M a_L(z) + q_M a_H(z)}\right] dz\,, \qquad (9)$$

[2] $c_M(z)$ in (8) is to be substituted for the unit-cost function in (2).

$$H_M\left(\frac{q_M}{w_M}\right) = \int_{z_1}^{z_2} B_M \theta \left[\frac{a_H(z)\alpha(Z)E}{w_M a_L(z) + q_M a_H(z)}\right] dz \ . \tag{10}$$

Consequently, the relative demand for skilled labor can be defined as follow.

$$D_M\left(\frac{q_M}{w_s}, z_1, z_2\right) \equiv \frac{\int_{z_1}^{z_2}\left[\frac{a_H(z)\alpha(Z)E}{w_M a_L(z) + q_M a_H(z)}\right]dz}{\int_{z_1}^{z_2}\left[\frac{a_L(z)\alpha(Z)E}{w_M a_L(z) + q_M a_H(z)}\right]dz} \ . \tag{11}$$

From (7) to (10), we can obtain 12 equations by considering the three types of countries: the north, the south, and middle countries. The unknown variables are the three factor prices of the three countries, the diving points z_j $(j = 1, 2)$, and the world expenditure E, and thus, there are 12 unknown variables. Because the number of equations is the same as that of variables, we can derive z_j by solving these 12 equations simultaneously.

Since we are interested in the relationship between global outsourcing and relative wage, we need to clarify the following two things: First, we need a way to determine how the relative demand in (11) responds to changes in z_j. Changes in z_j come from shifts in the unit-cost function for each country, and such shifts result from neutral technological changes or capital flows induced mainly by global outsourcing.[3] In other words, because of technological advances or capital flows, z_j changes through shifts in the unit-cost function for each country, and such changes in z_j determine the change in the relative demand for skilled labor. Second, it is necessary to confirm the relationship between relative wage and the relative demand for skilled labor. By determining the relationship between changes in the relative demand (induced by global outsourcing) and relative wage, we can describe the effects of global outsourcing on relative wage.

The relationship between the relative demand and z_j can be obtained by differentiating $\hbar D_M$ with respect to z_j. Letting $L_i'(z_j) = \theta a_L(z_j)\alpha(z_j)E/[w_i a_L(z_j) +$ *qiaHzj* and *Hi'zj=θaHzjαzjE/wiaLzj+qiaHzj,* we can write the partial derivative of $\hbar D_M$ as follows:

[3] Neutral technology change or capital flow is regarded as major driving force behind global outsourcing. See Feenstra and Hanson (1996a) and Chongvilivan *et al.* (2009).

$$\frac{\partial \hbar\, D_M}{\partial z_1} = \frac{\partial \hbar\, H_M}{\partial z_1} - \frac{\partial \hbar\, L_M}{\partial z_1} = -\frac{H_M^{'}}{H_M} + \frac{L_M^{'}}{L_M} = \frac{L_M^{'}}{H_M}\left(\frac{H_M}{L_M} - \frac{H_M^{'}}{L_M^{'}}\right) = \frac{L_M^{'}}{H_M}\left(\frac{H_M}{L_M} - \frac{a_H(z_1)}{a_L(z_1)}\right) > 0 \ , \quad (12)$$

$$\frac{\partial \hbar\, D_M}{\partial z_2} = \frac{\partial \hbar\, H_M}{\partial z_2} - \frac{\partial \hbar\, L_M}{\partial z_2} = \frac{H_M^{'}}{H_M} - \frac{L_M^{'}}{L_M} = \frac{L_M^{'}}{H_M}\left(-\frac{H_M}{L_M} + \frac{H_M^{'}}{L_M^{'}}\right) = \frac{L_M^{'}}{H_M}\left(\frac{a_H(z_2)}{a_L(z_2)} - \frac{H_M}{L_M}\right) > 0 \ . \quad (13)$$

Here, the ratio of the unit-labor requirement $\alpha_H(z_1)/\alpha_L(z_1)$ is the relative demand for skilled and unskilled labor at the critical value z_1.[4] Since the average relative demand in the middle-income country (i.e., H_M/L_M) exceeds that in z_1, $H_M/L_M - \alpha_H(z_1)/a_L(z_1)$ is positive. In the same context, $\alpha_H(z_1)/a_L(z_1) - H_M/L_M$ is also positive. Similarly, we can write the partial derivatives of $\hbar D_S$ and $\hbar D_N$ as follows:

$$\frac{\partial \hbar\, D_S}{\partial z_1} = \frac{\partial \hbar\, H_S}{\partial z_1} - \frac{\partial \hbar\, L_S}{\partial z_1} = \frac{H_S^{'}}{H_S} - \frac{L_S^{'}}{L_S} = \frac{L_S^{'}}{H_S}\left(-\frac{H_S}{L_S} + \frac{H_S^{'}}{L_S^{'}}\right) = \frac{L_S^{'}}{H_S}\left(\frac{a_H(z_1)}{a_L(z_1)} - \frac{H_M}{L_M}\right) > 0 \ , \quad (14)$$

$$\frac{\partial \hbar\, D_N}{\partial z_2} = \frac{\partial \hbar\, H_N}{\partial z_2} - \frac{\partial \hbar\, L_N}{\partial z_2} = -\frac{H_N^{'}}{H_N} + \frac{L_N^{'}}{L_N} = \frac{L_N^{'}}{H_N}\left(\frac{H_N}{L_N} - \frac{H_N^{'}}{L_N^{'}}\right) = \frac{L_N^{'}}{H_N}\left(\frac{H_N}{L_N} - \frac{a_H(z_2)}{a_L(z_2)}\right) > 0 \ . \quad (15)$$

Since z_1 is the intersection of unit-cost line between south and middle countries, it changes when outsourcing from the middle to south occurs. For instance, if the capital flows from the middle to the south, or if the middle country outsources its production activities to the south, then the unit-cost line of the south (C_SC_S) in [Figure 3] shifts downward. This is because the capital flow to the south reduces r_s. Simultaneously, C_MC_M shifts upward because of an increase in r_M. Hence, z_1 moves to the right, implying that the relative demand for skilled labor increases in the middle countries. On the other hand, when the middle countries outsource their production activities to the north, C_NC_N shifts downward, whereas C_MC_M shits upward.[5] Since z_2 moves to the left, the relative demand for skilled labor decreases in the middle countries. [Figure 4] and [Figure 5] show the middle-income country's outsourcing to the south and the north, respectively. Thus, for middle-income countries such as Korea, outsourcing to DCs can reduce the relative demand for skilled workers, whereas outsourcing to LDCs can increase it.

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[4] This is obvious because,

$$\frac{a_H(z_1)}{a_L(z_1)} = \frac{H(z_1)/x(z_1)}{L(z_1)/x(z_1)} = \frac{H(z_1)}{L(z_1)}..$$

[5] If it is not easy to grasp that capital flows from the middle to north, we can think of technological advances in north countries, which shift C_NC_N downward.

Insert [Figure 4] here

Insert [Figure 5] here

Now, it is required to expose the relationship between relative demand and relative wage, and it is already the stylized fact that they move in the opposite direction. Hence,

$$\partial h\ D_M/\partial(q_M/w_M) < 0\ . \qquad (17)^6$$

[Figure 6] provides a comprehensive illustration of outcomes when the middle country outsources its production activities abroad. When the middle country shares its production activities with DCs, the relative demand ($D_M(z_1, z_2)$) shifts to the left, and q_M/w_M decreases. On the other hand, when it outsources its production to LDCs, $D_M(z_1, z_2)$ shifts to the right, and q_M/w_M increases. In conclusion, outsourcing to DCs and outsourcing LDCs have opposite effects on relative wage in the middle-income country.

Insert [Figure 6] here

3. Empirical Strategies

The empirical model to estimate the effects of outsourcing on relative wage is based on Berman et al. (1994), Feenstra and Hanson (1996a), and Chongvilaivan et al. (2009). The production function which is linear-homothetic in price for industry i can be written as follow.[7]

$$Y_i = F_i\ (L_i, H_i, K_i; out_i^N, out_i^S, A_i), \qquad (18)$$

where L_i and H_i denote the total usage of unskilled labor and that of skilled labor. out_i^N and out_i^S denote outsourcing to DCs and outsourcing to LDCs, respectively. A_i means total factor productivity or the index of technological progress for industry i, and K_i means the

[6] For the proof, see Feenstra and Hanson (1996a).
[7] The subscript t (time) is omitted for simplicity.

real capital stock. The short-run cost function corresponding to (18), in which capital and output levels are fixed, is,

$$C_i\left(w_i, q_i, ;\ K_i, Y_i, out_i^N, out_i^S, A_i\right) = \min_{w_i, q_i} w_i L_i + q_i H_i \quad \text{subject to (18)}\ , \tag{19}$$

where w_i and q_i denote the wage of unskilled and skilled workers, respectively. According to Brown and Christensen (1981), this short-run cost function can be approximated by a translog function.

$$\ln C = a_0 + \sum_{j=1}^{2} \alpha_j \ln h_j + \sum_{k=1}^{K} \beta_k \ln x_k + \frac{1}{2}\left\{ \sum_{j=1}^{2}\sum_{l=1}^{L} \alpha_{jl} \ln h_j \ln h_l + \sum_{k=1}^{K}\sum_{m=1}^{M} \beta_{km} \ln x_k \ln x_m + \sum_{j=1}^{2}\sum_{k=1}^{K} \delta_{jk} \ln h_j \ln x_k \right\}. \tag{20}$$

Here, the industry subscript i is temporally dropped for notational simplicity. In addition, h_j denotes factor prices, that is, h_1 and h_2 are the wages of skilled and unskilled workers, respectively. Further, x_k denotes other shift parameters, including $K_i, Y_i, out_i^N, out_i^S$, and A_i. By differentiating (20) with respect to $\ln q_i$, we can obtain the wage share of skilled workers because $WH_i = \partial \ln C / \partial \ln q_i = H_i q_i / C$, where WH_i denotes the total wage share of skilled workers for industry i. Since the sum of wage shares of skilled and unskilled workers is 1, we focus on the wage share of skilled labor. Differentiating (20) with respect to $\ln q_i$ yields the estimation model under the symmetric assumption of the translog function:

$$WH_i = \alpha_1 + \theta \ln \frac{q_i}{w_i} + \delta_{11} \ln K_i + \delta_{12} \ln Y_i + \delta_{13} \ln out_i^N + \delta_{14} \ln out_i^S + \delta_{15} \ln A_i. \tag{21}$$

We need to correct the model for feasible estimation.

First, it is plausible to remove the term of relative factor price on the right-hand side, as in Berman et al. (1994), Feenstra and Hanson (2001), and Chongvilaivan et al. (2009), because the wage share of skilled labor, WH_i, already contains information of relative wage.

Second, the current wage share may be influenced by previous wage shares, indicating a need for using a dynamic panel model. In particular, the adjustment of employment is not immediate due to the cost of hiring, lay-offs, and reeducation for new jobs. In addition, we derive the estimation model with a short-run cost function with assuming

sticky prices and wage. As the wage share consists of variables that are influenced by their previous level, it is reasonable to establish a dynamic model. Therefore, the final estimation model is,

$$WH_{it} = \alpha + \beta_0 WH_{i,t-1} + \beta_1 h\ out_{it}^{N} + \beta_2 h\ out_{it}^{S} + \beta_3 h\ A_{it} + \beta_4 h\ K_{it} + \beta_5 h\ Y_{it} + u_i + \tau_t + \varepsilon_{it}, \quad \varepsilon_{it} \sim iid\ (0, \sigma_\varepsilon^2). \tag{22}$$

Hence, to test the empirical model, we employed difference GMM and system GMM estimation suggested in Blundell and Bond (1998).

4. Data and Descriptive Statistics

This study exploits three data sources to analyze the effect of global outsourcing on relative wage in 21 Korean manufacturing sectors[8] from 1992 to 2006.[9] As previously mentioned, the global outsourcing index is a ratio of imported intermediate inputs to total intermediate inputs. Hence,

$$outsourcing = \frac{imported\ intermediate\ input}{total\ intermediate\ input}. \tag{23}$$

If a certain production activity is outsourced abroad, then the produced intermediate input is retrieved as the imports. Various methods can be adopted measuring these imported intermediate inputs. Previous studies of outsourcing have measured imported intermediate inputs in three ways.

First, intra-firm trade between the parent firm and its affiliates or the amount of inter-firm trade between MNCs has been used as a proxy for outsourcing (Slaughter, 2000; Andersson and Fredriksson, 2000; Nobuaki, 2000).

Second, some studies have exploited international Input-Output (IO) table and traced the actual flow of imported intermediate inputs (Ahn et al., 2007; Koopman et al., 2008). The share of imported intermediate inputs measured in the IO table is used as a proxy for outsourcing in those researches.

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[8] The list of industries is suggested in the appendix.

[9] Since Korean Manufacturing Census has stopped providing wage of skilled and unskilled workers since 2007, we could not obtain recent data on the wage share of skilled labor. In addition, the industrial classification system changed in 1992. Thus, we considered the 1992-2006 period for the analysis.

Finally, based on the theory of production fragmentation, some studies have directly measured imported intermediate inputs from trade data by classifying trade items into intermediate inputs, capital goods, and consumption goods, among others (Yeats, 2001; Feenstra and Hanson, 1996a; Feenstra and Hanson, 1996b; Feenstra and Hanson, 1999). In this paper, we employ the third approach. That is, we obtain the information on imported intermediate inputs directly from trade data because it is easy to obtain such data, although the measurement error in the actual outsourcing activity may exceed that for the second method (i.e., the method based on the IO table).[10]

The data of imported intermediate inputs (in thousand USD) are from the UN Comtrade database. We obtained data on imports and exports for all products (SITC Rev.3) and classified them into primary, intermediate, and final goods based on the Broad Economic Categories (BEC). We obtained information on intermediate goods (semi-processed goods, parts, and components) from the UN Comtrade database as well. We then classified imported intermediate goods into two categories: imports from DCs and those from LDCs. The data on the total intermediate inputs from the IO table are provided by the Bank of Korea. The amount of total intermediate input is measured in million KRW, and thus, we converted them into thousand USD based on the average annual exchange rate. Finally, we determined outsourcing to DCs (out_t^N) by measuring the proportion of intermediate inputs imported from the *OECD high-income countries* and outsourcing to LDCs (out_t^S) by measuring the proportion of intermediate inputs imported from *WTO-low and middle-income countries*.[11]

[Figure 7] shows the average shares of intermediate inputs from DCs and LDCs. The share of imported intermediate inputs for DCs exceeded that for LDCs. The share for DCs reached the peak in 1997 and declined sharply afterward. On the other hand, the share for LDCs peaked in 1997 but had increased gradually since 2001. Hence, outsourcing to DCs decreased, whereas that to LDCs increased. Noteworthy is that both outsourcing strategies peaked in 1997, when the Asian financial crisis occurred, and then decreased for several years. This may be because Korea's total imports decreased after the financial crisis as a result of the depreciation of the Korean currency.

[10] In addition, both the first and second approaches have crucial disadvantages. In terms of the first approach, Feenstra and Hanson (1996a) and Krugman (1994) argued that MNCs' transactions cannot explain a substantial portion of outsourcing because it leaves much room for underestimating actual outsourcing activity. The second approach, which uses the international IO table, is considered the best method for measuring global outsourcing because it can accurately capture the flow of imported inputs. However, the international IO table is not published every year, and there is no worldwide version.

[11] The list of countries is shown in the appendix.

Insert [Figure 7] here

The rest of variables are obtained from the *Korean Census of Mining and Manufacturing Industry*, which provides general information on all firms with more than five employees. Here, skilled workers are defined as white-collar workers and unskilled workers are defined as blue-collar ones as in Feenstra and Hanson (1996a). Hence, the dependent variable WH_t is the ratio of the wage share of white-collar workers to that of blue-collar workers.[12] Even though the value of each wage is reported in million KRW, we did not convert it into USD because this variable is already a ratio.

[Figure 8] shows the annual changes in the wage share of skilled workers, which increased over time. This result is consistent with that in [Figure 7]. The increasing wage share of skilled workers may be due to two reasons: i) the decreasing import share of intermediate inputs for DCs, and ii) the increasing import share for LDCs. According to the proposed model in Section 2, a decrease in intermediate inputs from DCs increased relative wage of skilled worker through an increase in the relative demand for them. Equivalently, an increase in intermediate inputs from LDCs increased relative wage for skilled workers. Those two factors are observed in [Figure 7], which may explain the reason for the growing relative wage of skilled workers.

Insert [Figure 8] here

Since it is not possible to appropriately measure total factor productivity A_t by current data, we instead used R&D intensity, which is the ratio of R&D investment to total sales, as a proxy for TFP.[13] We obtained the real capital stock K_t by combining the stocks of plant, equipment, and transportation for each industry. The raw data provided the nominal value of K_t in million KRW. Thus, we deflated each term in K_t based on the year 2005 and converted it into USD. The real output Y_t is obtained by summing inventory changes and shipments. The data on Y_t are processed in the same way as the data on K_t.

[12] By referring to Feenstra and Hanson (1996a), the dependent variable can be written as,

$$WH_t = \frac{\text{total wage of skilled workers}}{\text{total wage of all workers}}.$$

[13] We did not covert KRW into USD because R&D intensity is a ratio as well.

[Table 1] shows the descriptive statistics for the variables used in the estimation. The average wage share of skilled workers is approximately 32%, and its variation is not that high compared to its average. The share of imported intermediate inputs for DCs is higher than that for LDCs, implying that Korean industries import intermediate inputs more from DCs than from LDCs. Noteworthy is that the average R&D intensity exceeded 100%, approaching 200%. This implies that, on average, R&D investment exceeded total sales. This may be because firms invest heavily in R&D relative to total sales for their future performance, or R&D investments by a small number of large firms dominate the manufacturing sector's total sales.

Insert [Table 1] here

5. Results

The estimation results of system GMM is suggested in [Table 2]. We regard *real capital* and *real output* as predetermined variables. In column (1), the dependent variable is regressed just on lagged dependent one, outsourcing, and time dummies. R&D intensity is added as a repressor in column (2), and real capital stock and real output is added in column (3). We decomposed real capital stock into plant, equipment, transportation in column (4) to figure out their separate effects on relative wage.

Insert [Table 2] here

It seems that both outsourcing variables have significant effects on the annual wage share of skilled workers. Noteworthy is that outsourcing to DCs reduces the wage share of skilled labor, whereas outsourcing to LDCs increases it. In other words, an increase in the proportion of intermediate inputs from DCs reduces the wage share of skilled workers. This result is not counterintuitive because firms engaging in high-skilled outsourcing may dismiss researchers or reduce wage of engineers as a result of the drop in the demand for skilled labor. On the other hand, a decrease in high-skilled outsourcing can increase the relative wage of skilled workers. When there is a decrease in outsourcing to DCs, skilled workers in the domestic labor market are more likely to have opportunities for technology-intensive jobs or to get higher wages. As shown in [Figure 7], there is substantial increase in the relative wage

of skilled labor. In addition, as shown in [Figure 8], outsourcing to DCs has generally decreased. Therefore, these empirical results suggest that a decrease in high-skilled outsourcing can help explain the wage gap between skilled and unskilled workers.

On the other hand, an increase in intermediate inputs from LDCs seems to raise the relative wage of skilled workers. This implies that low-skilled outsourcing is more likely to have a negative effect on unskilled workers than on skilled workers and is consistent with the findings of previous studies. However, as discussed earlier, early studies such as Feenstra and Hanson (1996a, 1996b) examined only one side of the coin because they consider only outsourcing to LDCs. This is because previous studies of global outsourcing have typically investigated only DCs such as the U.S. and Japan, which generally do not engage in high-skilled outsourcing because few countries are more technologically developed than they are. In addition, the reason why most studies have provided the same conclusion might be that the effect of outsourcing to LDCs dominates that of outsourcing to DCs. However, these two outsourcing strategies should be simultaneously considered for Korea because Korea is a middle-income country. As a result of considering that, the empirical evidence is found that these two types of outsourcing yield the opposite effects on relative wage.

R&D intensity had no significant effect on relative wage, but with the real capital stock and outputs controlled for, it had a significant effect. This result makes sense because R&D investment involves increment in wage of skilled workers such as researchers. As shown in Column (3), the *output* and *real capital stock* had no significant effects on relative wage, which is unexpected. As Krugman (1994) pointed out, technological advance had not played an important role in explaining the growth of economy. In other words, the growth of output in Korean economy is rather far from skill-biased growth. Therefore, the *qualitative* structure of the labor market may have nothing to do with the *output* in each industry.

The reason why the real capital stock has no significant effect on relative wage may be due to the aggregation of data on the real capital stock. For Column (4), we divided the real capital stock into plant, equipment, and transportation. The variable for plant has a significant positive effect on the wage share of skilled labor. This may be because constructing and operating a plant require a number of white-collar workers such as managers and supervisors. On the other hand, the variable for equipment has a significant negative effect. This may be because most equipment requires regular maintenance and manual repairs, which are provided by blue-collar workers. Thus, these opposite effects (plant and equipment) counterbalanced each other, and the real capital stock may have no significant effect on relative wage.

Through the whole models in both estimations, the Sargan test is not rejected, so the validity of instrument variables is confirmed. Moreover, AR test is rejected in the first-order, but not in the second one, which implies that the both estimators pass the AR test. [Table 3] provides the results for the difference GMM, which shows the similar results as the system GMM.

Insert [Table 3] here

6. Conclusion

Recent years have witnessed increases in the relative wage of skilled workers worldwide, including those in Korea. Because the global rise in relative wage cannot be explained by the traditional Heckscher-Ohlin theorem, previous studies have introduced global outsourcing to explain the wage inequality. Extending such studies, this paper investigates the effects of global outsourcing on relative wage in Korea. Being different from previous studies, however, we shed light on the outsourcing from middle-income countries because South Korea is one of them. We assumed that there are two types of outsourcing - outsourcing to DCs and outsourcing LDCs - and tried to prove these two outsourcings have the different impact on labor market.

The major contribution of this paper is to empirically verify whether the effect of outsourcing on relative wage depends on the outsourcing destination. In the theoretical framework, we prove the relative demand for skilled workers in middle-income country increases when less-skilled intensive activity is outsourced. On the other hand, when skilled-intensive production is outsourced, the relative demand turns out to decrease. These shifts of labor demand influence the relative wage. Increased relative demand by outsourcing to LDCs boosts up relative wage, and skilled workers are relatively better off. On the other hand, decreased relative demand by outsourcing to DCs lowers relative wage. We adopt couple of empirical strategies such as difference GMM and system GMM estimation to figure out these opposite effects. It turns out that outsourcing to DCs causes decrement in relative wage while outsourcing to LDCs causes its increment.

These theoretical and empirical results provide a better understanding of why relative wage increased in Korea in recent years. As shown in [Figure 7], outsourcing to DCs has decreased, whereas outsourcing to LDCs has increased over time. The results suggest that

both an increase in outsourcing to LDCs and decrease in outsourcing to DC have raised the relative wage, and thus, the synergy between these two effects might have exacerbated the wage inequality in Korea.

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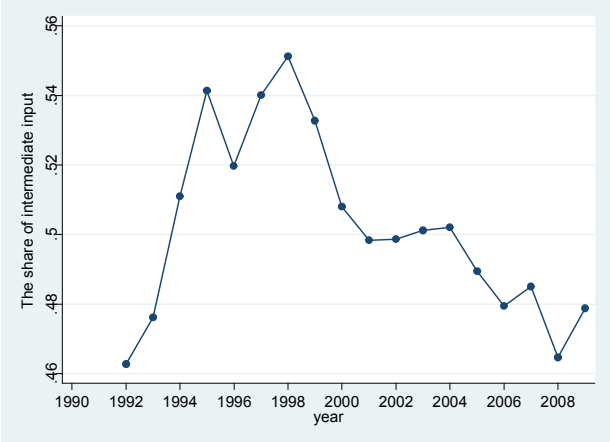
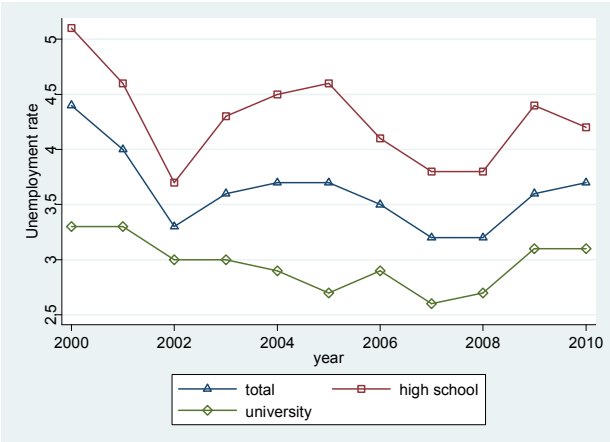
[Figure 1] Share of intermediate inputs in total trade in Korea



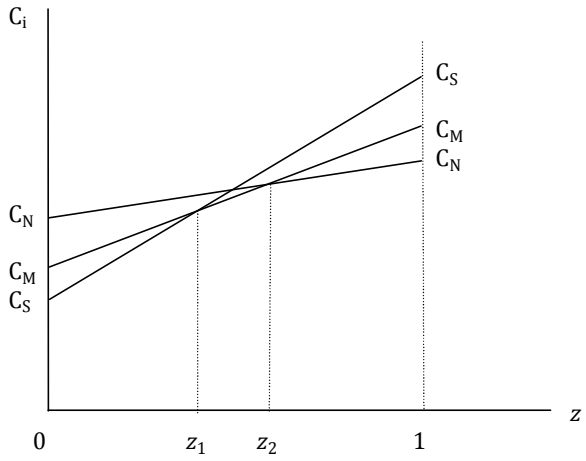
Source: UN Comtrade database (http://comtrade.un.org).

[Figure 2] Unemployment rate in Korea by education level

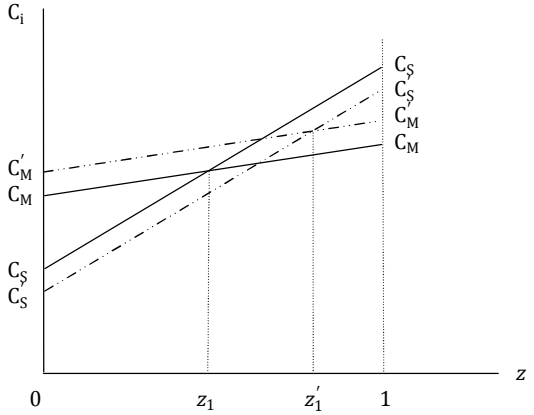


Source: Statistics Korea (http://kostat.go.kr).

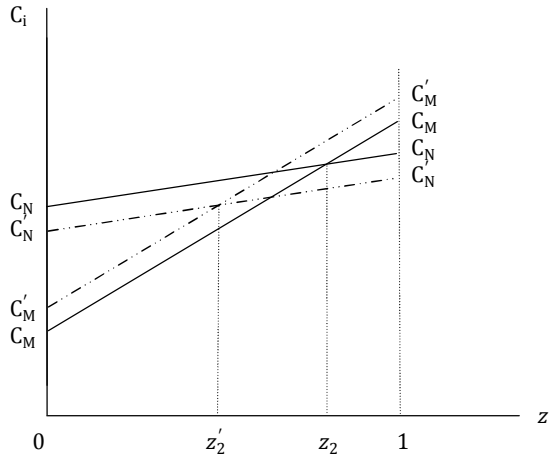
[Figure 3] Determinants of z_1 and z_2



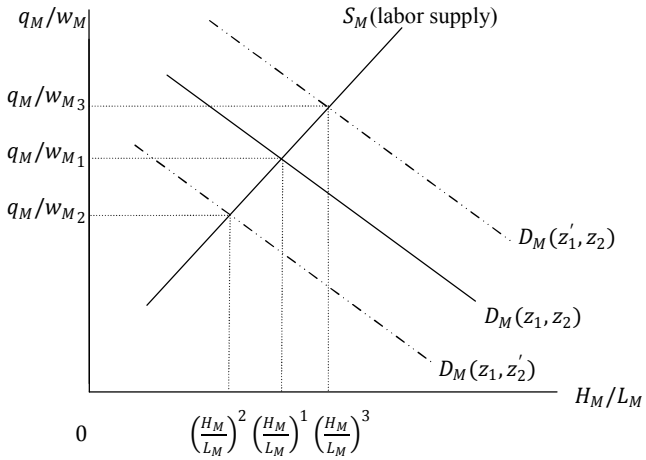
[Figure 4] Outsourcing from the middle to south country



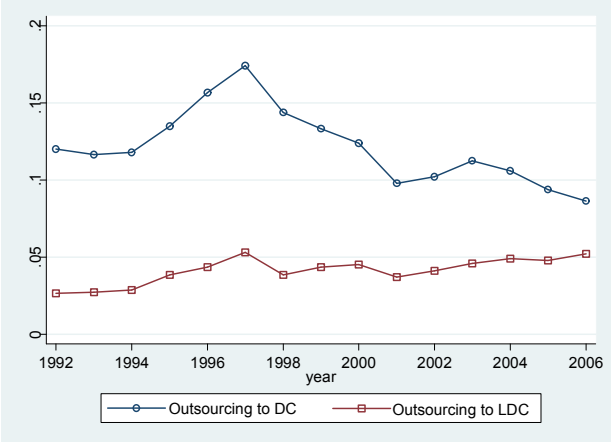
[Figure 5] Outsourcing from the middle to north country



[Figure 6] Labor market equilibrium in the middle country

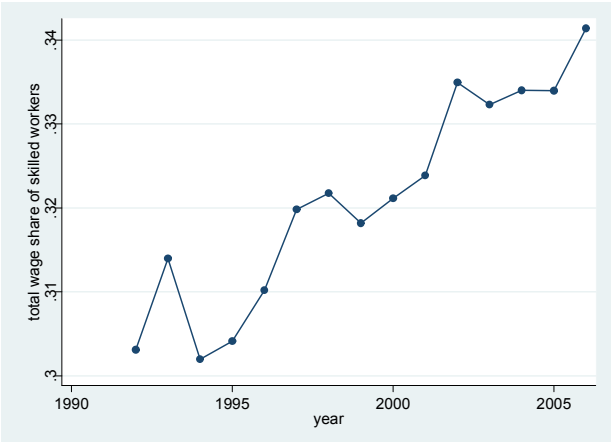


[Figure 7] Share of intermediate inputs imported from DCs and LDCs



Source: UN Comtrade database (http://comtrade.un.org).

[Figure 8] Total share of skilled workers' wage



Source: *Korean Census of Mining and Manufacturing Industry*.

[Table 1] Descriptive statistics

	Obs.	Mean	Std. Dev.	Min	Max
Total wage share of skilled workers	315	0.32	0.08	0.19	0.65
Outsourcing to DCs	315	0.11	0.10	0.00	0.45
Outsourcing to LDCs	315	0.05	0.07	0.00	0.47
R&D intensity	315	1.99	1.56	0.120	7.42
Real capital stock	315	7096.90	10041.14	269.48	63616.05
Real output	315	25229.47	30095.48	1829.80	193785.50

Note: 1) The real capital stock and the real output are in thousand USD (2005 standard).

2) The number of observations includes 21 industries over 15 years.

[Table 2] The result of system GMM estimation (dependent variable: skilled wage share)

Regressor	(1)	(2)	(3)	(4)
Lag of skilled wage share	0.631***	0.617***	0.440***	0.375***
	(0.103)	(0.105)	(0.077)	(0.075)
ln(outsourcing to DCs)	-0.011**	-0.011**	-0.015***	-0.019***
	(0.005)	(0.005)	(0.005)	(0.005)
ln(outsourcing to LDCs)	0.009*	0.009*	0.013***	0.017***
	(0.005)	(0.005)	(0.004)	(0.004)
ln(R&D intensity)		0.007	0.010*	0.012**
		(0.005)	(0.005)	(0.006)
ln(capital stock)			-0.008	
			(0.011)	
ln(plant)				0.017**
				(0.007)
ln(equipment)				-0.022*
				(0.013)
ln(transportation)				-0.012
				(0.008)
ln(real output)			0.011	0.000
			(0.014)	(0.014)
Constant	0.123***	0.124***	0.137	0.334***
	(0.038)	(0.038)	(0.102)	(0.112)
Including time dummies	Yes	Yes	Yes	Yes
AR(1) test statistics	-4.807***	-4.744***	-5.481***	-5.230***
(p-value)	(0.000)	(0.000)	(0.000)	(0.000)
AR(2) test statistics	-0.384	-0.478	-0.894	-0.854
(p-value)	(0.701)	(0.633)	(0.371)	(0.393)
Sargan test statistics	1.203	1.223	33.317	83.816
(p-value)	(1.000)	(1.000)	(0.798)	(0.108)

Note : 1) Standard errors are in parentheses.

2) *, **, and *** denote 10%, 5%, and 1% significance level, respectively.

[Table 3] The result of difference GMM estimation (dependent variable: skilled wage share)

Regressor	(1)	(2)	(3)	(4)
Lag of skilled wage share	0.558***	0.531***	0.416***	0.320*
	(0.175)	(0.181)	(0.122)	(0.172)
ln(outsourcing to DCs)	-0.012**	-0.013**	-0.016**	-0.030***
	(0.005)	(0.006)	(0.007)	(0.010)
ln(outsourcing to LDCs)	0.012**	0.012**	0.015***	0.026***
	(0.005)	(0.005)	(0.005)	(0.009)
ln(R&D intensity)		0.008	0.012**	0.021**
		(0.005)	(0.006)	(0.009)
ln(capital stock)			0.011	
			(0.048)	
ln(plant)				0.055**
				(0.028)
ln(equipment)				0.051
				(0.057)
ln(transportation)				-0.026
				(0.020)
ln(real output)			-0.001	-0.090*
			(0.045)	(0.054)
Including Time dummies	Yes	Yes	Yes	Yes
AR(1) test statistics	-4.470***	-4.244***	-4.784***	-3.039***
(p-value)	(0.000)	(0.000)	(0.000)	(0.002)
AR(2) test statistics	-0.555	-0.712	-0.945	-0.593
(p-value)	(0.579)	(0.477)	(0.345)	(0.553)
Sargan test statistics	0.168	0.178	2.098	7.067
(p-value)	(0.682)	(0.673)	(0.552)	(0.216)

Note : 1) Standard errors are in parentheses.

2) *, **, and *** denote 10%, 5%, and 1% significance level, respectively.

Appendix

The list of OECD High-Income Countries

Australia	France	Japan	Slovak Republic
Austria	Germany	Luxembourg	South Korea
Belgium	Greece	The Netherlands	Spain
Canada	Hungary	New Zealand	Sweden
Czech Republic	Iceland	Norway	Switzerland
Denmark	Ireland	Poland	The U.K.
Finland	Italy	Portugal	The U.S.

The list of WTO Low and Middle–Income Countries

Afghanistan	Benin	Djibouti	Mauritania
Albania	Dominica	Gabon	Mauritius
Algeria	Dominican Republic	Georgia	Mexico
American Samoa	Ecuador	The Gambia	Mongolia
Angola	El Salvador	Ghana	Moldova
Antigua and Barbuda	Ethiopia (excluding Eritrea)	Kiribati	Morocco
Azerbaijan	Eritrea	Grenada	Vietnam
Argentina	Mozambique	Guatemala	Somalia
Bangladesh	Namibia	Guinea	South Africa
Armenia	Nepal	Guyana	Zimbabwe
Bhutan	Vanuatu	Haiti	Sudan
Bolivia	Nicaragua	Honduras	Suriname
Bosnia and Herzegovina	Niger	India	Swaziland
Botswana	Nigeria	Indonesia	Syria
Brazil	Micronesia, Fed. Sts.	Iran	Tajikistan
Belize	Marshall Islands	Iraq	Thailand
Solomon Islands	Palau	Cote d'Ivoire	Togo
Bulgaria	Pakistan	Jamaica	Tonga

Myanmar	Panama	Kazakhstan	Tunisia
Burundi	Papua New Guinea	Jordan	Turkey
Belarus	Paraguay	Kenya	Turkmenistan
Cambodia	Peru	North Korea	Tuvalu
Cameroon	The Philippines	Kosovo	Uganda
Cape Verde	Guinea-Bissau	Kyrgyz Republic	Ukraine
The Central African Republic	East Timor	Lao PDR	Macedonia, FYR
Sri Lanka	Romania	Lebanon	Egypt
Chad	The Russian Federation	Lesotho	Tanzania
Chile	Rwanda	Latvia	Burkina Faso
China	St. Kitts and Nevis	Liberia	Uruguay
Colombia	St. Lucia	Libya	Uzbekistan
Comoros	St. Vincent and the Grenadines	Lithuania	Venezuela
Mayotte	Sao Tome and Principe	Madagascar	Samoa
Congo, Rep.	Senegal	Malawi	Yemen
Congo, Dem. Rep.	Seychelles	Malaysia	Zambia
Costa Rica	Sierra Leone	Maldives	
Cuba	Fiji	Mali	

Industries

Code	Industry
15	Manufacture of food products and beverages
16	Manufacture of tobacco products
17	Manufacture of textiles
18	Manufacture of wearing apparel; dressing and dyeing of fur
19	Tanning and dressing of leather; manufacture of luggage, handbags, saddlery, harnesses, and footwear
20	Manufacture of wood and wood/cork products except furniture; manufacture of articles of straw and plaiting materials
21	Manufacture of paper and paper products
22	Publishing, printing ,and reproduction of recorded media
23	Manufacture of coke, refined petroleum products, and nuclear fuel
24	Manufacture of chemicals and chemical products
25	Manufacture of rubber and plastic products
26	Manufacture of other non-metallic mineral products
27	Manufacture of basic metals
28	Manufacture of fabricated metal products except machinery and equipment
29	Manufacture of machinery and equipment n.e.c.
30	Manufacture of office, accounting, and computing machinery
31	Manufacture of electrical machinery and apparatus n.e.c.
32	Manufacture of radio, television, and communication equipment and apparatus
33	Manufacture of medical, precision, and optical instruments, watches, and clocks
34	Manufacture of motor vehicles, trailers, and semi-trailers
35	Manufacture of other transport equipment
36	Manufacture of furniture; manufacturing n.e.c.
37	Recycling