The Impact of Material and Service Outsourcing on Employment in Thailand's Manufacturing Industries*

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Abstract

With increasing emphasis on the importance of outsourcing, the 'fear of job losses' has been of significant interest, not only in developed countries, but also in developing countries. In this paper, we empirically investigate the impacts of intermediate inputs (material) and services outsourcing on the relative demands for skilled and unskilled labor in Thailand's manufacturing sectors from 1999 to 2003. Based on the aggregation of establishment-level data at 4-digit industrial classification, we find that both intermediate inputs and service outsourcing are relatively skill-biased. Further, our results show that intermediate inputs outsourcing has negative impacts on the relative demands for skilled and unskilled workers, whereas service outsourcing shifts the demand towards skilled workers at the expense of unskilled workers.

Running title: Outsourcing in Thailand Manufacturing Industries

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1. Introduction

Most of the current literature that is concerned with the economic impacts of outsourcing on the labor market focuses mainly on developed countries.[1] Due to technical advances in information technology and greater liberalization of trade globally, the current surge in outsourcing activities spurs the 'fear of job losses' in terms of 'exporting jobs' from developed to developing countries (see Amiti and Wei, 2006). Recent evidence indicates that developing countries are also affected by international fragmentation of the production and global outsourcing activities. In fact, outsourcing activities through intermediate goods trade among the developing countries have increased substantially, in particular among the East Asian and Asian countries (Ahn, et al., 2008). Although Japan has been the main source of intermediate inputs for East Asian and South-East Asian countries, recent evidence indicates that Korea and South-East Asian countries are also emerging as important source countries for intermediate inputs. Concurrently, we also observe that the East Asian and Southeast Asian countries have experienced increases in intermediate imports from China and the key ASEAN countries of Indonesia, Malaysia, Philippines, and Thailand. The current paper empirically investigates the impacts of international outsourcing of materials and services on the relative demands for unskilled and skilled workers in Thailand's manufacturing sectors from 1999 to 2003.[2]

In developing countries, outsourcing of intermediate inputs in the relatively scarce factor of production to a foreign country will affect the relative demand for skilled and unskilled workers in a number of ways. Several studies have highlighted that the positive impact on the demand for skilled workers is explained by the fact that outsourcing is skill-biased, where outsourcing entails labor productivity improvements that are biased towards skilled workers (Feenstra and Hanson, 1996, 1999; Slaugher, 2000; Egger and Egger, 2006). Given the competitive labor market, outsourcing would shift the relative demand for skilled labor.[3] Conversely, the

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[1] Following Feenstra and Hanson (1996, 1999), a number of literatures have analyzed the impacts of outsourcing on labor markets in various economies, such as Anderton and Brenton (1999) for UK, Geishecker (2002) for Germany, and Hsieh and Woo (2005) for Hong Kong, among others.

[2] As discussed later, there are two indexes of outsourcing of our interests: material outsourcing and service outsourcing. The former follows the broad definition of international outsourcing, the imports of intermediate inputs as in Feenstra and Hanson (1996). The service outsourcing refers to both domestic and foreign purchases of services by establishments as in Morrison and Siegel (2001).

[3] Egger and Egger (2006) investigate the impacts of outsourcing on the productivity of low skilled workers. Although they find that it improves productivity of low-skilled labor at least in long run, the

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standard Heckscher-Ohlin (H-O) Theorem also suggests that outsourcing will be in favor of the unskilled labor demand in developing economies, since developing countries are endowed with abundant unskilled labor. Specifically, the standard H-O model predicts that firms will be specializing in labor and unskilled-labor-intensive production activities and importing capital and skilled-labor-intensive intermediate inputs from developed countries. Given these opposing effects, it will be important to empirically identify the effects of outsourcing on the unskilled and skilled labor demand in the developing countries.[4]

The positive relationship between outsourcing and the relative demand for skilled labor is clearly observed in industrialized economies (see Feenstra and Hanson, 1996, 1999, Anderton and Brenton, 1999, and Geishecker, 2002).[5] In the study by Feenstra and Hanson (1996) on the U.S. manufacturing sectors, the extent of material outsourcing is given by the share of imports from a particular industry located abroad in the total domestic demand for products in that industry. In their paper, outsourcing is derived as an import penetration measure. Using the variable cost function with capital as a fixed input, they concluded that 15 to 33 percent of the increase in the cost share of non-production workers in the U.S. could be explained by outsourcing. According to their study, the outsourcing of intermediate inputs and the technological change are biased towards non-production workers, thereby leading to the higher wage share for non-production workers.[6]

Following Feenstra and Hanson (1996, 1999), there are several studies empirically investigate the impact of outsourcing on the relative demand for skilled workers in developed countries. Anderton and Brenton (1999) employed outsourcing proxies as in Feenstra and Hanson (1996) at the 4-digit ISIC for textiles and non-electrical machinery sectors in U.K., distinguishing between intermediate imports from developed and developing economies. Their results show that international outsourcing accounts for roughly 40 percent of the total increase in the wage bill share

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productivity impacts are biased towards high-skilled labor and capital stock, thereby reducing the relative demand for unskilled labor.

[4] See the theoretical discussions on cost-saving technological change and substitution effects of international outsourcing on relative factor returns by Kohler (2001) and Egger and Falkinger (2003).

[5] Most literatures on the impacts of outsourcing on the relative demand for skilled labor focus on the dataset collected from industrialized economies. The presence of outsourcing as an explanatory for widened wage inequalities within industries is consistently confirmed by these studies.

[6] According to Feenstra and Hanson (1999), technological improvement proxied by expenditures on computers accounts roughly for 35 percent of the rising non-production wage share, whereas outsourcing explains about 15 percent.

of skilled workers. Based on German manufacturing sectors during 1991-2000, Geishecker (2002) finds that international outsourcing is indeed an important factor that could explain the decline in the relative demand for unskilled workers in Germany. Specifically, by controlling for skill-biased and capital-upgrading effects, the study shows that international outsourcing explains nearly 24 percent of the decline in the relative demand for unskilled workers in the German manufacturing sectors.

Hsieh and Woo (2005) empirically investigate the impacts of a large reallocation of unskilled activities to China on the skill structure of Hong Kong's labor market. Their results show that the extent of outsourcing from Hong Kong to China has entailed strong and persistent relative demand shifts favoring skilled workers in Hong Kong since the early 1980s. The study reveals that the reallocation of workers from manufacturing to outsourcing services accounts for 15 percent and the increased utilization of skilled workers within individual manufacturing industries accounts for 30 percent of the aggregate demand shift respectively. They highlighted that the impacts of outsourcing on Hong Kong is similar to that of developed countries.

The present paper contributes to the outsourcing literature in a number of ways. Firstly, this paper is the first to study the impact of outsourcing on Thailand's manufacturing sectors at a disaggregated level of 4 digit industrial classification. Secondly, unlike the existing literature, the notion of outsourcing in this paper is beyond the standard trade-related material inputs as service outsourcing may also have an equally important impact on the labor market. Finally, we also account for the second-order impacts of outsourcing on the relative demands for unskilled and skilled labor. That is, outsourcing may not only shift the relative demands for variable factors but also affect them via the "rotating" effects or changes in the degree of substitution among all other factors of production.

The paper adopts a dual approach to investigating the effects of outsourcing on the relative demands for unskilled and skilled workers in Thailand's manufacturing industries by aggregating the establishment-level data at four-digit ISIC manufacturing sectors.[7] We formulate a translog cost function in such a way that there

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[7] As explained later in this paper, our establishment-level dataset deals with the unbalanced panel issues. Therefore, aggregation at four-digit ISIC manufacturing sectors is necessary to establish panel datasets.

are three variable factors of production: unskilled workers, skilled workers, and raw materials,[8] with both material and service outsourcing taken into consideration. By using the Iterative Three-stage Least Squares (I3SLS) estimation,[9] our results reveal that material outsourcing has negative impacts on the relative demands for both unskilled and skilled workers, whereas service outsourcing shifts the demands towards skilled workers at the expense of the unskilled ones. Despite this, both types of outsourcing have shown to be skill-biased, in the sense that the negative impacts of material outsourcing are more intensified for unskilled workers, whereas the positive impacts of service outsourcing are stronger for the skilled, and these skill-biased effects account for the increases in the relative demands for skilled workers. Besides the *'shift'* effects of outsourcing on labor demands, we also estimate the Hicks-Allen partial elasticities of substitution to analyze the second-order effects – the changes in the responsiveness of a particular type of factor demands with respect to factor prices. The results show that material and service outsourcing play a different role in changing the substitutability of factors of production.

The organization of this paper can be briefly outlined as follows. Section 2 discusses the data sources and measurements. Section 3 provides the overview of outsourcing in Thailand's manufacturing sectors. Section 4 explains the translog cost function framework, and the analysis of the second-order impacts of outsourcing. In Section 5, empirical results will be presented and analyzed. The concluding remarks are given in section 6.

2. Data Measurement

The data for our study is from the establishment-level data retrieved from the reports of the Manufacturing Industry Survey for 1999-2003,[10] provided by the National Statistical Office (NSO), Thailand. These datasets contain basic establishment-level information on manufacturing, such as the numbers of establishments, persons engaged, employees and the values of compensation, raw materials, parts and

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[8] The existing literatures, such as Anderton and Brenton (1999) and Geishecker (2002), assume that unskilled and skilled workers are the only variable factors of production. In our study, this assumption is too restrictive in the sense that it does not allow for complementarities between unskilled and skilled workers.

[9] As pointed out later in this paper, there are two main econometric issues taken into considerations: invariance of parameter estimates with respect to factor share equations arbitrarily dropped and endogeneity of quasi-fixed capital and outsourcing decisions.

[10] The 2002 dataset is absent because NSO did not conduct the survey in this year.

components purchased, sales of goods produced and purchased for resale, inventory, and fixed assets. In each year, there were approximately 5,000-8,000 establishments engaged in this survey.

According to the survey, establishments engaged in manufacturing are defined as the mechanical or chemical transformation of substances into new products. The assembly of component parts of manufactured products is also considered as manufacturing. Manufacturing industry activities are classified according to the 4-digit ISIC Rev.3. With establishments as the sampling units, the survey covered 62 types of the manufacturing activities (4-digit ISIC) in 21 industries (2-digit ISIC). The description of manufacturing aggregated at the 2-digit ISIC is given in Table A1 at the Appendix. To study the impact of outsourcing on technological development, the 4-digit ISIC industries are classified into three sub-industries according to their technology intensities (see Table A2 in the Appendix) of low-, medium-, and high-technology industries.[11]

The dataset is constructed by pooling firms across the 4-digit ISIC level from 1999 to 2003, and it is summarized in Table A3. The unskilled labor share (S_L) is measured by the ratio of the production worker wage bill to total production cost (the total wage bill plus material cost), and the skilled labor share (S_H) is likewise measured by the ratio of the non-production worker wage bill to total production cost.[12] Except for the price of materials, the data for unskilled (w_L) and skilled (w_H) wages (i.e., production and non-production average wages) can be directly retrieved from the datasets. In addition, capital stock (K_i) is calculated from the value of land, building and construction, and machinery and equipment at the end of each consecutive year, whereas total output (Y_i) is approximated by the sales of goods produced.

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[11] We group the manufacturing industries into three sub-industries, namely low-, medium-, and high-technology industries. The primary manufactures, such as food, tobacco, textile, and wood product, are regarded as low-technology industries. In contrast, more sophisticated productions, such as chemical, metal, computer, machinery, electronic product, medical product, and motor vehicle, are classified as high-technology industries. The rest are defined as medium-technology industries.

[12] Production workers are those engaged in assembling, packaging, inspecting, repair and maintenance, whereas non-production workers are those engaged in factory supervision, executives, financing, legal, professional and technical services. Since by definition the former activities require unskilled labor and the latter activities deal with skilled, well trained workers, it is conventionally accepted that production workers are unskilled, and non-production workers are skilled. This skill classification is commonly adopted by a number of studies, such as Feenstra and Hanson (1999), among others.

Unlike unskilled and skilled wages, our datasets do not report the average material price (w_M). We derived the price index of raw material inputs by making use of the Annual Input-Output Tables retrieved from Office of the National Economic and Social Development Board (NESDB), together with the annual producer price indexes at the 2-digit ISIC level from Bank of Thailand (BOT).

There are two relevant indexes of outsourcing utilized in our empirical estimation: material outsourcing (OM_i) and service outsourcing (OS_i). The index of material outsourcing follows the 'wide' definition of international outsourcing (see Feenstra and Hanson, 1996).[13] Specifically,

$$OM_i = \sum_j \frac{imported\ \ intermediate\ \ input\ \ j\ \ by\ \ industry\ \ i}{total\ \ intermediate\ \ inputs\ \ used\ \ by\ \ industry\ \ i}. \tag{1}$$

The index of service outsourcing follows that of Morrison and Siegel (2001) and is approximated by the ratio of services purchased to total production cost. In contrast with the material outsourcing, we do not segregate domestic and foreign outsourcing of services, as the mechanism by which foreign outsourcing of services affects the relative factor demands is unclear in both theoretical and empirical literatures. More importantly, the datasets from NSO report two types of service purchases: cost of contract and commission work and cost of repair and maintenance work done by others. These supporting services are likely to be non-tradables and result in intra-industry changes in the levels of employment.

The index of technological progress (T_i) is essentially represented by the intensities of R&D activities (Anderton and Brenton, 1999), since the industries with high intensities of R&D investment should enjoy higher rates of technological progress. As such, this index is proxied by the ratio of research, planning, and development cost to total expense of the establishment.

In addition to variables used in the structural system of labor share equations, we also need to create proxies for instrumental variables (IV) to tackle the potential problem of endogeneity. As discussed later, the quasi-fixed capital and outsourcing decisions are likely to be endogenously determined by, in addition to lagged values of

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[13] Feenstra and Hanson (1996) measure the index of material outsourcing by combining production data with the annual input-output table to proxy the imported intermediate inputs. However, since the imported intermediate inputs can be directly extracted from our datasets, we can employ the idea of a wide measure of material outsourcing directly.

structural variables, industry-specific factors, the proportions of foreign ownership ($FHOLD_i$) and international trade exposure as indicated by the number of firms engaged in exporting activities ($EXPORT_i$). The share of foreign ownership is derived by the number of firms with foreign share holdings to the total number of firms in that industry. Likewise, the international trade exposure is measured by the ratio of firms engaged in exporting activities to the total number of firms in that industry. We will discuss further the IV estimation in section 4.2.

3. Outsourcing in Thailand's Manufacturing Sector

The manufacturing sector is a key driving force of economic growth in Thailand in terms of both GDP contribution and employment. Since the late 1990s, Thailand's manufacturing sector has been characterized by sustained growth as shown by the manufacturing index in Figure 1. This expansion can be explained by increases in both domestic and international demands for its goods.

[Insert Figure 1 here]

Recent evidence suggests that the competitiveness of Thailand's manufacturing sectors has deteriorated due to rising domestic wages and prices. To maintain their competitiveness in the global market, local manufacturers have increasingly contracted out their business activities to overseas contractors, so called offshore outsourcing, so as to achieve more efficient operations in their production. In the plastic industry, for example, the R&D activities are internationally outsourced due to the lack of indigenous technology and human capital. The textile and fashion industries are also outsourcing their marketing and packaging activities to overseas contractors to gain more familiarity with overseas markets.

As in developed economies, the prevalence of outsourcing has triggered public concerns of domestic job losses as its impact is tantamount to 'exporting jobs'. An example can be found in the conflict between Thai Airways International Public Company Limited and its labor union (see *Bangkok Post*, February 11, 2005). The labor union protested against the outsourcing of new cabin crews by Thai Airways to various international agencies in order to protect its 5,200 local unionized crew staffs.

[Insert Figures 2 and 3 here]

[Insert Figures 4 and 5 here]

The Figures from 2 to 5 represent the establishment-level data grouped into 62 industries at the four-digit ISIC Rev.3 and averaged across the time horizon of 1999-2003.[14] We can discern from the Figures that material and service outsourcing affect the relative demands for unskilled and skilled workers differently. In particular, material outsourcing seems to entail a decline in the demands for both unskilled and skilled workers, which implies that the outsourcing of intermediate inputs is labor-saving. In contrast, service outsourcing increases the demand for both unskilled and skilled workers, but it seems to be in favor of skilled workers. It is clear from the Figures above that the 'fear of job losses' stemming from outsourcing also exists in Thailand's labor market. The next section will analyze in detail the impacts of both material and service outsourcing on the relative demands for unskilled and skilled workers in Thailand's manufacturing industries.

4. The Empirical Model

4.1 Methodological Framework: Translog Cost Function

To empirically investigate the economic impacts of outsourcing on the relative demands for skilled and unskilled workers, it is important to estimate a cost function that is sufficiently flexible to show the effects of outsourcing on the firms' labor demands. Following Morrison and Siegel (2001), our model is based on a non-homothetic variable cost function specification incorporating the quasi-fixed capital, and *external shift* factors.[15] For a given industry i, where $i = 1,\ldots, N$, the short-run (dual) cost function can be expressed in an implicit form as:

$$G_i = G(\mathbf{w_i}, K_i, Y_i, \mathbf{T_i}) \qquad (2)$$

where $\mathbf{w_i}$ is a vector of variable input prices, including unskilled workers, skilled workers, and raw materials; K_i is quasi-fixed capital; Y_i is output; and $\mathbf{T_i}$ is a vector of external trade and technological factors, including the indexes of material and service outsourcing. Therefore, the short-run total cost function is equal to $C_i = G(\mathbf{w_i}, K_i, Y_i, \mathbf{T_i}) + w_K K_i$, where w_K is the price of capital stock.

As in Berman, et al. (1994), we employ the non-homothetic translog functional form of a variable cost function. By assuming symmetry such that $\gamma_{ij} = \gamma_{ji}$,

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[14] Both material and service outsourcing indexes in Figures 2-5 are given in logarithm forms.
[15] Despite the three variable factors, our framework, unlike Morrison and Siegel (2001), is based on the non-homothetic translog cost function rather than the Generalized Leontief cost function.

$\phi_{ij} = \phi_{ji}$, and $\delta_{ij} = \delta_{ji}$ and temporarily dropping the time and industry subscripts, the cost function is given as:

$$\ln G = \alpha_0 + \alpha_L \ln(w_L) + \alpha_H \ln(w_H) + \alpha_M \ln(w_M) + \gamma_{HL} \ln w_H \ln w_L + \gamma_{HM} \ln w_H \ln w_M$$

$$+ \gamma_{LM} \ln w_L \ln w_M + \frac{1}{2}\gamma_{HH}(\ln w_H)^2 + \frac{1}{2}\gamma_{LL}(\ln w_L)^2 + \frac{1}{2}\gamma_{MM}(\ln w_M)^2 + \beta_K \ln K$$

$$+ \phi_{LK} \ln w_L \ln K + \phi_{HK} \ln w_H \ln K + \phi_{MK} \ln w_M \ln K + \frac{1}{2}\delta_{KK}(\ln K)^2 + \beta_Y \ln Y$$

$$+ \phi_{LY} \ln w_L \ln Y + \phi_{HY} \ln w_H \ln Y + \phi_{MY} \ln w_M \ln Y + \delta_{KY} \ln K \ln Y + \frac{1}{2}\delta_{YY}(\ln Y)^2$$

$$+ \beta_o \ln O + \phi_{Lo} \ln w_L \ln O + \phi_{Ho} \ln w_H \ln O + \phi_{Mo} \ln w_M \ln O + \delta_{Ko} \ln K \ln O$$

$$+ \delta_{Yo} \ln Y \ln O + \frac{1}{2}\delta_{oo}(\ln O)^2 + \beta_T \ln T + \phi_{LT} \ln w_L \ln T + \phi_{HT} \ln w_H \ln T$$

$$+ \phi_{MT} \ln w_M \ln T + \delta_{KT} \ln K \ln T + \delta_{YT} \ln Y \ln T + \delta_{oT} \ln O \ln T + \frac{1}{2}\delta_{TT}(\ln T)^2 \qquad (3)$$

where O is the indexes of outsourcing, and T is the index of technological progress. For a well-defined cost function, it must satisfy the condition of linear homogeneity in variable factor prices. This implies that we have to impose the following parameter restrictions on equation (3).

$$\alpha_L + \alpha_H + \alpha_M = 1 \qquad (4)$$

$$\gamma_{HL} + \gamma_{HH} + \gamma_{HM} = \gamma_{LL} + \gamma_{LH} + \gamma_{LM} = \gamma_{ML} + \gamma_{MH} + \gamma_{MM} = \phi_{Lj} + \phi_{Hj} + \phi_{Mj} = 0 \qquad (5)$$

where $j = K, Y, O$ and T.

By employing Sheppard's Lemma and logarithmically differentiating equation (3) with respect to variable input prices, we can show that $S_k \equiv w_k k / C = \partial \ln C / \partial w_k$, where $k = L$, H, and M. Furthermore, the adding-up condition requires that the summation of three factor shares must be equal to unity ($S_L + S_H + S_M = 1$), and therefore only two equations are linearly independent. Hence, we choose to drop the material share equation and estimate the followings:

$$S_L = \alpha_L + \gamma_{LL} \ln w_L + \gamma_{HL} \ln w_H + \gamma_{ML} \ln w_M + \phi_{LK} \ln K + \phi_{LY} \ln Y + \phi_{Lo} \ln O + \phi_{LT} \ln T \qquad (6A)$$

$$S_H = \alpha_H + \gamma_{HH} \ln w_H + \gamma_{HL} \ln w_L + \gamma_{HM} \ln w_M + \phi_{HK} \ln K + \phi_{HY} \ln Y + \phi_{Ho} \ln O + \phi_{HT} \ln T \qquad (6B)$$

The share equations of (6A) and (6B) can be deemed as a composite representation of the demands for unskilled and skilled labor, respectively. To estimate these share equations empirically, one must specify a stochastic framework. Typically, a random disturbance term u_K is added to each share equation and assumed

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to be multivariate normally distributed with a mean vector zero, $E(\mathbf{u}) = 0$, and a constant variance matrix, $Var(\mathbf{u}) = \Omega$. Furthermore, our econometric model specifications also include the time-specific (μ_t) and industry-specific (λ_i) dummies. These time- and industry-specific effects are meant to capture persistent industrial differences and overall technological progress affecting the industries. Accordingly, our fully specified econometric model is given as follows:

$$S_{Lit} = \alpha_L + \gamma_{LL} \ln w_{Lit} + \gamma_{HL} \ln w_{Hit} + \gamma_{ML} \ln w_{Mit} + \phi_{LK} \ln K_{it} + \phi_{LY} \ln Y_{it} + \phi_{Lo} \ln O_{it}$$
$$+ \phi_{LT} \ln T_{it} + \mu_t + \lambda_i + u_{Lit} \tag{7A}$$

$$S_{Hit} = \alpha_H + \gamma_{HH} \ln w_{Hit} + \gamma_{HL} \ln w_{Lit} + \gamma_{HM} \ln w_{Mit} + \phi_{HK} \ln K_{it} + \phi_{HY} \ln Y_{it} + \phi_{Ho} \ln O_{it}$$
$$+ \phi_{LT} \ln T_{it} + \mu_t + \lambda_i + u_{Hit} \tag{7B}$$

One attractive feature of the non-homothetic translog functional form of the dual cost function (3) is that it does not impose any restrictions on the elasticities of substitution between two variable inputs a priori. It may also be interesting to investigate the impacts of outsourcing on substitution among unskilled labor, skilled labor, and raw materials.[16] We define this second-order effect of outsourcing as the "rotating" effects henceforth.[17] The implication of the rotating effects of outsourcing on the relative demand for skilled workers is that the increases in the relative demand for skilled labor might stem not only from the shift effects of outsourcing, but also from the changes in the competitiveness of the labor market. If, say, outsourcing is skill-biased and reduces the elasticities of substitution between skilled and unskilled labor, the impacts of outsourcing are magnified. The rotating effects could be determined by the elasticities of substitution between unskilled and skilled labor. By using parameter estimates from the equations (6A) and (6B), the Hicks-Allen partial elasticities of substitution between two variable inputs i and j for the dual cost function G can be measured as:

$$\sigma_{ij} = \frac{G \cdot G_{ij}}{G_i G_j} \tag{8}$$

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[16] Egger and Egger (2006) have also analyzed the elasticities of substitution between capital and labor in the context of international outsourcing in the EU.

[17] In fact, the idea of the second-order effect is not new. It has been widely estimated in the literature on biases of technological changes. However, to the best of our knowledge, we are the first to investigate this effect with respect to outsourcing variables for Thailand.

where the *i, j = L, H,* and *M* subscripts denote the first and second partial derivatives of the dual cost function in the equation (3) with respect to input prices, w_i and w_j, respectively. By using the equations (3) and (8), it can be shown that

$$\sigma_{ij} = \begin{cases} \dfrac{\gamma_{ii}}{S_i^2} + 1 - \dfrac{1}{S_i} & ,if \quad i = j \\[3mm] \dfrac{\gamma_{ij}}{S_i S_j} + 1 & ,if \quad i \neq j \end{cases} \tag{9}$$

By differentiating the equation (9) with respect to the outsourcing variable, $\ln O$, we can show that the marginal effects of outsourcing on the elasticities of substitution between variable factors *i* and *j* are[18]

$$\frac{\partial \sigma_{ij}}{\partial \ln O} = \begin{cases} \phi_{io}\left[-\dfrac{2\gamma_{ii}}{(S_i)^3} + \dfrac{1}{(S_i)^2} \right] & ,if \quad i = j \\[3mm] -\dfrac{\gamma_{ij}}{(S_i S_j)^2}\left(\phi_{io}S_j + \phi_{jo}S_i\right) & ,if \quad i \neq j \end{cases} \tag{10}$$

4.2 The Model Estimations

The iterative two-step SUR (ISUR) estimation is employed to estimate the relative demands for skilled and unskilled workers. The ISUR estimation is particularly advantageous for our estimation, since the parameter estimates are invariant to the choices of share equations arbitrarily dropped due to the adding-up condition.

As argued by Amiti and Wei (2006), there may also be a problem of potential endogeneity in the variables from outsourcing. Intuitively, the decisions to outsource may be affected by industry-specific factors, such as the exposure to international trade and foreign ownership. Feenstra and Hanson (1997) find the evidence in Mexico that exporting firms are more likely to deal with outsourcing activities than non-exporting firms. It is also likely that foreign-owned firms outsource their activities due to their global networks and access to international contractors. Furthermore, as noted by Morrison (1999), the quasi-fixed capital is likely to be correlated with industry-specific factors, thereby entailing the potential endogeneity

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[18] Note that the logarithm prevails only in the denominator of equation (10), in order to be consistent with the typical specification of biases. See Morrison (1988) for more details regarding the bias specification.

problem in the ISUR estimations.[19] To account for this problem, the quasi-fixed capital (K) and the indexes of material (OM) and service (OS) outsourcing will be instrumented by the lagged structural variables (as suggested by Pindyck and Rotemberg, 1983), the indexes representing foreign ownership ($FHOLD$) and exposure to international trade ($EXPORT$).

The industries with high foreign ownership are characterized by high quasi-fixed capital and material outsourcing activities, and hence the index of foreign ownership may be a good IV for quasi-fixed capital and material outsourcing. Moreover, it is expected that the industries with high exposure to the international market tend to have high quasi-fixed capital and service outsourcing. In this sense, the index of international trade exposure is strongly correlated with quasi-fixed capital and service outsourcing.

It should also be noted these firm's characteristics at least in short run should be exogenous to the firms and strongly correlated to the exposure to outsourcing activities and capital utilization. Therefore, they satisfy the general requirements of the instrumental variables.[20] Given these potential instrumental variables, we account for the endogeneity bias problem by using the iterative three-stage least squares (I3SLS) estimation. The I3SLS estimation not only has its asymptotic consistency and invariant property but can also be shown that our I3SLS is asymptotically efficient if the instruments satisfy the general requirements of IV estimators.

5. Empirical Results

5.1 Impacts of Outsourcing on the Relative Demands for Unskilled and Skilled Workers

The empirical results from translog cost function are reported in Tables 1 and 2 based on the full sample of our data.

[Insert Table 1 here]

Table 1 highlights the preliminary results based on the ISUR estimations. The Chi-squared statistics reveal that the null hypothesis that all coefficients are jointly equal to zero is rejected at 1 percent level of statistical significance. With correlation

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[19] Amiti and Wei (2006) argue that the endogeneity problem may also exist in outsourcing variables. Nevertheless, due to the existence of the incomplete contract and firm-specific investment, they, at least in short run, can be treated as exogenously given.

[20] The first-stage regression has confirmed the validity of our IVs. The results are available upon request.

of residuals between two equations equal to 0.364 for the ISUR estimation, the Breusch-Pagan Test rejects the null that there are no industry- and time-specific effects, and therefore the inclusion of industry- and time-specific dummies seems to be justified in the model.[21]

[Insert Table 2 here]

To account for a potential endogeneity problem, Table 2 shows the I3SLS results in which the quasi-fixed capital ($\ln K$), material outsourcing ($\ln OM$), and service outsourcing ($\ln OS$) are instrumented by lagged values of structural variables and industry-specific factors, including the intensities of foreign ownership and exporters. The Hausman specification test asserts that the null hypothesis of no endogeneity problem can be rejected with 1 percent level of statistical significance. As a result, the ISUR parameter estimates reported above were inconsistent, and therefore our analyses henceforth will be based on the I3SLS estimates given in Table 2.

We find the following interesting results in our estimation. Firstly, the coefficients of $\ln w_L$ in the unskilled share equation and $\ln w_H$ in the skilled share equation (γ_{LL} and γ_{HH}) turn out to be negative and statistically significant at the 5 percent level. This ensures that the estimated translog cost function satisfy the standard neo-classical cost function. Both unskilled and skilled workers are substitutes, since the coefficient of $\ln w_H$ (γ_{HL}) in the unskilled share equation[22] is positive and statistically significant. The results also indicate that material inputs are substitutes for both unskilled and skilled labor. This suggests that an increase in material prices ($\ln w_M$) results in outward shifts of the relative demands for both types of labor.

Secondly, the effects of quasi-fixed capital on the relative demands for unskilled and skilled workers reveal that it is complementary to unskilled workers but substitutable for skilled workers ceteris paribus. This result is consistent with Helg and Tajoli (2005) who studied the labor market effects of international outsourcing, proxied by the outward processing trade, based on Italy and German data during the

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[21] We suppress the coefficients of industry- and time-specific dummies. The results are available upon request.

[22] The linear homogeneity and symmetry restrictions of equations (4) and (5) imply that the coefficient of $\ln w_H$ (γ_{HL}) in the unskilled share equation must be equal to that of $\ln w_L$ in the skilled share equation.

1990s. They find that capital stock has negative impacts on the demand for skilled workers.

Thirdly, the short-run expansion of output (economies of scale), given capital fixed, reduces both unskilled and skilled shares, thereby raising the raw material share. Intuitively, in the short run we could expect the labor market friction that may hinder firms to fully adjust workers to meet the production demands, thereby confining firms to increase the use of material inputs when production increases.

Fourthly, holding output and capital unchanged, material outsourcing ($\ln OM$) has a negative impact on both labor demands but more significant on unskilled workers.[23] As shown in Table 2, the estimation results reveal that the imports of intermediate inputs result in a decline in both relative demands for unskilled and skilled workers, which in turn implies positive impacts on the relative demands for materials. Specifically, the negative impacts of material outsourcing may suggest that Thailand's manufacturing industries may import labor-intensive intermediate inputs, reducing the demands for domestic labor. In this sense, the estimated coefficients reveal that the effects of material outsourcing in Thailand's manufacturing industries are analogous to those observed in industrialized countries in terms of 'exporting jobs'. Moreover, such negative impacts are more pronounced for unskilled workers mainly due to the imports of labor-intensive intermediate inputs.

Fifth, the impact of service outsourcing on the relative demand for unskilled workers is negative, though statistically insignificant. Meanwhile, skilled labor gains from specializing in core-competent activities, thereby raising its relative demand. This may suggest that contracting out service activities may enable firms to reap benefits from reallocating labor to core activities, and entailing gains from specialization. On the other hand, service activities, such as maintenance, call operators, and recruitment, in general are unskilled-labor-intensive. Therefore, outsourcing of such service activities is more likely to be skill-biased – an outward shift in the relative demand for skilled workers is greater than that for unskilled ones.

Interestingly, our empirical results are also consistent with the existing literature on the impacts of outsourcing on wage inequality in relation to industrialized economies since the coefficients of materials ($\ln OM$) and services

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[23] The coefficients of $\ln OM$ in both equations are negative, but the former is only statistically significant at the 10 percent level.

($\ln OS$) in the skilled share equation are always greater than those in the unskilled one (see Feenstra and Hanson, 1996, 1999; Anderton and Brenton, 1999; Geishecker, 2002; Egger and Egger, 2006). Given this, the prevalence of outsourcing activities will widen the gap between skilled and unskilled income in Thailand's manufacturing industries.

Lastly, technological progress is labor-augmenting – the greater intensities of R&D activities imply the greater relative demands on skilled relative to unskilled workers. It can also be observed that the labor-augmenting effects of technological progress are also skill-biased in that the magnitude of a shift in the relative demand for skilled workers is greater than that of the unskilled ones.

[Insert Table 3 here]

To see the impacts of outsourcing on the relative demand for skilled and unskilled workers more clearly, we further categorize the industries into low-, medium-, and high-technology industries. When the overall manufacturing industries are disaggregated according to their technological intensities, the null hypothesis of no endogeneity problem cannot be rejected except for low-technology industries (see Table 3).

Essentially, the main findings from Table 3 can be summarized as follows. Firstly, unskilled and skilled workers are substitutes for all industries, and the degree of their substitution seems to be the strongest in the low-technology industries. Material inputs are substitutes for workers employed only in the medium- and high-technology industries, whereas an increase in material prices will cause a decrease in the relative demands for those employed in the low-technology industries.[24]

Secondly, the quasi-fixed capital ($\ln K$) seems to be complementary to those employed in the low-technology industries. In addition, albeit statistically insignificant, our results show that capital and labor are complements in the medium-technology industry but are substitutes in the high-technology industry.

Thirdly, the negative impacts of output expansions ($\ln Y$) on the relative demands for unskilled and skilled labor prevail only in the low- and medium-technology industries. In the high-technology industry, the impacts of output

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[24] As portrayed in Table 3, in the low-technology industries, the effects of $\ln w_M$ are significant only for the unskilled share; in the medium-technology industries, merely skilled workers are significantly affected by material prices; and, neither unskilled nor skilled share is significantly affected in the high-technology industries.

expansion on the relative demands for both types of labor, though statistically insignificant, are positive.

Fourthly, the result that material outsourcing ($\ln OM$) leads to a decline in the relative demands for unskilled and skilled workers is observed solely in the medium- and high-technology industries. However, a statistically significant and positive relationship between material outsourcing and the relative labor demands characterizes the low-technology industries. Intuitively, these may imply that manufactures in the medium- and high-technology industries internationally source labor-intensive intermediate inputs, while those in the low-technology industries may choose to contract out capital-intensive ones. In contrast, service outsourcing ($\ln OS$) entails a positive effect on the relative demands for both unskilled and skilled workers, and the effects are particularly significant in the high-technology industries.

It is possible that increases in material and service outsourcing can enlarge the relative labor demands across skilled groups in the low- and high-technology industries. Nevertheless, we can observe such effects for only service outsourcing in the medium-technology industry.

Lastly, our results of labor-augmenting technological progress ($\ln T$) are rather robust across all sub-sectors.

5.2 Impacts of Outsourcing on Factors Substitution

It is expected that international outsourcing leads to cost-savings (shift in the unit isocost function) but also has the (biased) factor substitution effects in terms of "rotating" the unit isocost function (Arndt, 1997; Kohler, 2001; Egger and Falkinger, 2003). To study the impacts of outsourcing on (variable) factors substitution, we used the measure of Hicks-Allen partial elasticities of substitution.[25] By using the consistent I3SLS estimates in Table 2, the Hicks-Allen elasticities of substitution as given in equation (9) can be represented in a matrix form as follows:

$$
\begin{bmatrix}
\sigma_{LL} & \sigma_{LH} & \sigma_{LM} \\
 & \sigma_{HH} & \sigma_{HM} \\
 & & \sigma_{MM}
\end{bmatrix}
=
\begin{bmatrix}
-33.58 & 3.27 & 1.15 \\
 & -10.38 & 1.38 \\
 & & -0.26
\end{bmatrix}
\tag{11}
$$

As shown in equation (11), the own price elasticities represented by the diagonal elements are all negative, implying that the translog cost function estimated is a well behaved cost function. The relative demand for unskilled labor is the most

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[25] All derivations of the elasticities are evaluated at fitted means of the factor shares.

elastic and thus the most vulnerable to a change in its wage. In contrast, raw materials are the least sensitive to changes in their prices. The off-diagonal elements in equation (11) indicate the elasticities of substitution between two variable factors. Apparently, all variable factors, unskilled labor, skilled labor, and raw materials are substitutes.

Next, we calculate the marginal effects of material and service outsourcing by using equation (10). The impacts of material outsourcing on the substitution among variable factors of production are given in equation (12).

$$
\begin{bmatrix}
\partial\sigma_{LL}/\partial\ln OM & \partial\sigma_{LH}/\partial\ln OM & \partial\sigma_{LM}/\partial\ln OM \\
 & \partial\sigma_{HH}/\partial\ln OM & \partial\sigma_{HM}/\partial\ln OM \\
 & & \partial\sigma_{MM}/\partial\ln OM
\end{bmatrix}
=
\begin{bmatrix}
-47.64 & 2.49 & 0.155 \\
 & -0.41 & -0.011 \\
 & & 0.075
\end{bmatrix}
\quad (12)
$$

As shown in equation (12), material outsourcing increases the own price elasticities of unskilled and skilled demands, in the sense that when firms become more specialized in some particular core-competent activities, the existing workers prone to be more vulnerable to changes in their own returns.[26] This suggests that material outsourcing not only shifts the relative demands for unskilled and skilled workers, but also increases their responsiveness. Intuitively, as material outsourcing opportunities become more feasible, the firms' labor demands are more responsive to changes in their wages. Unlike those of unskilled and skilled workers, the elasticities of raw materials seem to be negatively correlated with material outsourcing – the demand for raw materials become more elastic as firms decide to internationally outsource intermediate inputs. This may be explained by the fact that material outsourcing requires firms to customize their raw materials to be perfectly compatible with intermediate inputs produced at arm's length, thereby making them less sensitive to their price changes.

Material outsourcing, based on our results, tends to have positive impacts on the substitution between unskilled and skilled workers and between unskilled and raw materials,, but negative, though negligible, impacts on the substitution between skilled workers and raw materials. This suggests that material outsourcing makes unskilled workers more substitutable by skilled workers and raw materials but reduces the substitution between skilled workers and raw materials.

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[26] Recall that the well behaved cost function requires that the own price elasticities are negative.

Likewise, the impacts of service outsourcing on substitution among variable factors of production are given in equation (13).

$$\begin{bmatrix} \partial\sigma_{LL}/\partial\ln OS & \partial\sigma_{LH}/\partial\ln OS & \partial\sigma_{LM}/\partial\ln OS \\ & \partial\sigma_{HH}/\partial\ln OS & \partial\sigma_{HM}/\partial\ln OS \\ & & \partial\sigma_{MM}/\partial\ln OS \end{bmatrix} = \begin{bmatrix} -2.93 & -0.9 & -0.0047 \\ & 7.35 & -0.164 \\ & & -.094 \end{bmatrix} \quad (13)$$

Service outsourcing makes the demands for unskilled workers and raw materials become more elastic and those for skilled workers less elastic. This may provide clearer insights into the skill-biased effect of service outsourcing, which results in more elastic demands for unskilled workers and raw materials and less elastic demands for skilled workers.

Interestingly, service outsourcing brings about lower elasticities of substitution among all factors of production. A decline in substitutability of factors of production may stem from the fact that service outsourcing, as discussed earlier, enables the remaining factors of production to be more specialized in core-competent activities, thereby reducing their substitutability.

6. Concluding Remarks

In this paper, we employ a non-homothetic translog function to empirically investigate the impacts of outsourcing on the relative demands for unskilled and skilled labor in Thailand's manufacturing sectors.

Our empirical results reveal that material outsourcing has negative impacts on the relative demands for unskilled and skilled workers and is skill-biased. We observed that Thailand's manufacturing industries in general are outsourcing labor-intensive intermediate inputs, thereby reducing their relative demands domestically. Our results support the observation of job losses due to the 'exporting of jobs' from material outsourcing in Thailand as observed in most industrialized economies. Moreover, service outsourcing is also found to have negative impacts on unskilled workers but positive impacts on skilled workers. This can be explained by the fact that service activities are in general unskilled-labor-intensive and the decisions to contract out those activities will undermine the relative demand for unskilled workers, whereas skilled workers employed in house reap greater benefits from specialization. Like material outsourcing, service outsourcing is also skill-biased. By combining both the effects of material and service outsourcing, we can directly infer that the skill bias of outsourcing could explain the rising wage inequality within industries.

We also employ our empirical results to uncover the impacts of outsourcing on the own-price and cross-price elasticities of substitution among variable factors of production by calculating the Hicks-Allen partial elasticities of substitution. Evaluated at fitted values of the factor shares, our results indicate that unskilled labor, skilled labor, and raw materials are substitutes. We find that material outsourcing makes both skilled and unskilled labor more susceptible to changes in their own wages, whereas it results in more inelastic demands for raw materials. Besides, it makes unskilled labor more substitutable by skilled labor and raw materials but reduces the substitution between skilled labor and materials. In contrast, service outsourcing is found to entail the more elastic demands for unskilled labor and raw materials and the more inelastic demand for skilled workers. Unlike material outsourcing, service outsourcing reduces substitutability among all variable factors of production.

Our results shed further light on the impacts of outsourcing on the labor market in Thailand's manufacturing sectors. The results show that outsourcing decisions by local manufacturers may not be always undesirable for domestic workers, depending on their underlying activities. In the case of Thailand, material outsourcing is found to have a negative impact on domestic employment, whereas the service outsourcing, though skill-biased, may be beneficial for domestic workers. As the manufacturing activities in Thailand are moving to more capital- and technology-intensive activities, the impact of intermediate inputs and service outsourcing will have important implications on the rising wage inequality and also on the skilled developments in the economy. The potential effect of outsourcing has a positive impact on the manufacturing industries in terms of improving their productivity. However, our evidence indicates that there are negative effects on unskilled workers, and thus the government has an important role in managing the negative effects without sacrificing the positive effects from international outsourcing. The training and upgrading of skills programmes will be crucial to move unskilled workers to more productive sectors in the economy. The improvement and upgrading of the education and innovation systems in Thailand's economy will be important factors to augment the potential benefits of outsourcing.

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Appendix

Table A1: The descriptions of industry classification (ISIC Rev.3)

Industry	Description
1	Manufacture of food products and beverages
2	Manufacture of tobacco products
3	Manufacture of textiles
4	Manufacture of wearing apparel; dressing and dyeing of fur
5	Tanning and dressing of leather; manufacture of luggage, handbags, saddlery, harness and footwear
6	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials
7	Manufacture of paper and paper products
8	Publishing, printing and reproduction of recorded media
9	Manufacture of coke, refined petroleum products and nuclear fuel
10	Manufacture of chemicals and chemical products
11	Manufacture of rubber and plastics products
12	Manufacture of other non-metallic mineral products
13	Manufacture of basic metals
14	Manufacture of fabricated metal products, except machinery and equipment
15	Manufacture of machinery and equipment n.e.c.
16	Manufacture of office, accounting and computing machinery
17	Manufacture of electrical machinery and apparatus n.e.c.
18	Manufacture of radio, television and communication equipment and apparatus
19	Manufacture of medical, precision and optical instruments, watches and clocks
20	Manufacture of motor vehicles, trailers and semi-trailers
21	Manufacture of other transport equipment
22	Manufacture of furniture; manufacturing n.e.c.
23	Recycling

Table A2: Technology Level Classification.

Technology Level	Industry
Low	1-6
Medium	7-9, 11-12, 22-23
High	10, 13-21

Table A3: Summary of Statistics

Variables	Obs.	Mean	S.D.	Min	Max
S_L	245	.0427	.0416	.0007	.4522
S_H	245	.1200	.0777	.0025	.4418
$\ln w_L$	245	11.3895	.3800	9.9331	12.4758
$\ln w_H$	245	11.9653	.4577	9.3394	13.0682
$\ln w_M$	245	4.6226	.0571	4.4153	4.7404
$\ln K$	245	22.0389	1.9100	11.0796	25.5946
$\ln Y$	245	22.7944	1.8330	13.4000	26.2451
$\ln OM$	235	-.9709	.3168	-2.1378	-.3178
$\ln OS$	244	-3.4761	.7513	-5.4526	-1.2968
$\ln T$	236	-7.0522	1.3701	-11.3337	-3.4910

FIGURES

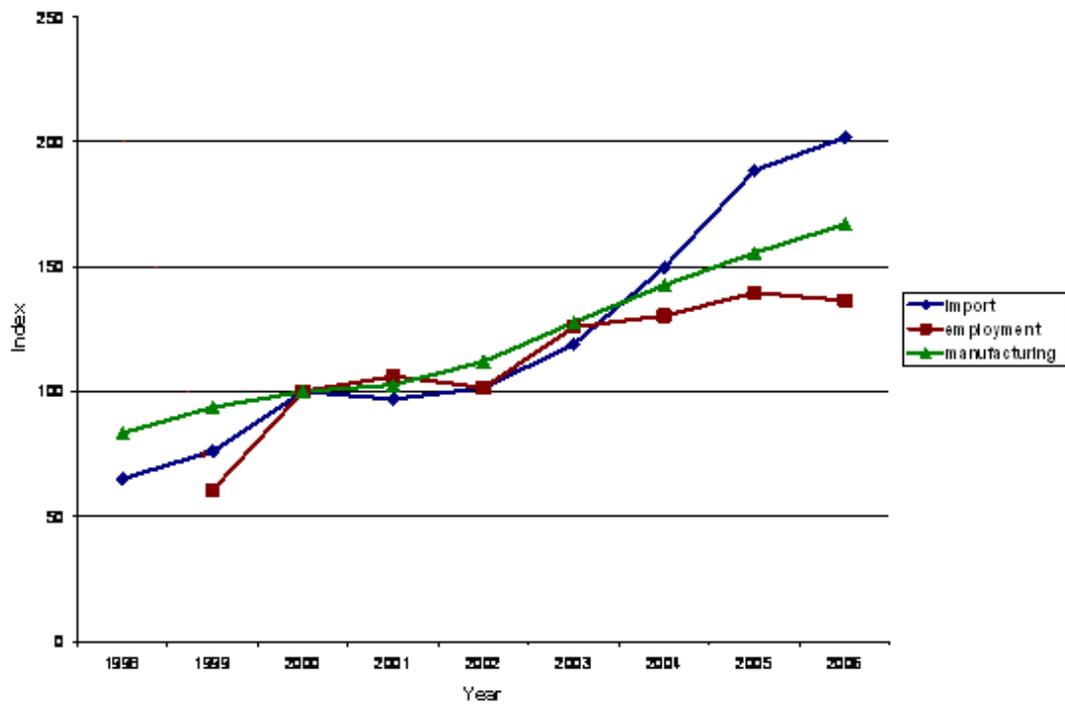Figure 1: The Import, Employment, and Manufacturing Indices (2000 = 100)
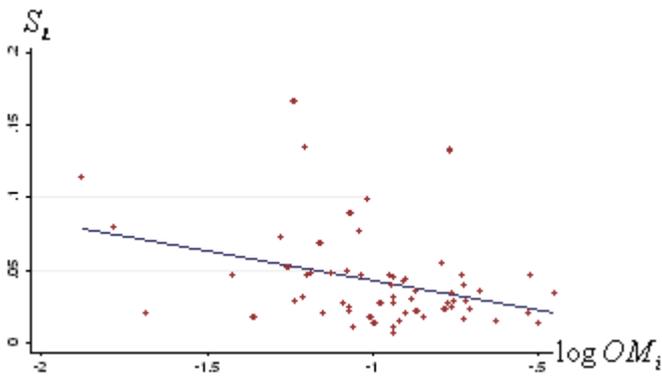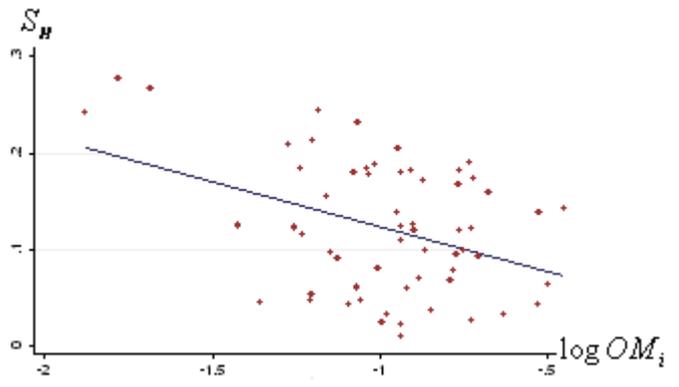(Source: Bank of Thailand)
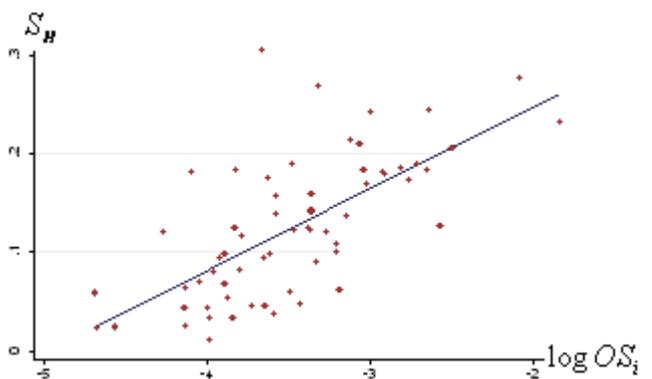

Figure 2

Figure 3

Figure 4

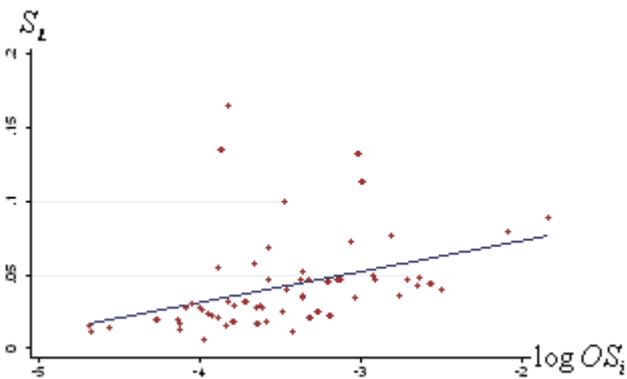Figure 5

TABLES

Table 1: Iterative Zellner's Seemingly Unrelated Regression (ISUR) Estimates, Thailand Manufacturing Industries from 1999-2003.

Independent Var.	Share Equations	
	Unskilled Share (S_L)	Skilled Share (S_H)
$\ln w_L$	0.0105(.0059)*	0.0100(.0052)*
$\ln w_H$	0.0100(.0052)*	-0.0453(.0097)***
$\ln w_M$	-0.0205(.0063)***	0.0353(.0112)***
$\ln K$	-0.0049(.0031)	0.0036(.0058)
$\ln Y$	-0.0023(.0034)	-0.0222(.0065)***
$\ln OM$	-0.0267(.0062)***	-0.0095(.0122)
$\ln OS$	0.0084(.0025)***	0.0397(.0050)***
$\ln T$	0.0027(.0013)**	0.0040(.0026)
Constant	0.0861(.0464)*	0.9932(.0878)***
No. of Obs.	232	232
R-squared	0.3378	0.5608
Chi-squared (p-value)	118.02(0.000)***	308.89(0.000)***
Correlation of Residual	0.3643	
Breusch-Pagan Test (p-value)	30.784(0.000)***	

Note: 1) Standard error is in parentheses. 2) * statistically significant at 10 percent, ** statistically significant at 5 percent, and *** statistically significant at 1 percent. 3) Breusch-Pagan Test is distributed as Chi-squared distribution with one degree of freedom under the null hypothesis that there are no industry- and time- specific effects jointly.

Table 2: Iterative Three-stage Least Squares (I3SLS) Estimates, Thailand Manufacturing Industries from 1999-2003.

Independent Var.	Share Equations	
	Unskilled Share (S_L)	Skilled Share (S_H)
$\ln w_L$	-0.0167(.0085)**	0.0115(.0073)
$\ln w_H$	0.0115(.0073)	-0.0509(.0141)***
$\ln w_M$	0.0052(.0075)	0.0395(.0150)***
$\ln K$	0.0178(.0096)*	-0.0044(.0179)
$\ln Y$	-0.0233(.0099)**	-0.0111(.0191)
$\ln OM$	-0.0435(.0224)*	-0.0035(.0490)
$\ln OS$	-0.0027(.0119)	0.0620(.0270)**
$\ln T$	0.0035(.0016)**	0.0062(.0036)*
Constant	0.1780(.0628)***	1.0452(.1283)***
No. of Obs.	158	158
R-squared	0.2998	0.5524
Chi-squared (p-value)	110.27(.000)***	199.68(.000)***
Hausman Test (p-value)	114.49(.000)***	

Note: 1) Standard error is in parentheses. 2) * statistically significant at 10 percent, ** statistically significant at 5 percent, and *** statistically significant at 1 percent. 3) $\ln K$, $\ln OM$ and $\ln OS$ are RHS endogenous and instrumented by lagged structural variables and industry-specific variables in logarithm forms, including the ratio of foreign-owned firms to total number of firms, and the ratio of exporters to total number of firms. 4) Hausman Specification Test Statistic is distributed as Chi-squared distribution with 24 degree of freedom under the null hypothesis of no endogeneity problem.

Table 3: Iterative Three-stage Least Squares (I3SLS) Estimates, Thailand Manufacturing industries from 1999-2003.

Independent Var.	Low-Technology Industries		Medium-Technology Industries		High-Technology Industries	
	Unskilled Share (S_L)	Skilled Share (S_H)	Unskilled Share (S_L)	Skilled Share (S_H)	Unskilled Share (S_L)	Skilled Share (S_H)
$\ln w_L$	0.0073(.009)	0.0302(.014)**	-0.0239(.013)*	0.0133(.014)	-0.0217(.01)***	0.0103(.007)
$\ln w_H$	0.0303(.014)**	0.0463(.053)	0.0133(.014)	-0.124(.030)***	0.0102(.007)	-0.0332(.019)*
$\ln w_M$	-0.0376(.02)**	-0.0765(.065)	0.0107(.019)	0.1107(.036)***	0.0114(.008)	0.0229(.022)
$\ln K$	0.0278(.008)***	0.0978(.031)***	0.0227(.014)	0.0256(.026)	-0.0072(.008)	-0.0313(.023)
$\ln Y$	-0.0309(.01)***	-0.114(.033)***	-0.038(.014)***	-0.0430(.025)*	0.0067(.009)	0.0152(.026)
$\ln OM$	0.0640(.026)**	0.2206(.102)**	-0.0162(.020)	-0.0212(.040)	-0.0421(.021)**	-0.0153(.062)
$\ln OS$	0.0150(.011)	0.0689(.042)*	0.0051(.013)	0.0646(.026)**	0.0170(.005)***	0.0601(.016)***
$\ln T$	0.0078(.003)**	0.0191(.013)	0.0088(.003)***	0.0047(.006)	0.0015(.001)	0.0073(.004)**
Constant	0.0302(.123)	0.6344(.461)	0.5222(.165)***	1.6009(.329)***	0.1465(.040)***	0.8892(.115)***
No. of Obs.	31	31	51	51	76	76
R-squared	0.2023	0.2593	0.4549	0.5663	0.4648	0.6337
Chi-squared (p-value)	22.78(.012)**	32.01(.000)***	55.54(.000)***	65.64(.000)***	80.44(.000)***	161.18(.000)***
Hausman Test (p-value)	32.61(.027)**		7.76(0.9889)		25.12(0.1565)	

Note: 1) Standard error is in parentheses. 2) * statistically significant at 10 percent, ** statistically significant at 5 percent, and *** statistically significant at 1 percent. 3) $\ln K$, $\ln OM$ and $\ln OS$ are RHS endogenous and instrumented by lagged structural variables and industry-specific variables in logarithm forms, including the ratio of foreign-owned firms to total number of firms, and the ratio of exporters to total number of firms. 4) Hausman Specification Test Statistic is distributed as Chi-squared distribution with 20 degree of freedom under the null hypothesis of no endogeneity problem.

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