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Time-Series Wage Differential in Taiwan: The Role of International Trade

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Abstract

Rising relative wages between skilled and unskilled workers in developed countries has been a popular subject of recent studies. This paper analyzes Taiwan, a semi-developed economy, where the relative wage reveals a declining trend since the mid-1980s. The authors study the role of international trade. A major point of departure is to distinguish the effects of net exports to OECD countries from those to non-OECD countries. The paper also differentiates the effects of net exports to China from those to non-OECD countries except China. It is found that net exports to the OECD countries raise the relative wage of skilled workers, whereas net exports to non-OECD countries and China diminish the relative wage. Moreover, the impacts of net exports to China are much larger than those to OECD and other non-OECD countries. The documented wage effects of international trade in this work diverge from what existing works have argued based on Heckscher–Ohlin theory.

1. Introduction

This paper investigates wage income inequality in Taiwan. Despite its rapid economic growth, the Taiwan economy showed more equal distribution in wage incomes after the mid-1980s. The structure and determinants of the time-series wage differential have recently been a popular subject for study. The relative wage incomes between skilled and less-skilled workers, or between individuals with a college degree or above and those without, were more unequal after the mid-1980s in the US and several other OECD countries where labor markets were decentralized (see, e.g., Freeman and Katz, 1995; Katz et al., 1995).

Many factors have been proposed to explain this relative-wage structural development for the OECD countries. Theoretically, the equilibrium relative wage rate is determined by the relative supplies of skilled and less-skilled workers, and by shifts in the relative demand for labor favoring skilled workers.[1] Intuitively, a larger relative labor supply of skilled workers decreases the relative wage of skilled workers, whereas a larger relative labor demand for skilled workers increases the relative wage of skilled workers, other things being equal. For shifts in the relative demand factors, two dimensions are mostly emphasized: one is the rapid advance in technology and the other is an increasing openness in global trade in the 1980s and 1990s. While the fast introduction of new technology was found to be biased against less-skilled workers in developed economies (e.g., Bound and Johnson, 1992; Katz and Murphy, 1992; Berman et al., 1994), this was not the case for an expansion in international trade.

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One line of research has found an important role of international trade in explaining increasing wage inequality in a fashion predicted by Heckscher–Ohlin theory (e.g., Murphy and Welch, 1991; Leamer, 1993; Borjas and Ramey, 1994; Wood, 1994), whereas another line has established that international trade has a small and often negligible effect (e.g., Lawrence and Slaughter, 1993; Krugman and Lawrence, 1994; Sachs and Shatz, 1996).

Although many workers have studied the wage structural change, focusing on developed countries and the US in particular, little attention has been paid to developing economies. In contrast to the developed countries, wage differentials between individuals with a college degree or above and those without have in fact revealed a declining trend for some East Asian countries since the mid-1970s. Kim and Topel (1995) and Chan et al. (1998) documented this trend for Korea and Taiwan, respectively.[2] Both works found that, among other factors, rapid upgrading of the educational attainment of the workforce is an important factor explaining the trend towards a more equal wage distribution. However, international trade expanded swiftly in the same period, and coincided with a declining wage dispersion for these two economies in the past two decades. Therefore, international trade seems to affect the wage dispersion. It is this observation that motivates our study.

The purpose of this work is to specifically study the effect of international trade on wage dispersion between skilled and less-skilled workers in Taiwan. We believe the results are applicable also to South Korea and other East Asian middle-income economies with similar wage dispersion trends. This study is thus valuable in at least three ways. First, along with the emergence of endogenous growth models, more attention has been paid recently to income distribution.[3] Our study investigates what made the wage income more equally distributed in a rapidly growing economy. Second, the effect of international trade on wage dispersion in developed economies has been the subject of an ongoing debate. Our study could shed light on this debate. Third, Taiwan is indeed a semi-industrialized economy, located between developing and developed stages. An understanding of the role of international trade on wage dispersion in Taiwan lends experience to lower-income countries such as Malaysia, Thailand, and other latecomers that used an expansion of international trade as a strategy for promoting economic growth.

With regard to the relationship between relative wage and international trade, the main theory concerned is the Heckscher–Ohlin model. According to the theory, comparative advantage dictates the international division of labor, whereby the developing countries export unskilled labor-intensive products to, and import skilled labor-intensive products from, developed countries.[4] As a result, an expansion in *net exports* of a developing country favors the relative demand for unskilled labor *vis-à-vis* skilled labor, and it follows that the relative wage between skilled and unskilled workers shrinks in a developing country. As mentioned earlier, however, conclusions both supporting and rejecting the relative wage effect predicted by the Heckscher–Ohlin theory have been reached.

If Taiwan is considered as a developing country, the fact that the declining wage dispersion coincided with the rising wage differential trend in many OECD countries may be thought to support the Heckscher–Ohlin prediction. This work departs from conventional wisdom in recognizing that Taiwan is a semi-developed country. We distinguish the relative wage effects of net international trade to more developed OECD countries from those to less-developed non-OECD countries. This distinction

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is vital, as the opening up of the low-income half of the world in the 1980s was argued as likely to alter the competitive advantage of middle-income countries like Taiwan (e.g., Wood, 1997). As both Taiwan's trade and net exports with China increased rapidly from the early 1980s,[5] we also differentiate the relative wage effects of Taiwan's net exports to China from those to other non-OECD countries. Using Taiwan's annual time-series data of male workers between 1979 and 1998, so controlling working experiences to be no more than ten years, we document the relationship between relative wage and net exports while controlling for other major demand and supply factors.

Our main findings are as follows. First, net exports to OECD countries raise the relative wage between skilled and unskilled workers, whereas net exports with non-OECD countries diminish the relative wage. Second, when net exports to non-OECD countries are decomposed into those with China and those with other non-OECD countries, the results are the same as those of net exports to non-OECD countries. Third, the effects of net exports to China are much larger than those to OECD and other non-OECD countries.

The results of this paper contribute to the debate in at least three aspects. First, as with Leamer (1993), Wood (1994), and others, our results indicate that international trade is an important determinant of wage dispersion. As opposed to these works, however, the effects of increasing net exports, no matter with OECD or non-OECD countries, on relative wage are opposite to the implications of the Heckscher–Ohlin theory. Second, the entry of low-income countries, China in particular, into the world market in the 1980s has been argued by Wood (1997) and others to increase the relative wage of skilled workers in developed countries. Our work is the first to study the wage dispersion effects of China and non-OECD countries in a semi-developed economy, but finds results different from those argued and predicted hitherto. Third, the relationship between trade and personal income distribution has recently been a popular topic of research in a cross-country analysis (e.g., Bourguignon and Morrisson, 1990; Edwards, 1997). Our time-series study of this relationship in a country complements this line of research.

In section 2, we describe the wage distribution and international trade in Taiwan. Section 3 then sets up a simple econometric model to study the determinants of wage dispersion. Section 4 describes the data, and section 5 analyzes the empirical results. Section 6 concludes.

2. Wage Distribution and International Trade in Taiwan

This section depicts the trends of wage distribution and international trade in Taiwan after the late 1970s. In documenting wage distribution, we restrict the samples to full-time, year-round male workers as males are the primary labor force. Since mandatory education was extended from six years to nine years in 1968 and, with few exceptions, age 65 is the retirement age, we confine the data to workers of age 15–64.

The data reveal that all the nominal wages for workers having a college degree or above (denoted as W_c), having a senior degree (denoted as W_s), and obtaining a mandatory education degree or less (denoted as W_m) increased a lot from 1978 to 1999, with the wage of workers holding the mandatory education degree rising most rapidly, followed by that of workers having a senior high school degree.[6] Indeed, our calculation shows that the wage of workers with a mandatory education degree or less was increased 6.02 times or at an annual compound growth rate of 9.76% in the

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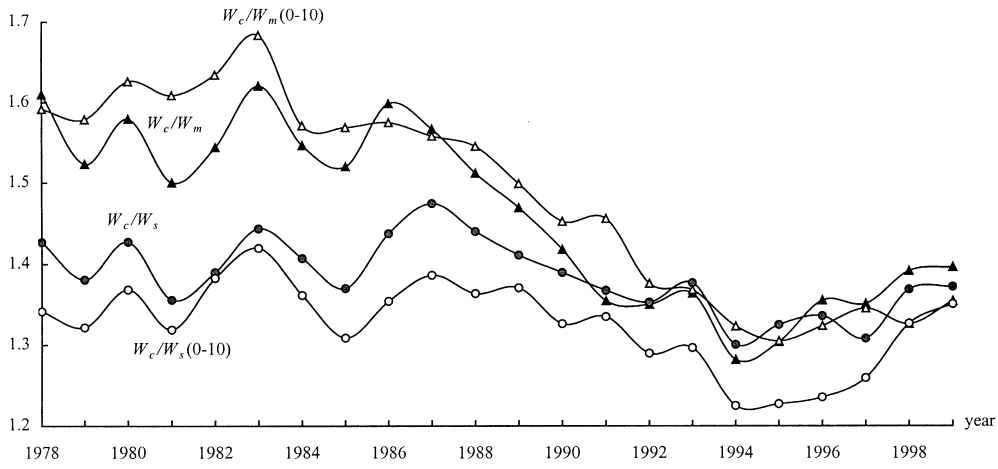
21-year period from 1978 to 1999, and that of workers with a senior high school degree and with a college degree increased respectively by 5.29 times and 4.82 times or at an annual compound growth rate of 8.93% and 8.37% in the same period. These rapid wage growth rates are the result of fast growth of the economy whose average real economic growth rate was 7.48% in this period.

The wage levels, however, do not convey information about the wage distribution between skilled and unskilled workers. Since workers holding a senior high school degree may work in high-skilled, mid-skilled, and low-skilled occupations, we use the relative wage between workers having a college degree or above and those obtaining a senior high school degree (W_c/W_s) as well as the relative wage between laborers getting a college degree or above and laborers acquiring a mandatory education degree or less (W_c/W_m) to represent the wage dispersion between skilled and unskilled workers. In Figure 1 we depict these two relative wage loci. According to the curves in the figure, the relative wage basically fluctuated before 1986, but it started to decline until 1995. After 1995, there seemed to be an increase in the relative wage.

The relative wage distribution data illustrated above may not be informative as it reflects not only educational levels but also working experiences. To control for the working experience, we restrict the data to workers with less experience, and specifically to the workers with less than or equal to ten years of working experience. Then, only workers of younger cohorts are included. The chosen working experiences are within the "overtaking stage" of working life *à la* Mincer (1974). With the control of working experience, Figure 1 also reports both the relative wage loci, denoted as $W_c/W_s(0–10)$ and $W_c/W_s(0–10)$. The $W_c/W_s(0–10)$ locus is higher than the



● relative wage between workers with a college degree or above and workers with a senior high school degree
▲ relative wage between workers with a college degree or above and workers with a mandatory education degree or less
○ relative wage between workers with a college degree or above and workers with a senior high school degree, with less than or equal to 10 years of working experience
△ relative wage between workers with a college degree or above and workers with a mandatory education degree or less, with less than or equal to 10 years of working experience

Source: *Man Power Utilization Survey in Taiwan*

Figure 1. Relative Wages, 1978–99

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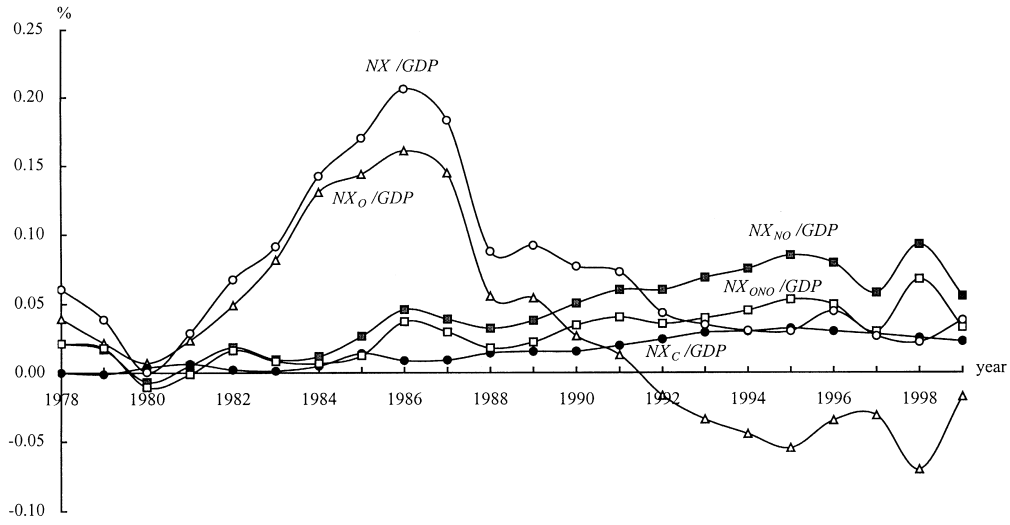

Sources: *Monthly Statistics of Exports and Imports* (for *NX*, NX_O, NX_{NO} and NX_{ONO})
Monthly Economics Statistics of Two Sides of The Straits (for NX_C)
Taiwan Statistical Data Book (for *GDP*)

Figure 2. Decomposition of Net Exports, 1978–99

W_c/W_s locus, while the W_c/W_s(0–10) locus is lower than the W_c/W_s locus. While the former two loci indicate that the relative wage between workers having more than or equal to a college degree and those obtaining a senior degree is smaller for less experienced workers, the latter two loci suggest an opposite relationship between workers holding more than or equal to a college degree and those obtaining less than or equal to a mandatory degree.

For net exports, we start by presenting the share of net exports in GDP (denoted as *NX*/*GDP*). It is illustrated in Figure 2. As can be seen, the share of net exports in GDP had a hump-shape; it fluctuated a lot, rising from less than zero to the peak of 20% in 1986 and then declining to 3.7% in 1999. The reason for the change is that exports rose more than imports before 1987. The liberalization of domestic markets and relaxation of foreign exchange control in 1987 made the imports increase rapidly. We also decompose the series of net exports in GDP to one of net exports with OECD countries (denoted as NX_O/GDP) and to another with non-OECD countries (denoted as NX_{NO}/GDP) and illustrate them in Figure 2. The share of net exports to OECD countries in GDP (the NX_O/GDP locus) also had a hump-shape which seemed to dominate the configuration of the *NX*/*GDP* locus before 1988. The NX_{NO}/GDP series reveals a rising trend since 1980, and the increase was rapid after 1988. The form of NX_{NO}/GDP after 1988 seemed to dictate that of *NX*/*GDP*. We notice that both the downward trend of NX_O/GDP and the upward trend of NX_{NO}/GDP after the mid-1980s appeared to coincide with the declining wage dispersion trend in Figure 1. In Figure 2 we also break down NX_{NO}/GDP into one with China (denoted as NX_C/GDP) and the remaining with other non-OECD countries (denoted as NX_{ONO}/GDP). Both NX_C/GDP and NX_{ONO}/GDP series had trends similar to that of NX_{NO}/GDP, albeit NX_{ONO}/GDP and NX_{NO}/GDP look more similar.

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3. Empirical Model

This section specifies the model determining the relative wage that will be employed in estimation and tests. There are two types of labor and the equilibrium relative wage is decided by the relative demand for and relative supply of labor. For expository simplification, we adopt a static model. The model could be extended to incorporate the dynamics and the growth effect. The extensions will not change qualitatively the substantial elements determining the relative wage rates below.

To write down the simple model, we follow Johnson (1997) and consider an economy in a variant of a Heckscher–Ohlin framework with two types of technology $i = 1$ and 2, and two types of labor, skilled (s) and unskilled (u), where both types of labor are necessary in production. Without loss of generality, we assume that technology 1 is more skilled-labor-intensive than technology 2. Given the technology level, the level of physical capital, and the market wage rates, a firm endowed with a particular kind of technology i in time t chooses the two types of labor to produce output in order to minimize its variable cost. Specifically, with a given technology $Y_i = A_i F_i(N_{is}, N_{iu}, K_i)$, where A_i is the level of technology, N_s and N_u indicate respectively skilled and unskilled labor, and K_i is physical capital, and with the assumption that $F_i(\cdot)$ is concave in its arguments, the problem of a representative firm in a particular sector i in time t is:

$$\min_{\{N_{is}, N_{iu}\}} C_i = w_s N_{is} + w_u N_{iu}, \quad i = 1, 2, \tag{1}$$

where t is omitted for convenience. Equation (1) is the total variable cost by treating physical capital as a fixed input. Optimization of the firm's problem leads to the following conditional factor demand for skilled and unskilled labor:

$$W_s = \hat{A}_i \partial F_i(N_{is}, N_{iu}, K_i) / \partial N_{is}, \quad i = 1, 2, \tag{2}$$

$$W_u = \hat{A}_i \partial F_i(N_{is}, N_{iu}, K_i) / \partial N_{iu}, \quad i = 1, 2, \tag{3}$$

where $\hat{A}_i = \lambda_i A_i$, and λ_i is the shadow price of output Y_i.

Assume that N_s^s and N_u^s are respectively the aggregate supplies of skilled and unskilled labor in the economy. By aggregating the economy's conditional demand for skilled and unskilled labor represented in equations (2)–(3), we can then solve for the equilibrium wage rates of skilled labor and unskilled labor as follows:

$$W_s = H_s(Y_1, Y_2, \hat{A}_1, \hat{A}_2, N_s^s, N_u^s), \tag{4}$$

$$W_u = H_u(Y_1, Y_2, \hat{A}_1, \hat{A}_2, N_s^s, N_u^s). \tag{5}$$

The equilibrium relative wage can then be written as:

$$W_s / W_u = H(Y_1, Y_2, \hat{A}_1, \hat{A}_2, N_s^s, N_u^s). \tag{6}$$

This equation says that the equilibrium relative wage between skilled and unskilled workers is determined by the relative supply of labor (N_s^s/N_u^s), the relative demand for labor represented both by the relative demand for skilled-intensive output (Y_1/Y_2) and by the relative technology level of skilled-labor intensive sector ($\hat{A}_1/\hat{A}_2$).

Equation (6) is the one that will be estimated and tested using data for Taiwan. To do that, we follow conventional wisdom by employing a linear functional form in the regressions; see, for example, Katz and Murphy (1992), Mincer (1993), and Kim and

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Topel (1995). The relative wage is used as the dependent variable whereas the relative quantities are used as the independent variables. The empirical equation is:

$$W_s/W_u = \beta_0 + \beta_1 N_s^s/N_u^s + \beta_2 \hat{A}_1/\hat{A}_2 + \beta_3 Y_1/Y_2 + \varepsilon, \tag{7}$$

where an error term ε is added to capture factors that are not included in the set of independent variables. We assume that ε is normally distributed with zero mean and unit variance.

For the effects of independent variables in equation (7), it is obvious that, other things being equal, an increase in the relative supply of skilled labor (N_s^s/N_u^s) reduces the relative wage between skilled and unskilled labor, implying $\beta_1 < 0$. As for the relative technology ($\hat{A}_1/\hat{A}_2$), we would expect $\beta_2 > 0$. However, the available data usually cannot tell whether a technology improvement is toward skilled labor ($\hat{A}_1$) or toward unskilled labor ($\hat{A}_2$). As a consequence, when there is a technological improvement, it can be biased toward either skilled or unskilled labor (e.g., Johnson, 1997), thereby making the effect of technological improvement on the relative wage ambiguous. Finally, for the relative demand for output (Y_1/Y_2), an increase in the demand for skilled-labor-intensive products enlarges the wage of skilled workers relative to unskilled workers, whereas an increase in the demand for unskilled-labor-intensive products shrinks the relative wage of skilled labor. The demands for domestic products consist of domestic demands and net exports (net foreign demands). As domestic demands are relatively more stable, we use the change in the net exports of goods and services as a proxy for the change in the demand composition. To guarantee a stationary series, we use the change in net exports in GDP as a measure. It has been argued that, other things being equal, an increase in net exports significantly reduces the relative wage between skilled and unskilled workers, but some others have considered the effect to be small.

As emphasized earlier, Taiwan is a semi-developed economy. To separate the effect of net exports to developed countries from those to developing countries, we decompose the net exports into those with OECD countries and those with non-OECD countries and expect their effect to be different. Equation (7) is therefore modified to become:

$$W_s/W_u = \beta_0 + \beta_1 N_s^s/N_u^s + \beta_2 \hat{A}_1/\hat{A}_2 + \beta_{3O}(Y_1/Y_2)_O + \beta_{3NO}(Y_1/Y_2)_{NO} + \varepsilon_1, \tag{8}$$

where the subscripts O and NO indicate respectively OECD and non-OECD countries.

According to the traditional Heckscher–Ohlin model, net exports to OECD countries $(Y_1/Y_2)_O$ reduce W_s/W_u in a less-developed country, whereas net exports to non-OECD countries $(Y_1/Y_2)_{NO}$ increase W_s/W_u in a more developed country. Therefore, β_{3O} is expected to be negative whereas β_{3NO} is expected to be positive. On the other hand, international trade with developed economies may accompany the transfer of new technology to a less-developed country, as Lau and Wan (1991) have made clear. As a result, the transfer is faster when the trade is more liberalized. Moreover, Pissarides (1997) has observed that learning new technology requires skilled labor. Consequently, a larger international trade with OECD countries enlarges the demand for skilled labor. Under this situation, the coefficient β_{3O} is expected to be positive. If this happens, commodity produced and exported to developing countries then uses more unskilled labor; and as a result, a larger net export to developing countries leads

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to an increase in the relative wage of unskilled workers, making $\beta_{3NO} < 0$. The net effect of β_{3O} and β_{3NO} depends on whether the effect via comparative advantage or that via transfer of technology dominates.

As Taiwan's trade with and net exports to China have become very large since the mid-1980s, we further isolate the effect of China by breaking down the net exports to non-OECD countries into those with China and those with other non-OECD countries. Equation (8) now changes to:

$$W_s/W_u = \beta_0 + \beta_1 N_s^s/N_u^s + \beta_2 \hat{A}_1/\hat{A}_2 + \beta_{3O}(Y_1/Y_2)_O + \beta_{3C}(Y_1/Y_2)_C + \beta_{3ONO}(\hat{Y}_1/\hat{Y}_2)_{ONO} + \varepsilon_2, \quad (9)$$

where the subscripts C and ONO symbolize, respectively, China and other non-OECD countries. The signs of β_{3C} and β_{3ONO} are expected to be the same as β_{3NO}.

Our empirical model thus includes equations (7)–(9). The annual time-series data are used in estimation. As noted in section 2, wage dispersion between skilled and unskilled workers revealed an obvious declining trend in Taiwan in the mid-1980s. This trend may be related to the fact that Taiwan's economic structure underwent a structural change in 1987. The employment share of the manufacturing industry in Taiwan rose after the Second World War and the trend continued after the oil shocks, but from 1987 the share declined. On the other hand, the tertiary sector expanded rapidly after 1987, gaining some share from manufacturing. This structural change happened when Taiwan liberalized domestic financial and goods markets in 1986 and drastically relaxed foreign exchange control in 1987 (Lee and Tsai, 1988). As a result, the exchange rate of new Taiwan dollars (NT$) with the US dollar appreciated from NT$39.8 in December 1985 to NT$28.5 in early 1987 and continued to appreciate afterwards; consequently many entrepreneurs in manufacturing rushed to invest in other countries to avoid the rising labor costs in Taiwan. In light of this, we add into equations (7)–(9) a dummy variable (D_t) to capture the effect of a structure change variable on wage dispersion, specifying $D_t = 1$ for all $t > 1987$ and $D_t = 0$ otherwise.[7] A gain in the employment share of the tertiary sector relative to manufacturing has been seen as an increase in the relative demand for skilled laborers (e.g., Mincer, 1993, chapter 13). By including a variable of this kind we can examine whether the industrial structural change had an effect on wage dispersion in Taiwan.

4. Construction of Variables and Sources of Data

Several sources are employed to construct variables used in this study. The annual wage data come from the *Manpower Utilization Survey in Taiwan*, 1979–1998.[8] For a description of the *Survey*, see Chan et al. (1998). We use only wage data of full-time, year-round male workers who had no more than ten years of working experience.[9] The relative wage between skilled and unskilled workers is constructed in two ways: one is the relative wage between workers with a college degree or above and those with a senior high school degree (denoted as W_c/W_s), and the other is the relative wage between laborers with a college degree or above and those with a mandatory education or below (denoted as W_c/W_m).

For the annual relative labor supply, data are not available for the three kinds of workers. There are nevertheless annual civilian population data at a 5-year cohort interval starting at 15 years old, sorted by educational attainment, published in

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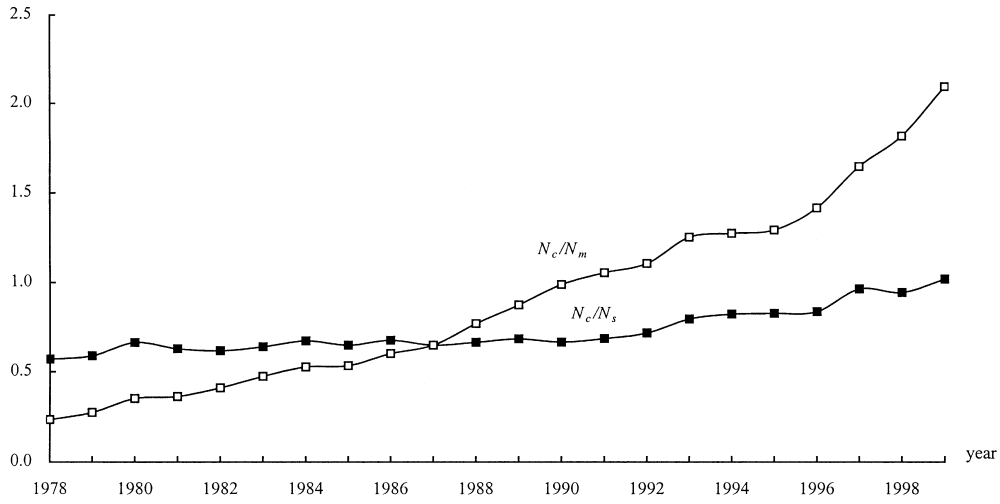

Source: *Monthly Bulletin of Man Power Statistics, Taiwan Area*

Figure 3. Relative Labor Supplies, 1978–99

the *Monthly Bulletin of Labor Statistics, Taiwan Area*, 1979–1998. The civilian population of working age is a potential labor force and thus may have influence on the wage rates. Although guest workers may affect the wage rates, they are not included because no data are available. We use the male civilian population having a college degree or above aged 25–34 to represent the male labor force with a college degree or above and with no more than ten years of working experience (denoted N_c); we use the male civilian population holding a senior high school degree aged 20–29 to represent the male labor force having a senior high school degree and with no more than ten years of working experience (denoted N_s); and we use the male civilian population obtaining a mandatory education degree or less aged 15–24 to represent the male labor force with no more than a mandatory education degree and no more than ten years of working experience (denoted N_m).[10] The time-series figures for N_c/N_s and N_c/N_m are illustrated in Figure 3. According to this, both the N_c/N_s and N_c/N_m loci had upward trends, but the N_c/N_m locus increased more rapidly due to the fact that most graduates of junior high school students enrolled in a senior high school.

It is obvious that the relative labor supply loci in Figure 3 are highly correlated with the loci of net exports to non-OECD countries as a fraction of GDP and of those to China as a fraction of GDP (i.e., NX_{NO}/GDP and NX_C/GDP loci) in Figure 2.[11] This could raise a problem of multicolinearity when both relative labor supply and net trade to non-OECD countries or to China as a fraction of GDP enter together in a regression. One way around this is to insert in a regression either one, but not both, of relative labor supply and net exports.[12] By doing so, however, we cannot control the relative demand-side effect of net exports when analyzing the relative supply-side effect, and vice versa, making the estimated coefficient inconsistent. In this work we thus insert both the relative labor supply and demand-side variables in a regression.

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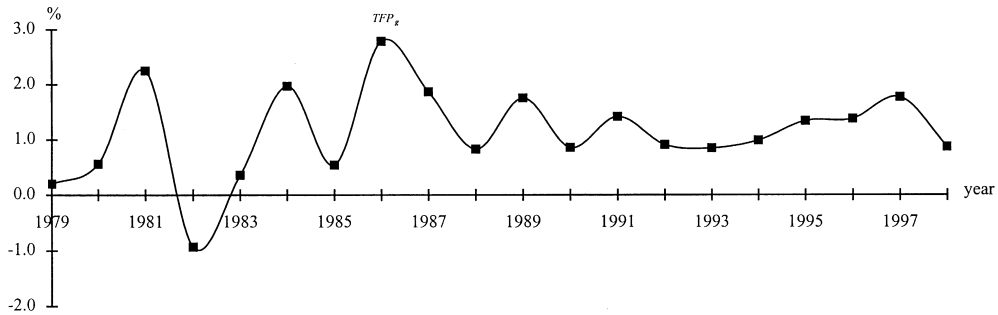

Sources: *The Trend in Multifactor Productivity Growth* (June, 1999, Table 10)

Figure 4. Total Factor Productivity Growth Rate, 1978–98

With regard to technology improvements, many measurements have been used in the literature. Examples include changes in the production process in particular industries (Mark, 1987), the rate of investment in computers (Krueger, 1993), the ratio of expenditure on R&D to sales (Berman et al., 1994), and the growth rate of total factor productivity (Lawrence and Slaughter, 1993). In this work we follow Chan et al. (1998) by employing the growth rate of total factor productivity as a measure of technology improvement (denoted as TFP_g). We use only the total factor productivity for the industrial and service sectors and do not include the agricultural sector.[13] The data come from *Trends in Multifactor Productivity* (1999) which are available starting from 1979 until 1998. Figure 4 shows the TFP_g series. According to the figure, the TFP_g series fluctuated before 1987, and it flattened out afterwards. The mean growth rate was 1.13%.

As for the measures of net exports, we construct total net exports to all foreign countries as a fraction of GDP (denoted as NX/GDP), total net exports to OECD countries as a fraction of GDP (NX_O/GDP), total net exports to all non-OECD countries as a fraction of GDP (NX_{NO}/GDP), net exports to China as a fraction of GDP (NX_C/GDP), and total net exports to all non-OECD countries except China as a fraction of GDP (NX_{ONO}/GDP). The data of exports to and imports from China, including indirect trade via Hong Kong, come from the *Monthly Economic Statistics of Two Sides of The Strait*, 1979–1999, collected by the Council of Mainland China Affairs, whereas data of all other exports and imports are from the *Monthly Statistics of Exports and Imports*, 1979–1998. The GDP data come from *Taiwan Statistical Data Book*.

For convenience, Table 1 summarizes the variables used in the regressions, their definitions, the sources of data, and the summary statistics of variables. According to the summary statistics, the relative wage of a worker with a college degree or above was on average 1.32 times higher than that of a worker with a senior high school degree, and was 1.49 times higher than that of a worker with a mandatory education degree in the period under our study. The labor supply of workers having a college degree or above is on average 72% the number of workers holding a senior high school degree and 89% that of workers obtaining a mandatory education degree. The net exports are on average positive with OECD and non-OECD countries.

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Table 1. Definitions, Sources, and Summary Statistics

Variable	*Definition*	*Source*	*Mean*	*SD*
W_c/W_s	Relative wage between workers with a college degree or above and those with a senior high school degree, no more than 10 years of working experience	*Man Power Utilization Survey in Taiwan* (each year)	1.3236	0.0552
W_c/W_m	Relative wage between workers with a college degree or above and those with a mandatory education or below (i.e., less than or equal to 9 years of education), no more than 10 years of working experience	*Man Power Utilization Survey in Taiwan* (each year)	1.4858	0.1246
D_t	1 if $t > 1987$ and 0 otherwise	By construction	0.5500	0.5104
N_c/N_s	Ratio of the number of male civilian population with a college degree or above aged 25–34 and the number of male civilian population with a senior high school degree aged 20–29 (foreign workers not included)	*Monthly Bulletin of Man Power Statistics, Taiwan Area* (various years)	0.7181	0.1068
N_c/N_m	Ratio of the number of male civilian population with a college degree or above aged 25–34 and the number of male civilian population with a mandatory education (foreign workers not included)	*Monthly Bulletin of Man Power Statistics, Taiwan Area* (various years)	0.8856	0.4598
TFP_g	Growth rate of total factor productivity in industrial and service sectors	*Trends in Multifactor Productivity* (1999)	1.1295	0.8275
NX/GDP	Ratio of total net exports to GDP	*Monthly Statistics of Exports and Imports*, and *Taiwan Statistical Data Book* (various years)	0.0745	0.0586
NX_O/GDP	Ratio of total net exports to OECD countries to GDP	*Monthly Statistics of Exports and Imports*, and *Taiwan Statistical Data Book* (various years)	0.0313	0.0709
NX_{NO}/GDP	Ratio of total net exports to non-OECD countries to GDP	*Monthly Statistics of Exports and Imports*, and *Taiwan Statistical Data Book* (various years)	0.0432	0.0287
NX_{ONO}/GDP	Ratio of total net exports to other non-OECD countries except China to GDP	*Monthly Statistics of Exports and Imports*, and *Taiwan Statistical Data Book* (various years)	0.0275	0.0194
NX_C/GDP	Ratio of net exports to China to GDP	*Monthly Economic Statistics of Two Sides of The Straits*, and *Taiwan Statistical Data Book* (various years)	0.0157	0.0110

Note: All data are annual time series, 1979–98.

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5. Empirical Results

We are ready to report the empirical estimations. The results are summarized in Table 2. Columns (1) and (2) in the table are based on model (7) in section 3. While the dependent variable for the former column is the relative wage between workers holding no less than a college degree and workers having a senior high school degree (W_c/W_s), the dependent variable for the latter column is the relative wage between workers holding no less than a college degree and workers obtaining no more than a mandatory education degree (W_c/W_m). While column (1) has explanatory power of only 37.07%, the explanatory power in column (2) is 85.87%, suggesting that the relative labor supply and demand factors under concern explain better the relative wage change between workers holding no less than a college degree and those obtaining no more than a mandatory degree. As the estimation coefficients show, the variable

Table 2. Empirical Results

Equation	*(1)*	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*
Dependent variables	W_c/W_s	W_c/W_m	W_c/W_s	W_c/W_m	W_c/W_s	W_c/W_m
Observation years	1979–98	1979–98	1979–98	1979–98	1979–98	1979–98
Constant	1.4793***	1.6818***	1.3559***	1.6415***	1.2591***	1.6425***
	(0.0924)	(0.0336)	(0.1065)	(0.0275)	(0.0833)	(0.0000)
D_t	–0.0202	–0.0462	0.0257	–0.0236	0.0767**	0.0037
	(0.0924)	(0.0415)	(0.0346)	(0.0316)	(0.0293)	(0.0223)
N_c/N_s	–0.2104$^{\triangle}$	—	–0.0041	—	0.1709	—
	(0.0024)		(0.1638)		(0.1307)	
N_c/N_m	—	–0.1965***	—	–0.0485	—	–0.0208
		(0.0456)		(0.0535)		(0.0445)
TFP_g	–0.0091	–0.0098	–0.0333	–0.0155	–0.0076	–0.0093
	(0.0142)	(0.0148)	(0.0132)	(0.0115)	(0.0099)	(0.0893)
NX/GDP	0.2252	0.1937	—	—	—	—
	(0.2246)	(0.2294)				
NX_O/GDP	—	—	0.4341*	0.4639**	0.3945**	0.3770**
			(0.2335)	(0.1873)	(0.1729)	(0.1549)
NX_{NO}/GDP	—	—	–0.9736$^{\#}$	–2.2414***	—	—
			(0.6563)	(0.7006)		
NX_{ONO}/GDP	—	—	—	—	–0.1505	–1.4032**
					(0.5791)	(0.6386)
NX_C/GDP	—	—	—	—	–6.9140***	–6.5732***
					(1.7404)	(1.6093)
Durbin-Watson d statistic	1.375	1.3120	1.7125	2.0802	2.1739	2.4583
Adj R^2	0.3707	0.8587	0.4668	0.9211	0.7087	0.9481

Note: Equations (1)–(2) are based on model (7), equations (3)–(4) are based on model (8), and the remaining equations are based on model (9). Standard deviations are in parentheses. ***, ** , *, $\triangle$ and # mean, respectively, statistical significance at the 1%, 5%, 10%, 15%, and 16% levels.

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capturing structural change (D_t) has a negative but statistically insignificant effect on relative wages in both columns. For other results in both columns, while the relative labor supplies of skilled workers (i.e., N_c/N_s and N_c/N_m) reduce the relative wage of skilled workers, only the relative supplies in column (2) are statistically significant at the l0% level. The technical progress proxied by the growth rate of TFP (i.e., TFP_g) does not statistically and significantly affect the relative wages. The estimated results of the technical progress differ from those found in Chan et al. (1998). Nevertheless, their effect of technical progress is the same as ours when only the workers in the industrial sector are used.[14] The total net exports in GDP increase both measures of the relative wage of skilled workers, but they are not statistically significant. The statistically insignificant effects of total net exports in GDP on the relative wages of skilled workers are due to the offsetting effects of net exports to developed countries and to developing countries, as documented below.

To distinguish the wage differential effects of net exports to developed counties from those of net exports to developing countries, we re-estimate the regressions by splitting the effects of total net exports into the effects of net exports to OECD countries and those to non-OECD countries. The estimated results are given in columns (3) and (4) of Table 2, where the dependent variable in columns (3)–(4) is W_c/W_s and W_c/W_m respectively. In these two columns, the effects of relative labor supplies remain negative as in columns, (1) and (2), albeit their estimated coefficients are statistically insignificant. This is probably due to the large correlation between these relative labor supplies and NX_{NO}/GDP. On the other hand, net exports to OECD countries as a fraction of GDP (NX_O/GDP) are found to statistically and significantly raise the two measures of relative wage of skilled workers. The fraction of net exports to non-OECD countries in GDP (NX_{NO}/GDP) are found to reduce the relative wage of skilled workers. While its effects are statistically significant at the 1% level in column (4), it is only weakly statistically significant in column (3). The effects of all other variables are about the same as those in columns (1) and (2).

As exports to China have been very important for Taiwan since the mid-1980s, we next break net exports to all non-OECD countries down into those with China and those with the remaining non-OECD countries. The empirical estimates are illustrated in columns (5)–(6) of Table 2. According to these two columns, both net exports to China and net exports to other non-OECD countries have statistically and significantly negative effects on the relative wage of skilled labor except the estimated coefficient of net exports to other non-OECD countries in equation (5). The effects of all other variables are about the same as in columns (3)–(4). Moreover, net exports to China have larger effects on the relative wage than net exports to OECD and to other non-OECD countries. Using the estimation results in column (6), we find that increasing the NX_O/GDP by its mean value raises the relative wage of skilled workers by 1.18 percentage points per year on average. Increasing the NX_{ONO}/GDP by its mean value reduces the relative wage of skilled workers by 3.86 percentage points per year on average. And increasing the NX_C/GDP by its mean value reduces the relative wage of skilled workers by 10.32 percentage points per year on average.[15] It is thus obvious that net exports to China had a much larger impact on the relative wages.

The estimated results, and in particular the large estimated mean impacts for those of net exports to China, indicate that international trade is an important variable in explaining wage dispersion, a result seemingly compatible with what has been claimed by Wood (1994) and Borjas and Ramaey (1994) and different from what was argued

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by Lawrence and Slaughter (1993) and Sachs and Shatz (1996). These results are nonetheless different from the prediction of the Heckscher–Ohlin model of comparative advantage, based on which the arguments by Wood (1994) and others were established. It is no doubt that Taiwan is less skilled-labor-intensive than OECD countries and more skilled-labor-intensive than non-OECD countries. Taiwan's net exports to OECD countries, however, are found *to increase rather than to decrease* the relative wage of skilled labor in Taiwan, whereas the net exports to non-OECD countries are found *to decrease* the relative wage of skilled labor in Taiwan.

Although the effects of international trade on wage dispersion in Taiwan differ from the prediction of the Heckscher–Ohlin model, we nevertheless think the result to be reasonable. Intuitively, exports to OECD countries are among the more complicated varieties of products that are produced in Taiwan. Taiwan's larger net exports to OECD countries thus represent a relatively higher demand for skilled labor. It has been argued that trade with more advanced countries serves to upgrade the technology sophistication level of a developing country through learning-by-doing, thus inducing demand for skilled labor (Chuang, 1998). In a modified North–South version of the Stolper–Samuelson model with a final good produced from a continuum of intermediate inputs which are in turn produced using skilled workers, unskilled workers, and capital, Feenstra and Hanson (1996) showed that, via the multinationals from the North, the South upgrades the range of intermediate inputs it produces and exports. Indeed, both Amsden (1977) and Van and Wan (1997) have found that competing in markets of advanced economies and the resulting technology transfer and accumulation of human capital is an important source in sustaining the Taiwan and East Asian tigers. As more skilled labor is employed in the sectors aiming at exporting to OECD countries, there is less skilled labor available to the sectors exporting mainly to developing countries. In fact, exports to China and other non-OECD countries are usually less sophisticated products, thereby demanding more unskilled labor.

Available data do not classify the compositions of Taiwan's exports to and imports from OECD and non-OECD countries, but there are data for selected countries. For the two major trade partners among advanced countries, the US and Japan, the skilled-labor-intensive products as a fraction of exports was 73.69% with the US and 62.35% with Japan in 1998, and the skilled-labor-intensive products as a fraction of imports was 65.97% with the US and 78.94% with Japan.[16] Among the items in exports and imports, machinery and electrical equipment predominated. In the same year, exports to the US of machinery and electrical equipment as a fraction of all exports to the US amounted to 58.74%, and to Japan, 46.42%. Imports of machinery and electrical equipment as a fraction of imports from the US amounted to 40.80%, and from Japan, 51.64%. For the largest trading partner among non-OECD countries (i.e., China), skilled-labor-intensive products amounted to 39% of exports and 9% of imports in 1998. More importantly, the fraction of machinery and equipment exported to China was less than 10% and no machinery and equipment was exported from China.[17]

Although the above data cover only three trading partners, they are the three largest trade partners of Taiwan, totally accounting for more than 50% of Taiwan's exports and more than 40% of Taiwan's imports. These data seem to suggest that Taiwan imported skilled-labor-intensive machinery and equipment from the technology frontier countries and used the imported machinery and equipment to produce skilled-labor-intensive products and to export mainly to advanced OECD countries. Therefore, the skill composition of exports and imports seems to be consistent with the

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learning models of Pissarides (1997) and Van and Wan (1997). This in turn supports the prediction of learning models regarding the change in relative wage of skilled workers in response to changes in international trade.

Some accounts have emphasized that the entry of large less-developed countries like China into the world market tends to reduce the relative wage of unskilled workers in more developed countries (e.g., Wood, 1995, 1997). Our results above do not point in this direction for Taiwan, but rather the effect of China's entry into the world market is found to increase the relative wage of unskilled workers in Taiwan. Indeed, the vast increase in net exports to China coincided with Taiwan's large foreign direct investment in China's coastal provinces.[18] Among Taiwan's foreign direct investment to China, most technology exported to China was less advanced, in a fashion following the product cycle theory *à la* Vernon (1966). The investment was mainly to make use of cheaper unskilled labor in China. Accompanied with foreign direct investment, these Taiwanese multinationals in China also imported less-advanced parts and intermediates from Taiwan in order for their plants in China to produce output either for sales in China or for exporting to other economies. Net exports to China thus increased as both Taiwanese and Chinese economies were more integrated. The effect of this market integration raised the relative wage of unskilled labor in Taiwan, as is clearly shown in our empirical results.

By employing net exports to estimate equations in Table 2, we implicitly impose the conditions that exports and imports affect the skilled and unskilled workers either in an opposite direction or in the same direction and the effects of exports dominate those of the imports. We have also estimated and tested to see the effects of exports and imports separately.[19] As the estimated results turn out (not reported here), the effects of exports to OECD countries are positive and the effects of imports from OECD countries have negative signs, and only the estimated coefficients of exports are statistically significant. Exports and imports with non-OECD countries have opposite and negative effects, respectively, but they are statistically significant only for the relative wage between workers holding no less than a college degree and those obtaining no more than a mandatory degree. By decomposing the group of non-OECD countries into China and other non-OECD countries, similar results hold for other non-OECD countries. The exports to China are found to bring down the relative wage of skilled workers significantly, while the imports from China have a statistically insignificant effect. As in Table 2, the effects of exports to China are large compared with exports to and imports from other countries. Overall, these results are consistent with the predictions based on net exports.

6. Concluding Remarks

Although Taiwan's exports to less-developed countries benefit unskilled workers and thus make the income distribution more equal, it is necessary to note a side-effect. In the process of economic development, Taiwan has emphasized upgrading its technological sophistication level to maintain its economic growth. As the developed world has comparative advantages in conducting innovation, it is reasonable for Taiwan to learn and adopt more complicated technology from the advanced world. Trade with developed countries seems to have served as a conduit of this purpose very well in the past, as shown by Amsden (1977) and Van and Wan (1997). It is essential for firms in Taiwan to produce products with satisfactory quality to service the

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advanced markets, and there are therefore pressures and incentives to upgrade the technology. This pressure does not appear in trade with less-developed countries. A decrease in trade with advanced countries and a rise in trade with less-developed countries seems to diminish the incentives to adopt technology, although it enhances income distribution.

We must point out some limitations and possible extensions of this paper. First, the data are for only 20 years, and that may be too short. Second, our work is restricted to male workers with no more than ten years of working experience. The wage effects of international trade to more experienced workers may be different, especially so for workers with a college degree or above. Since the mid-1980s, the developed world has seen much technological progress and many innovations. People with a higher education have a greater ability to learn about new technology, and therefore their wage relative to unskilled workers may not decline. This points to an avenue for further research.

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Notes

1. See, for example, Topel (1997) for factors involved in the relative supply of skilled and less-skilled workers; and Johnson (1997) for those included in the shifts in the relative demand favoring skilled workers.
2. Studies of other middle-income developing economies include those of Chile (Robbins, 1994) and of Mexico (Hanson and Harrison, 1995). In contrast to Korea and Taiwan, these two economies faced a rise in wage inequality after the mid-1980s. See Wood (1997) for a comparison of wage inequality trends between some countries in Latin America and some in East Asia.
3. See, for example, Benabou (1994) and Galor and Tsiddon (1997).
4. See, for example, Leamer (1984) and Wood (1994) for details of the Heckscher–Ohlin theory.
5. Taiwan's net exports to China increased from 0.38% of GDP in 1980, to 0.92% in 1987, and over 3% in 1994/95.
6. The college degree or above includes two-year junior colleges and their equivalents, meaning completing at least 14 years of education. A senior high school degree means completing 12 or 13 years of education and thus includes vocational schools. Those completing less than 12 years of education are classified as a mandatory education degree. For more detailed description of Taiwan's education and its contribution to economic growth, see Tallman and Wang (1994).
7. Although the estimated coefficient of the structural change variable is statistically insignificant as will be seen in Table 2 below, we found low explanatory power of regressions when omitting the structural change dummy, indicating that the inclusion of a structural change variable is necessary.
8. The time period used in regressions was chosen so as to be compatible with the growth rate of total factor productivity, to be discussed later, which is available from 1979 to 1998.
9. Those who worked in the agricultural sector or who were employed by the government are excluded from the samples.
10. Starting ages 15, 20, and 25 are used respectively for workers with a mandatory education, with a senior high school degree, or with a college degree, for the following reasons. The age 15 is the minimum working age in Taiwan. Senior high school students usually graduate at the age of 18, whereas college students graduate at 22. Two years of military service are required of males who are graduated and no longer in school. The available data are compiled at a 5-year cohort interval starting from the age 15.
11. The correlation coefficient between N_c/N_s and NX_{NO}/GDP is 0.914 and between N_c/N_s and NX_C/GDP is 0.912, while the correlation coefficient between N_c/N_m and NX_{NO}/GDP is 0.783 and between N_c/N_m and NX_C/GDP is 0.827.
12. This method was used by Kim and Topel (1995) for Korea, and by Chan et al. (1998) for Taiwan.
13. We exclude the total factor productivity of the agricultural sector because the male workers we chose from the data did not include those working in the agricultural sector.

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14. By restricting to 6–10 years of working experience, using as a dependent variable the relative wage between workers with a college degree or above and workers with a junior high school degree, and employing the growth rate of total factor productivity as a measure of technical progress, Chan et al. (1998) found that technical progress raises the relative wage of skilled workers in Taiwan. In their regressions, however, only the labor supply is controlled when analyzing the effect of technical progress. They conducted regressions for the entire economy, the industrial sector, and the tertiary sector.
15. The mean values of NX_O/GDP, NX_{ONO}/GDP and NX_C/GDP are 3.13%, 2.75%, and 1.57%, respectively, as listed in Table 1.
16. In the calculation, we classify machinery and electrical equipment, chemicals, transportation equipment, and basic metals and articles thereof as skilled-intensive products. The source is the *Taiwan Statistical Dada Book* (1999).
17. The source is the *Monthly Economic Statistics of Two Sides of the Strait* (January, 1999).
18. Taiwan's outward foreign direct investment (FDI) surged starting in the late 1980s as a response to rising labor costs and the loss of the GSP privileges of the US. China is the largest destination of FDI, followed by the US. Although data of Taiwan's FDI to China is not available prior to 1990, the available data show that Taiwan's accumulated FDI to China accounted for 44% of total accumulated outward FDI from 1991 to 1995 (Investment Commission, 1997, December, Tables 2 and 2A).
19. Karoly and Klemar (1994) and Borjas and Ramaey (1995) have argued different effects of exports and imports on the relative wage.

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