

ISSN 0819-2642
ISBN 0 7340 2508 4



THE UNIVERSITY OF
MELBOURNE

THE UNIVERSITY OF MELBOURNE
DEPARTMENT OF ECONOMICS

RESEARCH PAPER NUMBER 853

AUGUST 2002

**ARE FOREIGN WORKERS
RESPONSIBLE FOR THE
INCREASING UNEMPLOYMENT
RATE IN TAIWAN?**

by

Hsiao-chuan Chang

Department of Economics
The University of Melbourne
Melbourne Victoria 3010
Australia.

Are Foreign Workers Responsible for the Increasing Unemployment Rate in Taiwan?

Hsiao-chuan Chang^{*}

Department of Economics
The University of Melbourne

Phone: 61-3-83445364

Fax: 61-3-83446899

Email: changh@unimelb.edu.au

^{*} This research is supported by the Faculty Research Grant of the Faculty of Economics and Commerce, University of Melbourne. I would like to thank Robert Dixon and Jeff Borland for their constructive comments.

Are Foreign Workers Responsible for the Increasing Unemployment Rate in Taiwan?

Abstract

This paper investigates the current important issue in Taiwan that the impact of foreign workers on the rising unemployment by a dynamic intertemporal general equilibrium model.

The results show that the introduction of foreign workers plays a complementary role and reduces unemployment rate at the early stage, defined as the first period after the shock. However, over time, the importation of foreign workers robs jobs from local unskilled labor and lifts the unemployment rate. In contrast to existing literature, this paper supports the view that immigration increases the unemployment rate for nationals in the long run.

An appropriate policy regarding foreign workers for a small open economy like Taiwan needs to consider the state of the global economy. By considering the current ambiguity of world economic recovery and the high unemployment rate, a cautious policy for the Council of Labor Affairs to adopt is to maintain the current level of imported foreign workers.

JEL classification: C61; C68; D91; J21; J61; J68

1. Introduction

In line with the recent world recession, Taiwan's unemployment rate jumped from 2.99% in year 2000 to 4.57% in 2001. In comparison with other countries, this figure may not be compelling. However, compared to its own historical record, during the past four decades, Taiwan's unemployment rates were stable staying below 3% and for most years, below 2%. This new record in Taiwanese history over half a century has caused panic in the public psyche creating an outcry aimed at saving jobs.

A direct target of blame for job losses is the importation of foreign workers. Taiwan legalized the importation of foreign workers in October 1989. The two main reasons for the Taiwanese government taking this step were: first, there was a shortage of native unskilled labor. This situation impeded the continuation of the national Fourteen Major Construction Projects and the Six-year National Development Plan. Second, the unskilled wage had increased high enough to drive firms to look for cheaper workers overseas. This accelerated Taiwan's outward foreign direct investment and drained capital out of the country. The importation of foreign workers was aimed at resolving these problems, impelling the Taiwanese economy to move forward. In 1991, foreign workers were directly recruited to the government's major construction projects. Since 1992, there has been a gradual opening to allow an increasing number of industries to hire foreign workers. This shows that a high local unskilled wage dominates the increasing importation of foreign workers thereafter. One decade has elapsed since the first entry of foreign workers and a range of problems related to foreign workers, not only economic

but also social, have emerged and have become very important public policy issues in Taiwan. In particular, during this time of a high unemployment rate, a popular perception is that foreign workers rob jobs from native workers.

The impression of foreign workers being job robbers is also popular in other countries, especially those countries accommodating a significant number of immigrants. A large body of literature investigating the effect of immigration on native workers has been undertaken by U.S., Canada and Australian studies. Most of the findings suggest that immigration is not a cause of unemployment, or even that it reduces the rate of unemployment (Withers & Pope 1993, Tian & Shan 1999, Lalonde & Topel 1991, Altonji & Card 1991, Borjas 1994, Friedberg & Hunt 1995). However, Lee (1992) finds evidence of immigration contributing to the high unemployment rate in Canada. All existing research in this area is based on empirical studies in which the analysis is conducted by using cross-section or time series data.

Immigrants in Taiwan used to be a minor issue, therefore to date it has been given inadequate attention. Because the importation of foreign workers is continuous, this has the same effect as accepting immigrants into the Taiwanese labour market. By taking the suggestion in Borjas (1994) into account that we do not "understand the dynamic process through which natives respond to these supply shocks and reestablish labor market equilibrium", this paper takes the first step towards using a novel approach, dynamic

intertemporal general equilibrium modeling¹, to investigate the effect of foreign workers on Taiwan's unemployment. A relatively comprehensive dynamic framework is constructed, in which both short- and long-run transitions of the unemployment rate followed by foreign workers' shocks are disclosed. By calibrating this theoretical model with Taiwanese data, the simulation results provide empirical implications and can be compared to existing literature from studies in other countries.

Section 2 provides the theoretical framework of the model, section 3 presents the calibration of the model, section 4 shows the simulation results in comparison with the reality, section 5 reveals the policy implications and section 6 summarizes the conclusions.

2. The Model

A model with one-good, two types of labor (skilled and unskilled) and three agents (firms, households, and government) is established. The framework of this model is as follows. The whole economy is treated as one aggregate entity. Firms produce the good by hiring physical capital, skilled labor and unskilled labor, they then sell this good to the households for consumption, to the government for education capital investment and to themselves for physical capital investment. The objective of each firm is to maximize its intertemporal profit under constraints of capital accumulation and of investment with an adjustment cost. The ownership of firms belongs to households. Households supply

¹ The model follows the general approach of the G-Cubed model (McKibbin and Wilcoxon (1999)). The endogenized skill formation and education production mainly follow the model in Chang (1999) with the first-time application on the migration-employment issue of Taiwan studies.

unskilled labor to firms and skilled labor to both firms and the government in order to earn wages, together with the dividends from renting physical capital to firms, so as to finance the purchase of the good and education. Leisure is consumed by households with an opportunity cost of not working. Unemployment provides disutility in the households' utility function. In line with the existence of unemployment, the objective of the households is to maximize utility by an optimal distribution of consumption between the good and leisure under their budget and time constraints. It is assumed that time spent in schooling and expenditure on education are equally important for skill formation. The government buys the good from the firms and transforms it into education capital. This capital is combined with skilled labor hired by the government to produce education. The role of government as an education supplier is essential. This model captures the reality of government supplying education in consideration of the associated beneficial externalities. The government balances its budget by collecting labor income tax and selling education to households². The accumulation of physical capital, skill formation, education capital and financial assets drives the dynamic evolution of the economy over time.

By taking into account the reality in Taiwan, the role of foreign workers in this economy is characterized as follows. Foreign workers, categorized as unskilled labor, join in the production of the good with natives and are assumed to have the same productivity as native unskilled labor but receive a lower payment than do the natives³. In consideration

² To avoid unnecessary complexities, a subsidy rate on investment and a tax rate on financial dividends is assumed to be balanced out.

³ Foreign workers are protected under the Labor Standard Law in Taiwan and most are paid the regulated minimum wages. On average, foreign workers' wages are between 50% to 60% of natives'.

of the demand side of foreign workers, this model explicitly captures the foreign workers' consumption of goods⁴. By so doing, the domestic households' consumption in the utility function carries a fraction variable by which the proportion of domestic demand for goods is measured⁵. Foreign workers are assumed to pay the same tax rate as natives and not to join the activities in the financial markets.

Cobb-Douglas functional forms are used for goods production, skill formation, education production and utility function to assist in the simulation of this calibrated model. The model framework and the steady state are presented in Appendix 1.

3. Calibration of the Model

All data are from the official sources including the Directorate-General of Budget Accounting and Statistics (DGBAS), Ministry of Education (MOE), the Council of Labor Affairs (CLA) and the Council for Economic Planning and Development (CEPD). The monthly average wage data by education attainment is from the Manpower Utilization Survey, which is published by DGBAS. The real wage is the nominal wage deflated by the consumer price index (CPI) measured with 1991 as the base year. Following the convention in the literature, workers who have a degree of college or above are designated as skilled labor and the rest are unskilled labor. To manipulate the raw data,

⁴ Foreign workers in Taiwan have no consumption on education.

⁵ This fraction variable is defined as the total wage-weighted domestic labor force divided by the total wage-weighted labor force including the foreign workers in the economy. The weights state higher wage groups consume more goods. Before the entry of foreign workers, the fraction variable is equal to one. In each period, the numbers of domestic skilled and unskilled labor are endogenized, hence, this fraction variable is also endogenized.

which includes several categories in the group of unskilled labor⁶, the weighted average monthly wage is applied with the weights as the population proportion of each category in the group.

Since the restriction on the importation of foreign workers in Taiwan was lifted from October 1989 and the official data of numbers of foreign workers commenced in 1991, the base year for the calibration is 1990⁷. The only exception is the shares of skilled labor and unskilled labor in the production function which are estimated by running ordinary least square (OLS) on related data from 1978 to 2000. A detailed calibration is listed in Appendix 2.

4. Simulation Results and Reality

Foreign workers are allowed to stay in Taiwan for a maximum period of two years. A one-year extension is available only once. An additional six-month extension might be granted under special circumstances for foreign workers engaged in major construction projects. For each foreign worker, the stay in Taiwan is temporary. However, from the standpoint of the Taiwanese economy, to continue recruiting new foreign workers is tantamount to a permanent stay of foreign workers.

⁶ They are illiterate, self-educated, primary school, junior high (including junior vocational) school, senior high school, vocational school, and junior college.

⁷ Foreign workers were numbered much less before 1992 than after and before 1992 all of them were working for the government major construction projects.

The simulation is undertaken in the following way. At year t , there is no information of the imported quantity of foreign workers at $t+1$ and after. Therefore, the movement of the whole economy, including the transitions of the unemployment rate, depends on the effect from the current and past quantities of foreign workers, i.e. the shock for year t includes the quantities of foreign workers up to year t and remains the same as year t hereafter. A transitional path of the rate of unemployment captures the actual path to a fair extent (shown as Figure 1). This provides a good tool to forecast the unemployment rate attributed to foreign workers. Policies such as an increasing or decreasing growth rate of the importation of foreign workers can be tested and these policy implications are presented in the next section.

Figure 1. Unemployment Rate (Unit: Percentage Point)

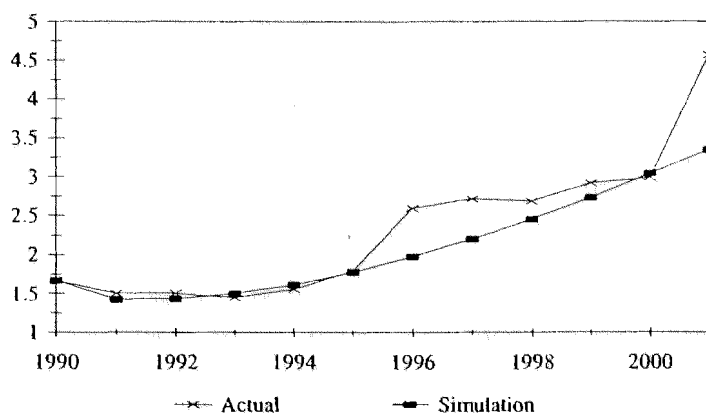


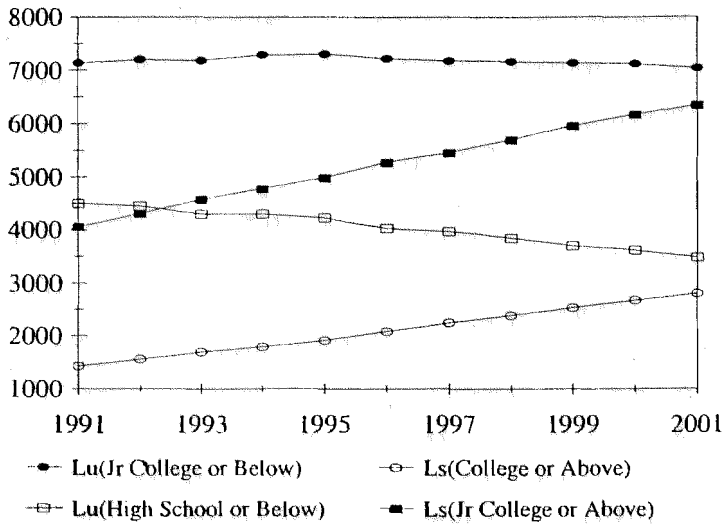
Figure 1 shows that prior to 1996 and at the year of 2000 the simulation path closely follows the actual path. In 1991, the simulated rate of unemployment dropped as did the actual rate, then follows an increasing path hereafter. In line with this, the simulation result also reveals that the native unskilled labor is increased in 1991 and is decreasing

over time afterwards. This provides a moderate support for a popular opinion that the foreign workers are the complementary inputs at the early stage and have become substitute inputs recently. From 1996 to 1999, the simulated unemployment rate falls below the actual rate and follows a smooth increasing path. The smooth transition can be explained by the fact that during this period the actual amount of imported foreign workers stays at a stable annual growth rate ranged from 1 to 1.25 times. In 2001, the amount of imported foreign workers drops to 0.93 percent of the amount in 2000. This opposite change of the shock to its ten-year pattern slightly slows down the increased rate of unemployment. The intuition for picturing the overall simulated transition of unemployment rate by giving a shock of importing foreign workers is as follows. In 1991, importing a minor number of foreign workers directly hired by the government's construction projects brought an output expansion and an increased demand for native workers. This drives down the unemployment rate for natives. Since 1992, foreign workers are allowed to work in other industries and more foreign workers (*ceteris paribus*) means dismissal of native unskilled labor. The pressure motivates the native unskilled labor to upgrade their skills via investment in schooling and drives all natives to work harder by reducing leisure. The change of pattern by reducing the number of imported foreign workers in 2001 alleviates the annual growth rate of unemployment. This is consistent with that over time foreign workers has become a substitute to natives, a reduction of them has a positive effect on moderating the growing unemployment rate. This result substantiates that a high unskilled wage, discussed earlier, predominates over the argument of the shortage of unskilled labor for the afterward importation of foreign workers. The popular opinion overstates the "laziness" of the Taiwanese for refusing to

undertake certain type of jobs. One thing that should be born in mind is that the amount of foreign workers only occupied by a small percentage of the Taiwan's labor force; it rose from 0.03% in 1991 to 3.34% in 2000 and dropped to 3.1% in 2001. Therefore, the simulation results can only provide a partial explanation of the effects on the actual unemployment rate. The gap between the simulated and the actual path, especially from 1996 to 1999 and at year 2001, should be filled in by other factors which are beyond the scope of this research.

To substantiate the simulation result with a continuing importation of foreign workers there is a decreasing supply for the native unskilled labor and an increasing supply for the native skilled labor after 1991, Figure 2 shows the actual labor supply during 1991-2001. The education system in Taiwan is slightly different from other countries. There is a category called "junior college". Students spend two, three, or five years to get a degree which is in a lower rank than a four-year college degree. The subjects offered in junior colleges are similar to those offered in colleges. Therefore, in Figure 2, the labor force is split based on two cases: first, take the conventional definition of college or above as the skilled labor and the rest as the unskilled labor; second, the junior college or above as the skilled labor and the rest as the unskilled labor.

Figure 2. Labor Force in Taiwan (Unit: Thousand People)



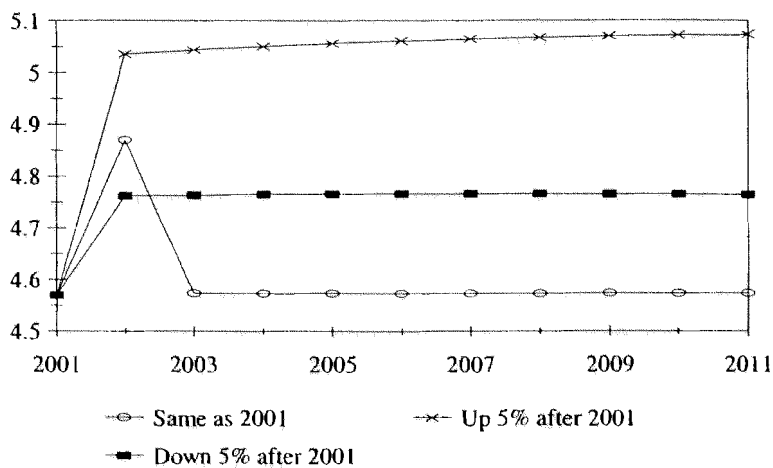
In terms of the first case, the native skilled labor did increase the supply since importation of foreign workers. However, the native unskilled labor showed a stable trend. Over the whole period, in 2001, the supply of unskilled labor had a minor reduction compared to that in 1990. The second case firmly substantiates the theoretical simulation that the native skilled labor and unskilled labor respectively increases and decreases the supply. This further confirms that foreign workers are the competitors, even job robbers, for the jobs used to be undertaken by graduates with a degree of high school or below.

5. Policy Implications

Recent disputes over the negative impact of foreign workers on unemployment have led the Taiwanese Government to reduce the number of foreign workers in 2001. Meanwhile, local employers argue that foreign workers are engaged in jobs in which natives show little interest, therefore, they demand more cheap foreign workers. Simulations with the

same level as 2001, an ascending 5% and a descending 5% of numbers of foreign workers after 2001 for a period of ten years have been conducted to provide policy suggestions to the Council of Labor Affairs. The forecast of unemployment rates from different policies of importing foreign workers are shown in Figure 3. An ascending number of foreign workers by 5% per annum causes a jump in the unemployment rate in the first period and keeps growing over time. This suggests that, at the current time with a high unemployment rate, the Council of Labor Affairs should consider imposing a non-increasing number of foreign workers' policy to prevent a further escalation of the unemployment rate.

Figure 3. Policy Implications: Forecast of Unemployment Rate in Taiwan



A policy of decreasing by 5% the number of imported foreign workers also increases the unemployment rate in the short run and stays the reached level afterwards. If the amount of foreign workers stays at the same level as 2001, the unemployment rate jumps in 2002 with the size between the magnitude of the previous two cases, then drops back and maintains a level close to that at 2001. Basically, the above three cases support the

argument that fewer foreign workers result in fewer job losses in the near future. Over time, after the economy has adjusted to accommodate more foreign workers, the rate of unemployment grows to a fairly small extent for policies of 5% ascending or of 5% descending number of foreign workers. The policy of the same number foreign workers as 2001 accomplishes the lowest unemployment rate among the three cases. An interesting point is that a policy of descending number of foreign workers has a higher unemployment rate in the lasting future than a policy of foreign workers same as 2001. It could be that foreign workers have pushed the economy into a positive growth path and with an increasing goods production more job opportunities can be created. The effect of foreign workers on local employment could be different during an economic downturn. During a recession, the drop of world demand highlights the importance of a low cost competitiveness. Foreign workers in Taiwan provide a possible reduction in the production costs and, over the past one decade, Taiwanese manufacturing and construction sectors have come to rely on the supply of foreign workers to some extent. Therefore, intuitively, foreign workers should be the impetus to upgrade the competitiveness of goods made in Taiwan and should be the source to sustain economic growth during a recession. A reduction in the importation of foreign workers may create an adverse effect on the Taiwanese economy and literally causes an increased unemployment of the native skilled labor if firms fail to survive. Although the simulation result substantiates the argument that foreign workers take jobs from native unskilled labor, the current jump in the unemployment rate in line with the world recession seems to go beyond that which can be explained by job robbing because an actual reduction of foreign workers occurred in 2001. This sheds light on an appropriate policy on foreign

workers for a small open economy like Taiwan needs to consider the state of the global economy. During a recession, in order to avoid a second wave of job losses from shutting down firms by keeping production costs low, importing a stable non-decreased number of foreign workers may be an alternative in the issue of unemployment.

To sum up, by considering the ambiguity of world economic recovery and the current high unemployment rate in Taiwan, a contemporary policy for the Council of Labor Affairs to adopt might be keeping the current imported level of foreign workers.

6. Conclusion

This paper investigates a current and very important issue in Taiwan, the impact of foreign workers on the rising unemployment. A dynamic intertemporal general equilibrium model is constructed and calibrated by Taiwanese data to deliver simulations and policy implications.

The results show that, in 1991, foreign workers who were only allowed to work for the government's projects brought an increased hiring of the native workers in goods production and reduce the unemployment rate in Taiwan. After 1991, foreign workers were allowed to work for other industries and have robbed jobs from natives. This suggests that, for the case of Taiwan, foreign workers are complementary inputs at the early stage and substitute inputs afterwards. In contrast to existing literature, this paper

supports the view that immigration increases the unemployment rate in the long run, but not necessarily true in the short run.

Three tests including an ascending, a descending and a zero growth rate of quantity of foreign workers after 2001 were conducted to investigate the variations of unemployment rate in order to provide policy suggestions for the Council of Labor Affairs. The results support the argument that foreign workers have a positive relationship with the unemployment rate in the near future, i.e. less foreign workers, less job losses. However, over time, after the economy has adjusted to accommodate more foreign workers, a policy of decreasing foreign workers is not necessary to reach a possible lowest rate of unemployment. Keeping the rate as same as the current level leads to the lowest unemployment rate for the future. The reason is as follows. At the stage of a sluggish Taiwanese and global economy such as the situation in 2001, the cheap foreign workers may be important to firms to maintain their competitiveness and to sustain the level of employment. The result suggests that an appropriate policy on foreign workers for a small open economy like Taiwan needs to consider the economic tendency of the world. By considering the current ambiguity of world economic recovery and the high unemployment rate, a cautious policy for the Council of Labor Affairs to adopt is to keep the current imported level of foreign workers.

Reference

Addison, Thomas. and Worswick, Christopher. 2002. "The Impact of Immigration on the Earnings of Natives: Evidence from Australian Micro Data" *Economic Record*, Forthcoming in March 2002.

Altonji, Joseph G. and Card, David. 1991. "The Effect of Immigration on the Labor Market Outcomes of Less-skilled Natives" *Immigration, Trade, and the Labor Market*. Edited by John M. Abowd and Richard B. Freeman. The University of Chicago Press.

Borjas, George J. 1994. "The Economics of Immigration" *Journal of Economic Literature*, Vol 32 (December), pp. 1667-1717.

Butcher, Kristin. and Card, David. 1991. "Immigration and Wages: Evidence from the 1980's" *American Economic Review* 81 (2), pp. 292-96.

Chang, H-C. 1999. "Wage Differential, Trade, Productivity Growth and Education" *Working Papers in Trade and Development*, No. 2000/1, The Australian National University.

Friedberg, Rachel M. and Hunt, Jennifer. 1995. "The Impact of Immigrants on Host Country wages, Employment and Growth" *Journal of Economic Perspectives*, Vol. 9, No. 2, pp. 23-44.

Heckman, James J, Lochner, Lance. And Taber, Christopher. 1998. "Explaining Rising Wage Inequality: Explorations with a Dynamic General Equilibrium Model of Labor Earnings with Heterogeneous Agents" NBER Working Paper No. 6384.

LaLonde, Robert J. and Topel, Robert H. 1991. "Labor Market Adjustments to Increased Immigration" *Immigration, Trade, and the Labor Market*. Edited by John M. Abowd and Richard B. Freeman. The University of Chicago Press.

Lee, Hahn Shik. 1992. "Maximum likelihood inference on cointegration and seasonal cointegration" *Journal of Econometrics*, Vol.54, pp.1-47.

McKibbin, Warwick J. and Wilcoxon, Peter J. 1999. "The Theoretical and Empirical Structure of the G-Cubed Model" *Economic Modelling*, 16, pp.123-48.

Pope, David. and Withers, Glenn. 1993. "Do Migrants Rob Jobs? Lessons of Australian History, 1861-1991" *Journal of Economic History*, Vol. 53, No. 4, pp.719-42.

Tian, Gary Gang. and Shan, Jordan. 1999. "Do Migrants Rob Jobs? New Evidence from Australia" *Australian Economic History Review*, Vol. 39, No. 2, pp.133-42.

Appendix 1

The Model

Firms:

$$\text{Max. } \int_0^{\infty} [Q_t - W_{s,t} \cdot L_{s,t}^F - W_{u,t} \cdot L_{u,t} - \eta \cdot W_{u,t} \cdot L_{m,t} - I_t] \cdot e^{-rt} \cdot dt$$

Subject to

$$(1) \quad \frac{dK}{dt} = J_t - \delta \cdot K_t,$$

$$(2) \quad I_t = J_t \cdot \left[1 + \frac{\Phi}{2} \cdot \frac{J_t}{K_t}\right],$$

$$(3) \quad Q_t = L_{s,t}^{F\alpha} \cdot (L_{u,t} + L_{m,t})^\beta \cdot K_t^{1-\alpha-\beta},$$

Households:

$$\text{Max. } \int_0^{\infty} U(C_t, l_t, N_t) \cdot e^{-\theta t} \cdot dt$$

Subject to

$$(4) \quad \frac{dF}{dt} = r \cdot F_t + (1 - \tau) \cdot (W_{s,t} \cdot L_{s,t} + W_{u,t} \cdot L_{u,t}) - V_t \cdot C_t - P_{E,t} \cdot S_{E,t},$$

$$(5) \quad \frac{dL_s}{dt} = J_{s,t} - \delta_s \cdot L_{s,t},$$

$$(6) \quad J_{s,t} = f(H_t, P_E \cdot S_E) = H^\Omega \cdot (P_E \cdot S_E)^{1-\Omega},$$

$$(7) \quad l_t = T - L_{s,t} - L_{u,t} - N_t - H_t,$$

$$(8) \quad F_t = \lambda_t \cdot K_t,$$

$$(9) \quad U(C_t, l_t, N_t) = \left(\frac{l_t}{N_t}\right)^\gamma \cdot C_t^{1-\gamma},$$

Government:

$$(10) \quad S_{E,t} = f(K_{E,t}, L_{s,t}^G) = K_{E,t}^\xi \cdot L_{s,t}^{1-\xi},$$

$$(11) \quad \frac{dK_E}{dt} = I_{E,t}^G - \delta_E \cdot K_{E,t},$$

$$(12) \quad I_E^G + W_{s,t} \cdot L_{s,t}^G = \tau \cdot [W_{s,t} \cdot L_{s,t} + W_{u,t} \cdot (L_{u,t} + \eta \cdot L_m)] + P_{E,t} \cdot S_{E,t}.$$

Model in the Steady State

Equations

$$Q_t = L_{s,t}^{\alpha} \cdot (L_{u,t} + L_{m,t})^{\beta} \cdot K_t^{1-\alpha-\beta}$$

$$I_t = \delta \cdot K_t$$

$$Q_{L_s} = W_s / P$$

$$Q_{L_u} = W_u / P$$

$$\lambda = 1 + \phi \cdot \delta$$

$$Q_K = (r + \delta) \cdot \lambda - \phi \cdot \delta^2 / 2$$

$$0 = r \cdot F_t + (1 - \tau) \cdot (W_{s,t} \cdot L_{s,t} + W_{u,t} \cdot L_{u,t}) - V_t \cdot C_t - P_{E,t} \cdot S_{E,t}$$

$$V = (W_s \cdot L_{s,t} + W_u \cdot L_{u,t}) / [W_s \cdot L_{s,t} + W_u \cdot (L_{u,t} + \eta \cdot L_m)]$$

$$J_{s,t} = \delta_s \cdot L_{s,t}$$

$$F_t = \lambda_t \cdot K_t$$

$$J_{s,t} = f(H_t, P_E \cdot S_E) = H^{\Omega} \cdot (P_E \cdot S_E)^{1-\Omega}$$

$$l_t = T - L_{s,t} - L_{u,t} - N_t - H_t$$

$$U_C = V \cdot \mu_1$$

$$U_{L_u} = -\mu_1 \cdot (1 - \tau) \cdot W_u$$

$$\mu_2 = \mu_1 \cdot \left(\frac{1}{1 - \Omega} \right) \cdot \left(\frac{J_s}{H} \right)^{\frac{\Omega}{1 - \Omega}}$$

$$r_t = \theta$$

$$U_{L_s} = (\theta + \delta_s) \cdot \mu_2 - \mu_1 \cdot (1 - \tau) \cdot W_s$$

$$L_{s,t} = L_{s,t}^G + L_{s,t}^F$$

$$S_{E,t} = K_{E,t}^{\xi} \cdot L_{s,t}^{1-\xi}$$

$$I_E^G = \delta_E \cdot K_E$$

$$I_E^G + W_{s,t} \cdot L_{s,t}^G = \tau \cdot [W_{s,t} \cdot L_{s,t} + W_{u,t} \cdot (L_{u,t} + \eta \cdot L_m)] + P_{E,t} \cdot S_{E,t}$$

$$Q_t = C_t + I_E^G + I_t$$

Notation:

Q: Production; L_s^F : Skilled labor hired by firms; L_s^G : Skilled labor hired by government;

L_s : Total skilled labor; L_u : Unskilled labor; L_m : Foreign Workers; K: Capital; l : Leisure;

J : Fixed capital formation; I : Capital investment; W_s : Skilled wage; W_u : Unskilled wage;
 P : Goods price (defined as 1); F : Financial asset; C : Consumption; N : Unemployment;
 S_E : Amount of education buying; J_s : Fixed skill formation; T : Time constraint;
 I_E : Household's education investment; U_Z : Marginal utility of Z ; P_E : Price of education;
 r : Interest rate; K_E : Education capital; τ : Tax rate; I_E^G : Government education investment;
 α, β : Input shares in goods production function; λ : Shadow price of capital;
 δ : Depreciation rate of capital; δ_s : Depreciation rate of skill; θ : Rate of time preference;
 μ_1 : shadow price of financial asset; μ_2 : shadow price of skill; H : Schooling;
 η : Wage proportion of foreign workers to local unskilled labor;
 ξ : Input share in education production function; Ω : the share in skill formation;
 δ_E : Depreciation rate of education capital;
 ϕ : Adjustment cost parameter of capital investment.

Appendix 2

$$\begin{aligned} T &= 8760; & \tau &= 0.201; & I_E^G &= 62; & \alpha &= 0.53; \\ \beta &= 0.26; & \delta &= 0.2; & \delta_s &= 0.09; & \delta_E &= 0.2; \\ \theta &= 0.0775; & \xi &= 0.3; & \gamma &= 0.56; & \eta &= 0.52; \\ \phi &= 0.1; & P_E &= 0.17; & \Omega &= 0.5; \end{aligned}$$

Note:

1. The shares of skilled labor (α) and unskilled labor (β) in the production function are estimated by running ordinary least square (OLS) using data from 1978-2000.
2. The depreciation rate of skill (δ_s) is estimated by using data of skilled labor of 1990 and of 1991 and graduates from university or above (J_s) in 1990.
3. The wage proportion of foreign workers to local unskilled labor (η) is estimated by the basic monthly wage (NT\$9750) as a proxy of foreign workers' wage divided by the average monthly unskilled wage (NT\$18699) in 1990.
4. The input share in education production function (ξ) is estimated by the government capital investment on education.
5. The unit of I_E^G is measured by NT\$billion.
6. The price of education (P_E) is an approximate estimation by using households' spending on education and recreation divided by households' spending on all others in 1990.
7. Interest Rate (θ) is the interest rate per annum for the bank's 3-month term deposit.
8. Tax rate τ is the tax burden in Table 9-9 of Taiwan Statistical Data Book 2001.
9. Time (T) is measured by the number of hours in one year.
10. Physical Capitals δ and δ_E are based on the 5-year depreciation time frame.
11. The share of leisure/unemployment (γ) is assumed slightly higher than the share of consumption goods ($1-\gamma$).
12. Spending of money to buy education and spending of time to study are assumed to be equally important for skill formation (Ω).

Data Source:

1. Directorate-General of Budget Accounting and Statistics, R.O.C.

2. Ministry of Education, R.O.C.
3. Taiwan Statistical Data Book 2001, Council for Economic Planning and Development R.O.C.
4. Statistical Yearbook of the Republic of China 2000.
5. Yearbook of Labor Statistics, Republic of China 1999.
6. Department of Statistics, the Council of Labor Affairs, R.O.C.

RESEARCH PAPER SERIES - RECENT PUBLICATIONS IN THE DEPARTMENT OF ECONOMICS

60

NO.	AUTHOR/S	TITLE	DATE	INTERNAT. WORKING PAPER NO.	ISBN NO.	TOTAL NO. OF PAGES
850	Bruce Phillips & William Griffiths	Female Earnings and Divorce Rates: Some Australian Evidence	July 2002	IWP 787	0 7340 2505 X	29
851	Robert Dixon	A Discussion of the Appropriate Method for Decomposing Changes Over Time in a Weighted Aggregate into its Proximate Determinants and an Application to Male Participation Rate Changes	July 2002	IWP 788	0 7340 2506 8	23
852	Jenny N. Lye & Joseph G. Hirschberg	Tests of Inference for Dummy Variables in Regressions with Logarithmic Transformed Dependent Variables	July 2002	IWP 789	0 7340 2507 6	16
853	Hsiao-chuan Chang	Are Foreign Workers Responsible for the Increasing Unemployment Rate in Taiwan?	August 2002	IWP 790	0 7340 2508 4	23
854	J. G. Hirschberg & D. J. Slottje	Bounding Estimates of Wage Discrimination	August 2002	IWP 791	0 7340 2509 2	24