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THE IMPACT OF IMMIGRATION ON THE WAGE DIFFERENTIAL IN AUSTRALIA

by

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The Impact of Immigration on the Wage Differential in Australia

Abstract

This paper investigates a significant current issue in Australia, the impact of immigration on the wage differential between skilled and unskilled labour, using simulation analysis from a dynamic intertemporal general equilibrium model.

The results show that immigration cannot explain variations of the wage differential in Australia during the past ten years. In most of the years investigated, immigration only explains a small part of the change in the wage differential. There is also no evidence that immigration exerts significant downward pressure on the unskilled wage.

A comparison of four policy options demonstrates that accepting an increased number of skilled immigrants per year at a certain rate will decrease the wage differential in both the short and long run. Cutting the number of skilled immigrants per year at a certain rate will increase the wage differential in the long run and decrease the wage differential in the short run. An effective policy to change the skilled-unskilled wage differential requires a mixture of a set of instruments aimed at other economic issues such as international trade, productivity growth and education.

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

The Impact of Immigration on the Wage Differential in Australia

1. Introduction

Australia has taken a significant number of immigrants throughout her current history. Since the Second World War, around 5.7 million people with permanent migration visas have arrived in Australia. Therefore, immigration is a central issue for policy makers. This issue is as much a political as an economic one. Of particular importance as a basis for policy is the economic impact of immigrants. Nowadays, with a focus on issues such as asylum seekers, studying the impact of immigrants on the skilled-unskilled wage differential is one aspect of the economic impact of immigration about which it is essential to have an understanding. This will provide a better understanding of the impact of immigrants on the earning inequality as well as resultant social instability in the country.

The issue of the impact of immigration on the wage differential between skilled and unskilled labour, which has attracted much attention in U.S. studies, has not been a focus for Australian studies. Related research which looks at the impact of immigration on the aggregate real wage or real wages in different industries/professions can be found in Foster and Withers (1992), Pope and Withers (1993) and Addison and Worswick (2002). The findings from this research are that immigration has either an insignificant or no retarding effect on real wages. Existing research has used either time series causality analysis or cross-section analysis. Findings from studies in other countries show mixed results. Most empirical studies find a small impact of immigration on native wages (Butcher and Card 1991, Lalonde and Topel 1991, and Friedberg and Hunt 1995). However, Altonji and Card (1991), Borjas et al (1992) and Borjas et al (1996) suggest that immigration has an adverse effect on the wages of native less-skilled workers. As Borjas (1999) points out, almost all empirical studies in this literature use a spatial correlations approach, and these studies have produced a confusing array of results[1]. Moreover, Schoeni (1997) using the same instrumental variables procedure as Altonji and Card (1991) obtains very different estimates (Borjas 1999). Kuhn and Wooton (1991) and Heckman et al (1998) construct theoretical models in order to investigate this issue, but, as Friedberg and Hunt (1995) point out, where this has been done the results are equivocal.

In addition to filling the gap in the literature by investigating the Australian case, this paper also uses a different methodology from the existing literature. This paper uses a theoretical dynamic intertemporal general equilibrium model to simulate the transition of the skilled-unskilled wage differential due to immigration shocks. An extensive set of empirical data is used to calibrate a range of parameters in this model.

The main finding is that during the past decade immigration cannot adequately explain the evolution of the skilled-unskilled wage differential in Australian. Also, immigration does not have a significant effect on aggregate average wage or on the wage of unskilled workers.

2. The Model

[1] The spatial correlation is the relationship between labour market outcomes in a locality and the extent of immigrant penetration. The sign of the relevant coefficient changes erratically over time.

The economy has one-good, two-labour types (skilled and unskilled) and three-agents (firms, households, and government). The framework of this model is as follows. The whole economy is treated as one aggregate entity. Firms produce the single good by hiring physical capital, skilled labour and unskilled labour, and then sell this good to 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. Firms belong to households in this model.

Households supply unskilled labour to firms and skilled labour to both firms and the government in order to earn wages, together with the dividends from renting physical capital to firms, to finance the purchase of the good and education. Leisure is consumed by households with an opportunity cost of not working. The objective of households is to maximize utility by an optimal distribution of consumption between the good and leisure under their budget and time constraints and the choice of investment on education. It is assumed that time spent in schooling and expenditure on education are equally important for skill formation.

The government buys the good from firms and transforms it into education capital. This capital is combined with skilled labour hired by the government to produce education[2]. 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 labour income tax and selling education to households[3]. The accumulation of physical

[2] It is assumed that lecturers and administrators working in the education sector are skilled labour.
[3] To avoid unnecessary complexities, a subsidy rate on investment and a tax rate on financial dividends is assumed to be balanced out.

capital, skill formation, education capital and financial assets drives the dynamic evolution of the economy over time.

The role of immigrants in this Australian model is characterized as follows. Immigrants, categorized as unskilled labour and skilled labour, join goods production and are homogeneous to domestic labour in productivity. It is assumed that skilled immigrants are not working in the education sector (which is managed by the government in the model) immediately after their arrival. Starting from the second period after arrival, skilled immigrant workers are treated exactly the same as domestic workers.

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 Australian Bureau of Statistics (ABS). All parameters are estimated using data for 1990, the base year of calibration, except for the shares of skilled and unskilled labour in goods production function which are estimated using time series data. Skilled and unskilled labour are grouped by occupation defined by ASCO2 (second edition statistical classifications). Skilled labour includes: (1) Managers and administrators; (2) Professionals; (3) Associated professionals; (4) Tradespersons and related workers; (5) Advanced clerical and service workers. Unskilled labour includes: (1) Intermediate clerical, sales and service workers; (2)

Elementary clerical, sales and service workers; (3) Intermediate production and transport workers; (4) Labourers and related workers. The wages in the skilled and unskilled group are the weighted average weekly earnings which respectively use the proportion of employees in each occupation in the skilled and unskilled group as the weights[4]. A detailed data processing is presented in Appendix 2 and a detailed calibration is listed in Appendix 3.

4. Simulation Results

In the past decade, Australia accepted more skilled than unskilled immigrants. Another group called "not in labour force", including the retired, pensioners, disabled, housekeepers, students and unemployed, captures the rest. The skilled immigrants have occupied a decreased share in total immigrants, 42.5% in 1990 down to 33.2% in 2000. The situation is the same for unskilled immigrants, 12.6% down to 3.6% during the same period. Immigrants who are not in the labour force have increased from 45% in 1990 to 63% in 2000. Figure 1 shows the composition and the variation of each group of Australia's immigrants from 1990 to 2000. Both skill and unskilled immigrants follow a fluctuated downward trend. During the same period of time, the differential of Australia's average weekly earnings between skilled and unskilled labour has accelerated. Figure 2 depicts this situation.

[4] There are two steps to calculate the weighted average skilled and unskilled wages for the data before 1986 because only the aggregate numbers of male and female workers are available. First, the ratios of employees in each occupation to workers in all occupations from 1986 are used to estimate the numbers of employees in each occupation. Then a female and a male weighted average wage in skilled and unskilled group is calculated. Secondly, we use the ratio of male workers to the total workers and the ratio of female workers to the total workers as weights to pool the two wages in each group.

Figure 1. Australia's Immigrants 1990-2000 (Unit: Person)

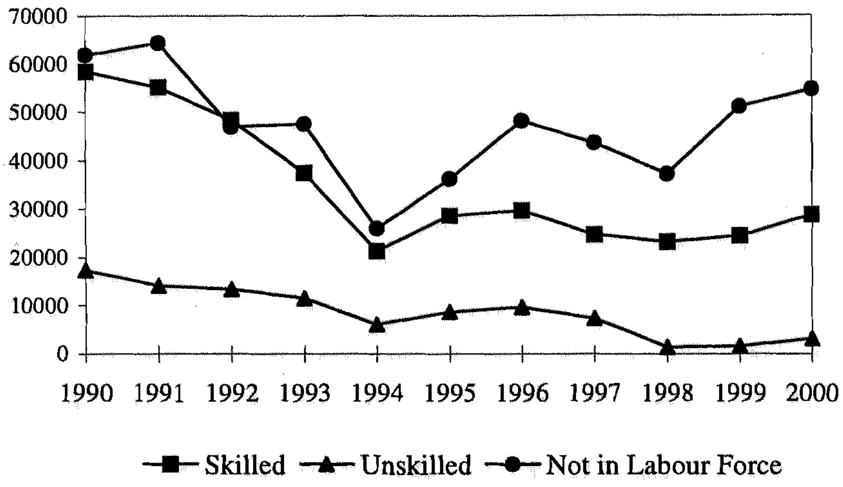
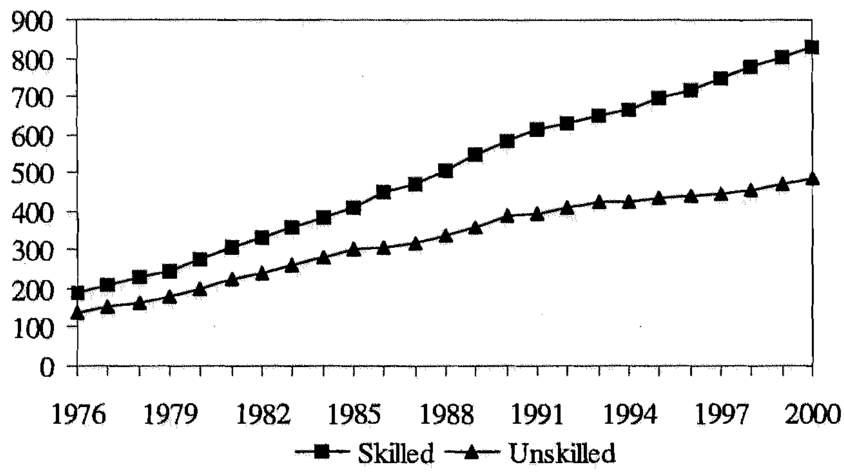


Figure 2. Australia's Average Weekly Earnings (unit: dollar)



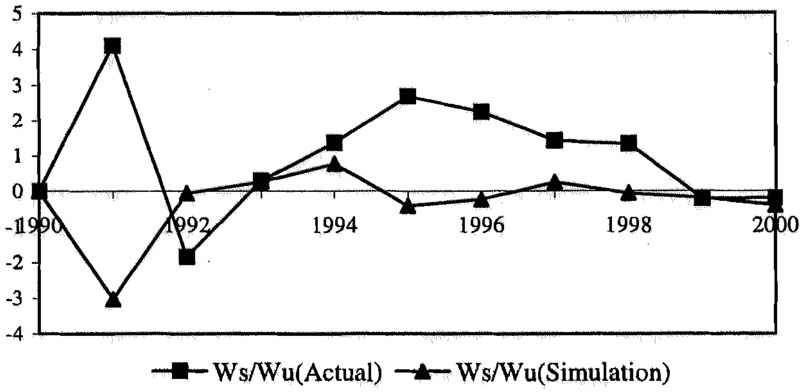
The simulation is undertaken in the following way. At year t, it is assumed there is no information of the quantity of immigrants at year t+1 or any year after. Therefore, steady state outcomes for the whole economy, including evolution of the wage differential, depend on the effect of the current and past quantities of immigrants, i.e. the shock for year t includes the quantities of immigrants up to year t and remains the same as year t hereafter. The ratio of the actual number of skilled immigrants to the number of domestic skilled workers multiplies the simulated number of domestic skilled workers in the steady state to rescale the size of shocks. The same method is used to rescale the shocks of unskilled immigrants. Alternative policies such as an increased number in both types of immigrants, one increased and the other decreased, or both decreased at a certain rate annually can be tested and these policy implications are presented in the next section.

The simulation result shows little connection between the predicted evolution of the skilled-unskilled wage differential and the actual data as illustrated in Table 1 and Figure 1. In addition to a countercyclical pattern depicted by these two series, except for 1991, the simulated effect of immigration on the wage differential has a relatively small magnitude in each year. The simulated result in 1991 shows the fact that, in 1990, Australia accepted the largest magnitude, 1.5% of the domestic skilled workers, of skilled immigrants during the past decade. In the same year, the unskilled immigrants only occupied 0.4% of the domestic unskilled workers. The supply effect of this shock carried over a decreased wage differential to a relatively large extent in 1991. Furthermore, there are only three years (1993, 1994 and 1997) during the past decade which have a positive growth rate of the wage differential; all other years have a negative rate. This provides evidence that immigration is not the main cause of an increased wage differential. The simulation result suggests that the existence of another factor or factors have dominated variation in the actual wage differential. Investigating these possible causes is beyond the scope of this paper but is an area for future research.

Table 1. Growth Rate of the Wage Differential in Australia (%)

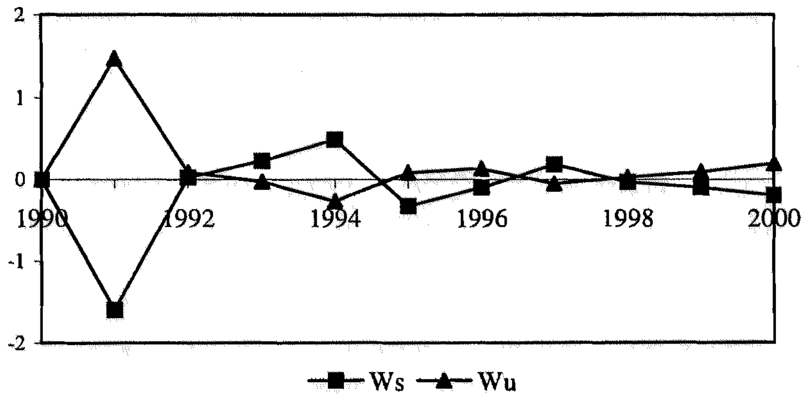
	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Actual	4.11	-1.85	0.28	1.36	2.67	2.24	1.42	1.33	-0.21	-0.20
Simulated	-3.03	-0.06	0.25	0.76	-0.41	-0.23	0.24	-0.06	-0.19	-0.39

Figure 1. Growth Rate of the Wage Differential in Australia (%)



Immigrants have been blamed for the deterioration of the unskilled wage in many countries including Australia. Figure 2 shows the growth rate of skilled and unskilled wages due to immigration. In all years, except for 1991, both wages vary in a relatively small band. This supports the conclusion from the existing research such as Addison and Worswick (2002: p.68) that "recent immigrants are not found to significantly affect the real wages of native Australians". For most years, the unskilled wage exhibits a positive growth rate. However, the skilled wage has more negative than positive growth rates during the past ten years. The intuition for this is that during that period Australia continuously accepted more skilled immigrants than unskilled ones.

Figure 2. Growth Rate of Skilled and Unskilled Wage (%)



5. Policy Implications

Recent disputes over asylum seekers have caused the Australian government to seriously re-consider its immigration policy. Simulations with 'shocks' from immigrants in skilled and unskilled categories: both ascending by 5%, one ascending by and the other descending by 5% and both descending by 5% over time after 2000, have been carried out to provide policy suggestions to the government[5]. The results show that as long as Australia accepts an increase in skilled immigrants by 5% per year, the wage differential will decrease in both the short and long run. The reason is that Australia accepted much more skilled than unskilled immigrants in each year throughout the past decade. A proportionate increase in both skilled and unskilled immigration therefore results in a much larger number of additional skilled immigrants. Hence, even accepting 5% more *unskilled* immigrants each year, the effect of supply of skilled immigrants is still greater than the effect of supply of unskilled immigrants. Reducing 5% of the skilled immigrants per year increases the wage differential in the long run and decreases the wage differential in the short run. The reason for this is that in the short run an annual cut of skilled immigrants by 5% still results in a relatively large number of skilled immigrants to unskilled immigrants. Consequently, the supply of skilled immigrants dominates the changing direction of the wage differential. However, a further cut of skilled immigrants over time creates a shortage of supply of skilled immigrants relative to unskilled immigrants. This explains an expected long-run increased wage differential. Figure 3 and 4 show these simulation results.

[5] These experiments are carried out using a time frame of one hundred years due to the set-up in the computer package. For practical purposes, we look at the results over the first twenty years as shown in Figure 3.

Figure 3. Policy Implications (1): the Wage Differential in Australia (%)

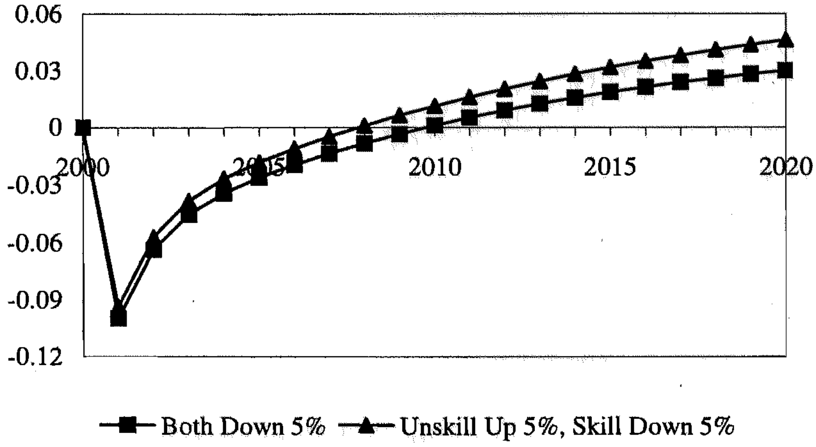
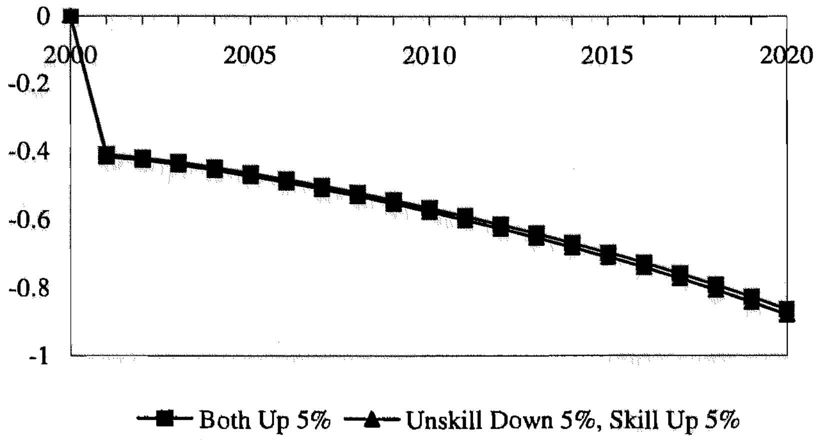


Figure 4. Policy Implications (2): the Wage Differential in Australia (%)



One has to bear in mind that the effect of immigration on the wage differential in the above experiment is fairly small. It seems that there is no simple policy merely aimed at immigration which is able to effectively counter a tendency towards an increased wage differential. Other factors affecting the wage differential should be discerned from future research to formulate a package of policy recommendations. An effective policy to change the skilled-unskilled wage differential would presumably require a mixture of a set of instruments aimed at other economic issues such as international trade, productivity growth and education, which are all plausible contributing factors behind a rising wage differential.

6. Conclusion

This paper constructs a dynamic intertemporal general equilibrium model and calibrates this theoretical model using Australian data to investigate the impact of immigrants on native wages, especially the wage differential between skilled and unskilled labour.

The results show that during the past ten years immigration cannot explain the variation in the skilled-unskilled wage differential in Australia. The simulated path due to 'shocks' to immigration basically runs counter to the path of actual wage differentials. For most years, immigration only plays a small role in the evolution of Australian skilled-unskilled wage differentials. This suggests the existence of other factors that have a dominant influence on the wage differential. There is also no evidence to support the hypothesis that immigrants have caused downward pressure on the unskilled wage. Consistent with the existing literature, this paper supports the view that during the past ten years Australian immigration has had an insignificant effect on native wages.

A comparison of four policy options: both numbers of skilled and unskilled immigrants increased, one increased and the other decreased and both decreased at a certain rate over time after 2000, demonstrates that as long as Australia accepts an increased number of skilled immigrants per year the wage differential will decrease in both the short and long run. By cutting the number of skilled immigrants per year it increases the wage differential in the long run and decreases the wage differential in the short run. As mentioned above that immigrants play a small role in the variation of the wage differential. An effective policy should be a mixture of a set of instruments aimed at other economic issues such as international trade, productivity growth and education debated among literature and this is a valuable area for future research.

References

Addison, Thomas. and Worswick, Christopher. 2002. "The Impact of Immigration on the Earnings of Natives: Evidence from Australian Micro Data" *Economic Record*, Vol. 78 (March), Iss. 240, p. 68-78.

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

Borjas, George J. 1999. "The Economic Analysis of Immigration" in *Handbook of Labour Economics*, Vol 3A. Edited by Orley Ashenfelter and David Card. Elsevier Science B.V.

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

Borjas, George J, Freeman, Richard B, and Katz, Lawrence F. 1992. "On the Labour Market Effects of Immigration and Trade" *Immigration and the Work Force*. Edited by George J. Borjas and Richard B. Freeman. The University of Chicago Press.

Borjas, George J, Freeman, Richard B, and Katz, Lawrence F. 1996. "Searching for the Effect of Immigration on the Labour Market" *American Economic Review* 86 (2), p. 246-51.

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

Foster, W and Withers, G. 1992. "Macroeconomic Consequences of International Migration", in *Nations of immigrants : Australia, the United States, and international migration.* Edited by Gary P. Freeman and James Jupp. Oxford University Press.

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, p. 23-44.

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

Kuhn, Peter. and Wooton, Ian. 1991. "Immigration, International Trade, and the Wages of Native Workers" *Immigration, Trade, and the Labour Market.* Edited by John M. Abowd and Richard B. Freeman. The University of Chicago Press.

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

Pope, D. and Withers, G. 1993. "Do Migrants Rob Jobs? Lessons of Australian History, 1861-1991" *Journal of Economic History*, No. 53, p.719-42.

Appendix 1

The Model

Firms:

Max. $\int_0^\infty [Q_t - W_{s,t}\cdot(L^F_{s,t}+L^m_{s,t}) - W_{u,t}\cdot(L_{u,t}+L^m_{u,t}) - I_t]\cdot e^{-r\cdot t}\cdot dt$

Subject to

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

(2) $$I_t = J_t\cdot(1+\frac{\Phi}{2}\cdot\frac{J_t}{K_t}),$$

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

Households:

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

Subject to

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

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

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

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

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

(9) $$U(C_t, l_t) = l_t^\gamma\cdot C_t^{1-r},$$

Government:

(10) $$S_{E,t} = f(K_{E,t}, L^G_{s,t}) = K^\xi_{E,t}\cdot L^{G\;1-\xi}_{s,t},$$

(11) $$\frac{dK_E}{dt} = I^G_{E,t} - \delta_E\cdot K_{E,t},$$

(12) $$I^G_E + W_{s,t}\cdot L^G_{s,t} = \tau\cdot[W_{s,t}\cdot(L_{s,t}+L^m_{s,t}) + W_{u,t}\cdot(L_{u,t}+L^m_{u,t})] + P_{E,t}\cdot S_{E,t}.$$

Model in the Steady State

Equations
$Q_t = (L_{s,t}^F + L_{s,t}^m)^\alpha \cdot (L_{u,t} + L_{u,t}^m)^\beta \cdot K_t^{1-\alpha-\beta}$
$J_t = \delta \cdot K_t$
$I_t = J_t \cdot (1 + \frac{\Phi}{2} \cdot \frac{J_t}{K_t})$
$Q_{L_s} = W_s / P$
$Q_{L_u} = W_u / P$
$\lambda = 1 + \phi \cdot \delta$
$Q_K = (r+\delta) \cdot \lambda - \phi \cdot \delta^2 / 2$
$0 = r \cdot F_t + (1-\tau) \cdot [W_{s,t} \cdot (L_{s,t} + L_{s,t}^m) + W_{u,t} \cdot (L_{u,t} + L_{u,t}^m)] - C_t - P_{E,t} \cdot S_{E,t}$
$J_{s,t} = \delta_s \cdot L_{s,t}$
$F_t = \lambda_t \cdot K_t$
$J_{s,t} = f(H_t, P_E \cdot S_E) = H^\Omega \cdot (P_E \cdot S_E)^{1-\Omega}$
$l_t = T - L_{s,t} - L_{u,t} - H_t$
$U_C = \mu_1$
$U_{L_u} = -\mu_1 \cdot (1-\tau) \cdot W_u$
$\mu_2 = \mu_1 \cdot (\frac{1}{1-\Omega}) \cdot (\frac{J_s}{H})^{\frac{\Omega}{1-\Omega}}$
$r_t = \theta$
$U_{L_s} = (\theta + \delta_s) \cdot \mu_2 - \mu_1 \cdot (1-\tau) \cdot W_s$
$L_{s,t} = L_{s,t}^G + L_{s,t}^F$
$S_{E,t} = K_{E,t}^\xi \cdot {L_{s,t}^G}^{1-\xi}$,
$I_E^G = \delta_E \cdot K_E$
$I_E^G + W_{s,t} \cdot L_{s,t}^G = \tau \cdot [W_{s,t} \cdot (L_{s,t} + L_{s,t}^m) + W_{u,t} \cdot (L_{u,t} + L_{u,t}^m)] + P_{E,t} \cdot S_{E,t}$
$Q_t = C_t + I_E^G + I_t$

Notation:

Q: Production; L_s^F : Domestic skilled labor hired by firms; L_s^G : Skilled labor hired by government; L_s : Total skilled labor; L_s^m : Skilled immigrants; L_u : Domestic unskilled labor; L_u^m : Unskilled immigrants; K : Capital; l: Leisure; J : Fixed capital formation; I : Capital investment; W_s : Skilled wage; W_u : Unskilled wage; F : Financial asset; C : Consumption; S_E : Amount of education buying; J_s : Fixed skill formation; T : Time constraint; P : Goods price (defined as 1); 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; λ: Shadow price of capital;

α, β: Input shares in goods production function; 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

The Data

In terms of immigrants, data in 1994-2000 are from *Migration ABS 3412* and data in 1990-1993 are unpublished data purchased from ABS. Data in 1990-1997 follow ASCO1 (Australian Standard Classification of Occupations, first edition statistical classifications) and data in 1998-2000 follow ASCO2. The category of occupation defined by ASCO1 are: (1) Managers and administrators; (2) Professionals; (3) Para-professional; (4) Tradespersons; (5) Clerks; (6) Salespersons and personal service workers; (7) Plant and machine operators and drivers; (8) Labourers and related workers. To combine ASCO1 and ASCO2, the ratios from ASCO2 in 1998 of advanced, intermediate, and elementary clerical, sales and service workers to the aggregate total clerical, sales and service workers are used to disaggregate the sum of (5) clerks and (6) salespersons and personal service workers defined in ASCO1.

The mapping between ASCO2 and ASCO1 is as follows:

	ASCO2	ASCO1
Skilled	(1) Managers and administrators	(1) Managers and administrators
	(2) Professionals	(2) Professionals
	(3) Associated professionals	(3) Para-professional
	(4) Tradespersons and related workers	(4) Tradespersons
	(5) Advanced clerical, sales and service workers	(5) Clerks + (6) Salespersons and personal service workers (A portion applied)
Unskilled	(6) Intermediate clerical, sales and service workers	(5) Clerks + (6) Salespersons and personal service workers (A portion applied)
	(7) Elementary clerical, sales and service workers	(5) Clerks + (6) Salespersons and personal service workers (A portion applied)
	(8) Intermediate production and transport workers	(7) Plant and machine operators and drivers
	(9) Labourers and related workers	(8) Labourers and related workers

In terms of domestic labour, data are from various issues of *The Labour Force Australia*. Data in 1968-1986 are from *ABS 6203*and *ABS 6204*; data in 1987-2001 are from *ABS 6291*. This time series from 1968 to 2001 covers three types of classification: CCLO (Classification and Classified List of Occupations, 1968-1986), ASCO1(1987-1996) and ASCO2 (1997-2001). The number of employee *by occupation* is not available for 1976-1985. The ratios used to split the total employment into different occupation in 1976-1985 are the ones in 1986. To convert 1968-86 data classified by CCLO into ASCO1, the correlation matrix between the two classifications in table 41 of *The Labour Force Australia August 1986 ABS 6203.0* is used. This is followed by using the mapping between ASCO1 and ASCO2 to calculate the number of skilled and unskilled labour. The same methodology as done for immigrants is used for splitting clerks and salespersons and personal service workers into advanced, intermediate and elementary groups and the ratio in 1996 classified by ASCO2 is used to divide clerk or salespersons for 1968-1995.

To calculate the wage differential between skilled and unskilled labour, data published in *Employee Earnings and Hours ABS 6306.0* are used. This survey is conducted in May either annually or biennially. The longest time series collected is from 1976 to 2000. During this period, it covers three different classifications for earnings by occupations: CCLO(1976-1986), ASCO1(1986-1995) and ASCO2(1996-2000). Since there is no survey in 1980,1982,1984,1997 and 1999, the mean earnings of these years are calculated by averaging the figures of the year before and after. Data in 1976-1985 classified by CCLO are mapped into ASCO1 according to a close definition of each occupation between these two classifications. In 1986, both of the classifications of CCLO and ASCO1 for earnings by occupation are available.

Therefore, in 1986, the mean earnings mapped from CCLO to ASCO1 and the mean earnings classified by ASCO1 can be compared to find out how well the mapping between CCLO and ASCO1 works. To calculate the mean earnings if two or more occupations are involved, the weights are the ratios of the employment number in each occupation to the number aggregated from all occupations involved. The comparison shows that the mapping provides a reasonable match for most of the occupations. However, the after-mapping mean earnings from CCLO to ASCO1 in one professional category, i.e. plant, machine operators and drivers, do not show a close approximation to the actual data. Therefore, as a precaution, an adjustment has been done by using the ratios in 1986 of the mean earnings classified by ASCO1 to the after-mapping ones of each occupation to adjust the estimated mean earnings prior to 1986.

Appendix 3

$T = 8760;$	$\tau = 0.3;$	$I_E^G = 14.711;$	$\alpha = 0.4;$
$\beta = 0.37;$	$\delta = 0.06;$	$\delta_s = 0.03;$	$\delta_E = 0.06;$
$\phi = 0.01;$	$\theta = 0.1473;$	$\xi = 0.1;$	$\gamma = 0.55;$
$\Omega = 0.5;$	$P_E = 0.011;$		

Note:

1. The shares of skilled labor (α) and unskilled labor (β) in the goods production function are estimated by running ordinary least square (OLS) using data from 1968-2001.
2. The depreciation rate of skill (δ_s) is estimated by using the number of skilled labor in 1990 and 1991 and the number of higher education completion (J_s) in 1990.
3. The unit of I_E^G is measured by AU$billion.
4. Interest rate (θ) is the interest rate of 6-month treasury notes in 1990.
5. Tax rate τ is estimated by tax revenue divided by GDP in the financial year 1989-90.
6. Time (T) is measured by the number of hours in one year.
7. The depreciation rate of physical capital (δ) is estimated by using data of the capital stock in 1990 and 1991 and investment in 1990. The depreciation rate of education capital (δ_E) is assumed to be the same as the rate as the physical capital.
8. The share of consumption goods (γ) and leisure ($1-\gamma$) are assumed equal.
9. The input share in education production function (ξ) is estimated by the government fixed capital formation in education divided by government total expenditure on education in 1990.
10. The price of education (P_E) is estimated by private outlay on education divided by GDP in 1990.
11. The share of leisure (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).

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