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**DO IMMIGRANTS ROB JOBS?**  
**A CASE STUDY OF AUSTRALIA**

by

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# **Do Immigrants Rob Jobs? A Case Study of Australia**

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## **Abstract**

This paper constructs a dynamic theoretical model and calibrates the model with the Australian data. The simulations provide new findings which demonstrate that skilled immigrants are not 'job robbers' but unskilled immigrants have the potential to become such. The result that immigrants are not job robbers is due to there having been a much larger number of skilled immigrants than the unskilled immigrants in Australia during the past twelve years, 1990-2002. The immigration policy adopted by the Australian government, which targets skilled immigrants, leads the economy to the direction of growth.

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

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# **Do Immigrants Rob Jobs? A Case Study of Australia**

## **I Introduction**

The economic effects of immigration are always matters of great interest in Australia. By the late 1970s, focus on the issue of immigration had switched from the demand side consequences, such as an adverse impact on inflation, investment and imports, to the labour market with concerns about effects on unemployment (Foster and Baker, 1991). Of particular importance was the question: do immigrants rob jobs from local Australians? Pope and Withers (1993) and Addison and Worswick (2002) concluded that there is no evidence of immigration raising the unemployment rate. Tian and Shan (1999) and Shan et al (1999) supported this view and found no Granger causality between immigration and unemployment. Chapman and Cobb-Clark (1999) developed a short-run model and concluded that immigration improves the job prospects of unemployed residents and an increase in employment is more likely the more recessed is the labour market.

In addition to studies based on the case of Australia, a large body of literature investigating the effect of immigration on local workers has also been undertaken by U.S., French, New Zealand, and Canadian studies (Lalonde & Topel 1991, Altonji & Card 1991, Borjas 1994, Friedberg & Hunt 1995, Gross 2002, Shan et al 1999, Marr and Siklos 1995 and Lee 1992). The evidence from these studies is inconclusive. Some of the empirical studies find a small or insignificant impact of immigration on local unemployment (Borjas 1994, Friedberg and Hunt 1995 and Shan et al 1999). Some find a negative relationship. Gross (2002) studies the case of France and concludes that there is a negative relationship between unemployment and immigration in the long run. Marr and

Siklos (1995) use Canadian data and find that immigration and unemployment are inversely related to a small extent. Altonji and Card (1991) use U.S. data and suggest that immigrants had an unexpected negative effect on unemployment. Others find a positive relationship, i.e. immigrants are job robbers. Lee (1992) finds that immigration has a positive effect on Canadian unemployment. Gross (2002) concludes in the short run, immigration leads to a temporary increase in unemployment to a small extent. Angrist and Kugler (2003) take cross-country differences in institutions among countries in EU into account and find that “an increase in the foreign share (the immigrant proportion of the labour force) of 10% would reduce native employment rates by 0.2-0.7 of a percentage point”. All existing research in this area is based on empirical studies in which the analysis mainly uses cross-section or time series data, which rely on the quantity and quality of the data used. These econometric approaches use either reduced forms from relatively simple theoretical models or somewhat ad hoc forms, neither of which is sufficiently comprehensive.

This paper uses a novel methodology which constructs a dynamic theoretical model, based on the behaviour of firms, households and the government, and uses empirical data to calibrate this model, then runs simulations. This model is able to illustrate the dynamic transitions of key variables in both the short and long run, providing important insights into immigration policies. This is precisely what existing research based on time series data (Tian and Shan 1999, Pope and Withers 1993, Addison and Worswick 2002 and Shan et al 1999) and a short-run model (Chapman and Cobb-Clark 1999) could not provide.

The main finding is that there is no evidence that immigrants take jobs away from the local Australian over the past twelve years. This is because skilled immigrants have dominated the overall effects. This supports the conclusion from existing research, such as Addison and Worswick (2002), Tian and Shan (1999) and Pope and Withers (1993). Furthermore, simulations from this theoretical model suggest that immigrants reduce the unemployment rate when demands for consumption and education by immigrants are taken into account. This is consistent with the findings of the Canadian study by Marr and Siklos (1995), of the U.S. study by Altonji and Card (1991), of the Australian study by Chapman and Cobb-Clark (1999) and of the French study looking for the long-run effect by Gross (2002).

This paper takes a more detailed look at the composition of immigrants by dividing them into skilled and unskilled groups. After separating the effect from the skilled and unskilled immigrants on the unemployment rate, a new finding is that skilled immigrants are not job robbers, but unskilled immigrants have the potential to rob jobs from the local unskilled labour.

Section II sets out the theoretical model, Section III shows the calibration of the model, Section IV presents the simulation results and Section V is the conclusion.

## **II The Model**

The framework of the theoretical model is as follows. The economy has one-good, two-labour types (skilled and unskilled) and three-agents (firms, households, and government). The whole economy is treated as one aggregate entity. Firms produce a

single good by hiring physical capital, skilled labour and unskilled labour, and then they 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. The ownership of firms belongs 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. Wages together with the dividends from renting physical capital to firms are used 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 goods and leisure under their budget and time constraints and the choice of investment in education to upgrade their skill. 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<sup>1</sup>. 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<sup>2</sup>. The accumulation of physical capital, skill formation, education capital and financial assets causes dynamic evolution of the economy over time.

Wage determination in Australia has been based on an awards system usually described as compulsory arbitration. The main feature of compulsory arbitration is the inflexibility

of relative wages. The evolution of the Australian Awards System is towards encouraging parties to bargain at the level of the enterprise. An individual agreement with their employers, known as a workplace agreement, is also under development. Since 1993 the Industrial Relations Commission no longer makes national wage decisions. However, it does make safety net decision covering workers, mostly lower-paid workers, who have not been able to enter an enterprise bargain (Norris 2000). Under the inflexibility of the lower wages in Australia, the unskilled wage is treated as exogenous to present a case of market failure which creates unemployment. The skilled wage is endogenized. Therefore, the relative wage evolves over time by which the contemporary activities from the evolution of the Australian Awards System are well captured.

The role of immigrants in this model is as follows. Immigrants, categorized as unskilled labour and skilled labour, provide inputs for goods production and are homogeneous to domestic labour in productivity. It is assumed that skilled immigrants cannot work in the education sector immediately after their arrival. From the second period after arrival, skilled immigrant workers are treated exactly the same as skilled domestic workers.

This theoretical model is an extension version of the model in Chang (2002) and follows the general approach of the G-Cubed model (McKibbin and Wilcoxon 1999). A step-by-step construction of the model can be found in Chang (2000). The model is presented in Table 1. Cobb-Douglas functional forms are used for goods production, skill formation, education production and the household utility function. The model in the steady state is presented in Appendix 1.

Table 1  
*The Theoretical Model*

Firms:

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

Subject to

$$dK / dt = J_t - \delta \cdot K_t,$$

$$I_t = J_t \cdot [1 + (\Phi / 2) \cdot (J_t / K_t)],$$

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

Households:

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

Subject to

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

$$dL_s / dt = J_{s,t} - \delta_s \cdot L_{s,t},$$

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

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

$$F_t = \lambda_t \cdot K_t,$$

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

Government:

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

$$dK_E / dt = I_{E,t}^G - \delta_E \cdot K_{E,t},$$

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

Notation:

Q: Production;  $L_s^F$ : Domestic skilled labour hired by firms;  $L_s^G$ : Skilled labour hired by government;  $L_s$ : Total skilled labour;  $L_s^m$ : Skilled immigrants;  $L_u$ : Domestic unskilled labour;  $L_u^m$ : 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;  $N$ : Unemployment;  $P_E$ : Price of education;  $r$ : Interest rate;  $K_E$ : Education capital;  $\tau$ : Tax rate;  $I_E^G$ : Government education investment;  $\lambda$ : Shadow price of capital;  $\alpha, \beta$ : Input shares in goods production function;  $\delta$ : Depreciation rate of capital;  $\delta_s$ : Depreciation rate of skill;  $\theta$ : Rate of time preference;  $H$ : Schooling;  $\xi$ : Input share in education production function;  $\Omega$ : the share in skill formation;  $\delta_E$ : Depreciation rate of education capital;  $\Phi$ : Adjustment cost parameter of capital investment.



### **III Calibration of the Model**

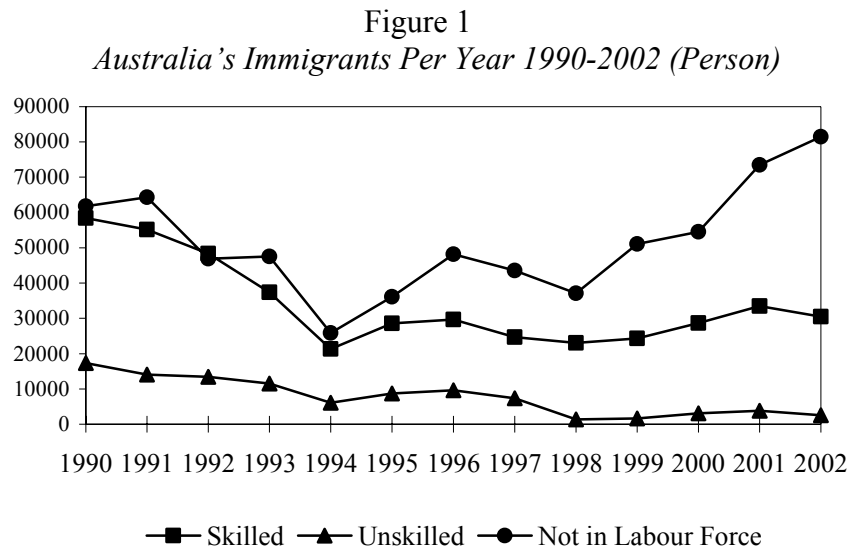
All data are from the Australian Bureau of Statistics (ABS). All parameters are estimated using data for 1990, the base year of calibration, except for the shares of skilled and unskilled labour in the goods production function which are estimated using time-series data. Three assumptions are made in calibration. First, the depreciation rate of education capital is the same as the depreciation rate of physical capital. Second, the consumption of leisure and of goods are equally important for households' utility. Third, spending of money and spending of time on education are equally important for skill formation.

Skilled and unskilled labour are grouped by occupation defined by the Australian Standard Classification of Occupations, second edition statistical classifications (ASCO2). Skilled labour includes: (1) Managers and administrators; (2) Professionals; (3) Associate 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. Details of the data are in Appendix 2, and details of the parameters and exogenous variables are in Appendix 3.

### **IV Simulation Results**

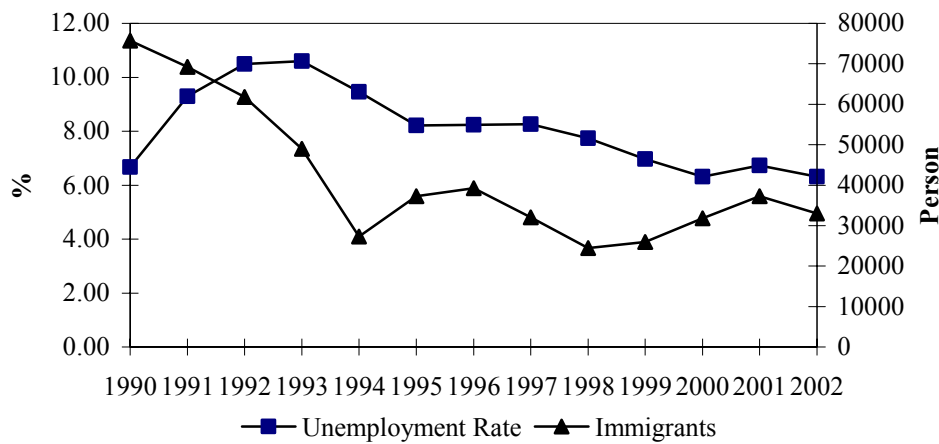
In the past twelve years (1990-2002), Australia accepted more skilled than unskilled immigrants. Another group called 'not in the labour force', including the retired, pensioners, disabled, housekeepers, students and unemployed, captures other immigrants. Skilled immigrants have accounted for a decreased share in total immigration, 42.5% in

1990 down to 26.6% in 2002. The situation is the same for unskilled immigrants, 12.6% down to 2.2% during the same period. Immigrants who are not in the labour force have increased as a share of all immigrants from 44.9% in 1990 to 71.2% in 2002. Figure 1 shows the composition and the variation of each group of Australia's immigrants from 1990 to 2002. Both skill and unskilled immigrants follow a fluctuating downward trend.



During the same period of time, the relationship between Australia's unemployment rate and the number of in-labour-force immigrants is shown in Figure 2. The number of in-labour-force immigrants follows a decreasing trend in the period of 1990-2002. The unemployment rate increases to its highest record in 1993. Since then, it has also followed a decreasing trend. A hypothesis that the unemployment rate falls along with decreases in the number of immigrants seems supported by the data. Hence immigrants could be job robbers. However, the correlation between these two series is only 0.3 and this suggests that the direction of variation of these two series is opposite in quite a number of years. Figure 2 cannot provide a clear picture of whether immigrants are job robbers. Thus, a closer investigation is needed.

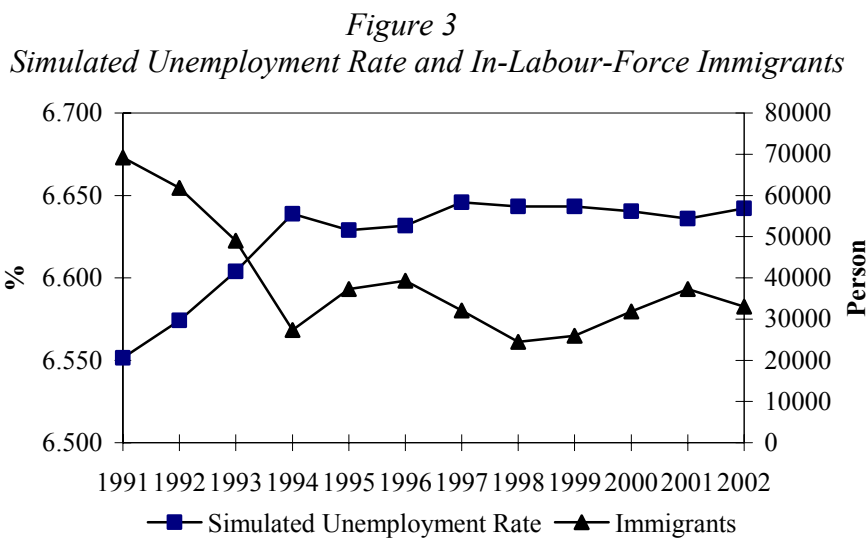
Figure 2  
*Australia's Unemployment Rate and Number of Immigrants*



The simulation is undertaken in the following way. At year  $t$ , it is assumed that there is no information on the quantity of immigrants at year  $t+1$  or any year thereafter. Therefore, the steady state outcomes for the whole economy, including evolution of the unemployment rate, depend on the effect of the current and past numbers of immigrants, i.e. the shock for year  $t$  includes the numbers of immigrants up to year  $t$  and is assumed to remain the same as year  $t$  thereafter. The ratio of the actual number of skilled immigrants to the actual number of domestic skilled workers is used to multiply the simulated number of domestic skilled workers in the steady state in order to rescale the size of the actual immigration shocks. The same method is used to rescale the shocks of unskilled immigrants.

In the period under investigation, numbers of in-labour-force immigrants and simulated unemployment rates follow a countercyclical relationship and have a correlation coefficient of  $-0.97$ . Figure 3 shows this pattern between these two series. This suggests that immigrants are not job robbers. Furthermore, immigrants have the potential to reduce the unemployment rate. There is no evidence to substantiate the perception in the public

psyche that immigrants are taking jobs away from locals. The fallacy of the argument of immigrants being job robbers is that only the labour supply of immigrants is considered and there is no role to play for the demand side of immigrants, such as consumption and education. In the theoretical model used in this paper, both the demand and the supply side are taken into account. The entries of immigrants are equivalent to an increase in Australian population and they are treated the same as locals. They have the equal wage rate to local workers', the choices to take education for upgrading their skills, the necessity to consume goods, and so on. All variables representing the effects from the demand side of immigrants are endogenous in the model.



In addition to the lack of evidence to support the argument of immigrants being job robbers, the comparison of the simulated and the actual unemployment rate suggests that other factors have dominated the variation in the actual unemployment rate. Investigating these possible causes is beyond the scope of this paper however it is an area for future research. This result is shown in Table 2 and Figure 4. The simulated effect of immigration on the unemployment rate varies in a fairly small band and, therefore, has a small magnitude in each year.

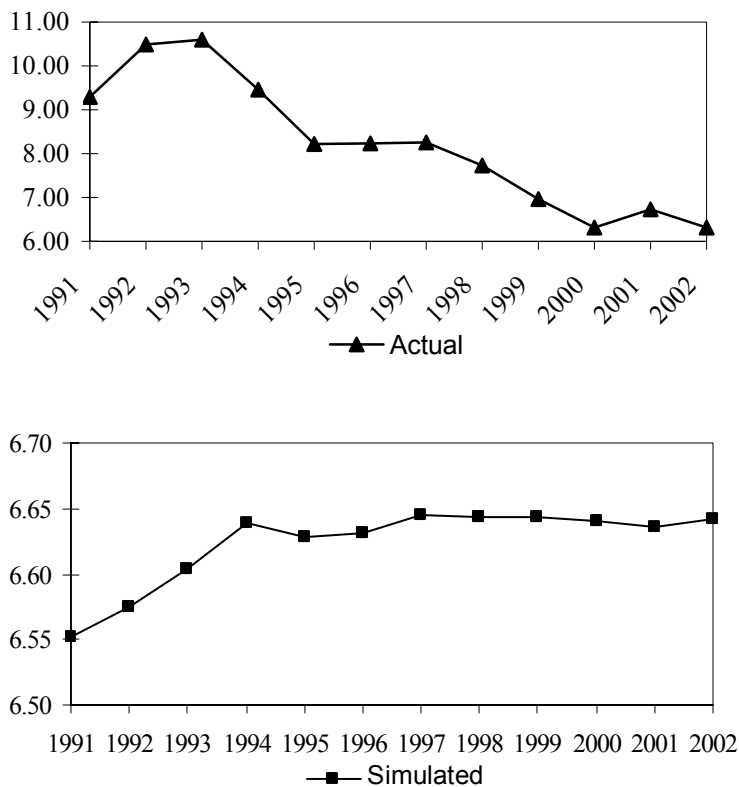
Table 2  
*Unemployment Rate in Australia (%)*

	1991	1992	1993	1994	1995	1996	1997
Actual	9.292	10.492	10.60	9.458	8.217	8.233	8.258
Simulated	6.551	6.574	6.604	6.639	6.629	6.632	6.646

	1998	1999	2000	2001	2002
Actual	7.733	6.967	6.317	6.733	6.317
Simulated	6.643	6.643	6.64	6.636	6.642

Figure 4  
*Unemployment Rate in Australia (%)*

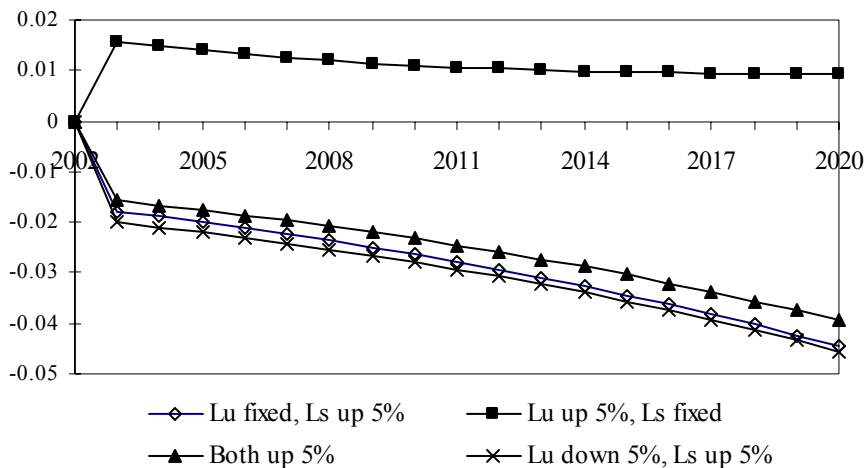


## V Policy Testing

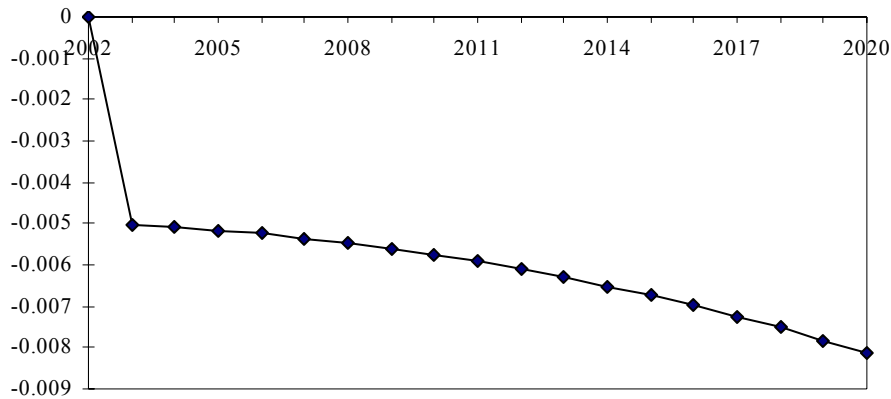
Recent disputes over asylum seekers have caused the Australian government to seriously re-consider its immigration policy. Simulations from the previous section show that during the past twelve years, Australian immigrants are not job robbers and indeed they have the potential to create more job opportunities for the locals. It can be noted that Australia accepted many more skilled than unskilled immigrants in each year throughout

the period between 1990 and 2002. The above result states an overall effect and does not distinguish the effect of skilled immigrants or of the unskilled immigrants on the unemployment rate. Therefore, different policies have been tested to illuminate this issue. Simulations with ‘shocks’ from immigrants in skilled and unskilled categories: both ascending by 5%, one ascending by 5% with the other fixed, and unskilled labour descending by 5% with skilled labour ascending by 5% over time after 2002<sup>3</sup>. The results are shown in Figure 5. A policy with an increased number of skilled immigrants contributes to the economy with a reduced unemployment rate in both the short and long run. This is evidence that skilled immigrants are not job robbers and, *ceteris paribus*, they have the capability to reduce the unemployment rate. However, if the number of skilled immigrants is kept the current level and the number of unskilled immigrants keeps growing, then the price the economy will pay is to face a higher unemployment rate in both the short and long run. This implies that unskilled immigrants have the potential to rob jobs from locals and which is substantiated by a decreasing number of local unskilled labour working in firms. Figure 6 shows this result. As the finding in Section IV, the effect of immigration on the unemployment rate in the above experiments is small.

*Figure 5*  
*The Effect of Different Policies on the Unemployment Rate in Australia (%)*



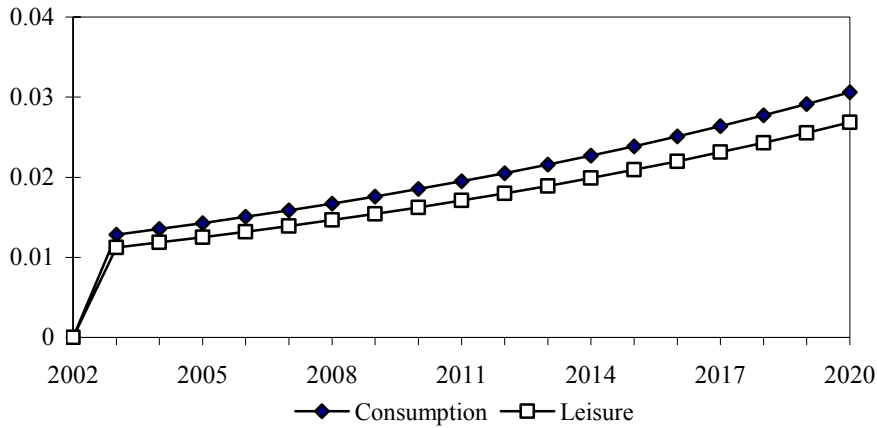
*Figure 6*  
*The Simulated Local Unskilled Labour in Australia (%)*



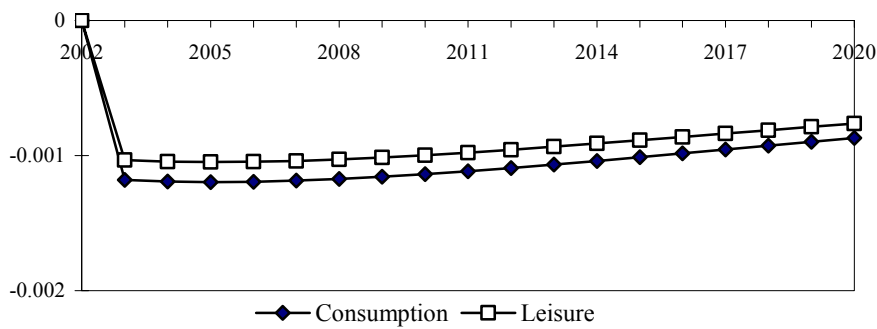
Another interesting point illuminated by the simulations is that an increasing number of skilled immigrants injects a growing momentum to the economy and increases the consumption of leisure and goods in the whole economy. However, an increasing number of unskilled immigrants with a fixed or a decreased number of skilled immigrants reduces the consumption of leisure and goods in the economy. This is because an increasing number of unskilled immigrants causes an increasing number of the unemployed. These unemployed, who do not participate in production but still have needs to consume goods, inject a slowing down momentum to the economy. Figure 7 shows these results<sup>4</sup>. This confirms that the Australian government's adoption of an immigration policy of targeting to the skilled immigrants in the past has helped the Australian economy move towards growth.

*Figure 7*  
*The Effects of Immigrants on Consumption and Leisure*

**5% Increase in Skilled , Fixed Unskilled**



**5% Increases in Unskilled, Skilled Fixed**



## VI Conclusion

This paper constructs a dynamic theoretical model and calibrates this model by using Australian data to investigate the impact of immigrants on the unemployment rate. In addition to using a novel methodology, this research also takes a further step than existing Australian studies to divide immigrants into skilled and unskilled groups. Therefore, the effect of different group on the unemployment rate can be illuminated.

The results show that during the period between 1990 and 2002 immigrants are not job robbers. This result is mainly due to the fact that Australia has accepted a much larger



number of skilled immigrants than unskilled immigrants. Skilled immigrants are not job robbers whereas unskilled immigrants are. The overall impact of immigration on the unemployment rate plays a fairly small role in the evolution of the Australian unemployment rate. This suggests the existence of other factors that have a dominant influence on the unemployment rate. Hence, policy makers should target other factors in the explanation of the variation in Australian unemployment.

Immigrants have been blamed for robbing jobs in many countries, including Australia. This research finds no evidence of immigrants robbing jobs which supports the conclusions from existing Australian research. Furthermore, simulations from this theoretical model suggest that immigrants create jobs when demands of consumption and education from immigrants are taken into account. This is consistent with the findings of the Canadian study by Marr and Siklos (1995), of the U.S. study by Altonji and Card (1991), of the Australian study by Chapman and Cobb-Clark (1999) and of the French study looking for the long-run effect by Gross (2002). In terms of the whole economy's welfare measured by the consumption of goods and leisure, skilled immigrants make it possible for the Australian economy to increase its consumption of both. The immigration policy of targeting skilled immigrants adopted by the Australian government leads the economy to the direction of growth. However, a new issue which has arisen is the increasing share of not-in-labour-force immigrants in the total number of immigrants, from 44.9% in 1990 to 71.2% in 2002. The effects of those immigrants on the Australian economy cannot be seen by looking at the labour market. The Australian government needs to take a close look at this issue to form its immigration policy for the future.

# Appendix 1

## Model in the Steady State

### Equations

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

### Notation:

Q: Production;  $L_s^F$ : Domestic skilled labour hired by firms;  $L_s^G$ : Skilled labour hired by government;  $L_s$ : Total skilled labour;  $L_s^m$ : Skilled immigrants;  $L_u$ : Domestic unskilled labour;  $L_u^m$ : Unskilled immigrants;  $K$ : Capital;  $l$ : Leisure;  $J$ : Fixed capital formation;  $I_E^G$ : Government education investment;  $\lambda$ : Shadow price of capital;  $N$ : Unemployment;  $I$ : 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;  $\tau$ . Tax rate;  
 $\alpha, \beta$ : Input shares in goods production function;  $\delta$ : Depreciation rate of capital;  
 $\delta_s$ : Depreciation rate of skill;  $\theta$ : Rate of time preference;  
 $\mu_1$ : shadow price of financial asset;  $\mu_2$ : shadow price of skill;  $H$  : Schooling;  
 $\xi$ : Input share in education production function;  $\Omega$ : the share in skill formation;  
 $\delta_E$ : Depreciation rate of education capital;  
 $\Phi$ : Adjustment cost parameter of capital investment.

## Appendix 2

### The Data

In terms of immigrants, data in 1994-2002 are from *Migration ABS 3412* and data in 1990-93 are unpublished data purchased from ABS. Data in 1990-97 follow ASCO1 (Australian Standard Classification of Occupations, first edition statistical classifications) and data in 1998-2002 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) Associate 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 1968-86 are from *ABS 6203* and *ABS 6204*; data in 1987-2002 are from *ABS 6291*. This time series from 1968 to 2002 covers three types of classification: CLO (Classification and Classified List of Occupations, 1968-86), ASCO1 (1987-1996) and ASCO2 (1997-2002). The number of employee *by occupation* is not available for 1976-85. The ratios used to split the total employment into different occupation in 1976-85 are the ones in 1986. To convert 1968-86 data classified by CLO 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 1968-95.

### Appendix 3

$$\begin{aligned} T = 8760; \quad \tau = 0.3; \quad I_E^G = 14.711; \quad \alpha = 0.4; \\ \beta = 0.37; \quad \delta = 0.06; \quad \delta_s = 0.03; \quad \delta_E = 0.06; \\ \Phi = 9.5; \quad \theta = 0.1473; \quad \xi = 0.1; \quad \gamma = 0.5; \\ \Omega = 0.5; \quad P_E = 0.011; \quad W_u = 0.3164; \end{aligned}$$

Note:

1. The shares of skilled labour ( $\alpha$ ) and unskilled labour ( $\beta$ ) in the goods production function are estimated by running ordinary least square (OLS) using data from 1968-2001.
2. The depreciation rate of skill ( $\delta_s$ ) is estimated by using the number of skilled labour in 1990 and in 1991, and the number of higher education completion ( $J_s$ ) in 1990.
3. The unit of  $I_E^G$  is billions of Australian dollars.
4. The proxy of  $\theta$  is the interest rate of six-month treasury notes in 1990.
5. The tax rate ( $\tau$ ) is estimated by using the 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 ( $\delta$ ) is estimated by using data of the capital stock in 1990 and in 1991, and investment in 1990. The depreciation rate of education capital ( $\delta_E$ ) is assumed to be the same as the rate of physical capital.
8. The share of leisure ( $\gamma$ ) in the utility function is assumed to be equal to the share of goods consumption ( $1-\gamma$ ).
9. The input share in the education production function ( $\xi$ ) 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 using the private outlay on education divided by GDP in 1990.
11. Spending of money to buy education and spending of time to study are assumed to be equally important for skill formation ( $\Omega$ ).
12. The value of  $W_u$  is picked to have a ratio to the skilled wage close to that from the actual data in the base year 1990.

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## Footnotes

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<sup>1</sup> It is assumed that lecturers and administrators working in the education sector are skilled labour.

<sup>2</sup> To avoid unnecessary complexities, a subsidy rate on investment and a tax rate on financial dividends are assumed to be balanced out.

<sup>3</sup> 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 eighteen years.

<sup>4</sup> All cases with an increasing number of skilled immigrants show similar patterns. Only the case which has a fixed number of unskilled labour and an increasing number of skilled immigrants is shown as a representative. Due the base numbers in year 2002 having a larger number of skilled immigrants than unskilled immigrants, a 5% increase in the number of skilled immigrants ends with a larger number than a 5% increase in the number of unskilled immigrants, therefore, carries with a relatively larger extent of effects.