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Skilled Immigration and Wages in Australia*

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This paper investigates the impact of the relative growth of skilled migration on the structure of Australian wages. Unlike conventional approaches, the present study uses macro data to examine the response of wages to immigration flows. We use instrumental variable techniques to control for the potential endogeneity of immigration. The results, using alternative estimation strategies, are consistent with the dominant findings from existing empirical work. There is no robust evidence that a relative increase in skilled immigrants exerts any discernible adverse consequences on the wage structure in Australia.

I Introduction

Australia is one of the world's major host nations for immigrants. The country has benefited from the important contributions that immigrants have made to her economic performance and development. However, immigration and its appropriate magnitude continue to be matters of public debate. One prominent issue sustaining the debate is the widespread concern in host countries that immigration harms the labour market prospects of native-born workers. That concern is not restricted to Australia but lies at the heart of the debate about immigration in many countries – including most European nations, the USA and Canada (Scheve & Slaughter, 2001). Accordingly, clarification of the nexus between immigration and domestic wages is called for. Better understanding of the Australian experience, specifically of the potential effect of the skill-mix of immigrants on the domestic wage structure, may prove useful in clarifying the issues in Australia and elsewhere.

Australian immigration policy has become increasingly focused on migrant skill as an entry criterion. Between 2000 and 2006, the total annual immigrant intake by Australia was about 140 000. Skilled migration accounted for approximately 65 per cent of the migration visas to Australia granted in 2004–2005, with approximately one-third of these accruing to foreign students (Productivity Commission, 2006). While skilled immigration may well improve the overall employment prospects of the native labour force, it may affect adversely the relative position of native skilled workers. *A priori*, changes in skilled wages are likely to dominate changes in the wage differential between skilled and unskilled labour. Unskilled wages tend to be relatively unresponsive to market forces and, hence, to immigration by virtue of the minimum wage setting practice in Australia that largely relies on union-negotiated wage increases. Skilled wages are not so restrained and typically respond

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readily to changing labour market conditions. Hence, in absolute terms, native skilled workers are potentially more exposed to competition from skilled migrants than are native unskilled workers.

Earlier investigations of aggregate employment and labour market outcomes for Australian-born workers dispel the popular notion that immigration reduces the level of domestic real wages. Questions of skill composition have started to receive attention only recently. Addison and Worswick (2002) find no evidence of adverse effects of immigration on either skilled or unskilled workers. Chang (2004) demonstrates that immigration cannot explain the variation in the skilled-unskilled wage differential in Australia during the 1900s. Borjas's (2003) examination of the interaction between skill composition of migrants and wage structure suggests a negative elasticity of approximately 0.35. According to his findings an immigrant influx that increases the size of a particular skill group by 10 per cent reduces the wages of native workers in that group by about three to 4 per cent. He corroborates this finding in a subsequent examination of US high-skill labour markets (Borjas, 2006). Card (2005) reviews the recent evidence on US immigration and concludes that immigration-induced changes in the skill composition of the domestic labour force have little effect on average domestic wages.

Empirical estimates using a variety of methodologies and estimation strategies in a variety of settings typically show that the effects of immigration on labour market outcomes are either very small or that they yield conflicting results. This inconclusive state warrants more work. One useful extension of existing empirical work is to employ a database that captures elements of systemic interaction such as the adjustment of wages and aggregate demand to immigration. Many authors including Friedberg and Hunt (1995), Borjas *et al*. (1996, 1997) and Borjas (2003) suggest that trends in relative wages associated with inflows of migrants should be investigated by time series analysis.[1] In this paper, we use aggregate time-series data to explore the impact of skilled immigration on wages in Australia.

A major problem in studying the impact of immigration is that the choice of host country may be endogenous. Immigrants may self-select to join labour markets in the better performing industrial countries (Friedberg & Hunt, 1995). In addition, host countries may base their annual target immigration rates on a predetermined immigration policy or on domestic labour market conditions. We address the resulting endogeneity problem by exploiting the fact that Australia's immigration policy and labour market outcomes in earlier periods may serve as choice criteria for immigrants' decisions to seek admission to Australia. We use quarterly time series data covering the period 1980–2006. The start of the observation period is fixed by the date at which data for different skill categories of immigrants becomes available for Australia.[2]

We estimate the effects of immigration on Australian wages using various instrumental variable (IV) methods. Since we are using quarterly data over a period of 26 years, we need to address small sample bias problems. We do so by applying Jackknife IV Estimation (JIVE) (Angrist *et al.*, 1999; Blomquist & Dahlberg, 1999) which is particularly suitable in our context. The choice of instruments is independently substantiated by various validity and specification tests. Our fundamental result is that neither skilled nor unskilled immigration exerts discernible adverse effects on wages in the Australian labour market. In fact, immigration may have some positive effects on aggregate wages.

II Empirical Strategy

If firm output is produced by two types of workers, immigrants and native born, then we can present the production function as:[3]

$$W_t = f(I/P)_t \qquad (1)$$

where I is the stock of skilled (or unskilled) immigrants in the Australian labour market, P is

[1] Existing time series studies such as Islam (2007) focuses on the short-run and long-run relationship or causality analysis (Withers & Pope, 1985) between immigration and job market prospects.

[2] Skilled workers entry into Australia is mainly based on the points system which was introduced in the early 1970s.

[3] Equation (1) can be obtained using any standard neoclassical production function (e.g. Cobb-Douglas) and equating wage with marginal product. A similar specification is derived by Borjas (1987a) and Islam (2008) from the generalised Leontief production function. Grossman (1982) and Card (2001) obtain corresponding specifications from translog and CES-type production functions, respectively. See also Altonji and Card (1991), Butcher and Card (1991), Pischke and Velling (1997) for similar specification to examine the effect of immigration flows on aggregate labour market outcomes.

the entire domestic workforce, W_t is the average weekly wage of workers at time t and $(I/P)_t$ is the skilled (or unskilled) immigrant share at time t. Equation (1) can be interpreted as approximating the first-order condition determining the level of wages, or as a general reduced-form relationship between the domestic wage level and the immigrant share of skilled (or unskilled) workers.[4]

Estimation of Equation (1) is potentially subject to omitted variable problems that would impart an upward bias to parameter estimates. One obvious omission is a term that represents the state of the labour market. The tightness of the market is typically captured by invoking some variant of the Phillips curve, efficiency wage models or bargaining models of wages. Higher unemployment rates weaken the bargaining position of employees and reduce the rate of wage increase. The Philips curve has been the dominant approach to modelling wage determination as it recognises the influence of the long-run equilibrium rate of unemployment on a fixed growth path. This pins down the equilibrium level of labour utilisation in the economy without recourse to other behavioural equations. Including the state of the labour market as well as state dependent determinants of wages outcomes generates the expanded Equation (2) for estimating the relationship between wages and immigration:

$$W_t = \alpha_0 + \alpha_1(I/P)_t + \alpha_2 U_t + \alpha_3 X + \xi_t \qquad (2)$$

Vector X captures the observable time invariant determinants of wages such as state of residence of immigrants and average age of different cohorts of immigrants. U_t is the unemployment rate, ξ_t is the innovation error and α_0 is a fixed effect that captures influences other than those associated directly with the variables in the model. It may include some unobservable policy shift parameters that are not reflected explicitly in the model.

Both theory and empirical evidence suggest a positive association between wages and productivity. In a perfectly competitive market, the wage rate is determined by the productivity of the marginal worker. Given diminishing returns, an increase in the labour force through immigration should influence the wage. We need therefore to include a variable that captures the time-varying productivity in the determination of the aggregate trend of wages. Productivity can be defined as output per man-hour at time t. We don't know exactly what drives productivity, whether work effort or skill. At the level of the plant or firm, improvements in labour productivity may come from using cooperating inputs of better quality, or they may reflect technological change. Any one of these drivers could cause productivity to improve, and usually more than one factor will be involved. Inclusion of the productivity measure also controls for the capacity of the host country to harness her human and physical resources. We therefore model productivity as exogenous in our wage determination system (Eqn 2a)

$$W_t = \alpha_0 + \alpha_1(I/P)_t + \alpha_2 U_t + \alpha_3 X + \alpha_4 prod_t + \varepsilon_t \qquad (2a)$$

where $prod_t$ represents the level of labour productivity at time t. After differencing over successive time periods the estimating equation assumes the form

$$\Delta W_t = \beta_1 \Delta(I/P)_t + \beta_2 \Delta U_t + \beta_3 prod_t + \Delta\varepsilon_t \qquad (3)$$

where $\Delta prod_t$ is the growth in labour productivity defined as the change in GDP per hour of labour worked and $\Delta(I/P)_t$ is the net immigration rate of skilled workers (or unskilled or both, depending on the population captured in the numerator). The differencing purges the equation of fixed effects and the potential biases they may introduce. It also effectively removes all time invariant variables that could possibly be included in vector X.

(I) Endogeneity of Immigration

The estimated value of β_1 in Equation (3) measures the impact of immigrant inflows on wages growth. It should not reflect any simultaneous causality in the opposite direction. However, immigrants are attracted to countries where their skills are in strong demand. Hence, a potential endogeneity problem arises from the choice of destination country. Furthermore, immigrants who choose to come to Australia are probably not a random subset of the source country workforce. We would expect immigrants to expect higher earnings in Australia than in their country of origin, and vice versa for those who stay (Borjas, 1987b). Immigrants are, typically, ambitious, aggressive, and entrepreneurial. They, especially skilled migrants, move across international borders from one place of work and residence to another in order to exploit the economic opportunities that are accessible to them. Another potential source of endogeneity arises from the fact that the

[4] Though we focus on skilled immigration in this paper, we also estimate the same regression for unskilled immigrants.

Australian immigration policy is based on past immigration rates.[5]

The endogeneity issue has previously been recognised in studies of local labour markets (Altonji & Card, 1991; Friedberg, 2001) but not in the context of cross-border migration. Those studies typically postulate that immigrants tend to move to cities or occupations where growth in demand for labour can accommodate their supply. Our study is not spatially based, and the endogeneity problems that may arise in the present context are at a higher level of aggregation. In terms of Equation (3), if the migrant flow is not independent of $\Delta\varepsilon$, then the conditional correlation between wages growth and the (skilled or unskilled or total) immigration rate will confound the two directions of causation, and bias the estimate of β_1. If, for example, immigrants are more skilled, and if they choose high-skilled jobs that have better prospects of high wage growth in Australia, then the estimate of β_1 will be biased upward. Conversely, if immigrants are concentrated in relatively low-paying jobs with little or no prospect of wage growth – possibly due to lack of recognition of foreign qualifications, language barriers or a dip in the earnings just after arrival – then the estimate of β_1 will be biased downward, leading to underestimation of the effect of immigration.

The endogeneity problem can be solved by identifying a source of exogenous variation in immigration flows. In our context, such instruments must be correlated with the inflow of immigrants over time, but must be uncorrelated with the unobserved component of wages growth subsequent to the immigrant's arrival.[6] We follow Altonji and Card (1991), Card (2001), Friedberg (2001) and use the lagged share of immigrants in the labour force as an instrument. The argument here is that the lagged value of the immigration share acts as information to potential immigrants about Australia's policy towards immigration. Accordingly, we assume that the selection process or the immigrants' decision to enter Australia is governed by the following relationship:

$$\Delta(I/P)_t = \gamma\Delta(I/P)_{t-j} + \mu_t \tag{4a}$$

where j is the lag between the decision to apply to immigrate, or setting the immigration policy at time $(t-j)$, and actual entry at time t.

One problem with our choice of instrument could be that it does not capture the decision of every immigrant and, hence, that it explains only a part of the variation of the proportion of immigrants at time t. It follows that our IV should be interpreted as reflecting an estimate of a specific group – *viz*., those migrants whose behaviour is influenced by the instrument (Imbens & Angrist, 1994). In the present context, that subset of migrants is likely to be dominated by relatively skilled workers if the possession of skill is an indication of a worker's inclination and ability to acquire and process job-relevant information.

The use of time-series data at the national level avoids any (downward) bias that could be attributable to factor price equalisation and endogenous regional choice by migrants. However, it introduces a different bias toward zero: Immigrants tend to come to countries when labour market outcomes are favourable. Other potential instruments that can affect the migration decision and that are related to labour market outcomes include the unemployment rate. This indicator could be particularly relevant for those migrants who are desperately looking for jobs. Alternatively, labour market conditions may capture salient aspects of Australia's immigration policy. Australia is a growing and thriving economy with skill shortages in many areas. In order to alleviate the skill shortages the government may select immigrants on the basis of local labour market conditions. In that case, the selection process could be modelled by the following relationship:

$$\Delta(I/P)_t = \gamma\omega U_{t-j} + \upsilon_t \tag{4b}$$

where ωU is the weighted average of antecedent unemployment rates, and ω is the weight. Since the immigration process from the time of the decision to migrate until the time of arrival takes considerable time, we select $j = 6$ in our quarterly data. The weight is taken over the six-quarter period (time $t-j$ is the weighted average of the $t-j-1$, $t-j-2$, ... $t-j-6$ periods). This specification is similar to Pischke and Velling (1997) and Dustmann *et al*. (2005).

It is possible and, indeed, plausible that the pull of family or of the 'diaspora' influences the choice of destination country. Immigrants may apply to Australia because relations and friends

[5] While immigration policy is generally described as a policy that balances social, economic, humanitarian and environmental objectives, it is ultimately the government that sets the rate – presumably keeping also in mind labour market conditions and other considerations relevant to potential migrants.

[6] The instrumentation is also useful if the error term in Equation (3) is correlated over time.

already live here or because of the presence of individuals with similar cultural and linguistic backgrounds. Therefore, a possible solution to the endogeneity problem is to use measures of historical settlement patterns as instruments for immigration inflows. Our use of the lagged immigrant share as an IV partly addresses this concern. However, family and 'diaspora' are not prominent drivers of immigrant flows to Australia (Islam & Fausten, 2007). Rather, the overwhelming impression from the available evidence is the variation over time in the pattern of immigration into Australia by source country and region. Moreover, in Australia the potential 'diaspora effect' is constrained by the points system. Skilled immigrants who satisfy those criteria typically prefer countries that offer better job prospects or more favourable immigration policies and labour market conditions. Family and cultural ties tend to be of lower orders of importance in selecting their destination country.

These considerations suggest that the decision of skilled foreign workers to migrate to Australia is based on past Australian immigration policy and on the prospective migrants' prospects for success in the Australian labour market. Accordingly, we use the past immigration rate and the past unemployment rate to model exogenous variations in the current immigration rate. Schematically, the decision path is:

> Skilled (or unskilled) foreign worker → decides to leave home country → investigates labour market conditions and/or stance of immigration policy in potential host countries → selects host country (Australia) → applies to host country (Australia) for immigration (→ gets visa → arrives in Australia → looks for job → earns wage).

The exclusion restriction implied by our IV regression is that, conditional on the controls included in the regression Equation (3), the six-quarter lagged unemployment and immigration rates have no effect on today's earnings growth other than through their effects on immigration. One concern with the exclusion restriction is that the historical (past) unemployment rate may have a direct effect on the current wage rate which may attract immigrants to Australia. To capture this effect we should include among the explanatory variables a measure of the effect of the past unemployment rate on the wage level received by immigrants. However, we are measuring the growth of wages, as opposed to their level, at time t, and the historical unemployment rate is unlikely to exert a prominent influence on current wage increases. The same considerations apply to the policy variable – the past immigration rate. Therefore, the implied exclusion restrictions are plausible. Since we are dealing with aggregate time-series data at the national level we do not need to worry about internal migration by natives in response to immigration inflows and subsequent changes in labour market outcomes. This concern arises when dealing with single cross-section data or local labour market situations (Pischke & Velling, 1997; Dustmann *et al*., 2005; Hatton & Tani, 2005; Borjas, 2006).[7]

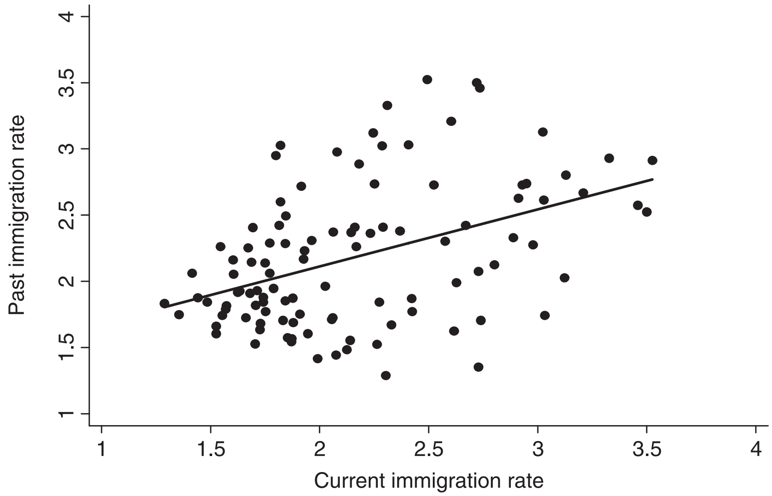
Figure 1 shows a strong positive relationship between the past (six-quarter lagged) immigration rate and its current level. The visual impression is confirmed by a statistically significant positive correlation coefficient relating current to past immigration rates. This strong association corroborates our conjecture that the relationship between wages and the immigration rate is influenced by the antecedent immigration policy and the state of the labour market. Without consideration of that endogeneity the relationship between wage growth and the immigration rate might be obscured by changes in the immigration policy.

With two instruments for our single endogenous regressor we estimate Equation (3) using two-stage least-squares (2SLS).[8] It is expected that the 2SLS estimates improve efficiency relative to OLS and provide better control for earnings growth. We account for possible serial correlation by computing Huber-White standard errors. In the presence of over-identifying restrictions it is sometimes useful to obtain a more efficient estimator when serial correlation may be present by applying the generalised method of moments (GMM) conditions (Hansen, 1982). Since our 2SLS with robust standard errors is *de facto* a GMM estimator we need not conduct separate GMM estimation as this may generate only small additional gains. Moreover, given that GMM is subject to small sample bias it

[7] One assumption we maintain here is that native skilled workers are not emigrating from Australia in response to the arrival of skilled immigrants. It is, however, possible that the overall gain in skilled workers to Australia from international labour movements may be obscuring significant losses amongst highly educated workers (see footnote 15).

[8] In this paper the term IV and 2SLS are not interchangeable. We refer to 2SLS estimates when we use multiple instruments, and to IV estimates in the case of a single instrument.

FIGURE 1
Relationship between Past and Current Immigration Rates, Australia: 1980–2006



Notes: Current immigration rate is the number of immigrants per one thousand adult (15–64 years of age) Australian population at time *t*. Past immigration rate is the six-quarter lag of the migration rate.
Source: Australian Bureau of Statistics.

would not seem appropriate to apply this estimator in the present context.[9]

III Data and Descriptive Statistics

Quarterly skill-based immigration data (Overseas Arrivals and Departures 3401.0) for the period 1980–2006 were obtained by special request from the ABS. The net immigration rate is expressed as the total number of immigrants in a given quarter per 1000 adult (15–64 years of age) Australians in that quarter.[10] It represents the arrival of migrants who have been granted the right to live permanently in Australia. Measuring skilled migrant flows is problematic because the Department of Immigration and Citizenship (DIC) records inflows by visa type. Visa categories do not map directly into the general skill classifications. The DIC defines skilled migrant workers as those people who have skills in particular occupations that are required in

[9] One problem with our specification (Eqn 3) is that we may be estimating short-run effects as opposed to long-run effects of skilled (or unskilled) immigration and differencing eliminates the long-run effect. Many authors (e.g. Pischke & Velling, 1997; Friedberg, 2001) have estimated the same type of equation for examining the labour market impact of immigration. An additional problem with level of wage as opposed to change in wage as the dependent variable is that variables with high persistence over time (such as weekly wage) will have very low correlation between the flow variable (immigration rate) and the level variable (wage). This problem of weak instruments can lead to substantial bias in finite samples.

[10] The 'net immigration rate' usually applies to persons born outside Australia but it may also apply to a small number of persons born inside Australia to parents who are foreign nationals. Note that the migration rate used here differs from the 'net migration' rate as the data did not include individuals departing Australia. According to the Productivity Commission report (2006), in recent decades there has been a significant movement of people from Australia on a long-term basis. But this proportion is relatively small for the Australian-born population. A significant share of emigrants consists of former permanent settlers and overseas visitors returning to their home countries. Moreover, a large number of Australian residents are also returning home every year from extended stays abroad. So, net Australian-born emigration is relatively low. Casual observation suggests that many Australian-born high skilled workers emigrate because of the relatively compressed domestic wage structure. However, to the extent that Australian-born and permanent residents are emigrating in response to the inflow of permanent migrants into Australia, our estimates will provide an upward bound of the true effects of immigration.

Australia. These occupations are identified in the skilled occupation list. The demand list contains a list of domestic occupations and specialisations for which there is a continuing national shortage. In order to match migrants with the skill classification system, we classify skill in terms of the occupation of immigrants recorded on their landing cards at the time of their first entry into Australia. Since most of the visas granted by Immigration Australia under the skilled category fall under the general skill stream there is substantial agreement between the two definitions. Our practice reflects a preference for defining skill in terms of generic attributes of migrants rather than temporary labour market requirements in the host country. The migrant attributes provide a better guide to the extent of human capital inflow into the host country as well as to subsequent employment relations of immigrants.

The unemployment rate is the percentage of the labour force that actively seeks work but is unable to find work in a particular quarter. Nominal wage data include average weekly compensation paid during the calendar quarter to all employees in Australia, regardless of when the services were performed. Since time-series data for wages of native skilled and unskilled workers are not available for Australia, we use aggregate wages (representing the composite average wage of immigrants and natives) as the dependent variable in our regression. Labour productivity is defined as GDP (at constant prices) per hour worked. The measures of labour productivity are presented as indices and as rates of change.

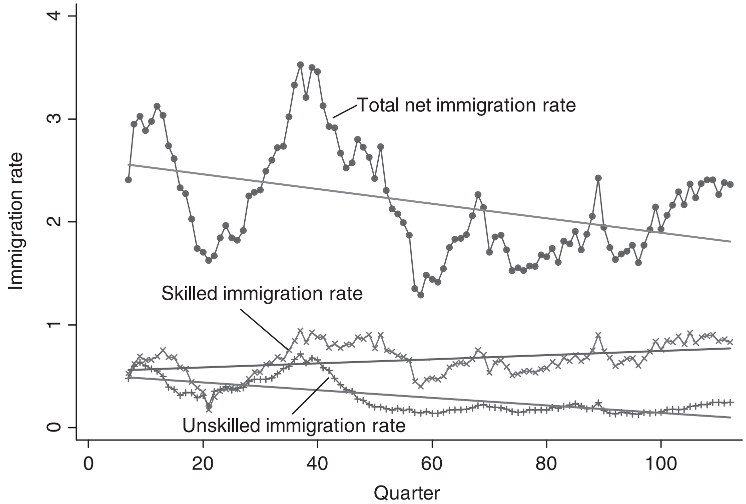
Table 1 provides descriptive statistics for the key variables of interest. The first two columns report the mean and standard deviation for the full sample. Average weekly wages of all workers have increased significantly over the observation period while unemployment has been declining. The average unemployment rate in recent years (2000–2006) is below the corresponding average over the entire observation period (Columns 7–8). The average change in the unemployment rate from its immediately preceding quarter is negative. Productivity is increasing over time. However, the average change in productivity, or productivity growth, of a given quarter compared to its immediately preceding quarter has slowed in 2000–2006 compared to 1990–1999. The immigration rate is relatively volatile (Figure 2). It declined from a relatively high level of 2.5 in the initial period to 1.8 in 1990–1999. However, the number and proportion of new immigrants have increased again in recent years to an average rate of 2.0 though

TABLE 1
Descriptive Statistics of the Key Variables

	1980–2006		1980–1990		1991–1999		2000–2006	
Variables	Mean	Standard deviation	Mean	Standard deviation	Mean	Standard deviation	Mean	Standard deviation
Average weekly wages per quarter	683.4	208.3	457.5	71.2	694.5	68.0	956.4	84.9
Quarterly Unemployment Rate	7.71	1.58	7.84	1.28	8.80	1.23	5.99	0.61
Immigration rate per 1000 Australian	2.1093	0.5166	2.505	0.5822	1.8235	0.343	2.0144	0.2705
Skilled immigrants	0.666	0.162	0.641	0.197	0.611	0.106	0.772	0.101
Unskilled immigrants	0.294	0.162	0.458	0.132	0.179	0.023	0.187	0.040
Productivity	83.87	10.19	73.28	1.69	83.68	5.05	97.70	2.86
Change in productivity	0.342	0.424	0.194	0.451	0.492	0.316	0.316	0.467
Growth of weekly wage of all workers in a quarter	8.21	3.21	7.92	1.89	6.19	2.47	11.48	2.87
Change in unemployment rate	−0.038	0.288	−0.032	0.355	−0.026	0.294	−0.061	0.166

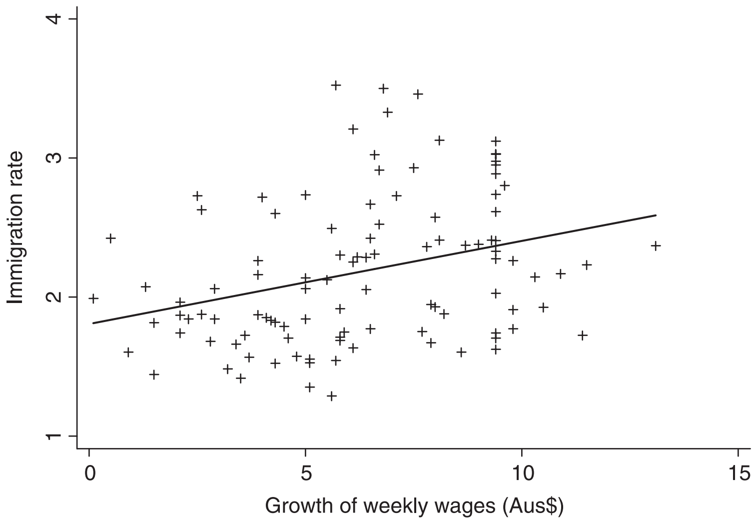
Notes: Skilled and unskilled migration rates represent the share of each migration category in total migration. A large number of immigrants did not reveal their occupation at their country of origin during their first entry into Australia, so skilled and unskilled immigration rates do not add up to the total migration rate.

FIGURE 2
Skilled and Unskilled Migration Rates in Australia



Notes: Migration rate in a given period is the number of immigrants per one thousand adult (15–64 years of age) Australian population for that period. Skilled and unskilled migration rates are the shares of each migration category in total migration. A large number of immigrants did not reveal their occupation at their country of origin during their first entry into Australia, so skilled and unskilled immigration rates do not add up to total migration rate.
Source: Australian Bureau of Statistics.

FIGURE 3
Relationship between Wages and Immigration Rates, Australia: 1984–2006



Notes: The growth of weekly wages is the change in the average weekly wage between adjacent quarters. The immigration rate is the number of all (skilled and unskilled) immigrants per thousand adult (15–64 years of age) Australian-born population.
Source: Australian Bureau of Statistics.

the rate is yet to match its 1980 level (Table 1). The proportion of skilled migrants has increased continuously over the observation period. On average, Australia received 2.3 skilled migrants for every unskilled migrant. That ratio has increased almost threefold over the observation period, rising from 1.4 in the 1980s to 3.4 in the 1990s and to 4.1 in the most recent period. Immigrants who were not of working age or did not adequately describe their occupational status at the time of arrival were not classified as either skilled or unskilled but were included in the total immigration rate.

Figure 3 shows a positive but not very strong relationship between earnings growth in Australia and the immigration rate. A bi-variate regression analysis confirms that this relationship is not statistically significant. In the next section, we examine whether this apparent relationship represents any causal effect of immigration on wages or whether it is merely a statistical association.

IV *Estimation Results*

(i) Ordinary Least Squares Regression

The top Panel of Table 2 reports the OLS results from regressing growth of weekly wages on each type of immigration rate, with and without controlling for changes in unemployment and productivity growth (Eqn 3).[11] In Columns 1, 4 and 7 we consider the immigration rate as the sole covariate. Columns 2, 5 and 8 control for the change in the unemployment rate but exclude productivity. Columns 3, 6 and 9 report results using the full set of covariates.

Overall, the results indicate that the immigration rate has a consistently significant positive effect on wages, irrespective of specification. The first three columns show that total immigration exerts a highly significant (1 per cent level) impact on wages in the Australian labour market. A one unit change in the immigration rate changes the growth of the average weekly wage in a particular quarter by AD\$1.55–\$1.67. In terms of percentages, a 10 per cent increase in the immigration rate is associated with a 1.9–2.0 per cent rise in the average wage of all workers.[12] The following two sets of three columns show that this qualitative finding applies to both component groups, skilled and unskilled migrants. The magnitude of the effect is consistently larger (approximately double) for skilled migrants than for total migrants, but the level of significance is lower (Columns 4–6). The effect on wage changes is stronger in the case of unskilled migrants than skilled migrants, and the coefficients corresponding to unskilled migrants are statistically significant at the 1 per cent level (Columns 7–9). Note also that in all three alternative specifications the magnitude of the coefficient of the immigration rate diminishes as we control for both changes in the unemployment rate and productivity growth. But the coefficients and the sign of the relationship remain stable and significant.

(ii) Reduced Form Estimates

Based on our previous specifications, we run the following reduced-form regression:

$$\Delta W_t = \alpha_0 + \alpha_1 \Delta (I/P)_{t-6} + \alpha_2 \omega U_{t-6} + \alpha_3 \Delta U_t + \alpha_4 \times \Delta prod_t + \zeta_t \quad (5)$$

The reduced-form results for the total immigration rate presented in Table 3[13] produce a fairly strong relationship between the instrument and changes in wages. The first two columns of the Table suggest that the past immigration rate and past unemployment rate each have statistically significant effects on wages growth, and that the instruments are not weak. The signs of the coefficient estimates suggest that the past immigration rate has a positive effect, while the past unemployment rate has the opposite effect on wage growth. These results indirectly support the conjecture about the endogeneity of immigration as immigration policy and labour market outcomes are potentially important determinants of the migration process. When we use both instruments in the reduced-form equation (last column, Table 3), the past immigration rate yields a statistically insignificant positive effect on the wage variable (t-ratio = 1.44). This implies that controlling for the past unemployment rate reduces the importance of the past immigration

[11] We examine changes in wages as opposed to the log specification because changes in wages between quarters are sometimes zero. In a log specification, the results can be fairly sensitive to how we deal with zero values.

[12] Since we are using level as opposed to log of the change in wages as the dependent variable, we need to divide the coefficient estimates by the mean value of the dependent variable to get the results in terms of percentages.

[13] Since the results for the skilled and unskilled immigration rates are similar we do not report both here for brevity. They are available from the authors.

TABLE 2
OLS and IV Estimates of the Effects of Immigration

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Total immigrants			Skilled immigrants			Unskilled immigrants		
Panel A: ordinary least squares (OLS) estimates									
Net immigration rate	1.66	1.67	1.55	3.6	3.55	3.18	4.22	4.27	3.89
	(0.39)*	(0.39)*	(0.40)*	(1.77)**	(1.78)**	(1.75)***	(1.30)*	(1.30)*	(1.38)*
Change in unemployment rate		–0.093	0.011		0.116	0.23		0.572	0.635
		(0.970)	(0.963)		(1.038)	(1.017)		(0.877)	(0.875)
Change in productivity			–0.477			–0.566			–0.537
			(0.297)			(0.297)***			(0.312)***
R^2	0.1	0.1	0.12	0.04	0.04	0.07	0.06	0.06	0.08
Panel B: instrumental variable (IV) estimates									
Net immigration rate	2.65	2.98	2.91	5.97	6.15	6.24	6.66	6.06	5.81
	(1.08)**	(1.23)**	(1.29)**	(3.66)	(3.89)	(3.78)	(1.97)*	(1.61)*	(1.71)*
Change in unemployment rate		–0.543	–0.476		–0.151	–0.096		0.61	0.668
		(1.134)	(1.147)		(1.193)	(1.191)		(0.860)	(0.856)
Change in productivity			–0.32			–0.48			–0.479
			(0.345)			(0.334)			(0.319)
R^2	0.1	0.1	0.12	0.04	0.04	0.07	0.06	0.06	0.08

Notes: The dependent variable in each regression is the growth in weekly wages in a given quarter. Each column in each panel represents a separate regression which also includes a constant term: in (1), (4), (7) the immigration rate is the sole regressor; (2), (5), (8) control for the unemployment rate; (3), (6) and (9) include also productivity growth. The migration rate in a given period is the number of immigrants per 1000 adult (15–64 years of age) Australian population for that period. Skilled and unskilled migration rates are the share of each migration category in total migration. Because a large number of immigrants did not reveal their occupation at their country of origin during their first entry into Australia, the entries for skilled and unskilled immigration rates do not add up to total migration rate. Huber-White standard errors in parentheses. *** Significant at 10%; ** significant at 5%; * significant at 1%.

TABLE 3
Reduced Form Estimates

	(1)	(2)	(3)
Change in unemployment rate	–0.338	–0.084	–0.484
	(0.921)	(0.848)	(0.838)
Change in productivity	–0.613	–0.631	–0.594
	(0.294)**	(0.287)**	(0.279)**
Six-quarter lag immigration rate	1.205		0.576
	(0.431)*		(0.399)
Six-quarter lag unemployment rate		–0.892	–0.827
		(0.150)*	(0.158)*
R^2	0.08	0.22	0.22

Notes: The dependent variable in each regression is the growth in weekly wages in a given quarter. Each column represents a separate regression which also includes a constant term. Past unemployment rate and past immigration rate are six-quarter lags of the respective variable. Huber-White standard errors in parentheses. *** Significant at 10%; ** significant at 5%; * significant at 1%.

rate in determining current wage growth. Though the magnitude of the immigration rate coefficients falls to less than half, they remain at an economically significant level. However, the reduced-form estimates in Columns 1 and 2 are each statistically significantly different from zero and therefore they support the presumption that the immigration rate without the controls does exert a systematic influence on changes in wages in Australia (Angrist & Krueger, 2001).[14]

(iii) IV Estimates

Panel B of Table 2 reports the results of IV estimations when the past immigration rate – a proxy for the policy variable – is used as an instrument. The first-stage results reported in Table 4 suggest that the selected instruments are not weak, and that their use carries no potential bias. In the second stage of IV estimation we run a regression of Equation (3) where the immigration rate, $\Delta(I/P)_t$, is replaced by its fitted value obtained from the first-stage. The IV estimates display some qualitative similarities with the OLS estimates in panel A. One notable difference is that in the IV estimates the sign of the unemployment rate changes when explaining the effect of skilled migrants. The magnitude of the coefficients of the total immigration rate and unskilled immigration rate is significantly larger in the IV estimations (Columns 1–3 and 6–9). We reject the hypothesis that the OLS and IV coefficients are the same on the basis of standard Hausman Test results (i.e. the difference in coefficient estimates using OLS and IV are systematic). The coefficients of the skilled migration rate become statistically insignificant, suggesting that the endogeneity bias is more effective in the case of skilled migration but that the bias is quantitatively important in the case of unskilled and total migration rates.

Table 2 shows that the total immigration rate has a positive and statistically significant (at the 5 per cent significance level) impact on current wages growth as does the rate of unskilled immigrants. However, the statistical significance of the IV estimates deteriorates sharply when we estimate the effects of skilled immigration on wages growth. None of the three specifications suggests that the rate of skilled immigrants has a statistically significant effect on domestic wages growth. Overall, the evidence suggests that skilled immigration does not exert a robust influence on wages growth in the Australian labour market. This result also indicates that we need to take the endogeneity of the immigration rate into account.

(iv) 2SLS Estimates

We now consider both instruments, the past immigration rate and the past unemployment rate, simultaneously. The first stage involves regressing the immigration rate on all predetermined variables. The estimates are presented in panel A of Table 5.

[14] In general, there need not be any relationship between significance of the reduced form and the significance of 2SLS estimates. However, we need a strong first-stage to ensure that we are not using a weak instrument. The standard IV/2SLS estimator $(z'x)^{-1}z'y$, with dependent variable (regressor) x, and instrument z, breaks down when $z'x$ is near singular while it does not when $z'y$ approaches zero.

TABLE 4
First-Stage Regression: Immigration Decision

	(1)	(2)	(3)	(4)	(5)	(6)
Change in unemployment rate†		0.023 (0.161)		0.166 (0.146)	0.17 (0.16)	0.514 (0.133)*
Change in productivity†			–0.376 (0.097)*	–0.399 (0.095)*	–0.419 (0.096)*	–0.48 (0.114)*
Past immigration rate	0.539 (0.076)*	0.534 (0.099)*	0.518 (0.071)*	0.483 (0.089)*	0.389 (0.090)*	
Past unemployment rate†	0.116 (0.038)*	0.116 (0.038)*	0.112 (0.035)*	0.113 (0.035)*		0.056 (0.030)***
Hansen's J-statistic (over-identification test)	[P = 0.31]	[P = 0.281]	[P = 0.260]	[P = 0.33]		
F-test of joint significance of instrument set	[P = 0.00]	[P = 0.00]	[P = 0.00]	[P = 0.00]		
Shea's partial R^2	0.2983	0.27	0.313	0.259		
Wu-Hausman F-test	[P = 0.061]	[P = 0.076]	[P = 0.109]	[P = 0.092]		
Durbin–Wu-Hausman χ^2-test	[P = 0.059]	[P = 0.071]	[P = 0.103]	[P = 0.085]		
Sargan statistic (over-identification test of all instruments)	[P = 0.368]	[P = 0.358]	[P = 0.351]	[P = 0.434]		
Value of F-statistic (for instruments)	24.3	14.5	25.7	13.9		
R^2	0.3	0.3	0.39	0.4	0.33	0.21

Notes: The dependent variable in each case is the current immigration rate. Each column represents a separate regression which also includes a constant term. Past unemployment rate and past immigration rate are six-quarter lags of the respective variable. Huber-White standard errors in parentheses. *** Significant at 10%; ** significant at 5%; * significant at 1%.
† Coefficient estimates are multiplied by 1000.

The exclusion restrictions are that the instruments do not appear in Equation (3).

2SLS estimates do not generate any compelling evidence that skilled immigrant flows exert a systematic effect on domestic wages growth. The total immigration rate is statistically significant (at the 10 per cent level) in the first two specifications (Columns 1 and 2). But its explanatory power vanishes in the full covariate specification of the wage equation, that is, when changes in the unemployment rate and productivity are included in the estimation. Estimates with the unskilled immigration rate display a statistically significant effect on wage change while none of the skilled immigration rate specifications generate any statistically significant effects at the conventional level. The coefficient estimates of the unskilled migration rate indicate that a 10 per cent increase in the immigration rate will result in wage growth of about 6 per cent.

IV and 2SLS estimators are popular and have been used extensively in the literature. Even though they may be consistent, several recent studies (e.g. Bound *et al*., 1995; Staiger & Stock, 1997) point out that the finite sample properties of both estimators can be very poor, especially when the sample size is very small or the instruments are weak. Often very large samples are needed for the asymptotic properties to yield good approximations. Both IV and 2SLS estimates are biased towards the probability limit of OLS estimates.

(v) Jackknife IV Estimates (JIVE)

The 2SLS estimator can also suffer from bias that is exacerbated when the instruments are only weakly correlated with the endogenous variable and when many instruments are used. In such situations JIVE (see Angrist *et al*., 1999) performs better than 2SLS. JIVE estimators eliminate the correlation between the first-stage fitted values and the structural error term that causes the traditional 2SLS estimator to be biased. Angrist *et al*. have shown that under certain forms of misspecification the JIVE estimator may have less bias than limited information maximum likelihood. It is also a useful alternative in applications when there is concern about the number of instruments. So we check the robustness of the earlier results using JIVE.

Panel B of Table 5 shows the results obtained with JIVE. The signs of the immigration rate in all three variants are consistent with those

TABLE 5
2SLS and JIVE Estimates of the Effects of Immigration

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Total immigrants			Skilled immigrants			Unskilled immigrants		
Panel A: two stage least square (2SLS)									
Net immigration rate	1.82	1.9	1.75	–0.49	–2	–1.94	5.14	5.23	4.95
	(1.00)***	(1.02)***	(1.07)	(3.61)	(3.98)	(3.80)	(1.98)*	(1.62)*	(1.70)*
Change in unemployment rate		–0.171	–0.062		0.688	0.775		0.593	0.653
		(1.005)	(1.007)		(0.934)	(0.919)		(0.856)	(0.848)
Change in productivity			–0.453			–0.711			–0.505
			(0.319)			(0.314)**			(0.311)
R^2	0.1	0.09	0.11	0.02	0.02	0.03	0.05	0.05	0.07
Panel B: Jackknife instrumental variable estimates (JIVE)									
Net immigration rate	1.86	2.15	2.05	–1.3	–2.97	–3.26	5.2	5.28	5.02
	(1.14)	(1.32)	(1.52)	(4.13)	(4.99)	(5.20)	(2.03)**	(1.65)*	(1.74)*
Change in unemployment rate		–0.258	–0.168		0.787	0.916		0.594	0.654
		(1.066)	(1.102)		(0.966)	(0.969)		(0.856)	(0.848)
Change in productivity			–0.419			–0.748			–0.503
			(0.345)			(0.332)**			(0.311)
Observations	106	106	106	106	106	106	106	106	106
R^2	0.1	0.09	0.11	0.02	0.02	0.03	0.05	0.05	0.07

Notes: The dependent variable in each regression is the growth in weekly wages in a given quarter. Each column in each panel represents a separate regression which also includes a constant term. Migration rate in a given period is the number of immigrants per 1000 adult (15–64 years of age) Australian population for that period. Skilled and unskilled migration rates are the share of each migrant category in total migration. A large number of immigrants did not reveal their occupation at their country of origin during their first entry into Australia, so skilled and unskilled immigration rates do not add up to total migration rate. Huber-White standard errors in parentheses. *** Significant at 10%; ** significant at 5%; * significant at 1%.

obtained from 2SLS estimates. The coefficient estimates for the total and skilled immigration rates are positive and negative, respectively. But they are statistically insignificant. Unskilled workers continue to exert a statistically significant positive effect on wage growth. The magnitude of the coefficients for the unskilled migration rate is similar to those obtained using 2SLS estimate. The point estimates suggest that a 10 per cent rise in the immigration rate increases Australian wages by about 2.2–2.5 per cent.[15] With the exception of the initial, and contentious, OLS regressions these findings reveal a persistent lack of robust evidence that skilled immigration affects wages growth in Australia, positively or adversely.

(vi) Tests for Validity of Instruments

Weak instruments tend to bias 2SLS estimates toward OLS estimates and may weaken standard tests for endogeneity. The existing econometric literature defines weakness of instrument based on the strength of the first-stage equation (Staiger & Stock, 1997; Stock & Yogo, 2005). Accordingly, we test the relevance and validity of the instruments. Specifically, we test whether the IVs are correlated with the endogenous regressor and orthogonal to the error process. We test the first condition by examining the fit of the first stage reduced-form regression of the immigration rate on the full set of instruments – both included and excluded instruments – for the 2SLS. We use the F-test of the joint significance of the excluded instruments in the first stage regression. The F-test rejects the null that the instruments are jointly insignificant (Table 4). The instruments are both individually significant as is evident from the first stage reduced-form regression coefficient estimates and the corresponding standard errors shown in Table 4.

We further check the relevance of instruments using a 'partial R^2' measure proposed by Shea (1997) that takes inter-correlations among the instruments into account. We also use a commonly used statistic – the partial R^2 of the regression of endogenous variables on the excluded set of instruments (Bound *et al.*, 1995). With a single instrument Shea's partial R^2 and the usual partial R^2 measures should be the same. But with multiple endogenous variables the two statistics should be different (Baum *et al.*, 2003). Shea's partial R^2 ranges from 0.25 to 0.31 in our four models. Thus, our instruments pass both the criteria recommended by Bound *et al.* (1995) and Shea (1997). We also test the over-identification problem using the common J-statistic of Hansen (1982). Under the null hypothesis of orthogonality we cannot reject it in all cases (Table 4). This confirms that the instruments are truly exogenous. This conclusion is corroborated by Sargan's (1958) statistic which is a special case of Hansen's J under the assumption of conditional homoskedasticity. We also adopt the general Hausman (1978) test of endogeneity. Under the null hypothesis that OLS is an appropriate estimation technique, we reject the null and conclude that the immigration rate is indeed endogenous (Table 4).

V Discussion and Interpretation of the Results

After correcting for the endogeneity of the immigration rate comparison of the OLS estimates with the 2SLS and JIVE results indicate:

- coefficient estimates of the skilled migration rate using 2SLS and JIVE are absolutely smaller and statistically insignificant compared to OLS;[16]
- for comparable levels of statistical significance the OLS estimates of the unskilled migration rate coefficients are downward biased.

As a robustness check, we also experiment with a specification that includes both skilled and unskilled migration rates as covariates in the same equation using the full set of instruments. The resulting coefficient estimates capture the partial effect of the skill categories. The results, not reported here, are similar. For the skilled migration rate the coefficient estimates become positive (t-ratio = +2/2.8 = 0.71) but OLS estimates remain upward

[15] We also experiment with GMM estimates. The results are qualitatively similar to those of JIVE and 2SLS estimates. They are available from the author.

[16] The results for the skilled migration rate using a single instrument are different in sign and magnitude from those obtained with multiple instrument 2SLS and JIVE estimates. This is not unusual in the IV literature. For example, Friedberg (2001) finds that the effects of immigration are opposite to those of OLS estimates once the immigration rate is instrumented. The divergence between results using single and multiple instruments for skilled migration is probably a combination of weak instrument and small sample problems. In particular, skilled migrants are probably less likely to be induced to take migration decision by looking at past immigration policy. Rather they look at the labour market characteristics. So we argue that the endogeneity issue, especially for skilled migration, is better dealt with using 2SLS/JIVE. We therefore focus on the OLS, 2SLS and JIVE estimates.

biased. This supports our conclusion drawn from the 2SLS/JIVE estimates. We conclude that OLS estimates tend to exaggerate the effects of skilled migrants on wages. Once endogeneity is taken into account there is no compelling evidence that skilled immigrants systematically affect wage growth in Australia. The results for the unskilled migration rate do not change either – OLS continues to underestimate the true effect.

Even though our results are consistent with other findings, it is helpful to understand why and how this might be the case. Since OLS estimates are smaller than the estimates that take endogeneity into account, skilled migration is subject to positive selection. If high ability individuals migrate to Australia, then the omitted ability characteristic affects both earnings capacity and the immigration decision. Hence, our results conform to the theoretical prediction. Positive selection implies that skilled immigrants can choose to enter high wage occupations (since skills are classified by occupation). It follows that a positive correlation may exist between earnings potential in Australia, general talent and skilled migration. Shortages of skilled workers in Australia suggest that skilled immigrants can readily find work. Accordingly, immigrants with very high expected returns to skill are likely to migrate to Australia if skills in the source country are correlated with skills valued in Australia. These results could also hold if high-skilled workers get jobs in the skilled labour market while relatively less-skilled migrants switch to unskilled professions or out-migrate from Australia.

The estimation results for unskilled migrants suggest negative selection since OLS estimates are lower than the instrumented migration rate coefficients. The difference between OLS and IV estimates could reflect the fact that a disproportionate share of immigrants enters unskilled occupations if, for instance, the host country is relatively attractive to low earning workers.[17] For example, moderately skilled immigrants may choose to migrate to Australia as unskilled migrants if they expect above average labour market outcomes or labour market outcomes that are superior to those available in other potential destination countries. This could indicate a considerable earnings premium in Australia for unskilled migrants. Relatively high minimum wages in Australia compared to similar immigrant receiving countries (USA and Canada) render this conjecture plausible. By 'subsidising' low skill, the wage structure in Australia attracts low-skill workers from abroad. In other words, low-skill workers want to migrate to take advantage of the 'insurance' provided by Australia, and by migrating to Australia rather than elsewhere they receive an 'earnings premium'. The possibility of coexistence of earnings premia with negative selection has been noted by Kugler and Sauer (2005) in the context of occupational choice by immigrants to Israel.

Alternative explanations of these results involve measurement errors in OLS estimates attributable, for example, to misclassification of immigrants into the unskilled category. Or skilled migrants work as unskilled workers after migrating to Australia because of onerous labour market requirements for skilled workers or, for that matter, language and other barriers or because the wage structure favours unskilled workers. Alternatively, greater opportunities for outside earnings in the unskilled sector compared to elsewhere could motivate such behaviour. However, measurement errors alone are unlikely to account for the entire difference in the estimates. The divergence between OLS and 2SLS/JIVE estimates is therefore likely to involve the endogeneity bias. Our results, however, allow for the possibility that the effect of immigration on wages can vary substantially depending on the type of migrant labour.[18]

The absence of a negative overall impact of immigration on wage growth could be attributable to the configuration of demand and supply elasticities in the Australian labour market (highly inelastic domestic labour supply and highly elastic labour demand). Our findings suggest the possibility of complementarity between Australian-born workers

[17] Wu *et al*. (2007) find that immigrants to Australia, especially those coming from non-western regions, are channelled into inferior jobs post migration. Chiswick and Miller (2007) document that the limited international transferability of human capital results in immigrants being channelled into relatively low status occupations when they first enter the Australian labour market.

[18] One notable limitation of 2SLS estimates is that it uses only a part of the variation in immigration rates that is induced by the instrument(s) (those who decide to migrate to Australia on the basis of her immigration policy or labour market outcome) whereas OLS estimates use all variation (Imbens & Angrist, 1994). If the marginal effects of immigration vary between those induced by the instruments and those who are not, then the estimated average effect of immigration will differ. However, as noted above, 2SLS estimates are an improvement over OLS estimates as we take the selection bias into account in the former. Moreover, IV estimates are consistent while OLS estimates may be biased.

and immigrant workers. This complementarity is stronger in the case of unskilled workers. Our results suggest that skilled migrants are either substitutes or complements to native workers. It is possible, for example, that assignment of unskilled immigrants to relatively basic jobs or supportive roles releases Australians to work on the more productive aspects of the job. By way of illustration, Friedberg (2001) and Kugler and Sauer (2005) point out that in Israel Russian doctors – even those with considerable prior experience and earnings – filled positions at the lower end of the job ladder, pushing Israelis up the ranks into more supervisory, high-paying roles. Anecdotal evidence supports this adjustment in the context of Australia. Informal observation, for example, of retail workers, hospitality service workers, office clerks, and others reveals that many unskilled immigrants often perform lower-level work, with Australian-born workers concentrated in more supervisory roles.

VI Conclusion

This paper examines empirically the implications for labour market outcomes in host countries of the increasing skill intensity of cross-border migration flows. It recognises the heterogeneous nature of the pool of immigrants and the recent thrust of Australian immigration policy to promote skill-intensive immigration patterns. The empirical estimations are based on a wage equation that takes into account macroeconomic aspects of the economy. Potential endogeneity problems due to selection and self-selection of immigrants are addressed by using various IV approaches that exploit the information content of antecedent immigration policy and labour market outcomes. The contrast between OLS and different versions of the IV models suggests that the immigration rate is not independent of unobserved determinants of wages. Comparing OLS estimates with the 2SLS and JIVE estimates provides evidence of negative selection for unskilled migrants. We also find evidence of positive selection in the case of skilled migrants reflecting the fact that they can choose to go to relatively high wage occupations. However, other consideration such as measurement errors could help to account for our results, and more research is needed to resolve these issues.

Our main finding is that there is no robust evidence that immigration exerts discernible adverse consequence on wages in the Australian labour market. Our examination of the skill composition of migration flows supports the many prevailing empirical findings that increasingly skill-intensive immigration need not cause labour market outcomes of native workers to deteriorate. In fact, there is some evidence that overall immigration may exert positive effects on wages in Australia.

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