Unemployment Dynamics in a Flow Model of the Australian Labor Market

G. D. Leeves[a] **and R. D. Herbert**[b]

[a] *University of Queensland, Department of Economics, Brisbane, Qld, 4072, Australia (g.leeves@economics.uq.edu.au)*

[b] *School of Business, The University of Newcastle, Ourimbah, NSW, 2258, Australia (ric.herbert@newcastle.edu.au)*

Abstract: The paper devlops an empirical model of the Australian labor market to assess the impact of supply shocks on employment and unemployment. The model is calibrated by using actual gross labor market flow data for Australia combined with estimates of job destruction and job creation. Simulation experiments are conducted through impulse response analysis. An asymetric response of employment and unemployment to adverse shocks is a feature of the model.

Keywords: Labor market dynamics; Unemployment duration

1. INTRODUCTION

Recent research into the dynamics of labour markets has emphasized the significant volatility associated with the employment adjustment processes as evidenced by the relatively large flows of workers and jobs compared to the associated changes in stocks of employment and unemployment. The relative size of labour market flows and stocks in Australia and the cyclical and secular properties of flows have been well documented [Leeves, 1997]. However, most macro modelling of the Australian labour market focuses on the adjustment of stocks in the labour market [Stacey and Downes, 1995; Murtough, Pearson and Wreford, 1998; Downes and Bernie, 1999] which fails to recognise the extent of dynamics in the adjustment process. There has been an attempt to reconcile the stock and flow changes in the economy [Borland, 1996b] using a simple accounting type framework. As yet, there has been no modelling of the stocks and flows relationships to analyse the Australian labour market in a general equilibrium setting.

This paper will develop an equilibrium job search model that draws upon Gautier and den Butter [1997], den Butter and Gorter [1999] and der Linden and Dor [2001] and calibrates the model to Australian data to investigate the adjustment dynamics of the flows of jobs and workers between labour market states. Two models are used. First, there is a basic model (Model 1) that treats all flows of workers between the labour market states of unemployment, employment and not-in-the-labour force and the flows of jobs (job destruction and job creation) as exogenous. Then the model is extended (Model 2) by allowing job creation to be endogenously determined. This is achieved by including a wage determination and vacancy supply processes. The paper builds upon previous models in two ways. Firstly, we are more explicit about the timing of wage formation and vacancy supply. Secondly, we relax the assumption that firms exploit all profitable vacancies in each period, which assumes that there is no deviation from the equilibrium vacancy supply curve. We find that this produces dynamic effects in unemployment in response to adverse shocks that characterise the asymmetry observed in Australian unemployment rates [Bodman, 1997; Borland and Kennedy, 1998].

2. THE MODEL

There are four labour market stocks in the model; employment, unemployment, vacancies and not-in-the-labour-force. Flows of persons between these stocks are denoted as F_{XY} for the flow between x and y; so the flow of people from employment to unemployment is F_{EU}. Vacancy inflows and outflows, the flows of jobs, are denoted by VI and VO respectively. Following Gautier and den Butter [1997] the asset value of being employed is:

$$rW_E = w - \frac{F_{EU}}{E}[W_E - W_U] + \dot{W}_E \qquad (1)$$

where r represents the discount rate, w is the wage, W_E is the asset value of being employed, W_U is the asset value of being unemployed, F_{EU} is the flow of workers from employment to unemployment and E is the employment stock. The equivalent expression for the asset value of unemployment is:

$$rW_U = b + \frac{F_{UE}}{U}[W_E - W_U] + \dot{W}_U \qquad (2)$$

where b is unemployment benefits, expressed as a proportion of the wage level, and U is the unemployment stock. The asset value of a filled job is:

$$\begin{aligned} rW_F &= y - \frac{\pi_{qn}F_{EN} + \pi_{qu}F_{EU}}{E}[W_F - W_V] \\ &\quad -w - \tau + \dot{W}_F \qquad (3) \end{aligned}$$

where y is added value per worker, τ is a lump sum employers payroll tax. π_q is the probability of a quit occuring, which is multiplied by the associated wealth change due to the quit. Finally, there is the asset value of an unfilled vacancy

$$\begin{aligned} rW_V &= \frac{F_{UEV} + F_{NEV}}{V}[W_F - W_V] \\ &\quad -c + \dot{W}_V \qquad (4) \end{aligned}$$

where c are the fixed costs of a vacant job per period (posting a vacancy, searching for applicants and selecting them). The asset value of a vacancy is the probability that it will be filled multiplied by the associated change in wealth when the vacancy is filled less the fixed costs of a vacancy. The surplus of a match is shared between worker and employer according to the following Nash bargaining rule

$$\max_{w_i}\Omega(w_i) = [W_E - W_U]^{\beta}[W_F - W_V]^{1-\beta} \qquad (5)$$

If $\beta = 0.5$ then workers representatives (unions) and employers organisations are equally powerful. The first order maximisation condition for worker and employer surplus is

$$(1-\beta)(W_E - W_U) = \beta(W_F - W_V) \qquad (6)$$

Solving for w gives

$$w = \frac{\beta(y + c - \tau)\xi_0 + (1-\beta)b\xi_1}{r + (1-\beta)(\xi_2 + \xi_3) + \beta\xi_4} \qquad (7)$$

where

$$\begin{aligned} \xi_0 &= r + \frac{F_{EU}}{E} + \frac{F_{UE}}{U} \\ \xi_1 &= r + \xi_2 + \xi_3 \\ \xi_2 &= \frac{\pi_{qn}F_{EN} + \pi_{qu}F_{EU}}{E} \\ \xi_3 &= \frac{F_{UEV} + F_{NEV}}{V} \\ \xi_4 &= \frac{F_{UE}}{U} + \frac{F_{EU}}{E} \end{aligned}$$

w is increasing in y, c and b and decreasing in τ. Using (3) and (4) gives the equilibrium stock of vacancies as:

$$V = \frac{(F_{UEV} + F_{NEV})(y - w - \tau)}{c(r + \xi_2)} \qquad (8)$$

We assume that $\dot{W}_V = 0$, this implies that in equilibrium (steady-state) all profitable job opportunites are exploited by firms. Firms will advertise only the warranted amount of vacancies.

The central feature of the model is a dynamic Cobb Douglas matching process where a distinction is drawn between short-term ($U_S < 1$ year) and long-term ($U_L > 1$ year) unemployed.

$$F_{UEV,t} = c_m V_{t-1}^{1-\alpha}(U_{S,t-1} + \theta U_{L,t-1})^{\alpha} \qquad (9)$$

c_m represents the efficiency of the matching process, α is the parameter of the Cobb Douglas function and θ is a measure of the duration dependence; the escape probability from long-term unemployment. As with Gautier and den Butter [1997] there are various duration classes of unemployment, and there is an escape propability from short-term unemployed (π_S) and long-term unemployed (π_L). We allow for the escape probablilities to change over time. They are represented respectively by:

$$\begin{aligned} \pi_{S,t} &= \frac{UO_t}{U_{S,t-1} + \theta U_{L,t-1}} \qquad (10) \\ \pi_{L,t} &= \theta\pi_{S,t} \qquad (11) \\ \text{where } UO_t &= F_{UEV,t} + UO_{EX,t} \end{aligned}$$

Now, the inflow into unemployment for the first duration class is:

$$U_{1,t} = UI_t \qquad (12)$$

For subsequent duration classes, unemployemnt is given by:

$$\begin{aligned} U_{k,t} &= (1 - \pi_{S,t})U_{k-1,t-1} \qquad (13) \\ U_{S,t} &= \sum_{k=1}^{12} U_{k,t} \qquad (14) \\ U_{L,t} &= U_t - U_{S,t} \qquad (15) \end{aligned}$$

By definition the outflow of vacancies matched with unemployed is equal to the flow from unemployment to vacancies (job creation) in the time period, so that:

$$VO_{U,t} = F_{UEV,t} \tag{16}$$

Finally, the equations of motion that close the model are:

$$\begin{aligned}
V_t &= V_{t-1} + VI_t - VO_t & (17)\\
&= V_{t-1} + VI_t - VO_{U,t} - VO_{EX,t} & (18)\\
VI_t &= V_t - V_{t-1} + VO_{U,t} + VO_{EX,t} & (19)\\
U_t &= U_{t-1} + UI_t - UO_t & (20)\\
&= U_{t-1} + F_{EU,t} + UI_{EX,t} & \\
&\quad -F_{UEV,t} - UO_{EX,t} & (21)\\
E_t &= E_{t-1} + EI_t - EO_t & (22)\\
&= E_{t-1} + F_{UEV,t} + EI_{EX,t} & \\
&\quad -F_{EU,t} - EO_{EX,t} & (23)
\end{aligned}$$

The inflow to unemployment (UI) consits of job destruction F_{EU} and the residual UI_{EX}, a composite flow made up of inflows from employment not associated with job destruction and non-participants who register as unemployed. The outflow from unemployment (UO) consists of F_{UEV} the flow into employment associated with job creation and UO_{EX} which consists of inflows to employment not related to job creation and flows of workers from unemployment to outside the labour force. A similar breakdown can be applied to inflows and outflows to the other states.

Model 1, where job creation is exogenous, consists of equations 9, 10, 13, 14, 15, 18, 21 and 23. For the extended model, model 2, we endogenises job creation through the addition of dynamic equations for wages and vacancies.

Equations 7 and 8 determine the equilibrium setting of wages and vacancies following the Nash bargaining rule. We assume that this equilibrium setting occurs at each of the (discrete) time periods in the model, and that bargaining takes place on the previous data set. Thus the dynamic versions of equations 7 and 8 have w_t and V_t on the left-hand-side and the previous time period's stocks on the right-hand-side (i.e. E_{t-1}, V_{t-1} and U_{t-1}). To allow for the partial adjustment of vacancies to changes in the asset value of a filled job or an unfilled vacancy we add a multiplicative parameter, a ($0 < a \leq 1$) to equation 8. Further, we assume that there is a constant component (ω) to wages and the wage bargaining is concerned with a top-up component. The wage equation then becomes:

$$w_t = \omega + \frac{\beta(y + c - \tau)\xi_{0,t} + (1-\beta)b\xi_{1,t}}{r + (1-\beta)(\xi_{2,t} + \xi_{3,t}) + \beta\xi_{4,t}} \tag{24}$$

Table 1. Numerical values for baseline model (Number of persons/jobs x 1000) annual averages).

Variable	Value	Variable	Value
U	750	F_{EU}	600
E	8,600	UI_{EX}	2,100
V	75	UO_{EX}	2,500
θ	0.5	EI_{EX}	3,300
α	0.5	EO_{EX}	2,900
VI	600	τ	0.08
VO_U	200	w/y	0.8
VO_{EX}	400	b/ω	0.5
r	0.01	c/y	0.9
a	0.1	ω	0.3

where

$$\begin{aligned}
\xi_{0,t} &= r + \frac{F_{EU,t}}{E_{t-1}} + \frac{F_{UE,t}}{U_{t-1}}\\
\xi_{1,t} &= r + \xi_{2,t} + \xi_{3,t}\\
\xi_{2,t} &= \frac{\pi_{qn}F_{EN,t} + \pi_{qu}F_{EU,t}}{E_{t-1}}\\
\xi_{3,t} &= \frac{F_{UEV,t} + F_{NEV,t}}{V_{t-1}}\\
\xi_{4,t} &= \frac{F_{UE,t}}{U_{t-1}} + \frac{F_{EU,t}}{E_{t-1}}
\end{aligned}$$

The dynamic vacancies equation becomes:

$$V_t = \frac{a(F_{UEV,t} + F_{NEV,t})(y - w_{t-1} - \tau)}{c(r + \xi_{2,t-1})} \tag{25}$$

Model 2 is made up of equations 9, 10, 13, 14, 15, 19, 21, 23, 24 and 25.

3. CALIBRATION

We solve the model to determine the steady-state and use this as a baseline model for impulse responses. Further, part of the solution is to determine the efficency parameter in the matching function, c_m, as it is determined by other parameters. We obtain differing steady-state values, and hence initial values to the simulations of stocks and flows depending on the different models. The values contained in Table 1 are considered to be a reasonable approximation of the Australian economy in 1998. The job destruction (F_{EU}) and creation (VI) levels of 600,000 jobs per year are supported by empirical evidence [Borland, 1996a; Mumford and Smith, 1996; Leeves, 2000]. In a recent paper De Francesco [1999] examined the matching function for Australia using multivariate cointegration techniques and found evidence for parameter estimates for θ of just under 0.5 and for α estimates generally fell between 0.4 and 0.8.

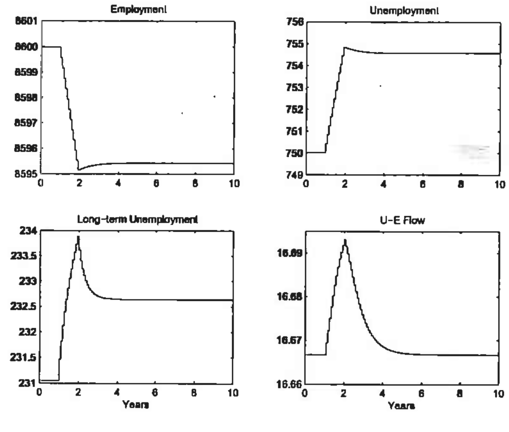

Figure 1. Model 1. Exogenous Job Creation.

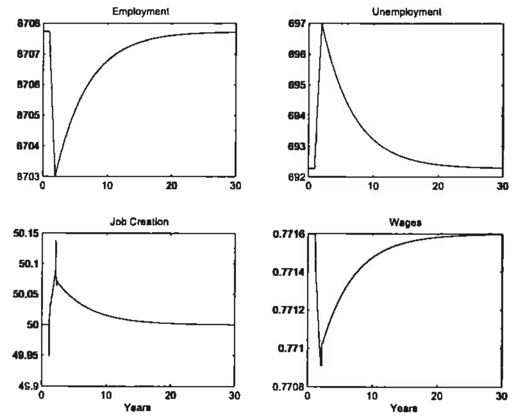

Figure 2. Model 2. Endogenous Job Creation.

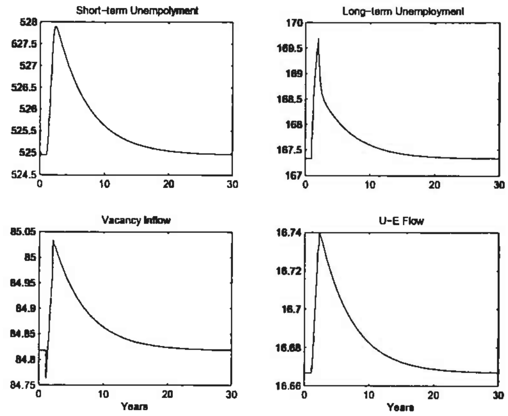

Figure 3. Model 2. Endogenous Job Creation.

In sensititvity tests these parameter values will be allowed to vary between this range, a greater value for α reflecting an increasing importance of unemployment in the matching process. The efficiency parameter c_m is determined by the other parameter values in the matching function and will differ in each projection. The value obtained in the baseline specification was 0.076; this compares to a value of 0.10 in den Butter and Gorter [1999] in their simulation of the Dutch economy. The flows are derived from average estimates of gross flows for the year 1998 (ABS 6203.0 various issues) and were then adjusted to comply with the restrictions imposed by the equations of motion. Vacancy stocks are provided in ABS 6354.0 March 1988. Unemployment and employment data were taken from ABS 6203.0 for March 1998. For the extended model, the fixed cost of a vacancy per period c was assumed to be 0.9. der Linden and Dor [2001] found that only high values of c were compatible with plausible values of β in the bargaining equation; similar values for vacancy costs relative to the value of a filled job were used by Mortensen and Pissarides [1999]. We shall examine the sensitivity of the results to differing values of c. The payroll tax was set at 8%. An estimate for unemployment benefits came from ABS 5206.0. The value of 0.5 is based on an average of the level of benefits to average earnings for a family with two children, a couple with no children and a single person. The real interest rate was set at 1%. Wages were determined to be approximately 80% of value added, which approximates to standard estimates from growth accounting studies.

4. SIMULATION RESULTS

Using the Model 1 we found that the steady state estimate for the proportion of long-term unemployed was 30.6% of total unemployment. This is very close to the actual figure. Hence, we feel the dynamic unemployment equilibrium and escape probabilites from unemployment are a reasonable description of the actual situation. The model was subjected to an adverse shock that comprised an autonomous increase in the employment outflow (F_{EU}), job destruction, of 5,000 spread over one year, with the shock starting at the beginning of year 1. The results of this simulation exercise are presented in Figure 1. Stocks of unemployment increase and employment decrease very rapidly to their new steady-state values. It is noticeable that the unemployment to employment flow temporarily increases even though job destruction has increased. This represents the influx of people into short-term unemployment where the escape probability is higher; as this feeds through into more long-term unemployment the F_{EU} flow stops increasing and then falls back to its original level. During this period, long-term unemployment rises and temporarily overshoots its new equilibrium level. These figures will provide a point of comparison for the extended model.

In Figures 2 and 3 we illustrate the results of the extended model (Model 2) using the parameter values in Table 1, and with the initial conditions from the resulting steady-state. We consider a similar shock to the F_{EU} flow. The major difference between these results and those in Figure 1 is that the system returns to its pre-shock equlibrium values. Employment (unemployment) decreases (increases) sharply in the period of increased job destruction and then gradually returns to its pre-shock steady-state values. This mimics the asymmetry observed in the Australian labour market following recent recessions [Bodman, 1997]. Thus, an 0.8% increase in job destruction for one year has increased the unemployment rate by 0.65% after one year and it is still 0.38% higher than the pre-shock value after 5 years and 0.1% higher after 10 years. Short-term and long-term unemployment (Figure 3) also increase rapidly and fall slowly back to equilibrium values in a manner similar to aggregate unemployment and long-term unemployment remained at just over 30% of the total stock. As before, the flow of individuals from unemployment to employment increases and then gradually falls back to its original level. Of course, in practice, the higher numbers in long-term unemployment may lead to more serious problems for workers as job search effectiveness may decrease beyond the levels determined by the model, particulalry for less skilled workers [Vickery, 1999], which would generate hysteresis in unemployment rates. The reason for the difference between models 1 and 2 can be seen in the wage and vacancy adjustment patterns. The rise in unemployment puts workers in a weaker bargaining position and exerts downward pressure on wages and this encourages firms to open up more jobs thereby increasing the number of vacancies. In the long run, the equilibrating forces in the wage formation process bring the system back to its original values.

The assumption about the fixed costs of a vacancy per period cannot be readily checked against actual data sources like most other variables in the model. Hence, we decided to test the sensitivity of our results to variations in the level of these costs. We took a reasonably extreme alternative value for c of 0.5. This caused the equilibrium value for vacancies to increase and the value for the wage to decrease as expected. However the change in values was small. The system's sensitivity to some other parameters was tested. The bargaining parameter, β, was given a value of 0.3 representing a weaker bargaining position for workers representatives (unions), in this instance in the steady state, wages were lower (0.7), vacancies higher (97.8) unemployment lower (612) as more jobs are created because the employer's surplus from a match has increased. If the value of β rises to 0.7 then wages rise to 0.84, vacancies fall to 70 and unemployment rises to 852. Next the parameter associated with the weighting of vacancies and unemployment in the matching function (α) was tested for sensitivity to varying values. Lower values caused the equilibrium value of the wage to rise and the values for unemployment and vacancies to fall. This results from vacancies having more weight in the matching process; vacancies are more effective in matching with workers.

5. CONCLUSION

There is a clear need for models that deal with the impact of job destruction and job creation in a general equlibrium setting to advance our understanding of the effects of changing patterns of job destruction and creation beyond the substantial empirical literatrure that exists. A basic job search model using a matching function for workers and jobs was put forward where, in the first instance, all flows were exogenous but the model did include a propogation mechanism for transfering the effects of shocks through various duration classes of unemployment.

The model was extended through the introduction of a wage formation process, which endogenised the level of vacancies and job creation. The models were calibrated to Australian data for 1998 and performed well in generating baseline specifications that contained features consistent with actual labour market outcomes; long-term unemployment was approximately 30% of total unemployment, which mirrored the actual situation.

However, the basic model suggested that a temporary adverse shock, an increase in job destruction, had permanent effects on the level of employment and unemployment. In the extended model, wages acted to bring the model back to to the pre-shock equibrium. Specifically, a temporary rise in job destruction led to a fall in wages and a rise in vacancies and job creation. However, the recovery of employment and unemployment to pre-shock levels was protracted. This is consistent with the asymmetric behaviour of unemployment rates in recent recessions [Bodman, 1997]. Hence, the dynamics of the model appear to succesfully represent some of the basic features of the adjustment of the Australian economy. Tests to examine the sensitivity of the steady-state values to variations in the models parameters revealed that greater union power in the wage bargaining process serves to reduce vacancies and increase unemployment. Increasing the matching effectiveness of workers, leads to less vacancies and less unemployment. Possible extensions of the model include breaking the link between unemployment benefits and the wage rate and extending the depiction of search effectiveness in unemployment duration categories to analyze different possiblities for hysteresis.

6. REFERENCES

Bodman, P. M., Asymmetry and duration dependence in Australian GDP and unemployment, The Economic Record 74,227, 399-411, 1997.

Borland, J., Job creation and job destruction in manufacturing inudustry in Australia, The Economic Record 72, 46–62, 1996a.

Borland, J., What can labour market flows tell us about unemployment?: Evidence for Australia, Australian National University, mimeo, pp. 1–28, 1996b.

Borland, J. and Kennedy, S., Dimensions, structure and history of australian unemployment, *in* G. Debelle and J. Borland (eds), *Unemployment and the Australian Labour Market*, Reserve Bank of Australia, 1998.

De Francesco, A. J., The relationship between unemployment and vacancies in Australia, Applied Economics 31, 641–652, 1999.

den Butter, F. and Gorter, C., Modelling labour market dynamics with on-the-job search, Economic Modelling 16, 545–567, 1999.

der Linden, B. V. and Dor, E., Labor market policies and equilibrium employment: Theory and application for Belgium. Universite catholique de Louvain, Institut de Recherches Economiques et Sociales, mimeo, 2001.

Downes, P. and Bernie, K., The macroeconomics of unemployment in the Treasury macroeconomic (TRYM) model. RBA Seminar Series, 1999.

Gautier, P. and den Butter, F., Job creation, wage formation and unemployment dynamics in an empirical flow model for the albour market, Free University,Amsterdam, mimeo, pp. 1–23, 1997.

Leeves, G. D., Labour market gross flows and transition rates: 1980-1992, The Economic and Labour Relations Review 8, 110–127, 1997.

Leeves, G. D., Job creation and job destruction in small and and medium-sized establishments in Australia. Paper presented at Conference of Economists, Gold Coast, 2000.

Mortensen, D. and Pissarides, C., Unemployment responses to 'skill-biased' technology shocks: The role of labour market policy, Economic Journal 109, 242–266, 1999.

Mumford, K. and Smith, P. N., Gross worker flows, cycles and hiring of men and women in Australia. Paper presented at Conference of Economists, Canberra, 1996.

Murtough, G., Pearson, K. and Wreford, P., Trade liberalisation and earnings distribution in Australia. Industry Commission, Staff Research Paper, 1998.

Stacey, G. and Downes, P., Wage determination and the labour market in the Treasury macroeconomics (TRYM) model. Paper presented at Conference of Economists, Adelaide, 1995.

Vickery, J., Unemployment and skills in Australia. Reserve Bank of Australia, Discussion paper RDP 1999-12, 1999.