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A New Specification of Labour Supply in the MONASH Model with an Illustrative Application

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Abstract

MONASH is a dynamic general equilibrium model of the Australian economy. This article describes a new labour-market specification for MONASH in which people are allocated in year t to categories *according to their labour-market* activities *in year t* – 1. *People in each category plan their labour supplies by solving an optimisation problem. Via these problems, we introduce the assumption that people in employment categories supply labour more strongly to employment activities than do people in unemployment categories. Thus we find that employment-stimulating policies in t* – 1 *increase labour supply in t by shifting the composition of the labour force in t in favour of employment categories and away from unemployment categories. We illustrate this idea by using MONASH to simulate the Dawkins proposal to combine a freeze on award wage rates with tax credits for low-wage workers in low-income families. We find that the Dawkins policy would generate a significant short-run increase in employment. With the increase in employment generating an increase in labour supply, the employment benefits of the policy would persist over many years. However, in the long run, we would expect the effect of the policy on aggregate employment to be small and to depend on how the policy affected the ratio of real after-tax wage rates to unemployment benefits.*

1. Introduction

MONASH is a dynamic, computable general equilibrium model of the Australian economy. It is used in forecasting and policy analysis.[1] In most applications it is assumed that real wage rates adjust slowly in response to gaps between the demand for and the supply of labour. Normally we have assumed that the supply of labour is independent of policy shocks and other shocks under investigation. Thus the model shows a short-run increase in employment in response to favourable shocks. For the long run, the response is an increase in real wage rates and no effect on aggregate employment. This is consistent with the assumption of an exogenous NAIRU.

In this article we experiment with a new specification of labour supply. We divide the labour force into employment categories covering different occupations and into non-employment categories covering short-term unemployment, long-term unemployment and new entrants to the labour market. We assume that the ability of people to make effective labour supplies varies across categories, with unemployed people, particularly the long-term unemployed, showing less ability to make effective labour supplies than employed people. Thus, in this new version of MONASH, a policy that stimulates employment, thereby reducing the number of people in unemployment, will increase labour supply. We find however that this mechanism alone is not sufficient to ensure a permanent increase in the labour supply and employment in response to favourable shocks.

Section 2 sets out the new specification and Section 3 provides an illustrative application. Concluding remarks are in Section 4.

The illustrative application is concerned with the proposal that there should be a three-year freeze on nominal award wage rates combined with tax credits (equivalent to tax cuts) for low-wage workers living in low-income families. We refer to this as *the Dawkins policy*.[2] Through this policy, Dawkins and his colleagues hope to achieve a significant reduction in real wage costs directly from reductions in the actual wage rates of award workers and indirectly from induced effects on wage rates of non-award workers. At the same time, they hope their proposed tax credits will mitigate adverse distributional effects and increase incentives to work.

In our example of the policy, real award wage rates are reduced by 9 per cent over three years relative to the value they would have reached in the absence of the policy. This is worked out as follows. In the absence of the policy, we would expect real award wages to increase by about 1 per cent a year, approximately in line with real wage increases throughout the economy. With the policy, we would expect an annual rate of reduction in real award wage rates of about 2 per cent, reflecting 2 per cent annual inflation.

The tax credits in our example of the policy build up over three years from 1.5 to 3 to 4.5 per cent of the labour income of entitled workers, that is workers living in low-income families.[3] As can be seen from Table 1, workers entitled to the tax credits account for about 22 per cent of the total wage bill. With Australia's wage bill being about $300 billion, the annual cost of the tax credits to the government for the third and subsequent years is about $3.0 billion (= 0.045 * 0.22 * 300).

In using MONASH to analyse the policy, we conduct simulations as pairs of computations. The first computation in each pair generates base-case forecasts under business-as-usual assumptions. The second generates forecasts which include the policy. Then we calculate the gaps between the two sets of results; that is, we calculate deviations from the base-case forecasts induced by the policy.

Table 1 Percentages in Total Wage Bill

	Award	*Non-award*	*Total*
Entitled	7	15	22
Not entitled	14	64	78
Total	21	79	100

Note: This table shows the percentages of total labour income accounted for by workers partitioned into four categories: on award and entitled to tax credits under the Dawkins policy (AW-EN); not on award and entitled to tax credits (NAW-EN); on award and not entitled to tax credits (AW-NEN); and not on award and not entitled to tax credits (NAW-NEN).

Source: Data provided by the National Centre for Social and Economic Modelling (NATSEM).

Despite our reliance on model simulations, readers will not require familiarity with MONASH to follow the article or to assess the results. Section 2 provides descriptions of the relevant features of the model and our explanations in Section 3 of the results involve well-known mechanisms.

2. A New Labour-Market Specification for MONASH

The equations in our new specification of the labour market are set out in slightly stylised form in Table 2.

2.1 Planned Labour Supply: Equations (T1) and (T2)

In the new specification, the labour force contains n categories. In each year t, people in category q for $q = 1, \dots, n-2$ are those who were in activity q in year $t-1$ and who are continuing in the labour force in year t. Activities 1 to m are types of jobs and activities $m+1$ to $n-2$ are types of unemployment. People in categories $n-1$ and n are new entrants to the labour force in year t. They were neither employed nor unemployed in year $t-1$; that is, they were not engaged in any activity. In our illustrative application described in Section 3, there are 28 employment categories ($m = 28$) made up of seven occupations by two payment statuses (award, non-award) by two entitlement statuses (entitled, not entitled). There are four unemployment categories ($n-2-m = 4$) made up of short-term unemployed and long-term unemployed by the two entitlement statuses. Finally, there are two new entrant categories: those who would be entitled to tax credits if employed and those who would not be entitled.

At the beginning of year t, people in category q decide their labour-market offers for the year by solving a problem of the form: choose $L_{qc}(t), c = 1, \ldots, n-2$

to maximise

$$U_q[ATW_1(t) * L_{q1}(t), \ldots, ATW_{n-2}(t) * L_{q(n-2)}(t)] \quad (1)$$

subject to:

$$\sum_{c=1}^{n-2} L_{qc}(t) = N_q(t) \quad (2)$$

where $L_{qc}(t)$ is the labour supply that people of category q plan to make to activity c; $N_q(t)$ is the number of people in category q; $ATW_c(t)$ is the real after-tax wage rate of labour in activity c (for non-employment activities, $c = m+1, \ldots, n-2$, $ATW_c(t)$ can be thought of as a real benefit rate); and U_q is a homothetic function with the usual properties of utility functions (positive first derivatives and quasi-concavity).

Table 2 MONASH Representation of the Labour Market

Planned labour supply

$$L_{qc}(t) = N_q(t) * G_{qc}[ATW_1(t), \ldots, ATW_{n-2}(t)] \quad q = 1, \ldots, n; c = 1, \ldots, n-2 \quad \text{(T1)}$$

$$L_c(t) = \sum_{q=1}^{n} L_{qc}(t) \quad c = 1, \ldots, m \quad \text{(T2)}$$

Demand for labour, and employment

$$D_c(t) = H_c[BTW_1(t), \ldots, BTW_m(t); A(t)] \quad c = 1, \ldots, m \quad \text{(T3)}$$

$$E_c(t) = D_c(t) \quad c = 1, \ldots, m \quad \text{(T4)}$$

Relationship between after-tax and before-tax wage rates

$$ATW_c(t) = BTW_c(t) * [1 - T_c(t)] \quad c = 1, \ldots, m \quad \text{(T5)}$$

$$ATW_c(t) = BTW_{ave}(t) * F_c(t) \quad c = m+1, \ldots, n-2 \quad \text{(T6)}$$

Wage adjustment

$$\frac{ATW_c(t)}{ATW_c^b(t)} - \frac{ATW_c(t-1)}{ATW_c^b(t-1)} = \alpha\left[\frac{D_c(t)}{D_c^b(t)} - \frac{L_c(t)}{L_c^b(t)}\right] + J_c(t) \quad c = 1, \ldots, m \quad \text{(T7)}$$

Numbers in each labour-force category at the beginning of year t

$$N_q(t) = E_q(t-1) * (1 - \rho_q) \quad q = 1, \ldots, n-2 \quad \text{(T8)}$$

$$N_q(t) = JJ_q(t) \quad q = n-1, n \quad \text{(T9)}$$

Vacancies, and movements into employment activities

$$V_q(t) = E_q(t) - E_{qq}(t) \quad q = 1, \ldots, m \quad \text{(T10)}$$

$$E_{qc}(t) = V_c(t) * \left[\frac{L_{qc}(t)}{\sum_{s=1(s \neq c)}^{n} L_{sc}(t)}\right] \quad q = 1, \ldots, n; c = 1, \ldots, m; c \neq q \quad \text{(T11)}$$

$$E_{qq}(t) = N_q(t) - \sum_{c=1(c \neq q)}^{n-2} E_{qc}(t) \quad q = 1, \ldots, m \quad \text{(T12)}$$

For each category q this problem implies planned labour-supply functions of the form (T1), giving a total planned labour supply to employment in activity c ($c = 1, \ldots, m$) as defined in (T2).

In the application presented in Section 3, U_q for $q = 1, \ldots, n$ has the nested CES form:

$$U_q = \left\{ \sum_{x \in OE} B_{qx} [CES^q_{c(x)}(ATW_c L_{qc})]^{-\gamma} + \sum_{c=m+1}^{n-2} B_{qc}(ATW_c L_{qc})^{-\gamma} \right\}^{-1/\gamma} \quad (3)$$

In (3), OE is a set of size $m/2$ with typical element identifying the activity of working in occupation o with entitlement status e. Thus, in our application, OE contains 14 elements. Compared with the set of m employment activities, OE excludes the award/non-award distinction. B_{qx} and B_{qc} are non-negative parameters, to be discussed below. $CES^q_{c(x)}(ATW_c L_{qc})$ denotes a CES function of $ATW_c L_{qc}$ for c in the set $c(x)$. The set $c(x)$ contains the two employment activities with the same occupation/entitlement characteristics as x. In other words, if x refers to occupation o

Table 2 Continued

Movements into unemployment activities

$$E_{qc}(t) = \kappa_{qc} * \left[\sum_{s=m+1}^{n-2} L_{qs}(t) + \mu * N_q(t) \right] \quad q = 1, \ldots, m; c = m+1, \ldots, n-2 \quad \text{(T13)}$$

$$E_{qc}(t) = \kappa\kappa_{qc} * \left[N_q(t) - \sum_{s=1}^{m} E_{qs}(t) \right] \quad q = m+1, \ldots, n; c = m+1, \ldots, n-2 \quad \text{(T14)}$$

$$E_c(t) = \sum_{q=1}^{n} E_{qc}(t) \quad c = m+1, \ldots, n-2 \quad \text{(T15)}$$

Notes: $D_c(t)$ is the demand for labour in employment-activity c in year t;
$BTW_c(t)$ is the real before-tax wage rate of labour in employment-activity c in year t;
$A(t)$ is a vector of non-wage variables such as capital stocks and technology, which influence the demand for labour in employment-activity c;
$L_{qc}(t)$ is the supply of labour from category q to activity c in year t;
$N_q(t)$ is the number of people in category q at the beginning of year t;
$ATW_c(t)$ is the real after-tax wage rate of labour in employment-activity c or the real after-tax benefit received by people in non-employment-activity c in year t;
$T_c(t)$ is the rate of taxes (income and payroll tax) applying to labour income in employment-activity c;
$BTW_{ave}(t)$ is the average real before-tax wage rate (an average of $BTW_c(t)$ for $c = 1, \ldots, m$);
$F_c(t)$ is the real after-tax benefit received by people in unemployment-activity c expressed as a fraction of the average real before-tax wage rate;
$E_c(t)$ is the total number of hours spent in activity c during year t;
$L_c(t)$ is the supply of labour to employment-activity c;
$ATW^b_c(t)$, $D^b_c(t)$ and $L^b_c(t)$ are base-case forecasts for employment-activity c of the real after-tax wage rate, the demand for labour and the supply of labour;
$J_c(t)$ is a variable allowing for shifts in employment-activity c's wage-adjustment function;
α is a positive parameter;
ρ_q is the fraction of people occupied during the year in activity q who leave the labour force at the end of the year;
$JJ_q(t)$ is an exogenous variable used to determine the number of new entrants in year t;
$E_{qc}(t)$ is the number of hours that people from category q spend in activity c during year t;
$V_c(t)$ is the number of vacancies in employment-activity c in year t;
μ is the fraction of people in any employment-category q who move involuntarily into unemployment in year t;
κ_{qc} is a zero/one parameter used to ensure that all flows from employment-category q to unemployment activities are flows into short-term unemployment of q's entitlement type;
$\kappa\kappa_{qc}$ is a zero/one parameter used to ensure that all flows from non-employment categories to non-employment activities maintain entitlement types and are such that people from short-term and long-term unemployment categories flow to long-term unemployment and that new entrants flow to short-term unemployment.

entitlement e, then $CES^q_{c(x)}$ indicates a CES combination of the wage incomes planned by people in category q from working with entitlement e in award and non-award employment in occupation o. By adopting high substitution parameters in the $CES^q_{c(x)}$ functions, we recognise that people in category q who are thinking of working in occupation o are not very concerned about the award/non-award status of their planned employment. In our application we set all of the award/non-award supply substitution elasticities at 5. Finally, γ is the parameter that controls group q's substitution between different labour-market activities, not distinguished by award/non-award status. In particular, γ influences the response of q's labour-market choices to changes in the relative wages (or benefits) between employment activities and unemployment. Thus, γ is an important determinant of the elasticity of labour supply from group q (defined as the percentage increase in q's offers to employment for a 1 per cent increase in q's average wage in employment activities relative to q's benefits in unemployment). In setting a value for γ we ensured that the resulting economy-wide elasticity of labour supply was empirically realistic. For the main simulation in Section 3 we set $\gamma = -0.67$ which gave an economy-wide elasticity of labour supply of 0.12.[4] In a sensitivity simulation, we reset γ at –0.5 which reduced the economy-wide elasticity of labour supply to 0.07. As can be seen from Figure 7, our principal results are not sensitive to variations in γ.

With given values for γ and for the award/non-award substitution elasticities, we were able to set the B parameters and the distribution parameters in the award/non-award CES functions by calibration to an $n \times (n-2)$ matrix of $L_{qc}(t)$'s for $t = 2000$.[5]

In forming this L_{qc} matrix we started with the identity:

$$N_q(t) = \sum_{c=1}^{n-2} L_{qc}(t) \quad q = 1, \ldots, n \tag{4}$$

Values for $N_q(t)$, $q = 1, \ldots, m$, were obtained from the MONASH database on occupations combined with NATSEM information on the shares of payment and entitlement statuses in each occupation. Values for $N_q(t)$, where q refers to a category of unemployment, were obtained by assuming that 50 per cent of the unemployed were entitled and 50 per cent were not entitled, and that the total numbers of short-term and long-term unemployed were 6 per cent and 11 per cent of the total number of employed, respectively. In assuming long-term unemployment of 11 per cent of total employment, we include in long-term unemployment people who have been out of work for a year or more and who, while they may not be actively seeking employment, would take a job if it were offered.[6] Values for $N_q(t)$, where q refers to new entrants, were obtained by assuming that new entrants are 3 per cent of total employment and that they are split 50/50 between entitled and not-entitled.

To obtain the L_{qc}'s for 2000 we then distributed the N_q's across the activities c, $c = 1$ to $n-2$ according to:

$$L_{qc} = \delta_q \frac{\psi_{qc} N_c}{\sum_{g=1(g \neq q)}^{m} \psi_{qg} N_g} N_q$$

$$q = 1, \ldots, n;\ c = 1, \ldots, m;\ c \neq q \tag{5}$$

$$L_{qc} = \Pi_{qc} N_q \quad q = 1, \ldots, n;\ c = m+1, \ldots, n-2 \tag{6}$$

and:

$$L_{qq} = N_q - \sum_{c=1(c \neq q)}^{n-2} L_{qc} \quad q = 1, \ldots, n \tag{7}$$

where the δ's, ψ's and Π's are non-negative parameters.

For $q = 1, \ldots, m$, we set $\delta_q = 0.045$. Thus we assumed that at the beginning of 2000, 4.5 per cent of employed workers planned to move to a different category of employment. Our model implies that the number who succeed in moving is less than the number who plan to move. We judge that a setting of 0.045 for δ_q, $q = 1, \ldots, m$, is consistent with mobility surveys which typically show 2 or 3 per cent of employed workers moving between broadly defined occupations in each year.[7] If q is a category of short-term unemployment, then we set $\delta_q = 0.75$. Thus we assumed that at the beginning of 2000, 75 per cent of the short-term unemployed planned to move into employment. The other 25 per cent planned to remain unemployed. If q is a category of long-term unemployment, then we set $\delta_q = 0.50$; that is, we assumed that 50 per cent of the long-term unemployed plan to enter employment. By setting δ_q for people in long-term unemployment at a lower number than for people in short-term unemployment, we recognised that the percentage of the long-term unemployed who can make credible labour-market offers is less than the corresponding percentage for the short-term unemployed. If q is a category of new entrant, then we set $\delta_q = 1$; that is, we assumed that all of the new entrants plan to enter employment.

The ψ's are transfer-bias parameters. If for a given q all the ψ_{qc}'s are set at one and employment-activity c accounts for y per cent of total employment outside activity q, then the 100 * δ_q per cent of people in category q who plan to move to employment in an activity other than q will make y per cent of their offers to employment-activity c. We adopt this assumption when q is a new entrant category; that is, we assume that the occupational profile of new entrants in 2000 reflected the occupational profile of total employment. For other categories q we chose high values for some ψ_{qc}'s and low values for others. Thus we introduced the idea that people in category q can transfer more easily to some activities than to others. For example, where q and c have different entitlement characteristics we assumed that $\psi_{qc} = 0$. Where q and c have the same occupational and entitlement characteristics but different award characteristics we assumed a high value (5.0) for ψ_{qc}. Where the occupational characteristic for q is 'manager' and the occupational characteristic for c is 'trades person', 'machine operator' or 'labourer', then, if the entitlement characteristics of q and c are the same, we assumed a low but non-zero value (0.5) for ψ_{qc}. All of our decisions concerning the ψ_{qc}'s can be seen in Table 3.

Via the Π's in (6) we introduce our assumptions concerning planned movements to unemployment in 2000. We assume that employed workers cannot move immediately to long-term unemployment but that 0.5 per cent of them planned to move to short-term unemployment. We assume that short-term unemployed workers cannot stay in short-term unemployment. Complementing our assumption that 75 per cent of these workers planned to move into employment, we assume that 25 per cent planned to move into long-term unemployment. Similarly, complementing our assumption that 50 per cent of the long-term unemployed planned to move into employment, we assume that 50 per cent planned to

Table 3 Transfer-Bias Parameters (ψ_{qc})[a]

	Manager	*Professionals*	*Para-professionals*	*Trades persons*	*Clerks and sales*	*Machine operators*	*Labourers*
Manager	–	2.0	2.0	0.5	1.0	0.5	0.5
Professionals	2.0	–	2.0	0.5	1.0	0.5	0.5
Para-professionals	2.0	0.5	–	0.5	1.0	0.5	0.5
Trades persons	1.0	0.5	1.0	–	1.0	1.0	1.0
Clerks and sales	1.5	0.5	1.0	0.5	–	1.0	1.0
Machine operators	1.0	0.5	1.0	1.0	1.0	–	2.0
Labourers	0.5	0.2	0.5	0.5	1.0	2.0	–
Short-term unemployed	1.0	1.0	2.0	3.0	5.0	2.0	3.0
Long-term unemployed	1.0	1.0	2.0	3.0	5.0	2.0	3.0
New entrants	1.0	1.0	1.0	1.0	1.0	1.0	1.0

Note: (a) The entry 2 in the Manager/Professionals cell means that $\psi_{qc} = 2$ if q refers to Manager of award and entitlement status (s, e) and c refers to Professionals of entitlement status e and either award status.

stay in long-term unemployment. Finally, we assume that none of the new entrants planned to be unemployed.

Having developed an L_{qc} matrix for the base year (2000), we deduced the B-parameters in (3) by substituting values for L_{qc} and ATW_i into the specific form of (T1).[8, 9]

2.2 *Demand for Labour, and Employment: Equations (T3) and (T4)*

Equation (T3) relates the demand for labour in each employment activity to costs per unit of labour (real before-tax wage rates) and to other variables $[A(t)]$, and equation (T4) imposes the assumption that employers always operate on their demand curves.

In building the demand side (equation (T3)) of our labour-market specification we assumed that:

$$d_{opej} = -\theta_{op} * (w_{opej} - w_{opj}) - \theta_o * (w_{opj} - w_{oj}) - \theta * (w_{oj} - w_j) + Q_j(w_j, a_j) \quad (8)$$

where:

$$w_{opj} = \sum_{e=1}^{2} R_{opej} * w_{opej} \quad (9)$$

$$w_{oj} = \sum_{p=1}^{2} R_{opj} * w_{opj} \quad (10)$$

and:

$$w_j = \sum_{o=1}^{m} R_{oj} * w_{oj} \quad (11)$$

In these equations:

d_{opej} is the percentage change from year $t - 1$ to t in industry j's demand for labour of type *ope* (occupation o, award/non-award status p, entitlement status e);

w_{opej} is the percentage change in the real before-tax wage rate which must be paid by industry j for labour in category *ope*;

R_{opej} is the share of e in industry j's costs of employing *op*;

R_{opj} is the share of p in industry j's costs of employing o;

R_{oj} is the share of o in industry j's total labour costs;

w_{opj} is the percentage change to industry j in the real before-tax wage rate of *op* workers, defined in (9) as a share-weighted average of w_{opej} over both values of e;

w_{oj} is the percentage change to industry j in the real before-tax wage rate of occupation o, defined in (10) as a share-weighted average of w_{opj} over both values of p;

w_j is the percentage change to industry j in the overall real before-tax wage rate, defined in (11) as a share-weighted average of w_{oj} over all o;

θ_{op}, θ_o and θ are positive parameters; and

Q_j is a function relating the percentage change in j's overall demand for labour to the percentage change in the average real before-tax wage rate applying to workers in industry j, and to other variables (a_j) such as the growth in j's capital stock.

Via the first term on the right-hand side of (8) we allow industry j to substitute between *op* workers in different entitlement groups. We assume that employers are barely able to distinguish between these groups. Thus we set the substitution parameter θ_{op} at a high value, 10.

Via the second term on the right-hand side of (8) we allow industry j to substitute between award and non-award workers in occupation o. We set the substitution parameter θ_o at 2, thereby assuming that employers respond quite strongly to changes in the differential between award and non-award wage rates.

Via the third term on the right-hand side of (8) we allow industry j to substitute between workers in different occupations. We set the substitution parameter θ at 0.35, thereby assuming that employers have only moderate scope to respond to changes in the relative costs of different occupations.

Via the last term on the right-hand side of (8), we allow changes in the average wage payable by industry j to influence j's demand for labour through labour-capital substitution.[10] In this last term we also include technical change and other non-wage variables which affect j's demand for labour.

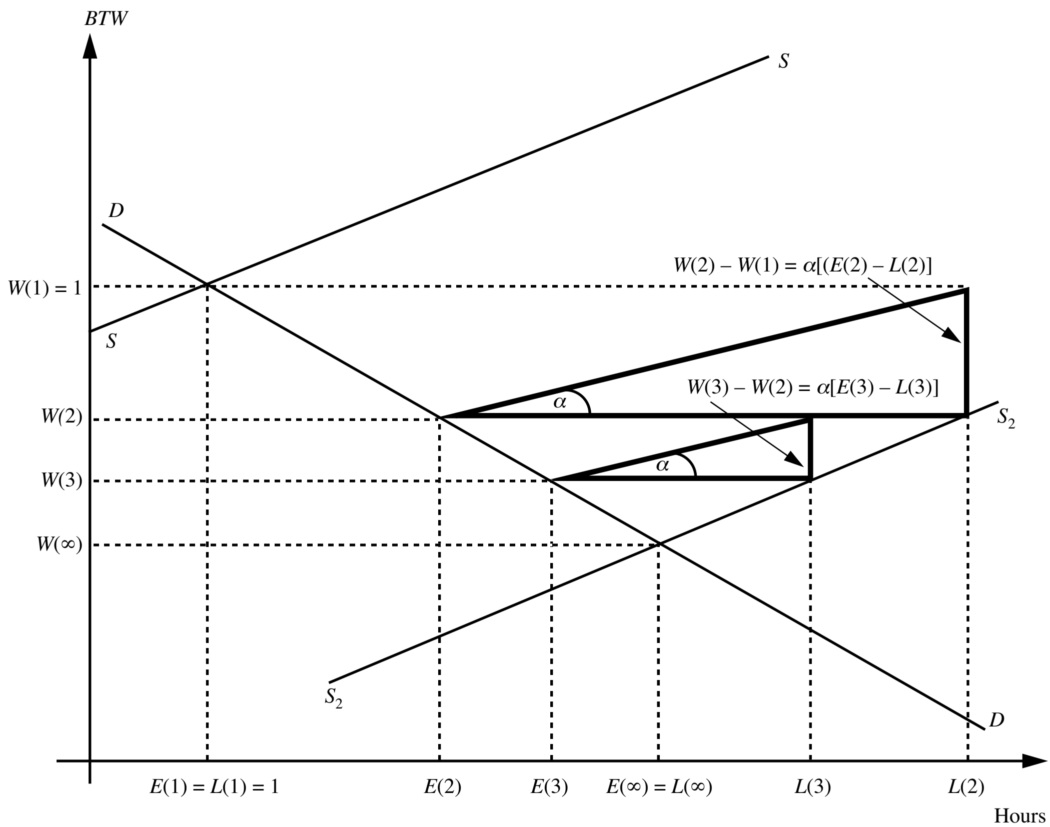
2.3 *Relationship between After-Tax and Before-Tax Wage Rates: Equations (T5) and (T6)*

Equation (T5) defines real after-tax wage rates for employed people as before-tax rates less income and payroll taxes. In (T6) we assume that unemployed workers of type *c* receive an after-tax benefit which is a fraction F_c of average before-tax wage rates. In the main simulation described in Section 3, we assumed that the F_c's are unaffected by the implementation of the Dawkins policy; that is, we assumed that percentage movements in unemployment benefits match those in average *before*-tax wage rates. In a sensitivity simulation (Figure 8) we linked unemployment benefits to average *after*-tax wage rates.

2.4 *Wage Adjustment: Equation (T7)*

Equation (T7) introduces a wage-adjustment mechanism to close gaps between demand and planned supply. It implies that if a policy

Figure 1 Wage Adjustment in a Steady State with One Type of Employment: A Supply Shock



Notes: In this illustration, but not in MONASH, we assume that the base case was generated under steady-state assumptions in which technology, consumer tastes, foreign prices, capital availability, taxes, the size of the labour force and other variables affecting the demand for and supply of labour are unchanged from year to year. In this steady state the demand curve for labour (equation (T3)) is *DD* and the planned supply curve (equations (T1) and (T2)), drawn for a fixed tax rate, is *SS*. For convenience we assume that the before-tax wage rate, employment and the planned supply of labour are one in the steady state, allowing us to eliminate the base-case forecasts from equation (T7). Now consider a policy simulation (for example, an increase in migrant intake) involving a shift in the planned supply curve in year 2 to S_2S_2, where it remains for all future years. Assuming that the shift variable in (T7) is fixed on zero and there is no change in tax rates (so that changes in before-tax wage rates on the vertical axis are also changes in after-tax wage rates), then employment increases from $E(1)$ to $E(2)$ to … $E(\infty)$, planned labour supply increases from $L(1)$ to $L(2)$ and then falls from $L(2)$ to $L(3)$ to … $L(\infty)$, and wages fall from $W(1)$ to $W(2)$ to … $W(\infty)$.

causes the market for employment-activity c in year t to be tighter than it was in the base-case forecast (that is, if the policy causes a larger percentage deviation in demand than in planned supply), then there will be an increase between years $t-1$ and t in the deviation in c's real after-tax wage rate. In other words, in periods in which a policy has elevated demand relative to planned supply, real wages will grow relative to their base-case values. Figure 1 illustrates the operation of equation (T7) in conjunction with (T1) to (T6) for a one-employment-activity model.

2.5 *Numbers in Each Labour-Force Category at the Beginning of Year t: Equations (T8) and (T9)*

For category q, where q does not refer to new entrants, (T8) sets the number of people in the category in year t as the number who were in activity q in year $t-1$ depreciated by the retirement rate ρ_q. In Section 3, the ρ_q's were all set at 0.01. In equation (T9) we allow the numbers of new entrants to be set exogenously via the variables JJ_q, $q = n-1, n$.

2.6 *Vacancies and Movements into Employment Activities: Equations (T10) to (T12)*

Equation (T10) defines vacancies in employment-activity q in year t as employment in q $[E_q(t)]$ less the quantity of labour supplied to activity q from people in category q $[E_{qq}(t)]$; that is, vacancies in q are jobs in q less those filled by incumbents.

In (T11) we model the flow of people from category q to employment-activity c as being proportional to the vacancies in c and to the share of category q in the planned supply of labour to activity c from people outside c. Thus, if people in category q account for 10 per cent of the people outside category c who want jobs in employment-activity c, then people in category q fill 10 per cent of the vacancies in c. In (T11), we assume that there is always competition for jobs; that is, we assume that the number of people from outside category c who plan to work in employment-activity c $[\Sigma_{s=1(s \neq c)}^{n} L_{sc}(t)]$ is greater or equal to the number of vacancies $[V_c(t)]$ in c.[11] This ensures that $E_{qc}(t)$ is less than or equal to $L_{qc}(t)$ for $q = 1, \ldots, n, c = 1, \ldots, m, c \neq q$.

A familiar idea in labour economics is that unemployed people, especially long-term unemployed people, have a lower probability of filling vacancies than employed people wanting to move. This idea could be handled in (T11) by attaching weights to the L's appearing on the right-hand side. We achieve a similar effect by assuming that the unemployed, especially the long-term unemployed, make comparatively weak offers for employment. That is, $\Sigma_{c=1}^{m} L_{qc}/N_q$ is low for people in unemployment categories q relative to people in employment categories. (Recall that we assumed for the base year that 50 per cent of the long-term unemployed and 25 per cent of the short-term unemployed planned to remain unemployed, whereas only 0.5 per cent of the employed planned to move to unemployment.) Relative to relying solely on weights in (T11), an advantage of our method is that it recognises that changes in the composition of the labour force between employment and unemployment influence the effective supply of labour $[\Sigma_{c=1}^{m} L_c(t)]$ and consequently affect the setting of wages. This supply effect is missed under the alternative method.

In equation (T12) the number of incumbents in employment-category q who remain in activity q (E_{qq}) is defined as the number of people in category q less the number who move out of activity q. With $E_{qc}(t)$ being less than or equal to $L_{qc}(t)$ for $c \neq q$, $E_{qq}(t)$ is greater than or equal to $L_{qq}(t)$. People in employment-category q who planned to work in activity $c \neq q$ but who are unable to move to c due to insufficient vacancies simply remain in q.

2.7 *Movements into Unemployment Activities: Equations (T13) to (T15)*

In equation (T13) the number of people who move from employment-category q to unemployment-activity c is made up of two parts: voluntary moves (L_{qc}) and involuntary moves. We model involuntary moves as a fraction (μ, assumed to be 0.03) of the number of people in category q. The coefficient κ_{qc} ensures that all moves from employment into unemployment are moves to short-run unemployment.[12]

A theoretically simple enhancement of (T13) would be the addition of a q subscript to μ. However, at this stage of our research we have not found any empirical basis for distinguishing between employment categories in their rates of flow to involuntary unemployment. A theoretically more fundamental problem with (T13) is that it rules out involuntary moves to unemployment caused by overall shortages of jobs. In (T13) we assume that involuntary moves by the employed to unemployment arise from closures of individual businesses, from dismissals of individuals and from dissatisfaction-related resignations.

A more elaborate version of (T13) which allows for involuntary moves to unemployment caused by overall shortages of jobs is:

$$E_{qc}(t) = \kappa_{qc} * \max\left[N_q(t) - \sum_{s=1(s\neq q)}^{m} E_{qs}(t) - E_q(t); \sum_{s=m+1}^{n-2} L_{qs}(t) + \mu * N_q(t) \right]$$

$$q = 1, \ldots, m;\ c = m+1, \ldots, n-2 \qquad (12)$$

The first expression in the brackets on the right-hand side of (12) is the number of people in category q who are compelled to move into unemployment because of a shortfall in the number of jobs in activity q [$E_q(t)$] compared with the number of category-q people who need to remain in activity q if they are to maintain employment. The second expression is, as already seen from (T13), the number of voluntary moves from q to unemployment plus the number of moves to unemployment associated with individual factors (closures, dismissals and resignations). Under (12) the flow of people from employment-category q to unemployment is the larger of these two expressions. In the simulations reported in Section 3, in all years and in all categories the second expression is larger than the first. Thus, in these simulations, (T13) is adequate.

Equation (T14) deals with flows between non-employment categories. It ensures that short-term unemployed people who fail to obtain a job flow to long-term unemployment; that new entrants who fail to obtain a job flow to short-term unemployment; and that long-term unemployed people who fail to obtain a job remain in long-term unemployment.

Equation (T15) computes the numbers of people in each unemployment activity as the sum of the flows into the activity.

3. Illustrative Application

Using MONASH, we simulate the Dawkins policy of freezing award wages and introducing tax credits. We assume that award wage rates dominate the determination of actual wage rates for award workers during the three-year implementation period, implying that the Dawkins policy leads to 9 per cent reductions (relative to forecast) in actual real wage rates for award workers.

The reduction in the actual real wage rates of award workers is made possible in our policy simulation by a temporary change in the wage-adjustment dynamics of the labour market. In terms of the model in Table 2, for all award employment activities we exogenise $BTW_c(t)$, reducing it by 9 per cent over three years, and we endogenise $J_c(t)$. Over the three-year implementation period, the endogenous $J_c(t)$'s are negative whereas they were zero in the base-case forecasts. Temporary negative values for the $J_c(t)$'s would be the outcome under the policy if award wage rates exert a temporary influence on the actual wage rates of award workers, an influence that is eventually overcome by market forces. Beyond the three-year implementation period we fixed the J_c's at their forecast values of zero.

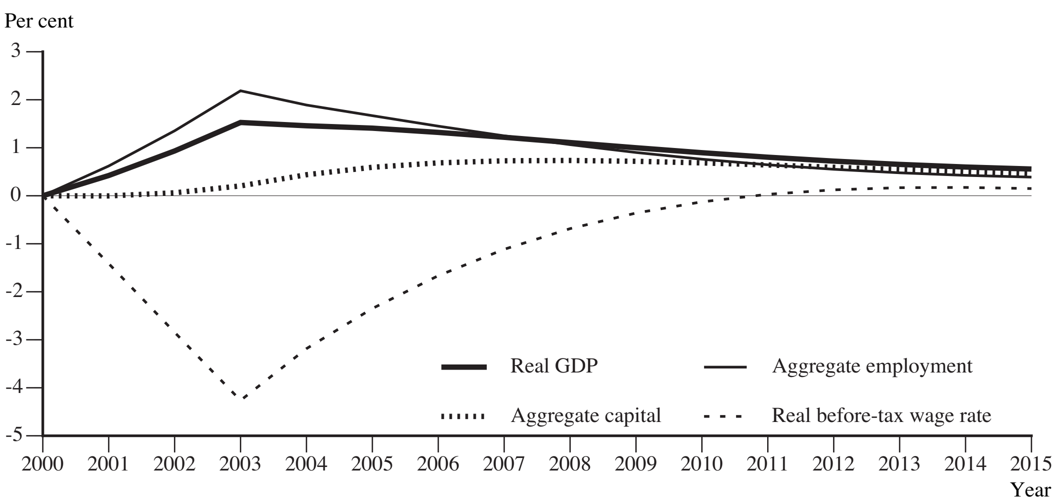
We assume that the government does not allow the policy to cause the ratio of the public sector deficit to GDP to deviate from its base-case forecast path. We do this by allowing a uniform shift in the income tax rates applying to labour and capital income. In the absence of tax-generating changes in activity, the tax credits of $3 billion would be paid for by an increase in income tax rates of about 0.6 percentage points ($3 billion is 0.6 per cent of labour and capital income). Thus, in the third year and beyond, workers entitled to tax credits would get a net reduction in their tax rate of 3.9 percentage points and workers not entitled would get a net increase of 0.6 percentage points. Under the assumptions of our simulation, the Dawkins policy produces increases in tax-generating activity, allowing the tax credits to be paid for with budget-balancing shifts in income tax rates of less than 0.6 percentage points for most of the simulation period. In the short run, the tax-generating changes in activity are sufficiently great that the deficit-to-GDP target is achieved with negative income-tax shifts.

In using MONASH to analyse the Dawkins policy, we performed a main simulation and two sensitivity simulations. Figures 2 to 6 are results from the main simulation for deviations from base-case forecasts caused by the Dawkins policy. Figure 7, which has already been mentioned in Section 2, shows the sensitivity of the employment effects under the Dawkins policy to the setting of the labour-supply parameter γ. Figure 8, which will be discussed below, shows results from a sensitivity simulation in which benefits to unemployed workers are linked to after-tax wage rates. As mentioned in Section 2, in the main simulation these benefits are linked to before-tax wage rates.

As can be seen from Figure 2, after three years the policy imposes a reduction in the average real before-tax wage rate of 4.3 per cent. This is made up of a reduction of 9 per cent for award workers and an induced reduction of 3 per cent for non-award workers (0.21 * 9 + 0.79 * 3 = 4.3). The induced reduction in the wages of non-award workers reflects substitution by employers towards the relatively cheaper award workers and substitution by workers away from award jobs towards non-award jobs. Corresponding to the 4.3 per cent real before-tax wage reduction there is a 2.2 per cent increase in employment. In the longer term, Figure 2 shows a small increase in the average real before-tax wage rate (0.15 per cent). However, the employment deviation remains positive (0.39 per cent).

For describing the employment-wage relationship, economists usually think in terms of the elasticity of demand for labour. In general equilibrium models such as MONASH, producers are represented as profit maximisers subject to technology and market constraints. Consequently, the elasticity of demand for labour is not a directly imposed parameter. Nevertheless we can deduce implied elasticities. In Figure 2 the implied elasticity starts at 0.43 in 2001 (a 1.4 per cent reduction in the real before-tax wage rate produces a 0.6 per cent

Figure 2 Macro Effects of the Dawkins Policy: Main Simulation
(percentage deviations from base-case forecasts)



increase in employment) and reaches 0.51 in 2003 (a 4.3 per cent reduction in the real before-tax wage rate is associated with a 2.2 per cent increase in employment). For periods of three years, elasticity values in the range 0.43 to 0.51 seem reasonable in light of the available econometric evidence (see, for example, Debelle and Vickery 1998). By 2010 the implied elasticity is 6.03 (a 0.13 per cent reduction in the real before-tax wage rate is associated with a 0.76 per cent increase in employment) and beyond 2010 it has the 'wrong' sign (positive deviations in real before-tax wage rates are associated with positive deviations in employment). The implied elasticity grows steadily between 2001 and 2010 because reduced real labour costs generate higher rates of return on capital, higher investment and, with a lag, higher levels of capital stock (Figure 4). Increases in the capital stock allow higher levels of employment at any given real before-tax wage rate.

Figure 3 Real Before-Tax Wage Rates: Main Simulation
(percentage deviations from base-case forecasts)

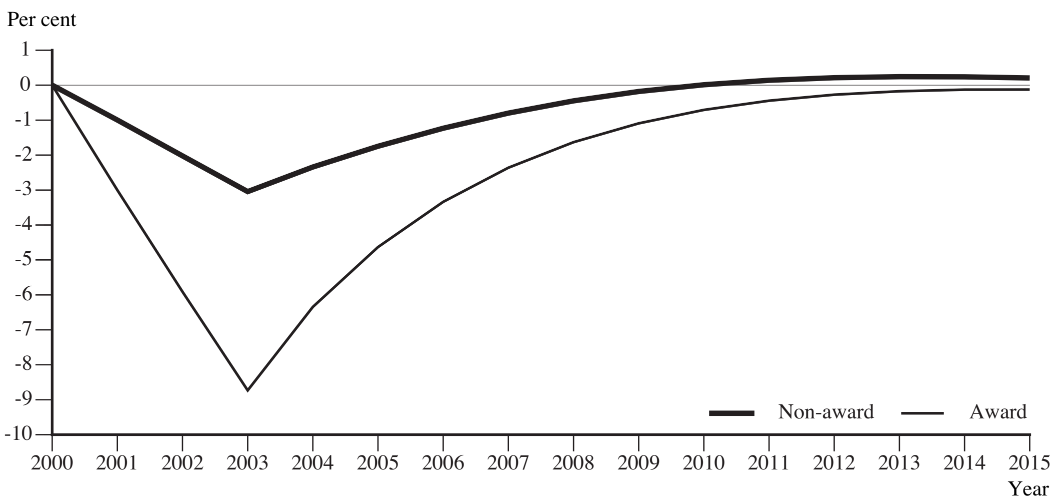
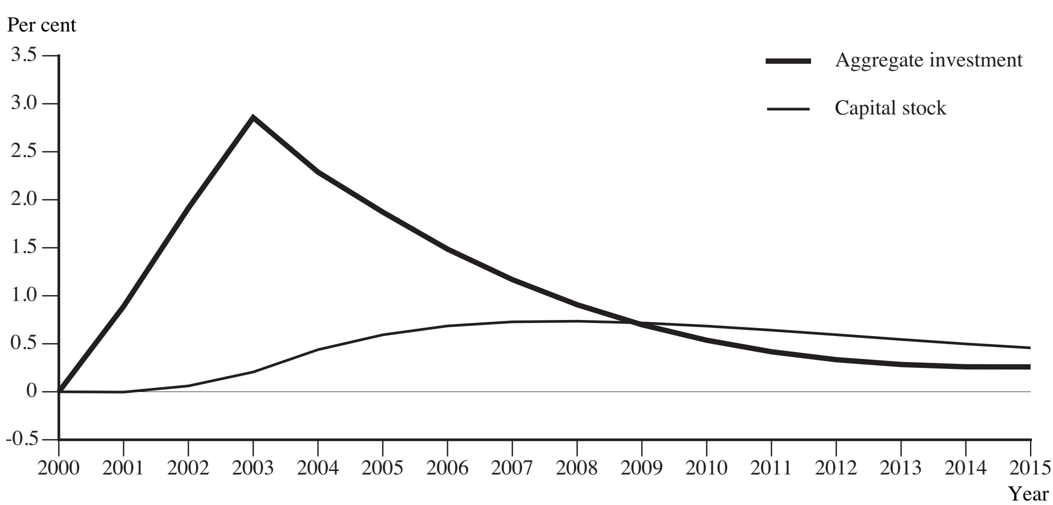


Figure 4 Investment and the Capital Stock: Main Simulation
(percentage deviations from base-case forecasts)



Why does the implied elasticity have the wrong sign in the long run? We would expect the long-run implied labour-demand elasticity to be poorly defined. This is because (as explained shortly) we would expect the deviation in the real before-tax wage rate (the denominator) to be close to zero. If, as in the current simulation, the long-run deviation in the real before-tax wage rate is slightly positive and the long-run deviation in labour supply (and hence employment)[13] is also positive (see Figure 5), then an implied long-run elasticity of the wrong sign will result.

The reason that we expect close to zero long-run deviation in the real before-tax wage rate can be explained in terms of the equations:

$$MPK\left(\frac{K}{L}\right) = \left(\frac{Q}{P}\right) \text{ and } MPL\left(\frac{K}{L}\right) = \left(\frac{W}{P}\right) \qquad (13)$$

where MPK and MPL are the marginal products of labour and capital, Q and W are the

Figure 5 Labour Supply, Employment and Average Real Wage Rates: Main Simulation
(percentage deviations from base-case forecasts)

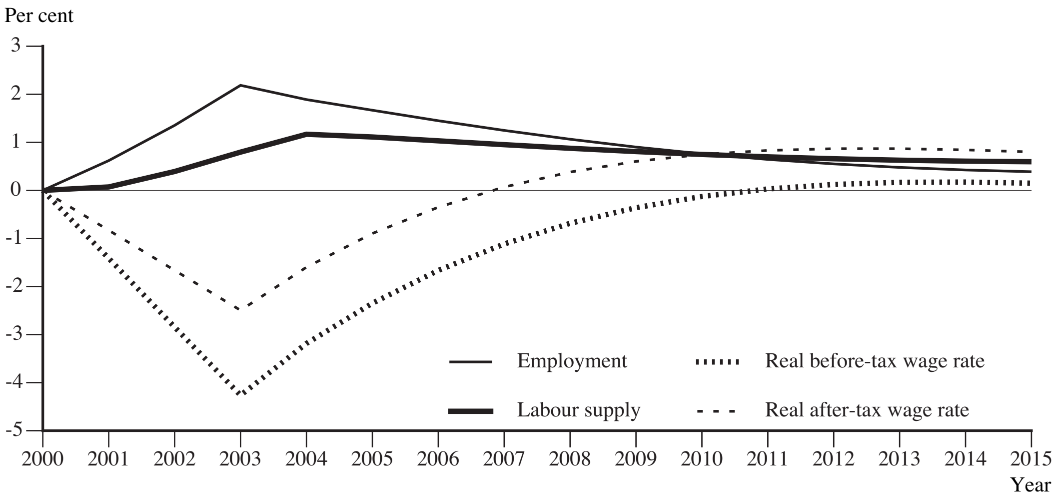
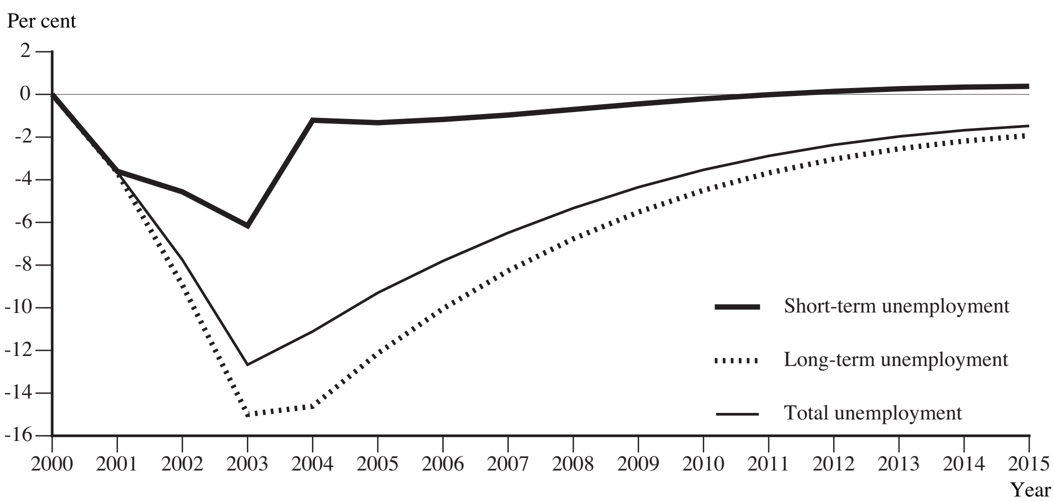


Figure 6 Unemployment: Main Simulation
(percentage deviations from base-case forecasts)



before-tax rental and wage rates and *P* is the product price. In the long run, rates of return on capital in Australia must reflect world rates. Thus, assuming that *P* can represent capital asset prices, we would expect the Dawkins policy to have little long-run effect on *Q*/*P*.[14] Therefore the percentage increase in employment must be matched eventually by the percentage increase in capital, implying a zero long-run deviation in *K*/*L* and consequently in *W*/*P*.

While, consistent with our expectations, the long-run deviation in the real *before-tax* wage rate is close to zero, there is a significant long-run positive deviation in the real *after-tax* wage rate (0.8 per cent in 2015, Figure 5). This reflects an overall reduction in the rate of taxation on labour income. Rates of tax on labour income decline for two reasons. First, part of the bill for the tax credits is met by increased taxes on non-labour income. Second, in our simulation the Dawkins policy generates a

Figure 7 Employment with Different Values for the Parameter γ: See Equation (3)
(percentage deviations from base-case forecasts)

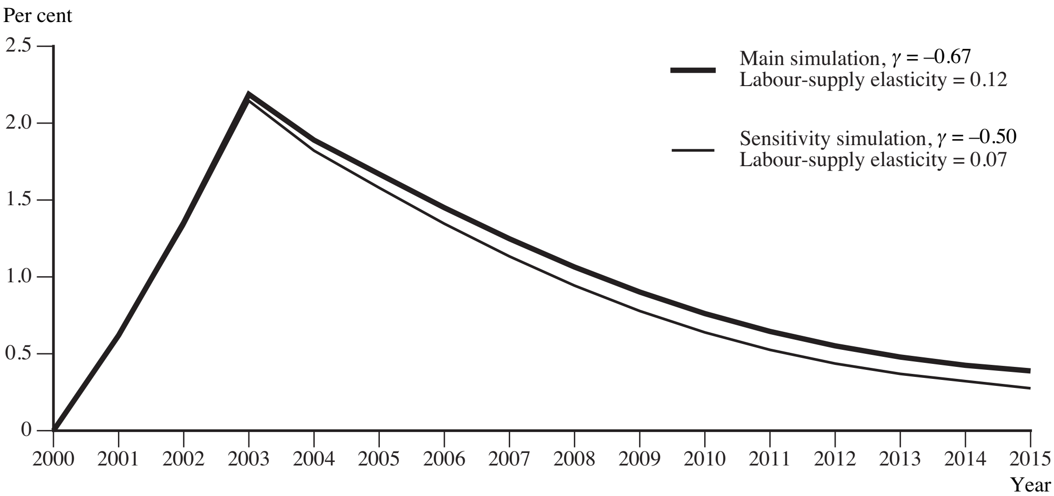
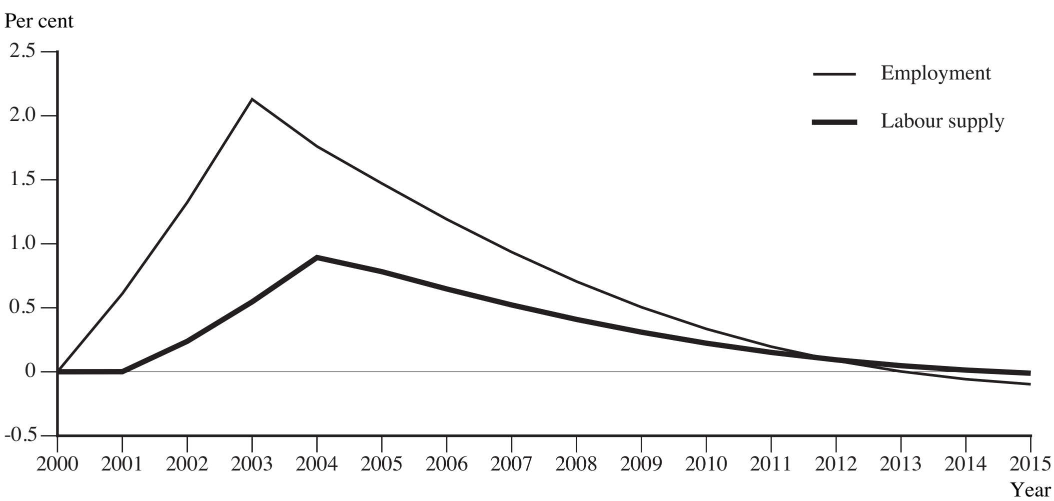


Figure 8 Employment and Labour Supply with Unemployment Benefits Linked to After-Tax Wage Rates
(percentage deviations from base-case forecasts)



long-run increase in employment with consequent increases in tax-generating activity and reductions in unemployment benefits. These factors allow the tax credits to be paid for with relatively small shifts in the tax rates on labour income, leaving the net movement in the labour tax rates (including the tax credits) as negative.

As alluded to in endnote 13, we would expect the wage-adjustment mechanism (equation (T7) in Table 2) to force the long-run percentage increase in employment generated by the Dawkins policy to be of a similar magnitude to the long-run percentage increase in labour supply. When the percentage stimulation in employment is greater than the percentage stimulation in planned supply, then via (T7) the deviation in real wage rates increases. This reduces the deviation in employment relative to the deviation in supply, thus closing the employment/supply gap. Similarly, when the percentage deviation in employment is less than the percentage deviation in supply, then the employment/supply gap is closed by downward movements in real wage rates. Consistent with our expectations, Figure 5 shows similar long-run percentage deviations in labour supply to those in employment.[15] Thus, to understand the long-run increase in employment all we need to do is understand the long-run increase in labour supply.

We traced the long-run increase in labour supply to the movements in real after-tax wage rates for people in employment relative to the movements in real benefit payments to people in unemployment. With unemployment benefit rates moving in line with *before-tax* wage rates and with *after-tax* wage rates increasing relative to before-tax wage rates (Figure 5), after-tax wage rates increase relative to benefit rates. Via (T1), this stimulates the planned supply of labour to employment, especially by the unemployed. To check that this is the explanation of the long-run increase in labour supply (and hence employment), we reran the simulation with a modified version of (T6) in which unemployment benefits are linked to real after-tax wage rates. As can be seen in Figure 8, once we remove the increase in the attractiveness of employment relative to unemployment, the long-run increases in both labour supply and employment disappear.

While we would expect our model to show very little long-run gap between the deviations in employment and planned labour supply, for the short run the gap can be considerable. Over the period 2001 to 2003, employment responds strongly to the imposed reductions in real before-tax wage rates. As discussed below, despite the wage reductions, planned labour supply also increases, but relatively weakly. In Figure 5, the employment deviation in 2003 is 2.2 per cent while the supply deviation is 0.8 per cent. In 2004, when the wage-adjustment mechanism is reinstated for award workers, the employment/supply gap begins to close, with the employment deviation falling to 1.9 per cent and the supply deviation rising to 1.2 per cent. With further increases in real wages the employment deviation continues to fall. The supply deviation also falls but not sufficiently to prevent the employment/supply gap from closing.

The apparent negative relationship between deviations in wages and labour supply can be explained as a lagged response of labour supply to employment. Assume that forecast employment in year $t-1$ is 100 and that the policy-induced deviation in employment is x per cent, that is x jobs. Because the policy-induced deviation in employment can be generated only by reductions in unemployment, the unemployment deviation in year $t-1$ is $-x$ jobs. If the reduction in unemployment applies equally to both long-term and short-term categories, then we would expect the percentage deviation in labour supply in year t to be given approximately by:[16]

$$\text{percentage deviation in labour supply in year } t = 100 \times \left[\frac{0.99x(0.995) - 0.99x\left(\frac{11}{17}\right)(0.5) - 0.99x\left(\frac{6}{17}\right)(0.75)}{0.99(100)(0.995) + 0.99(11)(0.5) + 0.99(6)(0.75) + 3}\right] \tag{14}$$

With x more jobs in year $t-1$ there would be an increase in the number of people in employment categories in year t of $0.99x$. (Recall from the discussion of (T8) in Section 2 that all of the retirement rates, ρ_q, are set at 0.01.)

This would generate an increase in labour supply from people in employment categories in year t of about $0.99x(0.995)$. (Recall that in setting up the L_{qc} matrix for 2000 we assumed that 99.5 per cent of people in employment categories make labour supply offers to employment activities.) With the reduction in unemployment spread proportionately between short-term and long-term and with x less people in unemployment in year $t-1$, there will be $x(11/17)$ less people in long-term unemployment and $x(6/17)$ less people in short-term unemployment. (Recall from Section 2 that for 2000 we assumed that the ratio of unemployed to employed was 17/100 and that the ratio of short-term to long-term unemployment was 6/11.) Corresponding to these reductions in short-term and long-term unemployment in year $t-1$, there will be reductions in year t of approximately $0.99x(11/17)(0.5)$ and $0.99x(6/17)(0.75)$ in the planned offers to employment by people in long-term and short-term unemployment categories. (Recall that for the year 2000 we assumed that 50 per cent of the long-term unemployed make offers to employment and that 75 per cent of the short-term unemployed make offers to employment.) Altogether the policy-induced change in planned labour supply in year t is given by the three terms in the numerator of the bracketed expression on the right-hand side of (14). The denominator of this expression is the forecast labour supply in year t. (Recall that new entrants are about 3 per cent of total employment.) After some arithmetic (14) reduces to:

$$\text{percentage deviation in labour supply in year } t = 0.36x_{t-1} \tag{15}$$

where we have added the subscript $t-1$ to x to emphasise the idea that deviations in labour supply in year t depend on deviations in employment in year $t-1$. With labour supply responding to lagged employment, we can now understand how negative deviations in wage rates can be associated with positive deviations in labour supply. Negative deviations in wage rates in year $t-1$ will generate positive deviations in employment in year $t-1$ and positive deviations in labour supply in year t via relationships such as (15). If the negative deviation in wages is maintained in year t, then an apparent inverse relationship between contemporaneous labour supply and wage deviations can result.

While (15) is adequate to establish the idea of a lagged relationship between labour supply and employment, it underestimates the strength of this relationship. This is because under the Dawkins policy, the reduction in unemployment is not spread proportionately between the short-term and long-term unemployed. As can be seen from Figure 6, the reductions in unemployment for most of the simulation period are concentrated on the long-term unemployed. If we rework (14) with all of the reduction in unemployment being for the long-term unemployed, then (15) becomes:

$$\text{percentage deviation in labour supply in year } t = 0.44x_{t-1} \tag{16}$$

Why are the reductions in unemployment under the Dawkins policy concentrated in the long-term category? There are two reasons. First, any reductions in short-term unemployment soon turn into reductions in long-term unemployment because reductions in short-term unemployment cut the flow to long-term unemployment. Second, the number of people in short-term unemployment in any year is dominated by the number entering short-term unemployment from employment categories. This is modelled as an almost fixed share of employment, and is barely affected by policy-induced deviations in employment.

4. Concluding Remarks

In this article we have implemented a labour-market specification in which unemployed people make less effective offers to employers than do employed people. With this specification we find that employment-stimulating policies in year $t-1$ increase effective labour supply in year t by increasing the share of the labour force in year t accounted for by people who were employed in year $t-1$ and decreasing the share of people who were unemployed in year $t-1$.

The introduction of this mechanism in MONASH simulations gives results suggesting more prolonged benefits from employment-creating policies than were suggested by results from earlier MONASH simulations in which the labour supply was exogenous. For example, in this article we find that three years after the end of the freeze on award wages, the employment deviation caused by the Dawkins policy is 1.4 per cent (see the employment result for 2006 in Figure 2), whereas in a comparable simulation in which the labour supply was exogenous, the employment deviation in 2006 was only 0.7 per cent (see Figure 12 in Dixon and Rimmer 2001).

In our main simulation of the Dawkins policy, the employment benefits were not only prolonged but were permanent. However, this was not an inevitable implication of our new labour-market specification. As demonstrated in Section 3 (see the discussion of Figure 8), the long-run increase in employment was associated with a reduction in unemployment benefits relative to after-tax wage rates.

In thinking about the long-run properties of our labour-market specification, particularly the issue of whether or not it inevitably implies permanent labour-supply effects from temporary labour-market shocks, we looked at the following highly stylised version:

$$w(t) = w(t-1) + \alpha[e(t) - l(t)] + f(t) \tag{17}$$

$$k(t) = k(t-1) - \beta w(t) \tag{18}$$

$$e(t) = k(t) - \gamma w(t) \tag{19}$$

and:

$$l(t) = \delta e(t-1) \tag{20}$$

where $w(t)$ is the policy-induced percentage deviation in real wage rates in year t; $f(t)$ is the policy-administered shock to the wage-setting system in year t; $e(t)$ is the policy-induced percentage deviation in employment in year t; $l(t)$ is the policy-induced percentage deviation in labour supply in year t; $k(t)$ is the policy-induced percentage deviation in capital in year t; and α, β, γ and δ are positive parameters.

Equation (17) is a simplified version of the wage-adjustment equation, (T7), in Table 2. Equation (18) recognises the idea, embedded in MONASH, that decreases in real wages generate increased rates of return and investment. Equation (19) is a stylised version of the MONASH labour-demand equations, and equation (20) captures the lagged response mechanism identified in Section 3 in the development of equations (14) and (15).

Analysis of (17) to (20) with realistic values for α, β, γ and δ quickly suggests that if only a temporary shock is applied (for example, if $f(t)$ takes negative values for years 1, 2 and 3 and zero values thereafter), then the long-run results for $w(t)$, $k(t)$, $e(t)$ and $l(t)$ will be zero. This confirms our impression from the research reported in Section 3 that results indicating permanent employment and labour-supply effects arising from a temporary shock need to be carefully justified. They are not a simple implication of our labour-market specification.

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Endnotes

1. For a complete description of MONASH, see Dixon and Rimmer (2002).

2. This policy is sometimes called the five economists' proposal in recognition of its original proponents: Peter Dawkins, John Freebairn, Ross Garnaut, Michael Keating and Chris Richardson. For details see Dawkins et al. (1999) and Dawkins (1999).

3. Details can be found in Lambert (1999) and Apps (2001).

4. Labour-supply elasticities of this magnitude are consistent with those found by Kalb (1997). Details of the relationship between γ and the economy-wide labour-supply elasticity are contained in a technical appendix available from the authors. The technical appendix also contains the derivation of the particular form of (T1) implied by problem (1) to (2) with the utility function specified by (3).

5. The calibration process is described in more detail in the technical appendix available from the authors.

6. Our assumed unemployment rates are high relative to those reported by the Australian Bureau of Statistics (ABS). Under the ABS definition, only people who are actively looking for jobs are included among the unemployed. We also include discouraged workers and others who, while not looking for work, would be willing to accept a job compatible with their skills if it were offered at the going wage rate or a little below.

7. See, for example, ABS Cat. no. 6209.0.

8. Values for the N_q's can be obtained by adding the L_{qc}'s over all c.

9. As mentioned in endnote 4, the specific form of (T1) is derived in a technical appendix that is available from the authors.

10. In the MONASH simulations reported in this article, we set the labour-capital substitution elasticities for all industries at 0.15. As shown in Section 3, with this value MONASH generates empirically realistic short-run macro employment responses to changes in the economy-wide average real wage rate.

11. While this condition is not guaranteed by the equations in Table 2, it was in fact satisfied in our illustrative application.

12. Voluntary moves are in any case entirely to short-run unemployment. This is ensured via the setting of B_{qc}'s in the second term on the right-hand side of (3).

13. We would expect the long-run shift in labour supply (whatever it may be) to be matched by the long-run increase in employment. Otherwise wages would continue moving.

14. In MONASH, the rate of return variables that are assumed to motivate investment involve ratios of *post-tax* rentals to asset prices. In the current application there are only minor changes in the taxes on capital income. Thus, in a back-of-the-envelope explanation of results, it is reasonable to use *pre-tax* rentals in the definition of rates of return.

15. In Figure 5, the employment and labour-supply lines cross in year 2010, yet the average real after-tax wage rate continues to rise until 2013. We traced this apparent contradiction of (T7) to the different weights used in calculating aggregate employment and aggregate labour supply. We found that on balance the employment weights happened to be smaller than the supply weights for activities with large positive employment and supply deviations.

16. Here we ignore the effects on labour supply of changes in after-tax wage rates relative to benefit rates.

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