Perspectives on Unemployment from a General Equilibrium Search Model

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Abstract

Australia has experienced a varied track record on unemployment. For the third quarter of the 20^{th} century unemployment averaged 2.0 per cent. This is bracketed by average unemployment rates of 8.6 and 7.4 per cent in the second and fourth quarter centuries. Explanations of this phenomena vary. In this paper we explore supply side explanations using a model developed by Ljungqvist and Sargent (LS). We adapt the LS model to the Australian tax and welfare system and calibrate it to the Australian economy.

Two simulation experiments are considered. In the first we study the effect of varying the unemployment benefit on the level and composition of unemployment. In the second simulation we examine the effects of increasing the degree of turbulence experienced by the economy. In the former simulation we find that: raising benefits causes a rise in the duration of unemployment; unemployment rates rise; across voluntary and involuntary unemployment classes; the rise is relatively larger in the range of low skill workers whose job-search intensity falls the greatest. Job-search intensity of voluntarily unemployed workers does not change with benefits; and reservation wages of individuals with high skill levels are unaffected by unemployment benefits but the reservation wage low skilled workers increases with the unemployment benefit. In the second simulation increasing turbulence in the economic environment causes an increase in total unemployment and in involuntary unemployment. However, voluntary unemployment falls, because people alter their reservation wages and search intensities in response to increased turbulence; overall the average duration of unemployment rises. Finally, we replicate the LS finding that the adverse consequences of increased turbulence are larger in economies with more generous welfare systems.

We interpret the findings reported above as suggesting that the LS model is a useful tool of analysis and in the final version of the paper we propose to calibrate the model to the changes in the level of unemployment benefits and the progressivity of the income tax schedule that occured towards the end of the third quarter of the 20^{th} century. Our objectives will be to to quantify how much of the change in unemployment can be attributed to these factors and to quantify the extent to which higher unemployment is attributable to increased turbulance.

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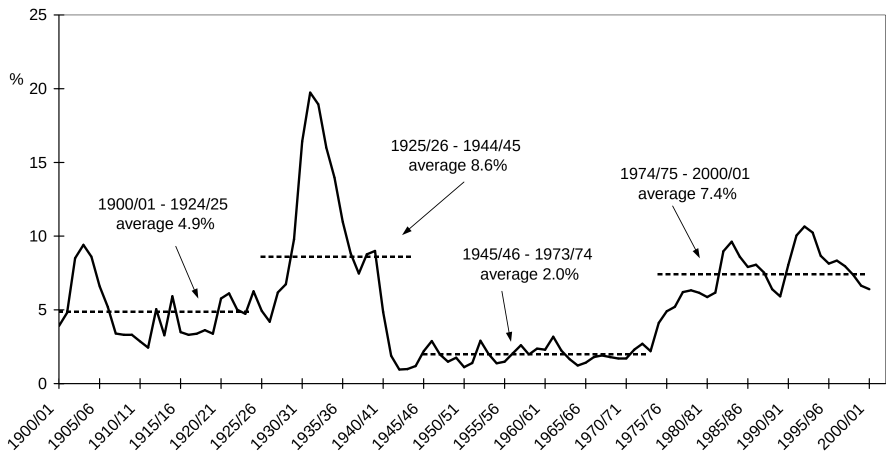
1 Introduction

Australia has experienced a varied track record on unemployment. For twenty eight years, mainly in the third quarter of the 20^{th} century, unemployment was persistently low averaging just 2.0 per cent. This period is bracketed by two periods in which unemployment was high and persistent. There are many possible explantions of such phenomena. The objective of this paper is to explore explanations that are based on supply side considerations. In a series of papers Ljungqvist and Sargent have explored the causes of European unemployment in a calibrated dynamic general equilibrium search model. The emphasis in their model is on the interaction between individuals search and reservation wages on the one hand and the tax and welfare system on the other.

Figure 1: Australian unemployment over the twentieth century



Sources: M. W. Butlin, *A Preliminary Annual Database 1900/01 to 1973/74*, Research Discussion Paper 7701, RBA; ABS, *The Labour Force, Australia* Cat. No. 6203.0; Committee on Employment Opportunities 1993, *Restoring Full Employment: A Discussion Paper*, AGPS, Canberra.

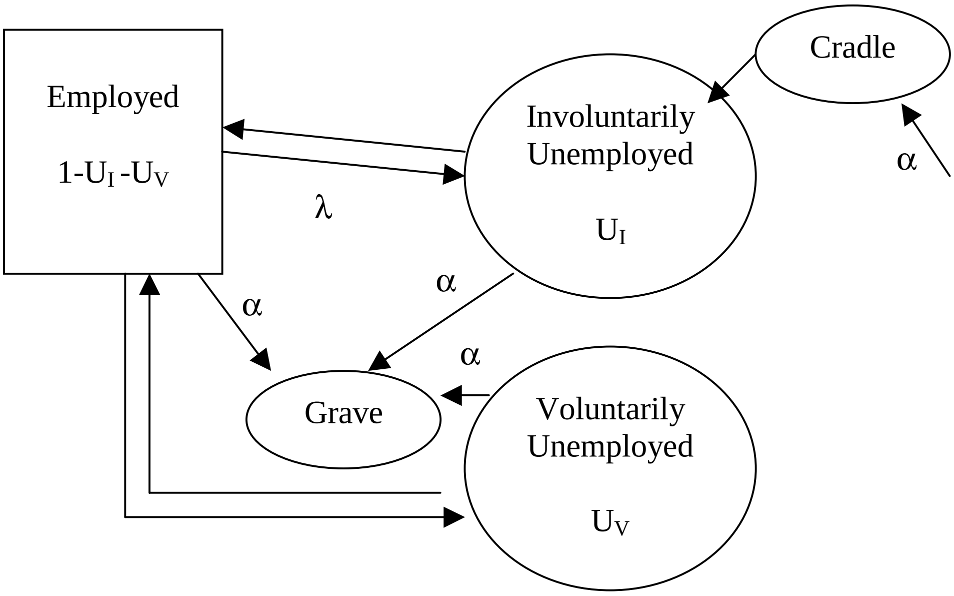
The Australian tax and transfer system is somewhat different from the European and American systems studied by Ljungqvist and Sargent. Most notably unemployment benefits are independent of past earnings in Australia whereas they are typically set as a fraction of earnings in the last job in the European system. This difference in welfare systems suggests that disincentives caused by unemployment benefits may vary more by skill in Australia than is the case with a European style welfare system. This consideration alone warrants studying the extent to which Ljungqvist and Sargent's findings can be replicated for the Australian economy.

Our primary objective in this version of the paper is to assess how useful the LS model is in quantifying supply side explanations of the rise in unemployment. The model which is an adaptation of Ljungqvist and Sargent (1998) is set out in section 2. Calibration of the model to an idealised representation of the Australian economy is discussed in section 3. Simulation results are reported in 4. Section 5 reports our conclusions.

2 Model

An individual's life within the model starts in being born with probability α and each period the individual faces death with probability α.[1] Thus, the model abstracts from population growth. An individual moves from the cradle into involuntary unemployment where they join other newborns together with workers who have been laid off. The other pools that make up the population comprise the employed and involuntary unemployed. These pools and the flows between them are depicted in Figure 2. The proportions of people in the pools of involuntary unemployed and voluntarily unemployed are U_I and U_V respectively. The remainder of the population is employed.

Figure 2: Employment Flows in the model



Within each pool, there is a mixture of skill types, denoted by the variable h.[2] People can move from one skill type to the next with the transition probability depending only on their current skill and not on thir history.[3] The idea here is to capture the notion that there is some element of chance in the accumulation and deterioration of skills. Earnings in the model is

[1] There are a continium of agents distributed uniformly on the unit interval. Thus α per cent of the population consists of new borns each period.

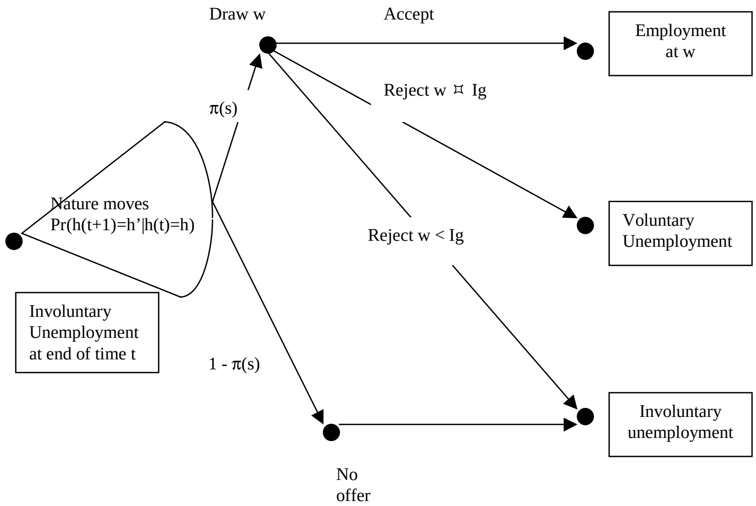
[2] All newborn workers begin with the lowest skill. Skill type is segmented into 21 discrete elements along and including the boundary values of the interval $\mathcal{I}_h = [1, 2]$.

[3] The transition probabilities of moving from skill level h in one period to h' in the next (conditional on not dying), $\Pr(h_{t+1} = h' | h_t = h)$, are denoted by the shorthand measures $\mu_u(h, h')$ and $\mu_e(h, h')$ for an unemployed and an employed worker, respectively. In the event of a layoff, this is $\mu_l(h, h')$. After this period of a lay off, the stochastic skill level of the unemployed worker is again governed by the transition probability $\mu_u(h, h')$.

defined as the product of wage (or benefit) received at each period with the skill level at that time. Thus, the dispersion of skill affects the dispersion of earnings.

At the end of each period α proportion of the population die. The survivors move to the next time period and depending on their circumstances face the sequence of events and decisions shown in Figures 3, 4 and 5 At the beginning of the period the individual learns how their skill has changed from the last period. The unemployed then chooses a search intensity $s_t \in [0, 1]$. This search intensity as part of the solution to the intertemporal intertemporal choice problem faced by all individuals. The other relevant part of that choice decision is a reservation wage rule.

Figure 3: Sequence of events and choices facing the involuntary unemployed



There is some probability $\pi(s_t)$ that the unemployed receives one wage offer drawn from the distribution $F(w) = \Pr(w_{t+1} \leq w)$. The distribution $F(w)$, assumed to be normal with a mean of 0.5 and variance of 0.1, is truncated to the unit interval and then normalized such that it integrates to one. It is assumed that $\pi(s_t) \in [0, 1]$ and is increasing with search intensity, s_t. The specific functional form chosen is:

$$\pi(s_t) = \mu_c s_t^{\mu_e};\ \mu_c, \mu_e > 0, s_t \in [0, 1]. \quad (1)$$

A worker, in each period faces a probability $\lambda \in (0, 1)$ of being laid off. The worker who is not laid off remains in the same job as there is no scope in this model for the employed to face alternative wage offers. Workers who are laid off are eligible for unemployment benefits.[4] In the original Ljungqvist and Sargent (1998) setup unemployment benefits were assumed to

[4] Newborn workers and those who quit their jobs are not eligible for benefits.

Figure 4: Sequence of events facing the voluntarily unemployed person

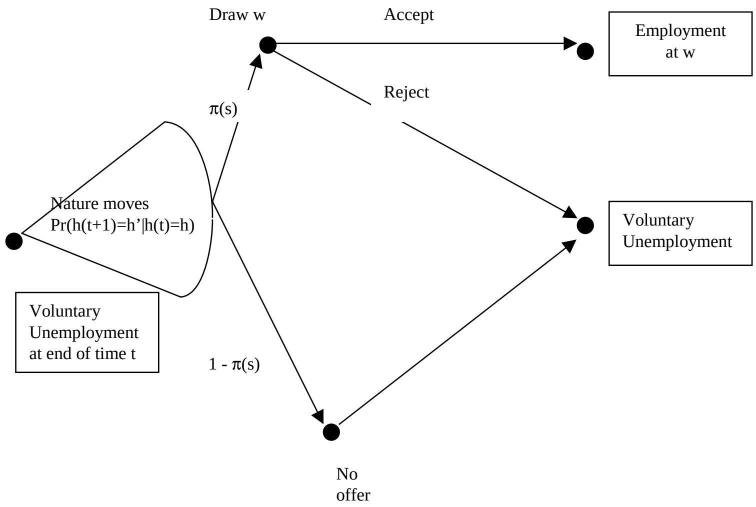
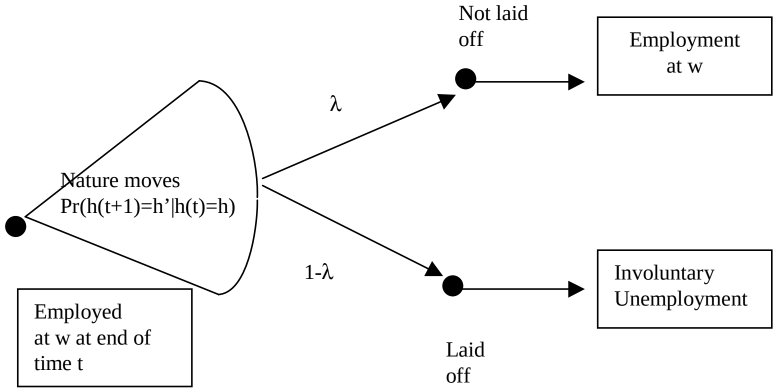


Figure 5: Sequence of events facing the employed



be proportional to the workers last earnings. This was a reasonable approximation to the European situation but the Australian case is different. Abstracting from other forms of benefits like rent assistance, the basic unemployment benefit is a flat \$360 fortnightly. Thus we set the unemployment benefit as a constant (γ). Aside from the benefit level the other policy instruments in this model are the marginal income tax rates and a "suitable salary" function which determines the eligibility of an unemployed worker, who turns down a wage offer, for benefits. If a laid-off worker rejects a job offer, w, which exceeds the government-determined "suitable earnings" will be "breached" and their unemployment benefit terminated.[5]

Both earnings from employment and benefits are taxed. The Australian tax rates are shown in Table 1. The tax system in the model approximates the six marginal rates with a tax system that has just two rates. Incomes below I_τ are taxed at rate, τ, while incomes above I_τ are taxed at rate $\tau\rho$.[6]

Table 1: Personal income tax rate schedule, 2000 reform

Threshold, \$	**Marginal tax rate**
0	0
6,001	0.17
20,001	0.30
50,001	0.42
60,001	0.47

With this informal description of the model in place we can turn to the behavior of the individuals who populate this model. They choose a sequence of search intensities and a reservation wage rule to maximize expected discounted lifetime utility of income.

$$\mathbb{E}_t \sum_{i=0}^{\infty} \beta^i (1-\alpha)^i y_{t+i} \tag{2}$$

where $\mathbb{E}_t$ is the expectation operator conditional on the information avialble at time t, β is the worker's subjective discount factor applied to the next period's utility value, $1-\alpha$ is the probability of surviving death from one period to another, and y_{t+i} is the worker's post-tax income from employment and unemployment compensation net of the disutility of job search at time $c(s_t)$, which is increasing in s_t. Specifically, the chosen functional form is

$$c(s_t) = A_c s_t^{\sigma} \tag{3}$$

The formalization of this choice problem via a the Bellman functional equation is set out in the Appendix. The final part of the model comprises the equilibrium conditions which ensure

[5]It should be noted that there is no institutional mechanism that specifies what a reasonable wage offer which cannot be declined by a benefit-seeker is. The function used here is a characterization of the behavior of a typical unemployment officer in assessing eligibility. In particular, we assume that the officer's expectations are backward looking in that what is a suitable salary which cannot be rejected is some fraction of the applicant's past earnings.

[6]At this stage increasing the number of marginal tax rates in the model would increase its complexity without yielding ncreased insights into unemployment.

that all agent's plans are optimal and jointly consistent. The equilibrium conditions, which are described formally in the Appendix, ensure that production constraints are met and that taxes are set so as to balance the governments budget.

3 Calibration

A single period in the model refers to a time of two weeks. Table 2 summarizes the calibration of the various parameters in the model used for simulation. The probabilities of dying and being laid off, α and λ, respectively, imply that the expected working life of an individual is 42.7 years and the expected duration of being employed before being laid off is 4.27 years.[7] The parameter $\theta \in [0, 1]$ is used to calculate the "suitable salary" or, which is proportional to last period's earnings.[8] We set $\theta = 0.7$.

Table 2: Parameter calibrations

Parameter description	**Mnemonics**	**Value**
Probability of dying	α	0.0009
Discount factor	β	0.9985
Fixed benefit	γ	$\gamma \in (0, 1]$
Probability of layoff	λ	0.009
Scale factor in $\pi(s)$	μ_c	1
Curvature of $\pi(s)$	μ_e	0.3
Scale factor in search cost function	A_c	0.5
Curvature of search cost function	σ	1
Threshold income for tax progressivity	I_τ	0.7
Fraction for calculating "suitable salary"	θ	0.7
Ratio of taxable income in a higher bracket to that below it	ρ	1.6261
Probability of retaining the same skill when employed	$\mu_e(h, h)$	0.98
Probability of gaining one skill level up when employed	$\mu_e(h, h')$	0.02
Probability of retaining the same skill when unemployed	$\mu_u(h, h)$	0.97
Probability of losing one skill level down when unemployed	$\mu_u(h, h')$	0.03
Number of skill levels lost when laid off	μ_l	99
Variance of a normal distribution with mean 0.5, for a given μ_l	$\sigma^2_{\mu_l}$	0.02

We made a two-step approximation of the Australian progressive income tax system in Australia The following figure shows the actual tax scheme be normalized within the the models notion of earnings which lies in the interval $[0, 2]$. As there is no guide to what the maximum income is in actual data, we take the threshold income of \$60,001 to be the maximum relevant for the model. This latter assumption is justified on the grounds that the model is describing an economy populated entirely by "blue collar" workers.

[7] This is of course $\alpha^{-1} \div 52/2$ years and $\lambda^{-1} \div 52/2$ years, respectively.

[8] $I_{g,t}(I_{t-1}) = \theta I_{t-1}$.

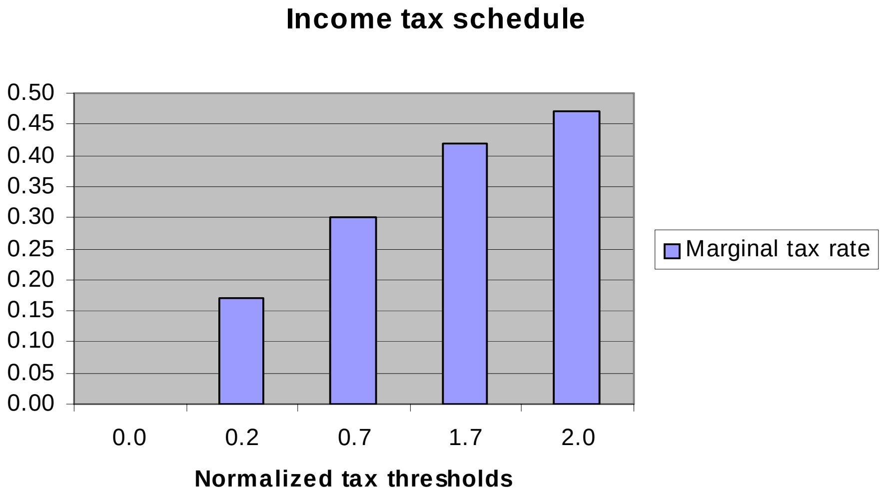


Figure 6:

The higher marginal tax rate in the model is approximately the weighted average of the two highest tax rates in the actual schedule, using the threshold income indices as weights. Similarly, the lower tax rate was approximated by the weighted average of the two lowest tax rates. The ratio of these two averages gives the value of $\rho = 1.6261$.[9]

The two transition probabilities for $\mu_e(h,h)$ and $\mu_e(h,h')$ have been set such that for a person, whilst employed, will only be accumulating skill from one period to another if she is not laidoff. That is the Markov chain describing skill accumulation has each state h which is *essential*, except when $h = 21$, which then is an *absorbing* state.[10] This yields a banded matrix of bandwidth 2 with dimension 21×21 which has the elements $\mu_e(h,h)$ along its principal diagonal except for the $(21,21)$ position which is 1 (the absorbing state). The upper band consists of the elements $\mu_e(h,h')$. Similarly, the stochastic matrix for skill depreciation, as applied to an individual if he is unemployed, will be banded, with the principal diagonal consisting of $\mu_u(h,h)$ and the lower band filled with $\mu_u(h,h')$. That is the transition is in general only downwards in terms of skill level when one remains unemployed. However, in this case the absorbing state is $h = 1$, being the lowest skill level. The values of the transition probabilities for skill accumulation are assumed to be close to the transition probabilities of a low-paid worker's earnings in one year, scaled for the model's two weeks periods. Data for these are available from Table 5.1 in Dunlop (2000). We assume that $\mu_u(h,h')$ will be slightly larger than $\mu_e(h,h')$, implying that the rate of losing one's skill is faster while unemployed compared to the rate of improving one's skill while employed.

LS suggest that one way to model economic turbulance is to think of workers experiencing

[9] That is, $\rho = \frac{\frac{1.7}{2}(0.42)+\frac{0.3}{2}(0.47)}{\frac{0.2}{0.7}(0.17)+\frac{0.5}{0.7}(0.3)} = 1.6261$.

[10] A state h is called *non-essential* if there exists a some state h' such that $h \mapsto h'$, but $h' \nrightarrow h$. That is for some $s > 0$, $\mu_e(h,h')^s > 0$, but $\mu_e(h',h)^t = 0$, for all $t > 0$.

skill loss at the time of layoff. This skill loss is modelled via a distribution that ranges from the lowest skill to skill level that the worker held just prior to layoff. The particular functional form used is a truncated normal with variance $\sigma^2_{\mu_l}$, which is conditioned on the workers skill level imediately prior to job loss. Larger values of $\sigma^2_{\mu_l}$ represent a more turbulent economy.

4 Simulations

We conduct two sets of experiments relative to what we believe is a first approximation to the current scheme of unemployment benefits in Australia. First, we conduct an experiment studying the effect of change the level of the unemployment benefits on the distribution of unemployment by skill level. Second, we analyze the impact of a increased turbulence on unemployment. The later simulation is intended to explore in an Australian setting the idea that the effects of increased generosity of the welfare system may not be immediately apparent but can become apparent if the economy experiences increased turbulance.

4.1 Experiment 1: Unemployment benefits progression

In the model $\gamma = 0.333$ corresponds to setting the unemployment benefit to the current level of \$360 per fortnight.[11] The cases $\gamma = 0.156$, $\gamma = 0.667$ and $\gamma = 1$ represent welfare arrangements where the benefits are cut to \$180 per fornight and raised to \$720 and \$1080 per fortnight respectively. To put these in perspective an unemployment benefit at \$180 per fortnight would be about 12.5 per cent of average earnings. The actual ratio of unemployment benefits to earnings fluctuated quite a bit between the end of WWII and 1973 but the lowest ratio in any year was about 15 per cent of earnings. Thus 12.5 is a reasonable lower bound for what any Australian government would contemplate. An unemployment benefit of \$1080 per week would correspond to about 75 per cent of average earnings and thus, is comparable to European levels of generosity of unemployment benefits. It seems unlikely that an Australian government would contemplate unemployment benefits more generous than those in Europe. Thus, by focusing on the selected range we can assess the extent to which it is feasible for government to influence unemployment through changes to the level of benefits.

As can be seen from Figure 7 higer unemployment benefits cause higher unemployment in the model. For example, doubling benefits to \$760 per fortnight causes an increase in total unemployment of four tenths of one percentage point from 6.2 per cent to 6.6 per cent and increases the average duration of unemployment by about four days from about 13 weeks to 13 weeks and six days (See Figure 8). Providing European levels of unemployment benefits would increase the total unemployment rate by 2.4 percentage points to 8.6 per cent and would increase the duration of unemployment by five and one-half weeks to eighteen and one-half weeks.

One interesting feature of the model is that it suggests that the increase in unemployment benefits that occurred in the early 1970's from about 18 to 25 per cent of average earnings caused only a modest increase (just under one tenth of one percentage point) in the unemployment rate. This result is, however, obtained holding the turbulence of the economy unchanged and as discussed in section 4.2 it may be that the increase in umemployment benefit interacted with increased economic turbulence to produce higher unemployment.

[11] To calculate this we simulated the economy with the Australian tax system in place and unemployment benefits set to zero. Average earnings in that case are 1.3355 units on a interval $[0, 2]$. We took the current benefits of \$360 per fortnight as being about 25 per cent of average earnings. This suggests that setting $\gamma = 0.333$ provides a good approximation, within the model, to the level of unemployment benefits in Australia.

Figure 7: Unemployment rates and benefits paid

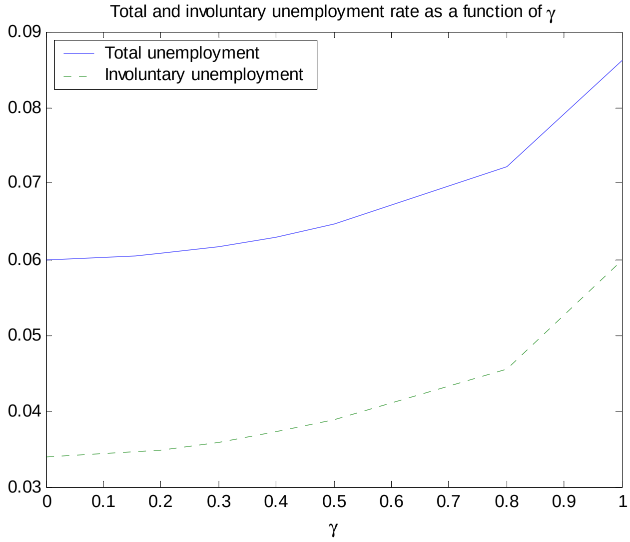
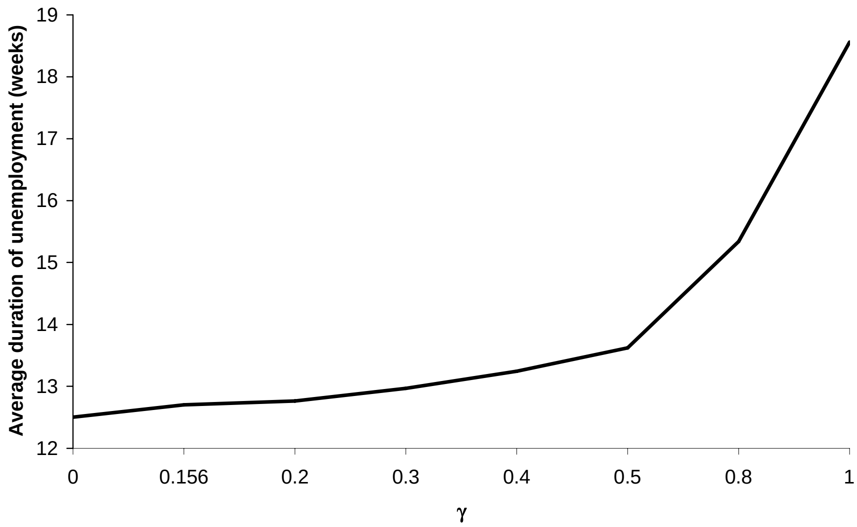


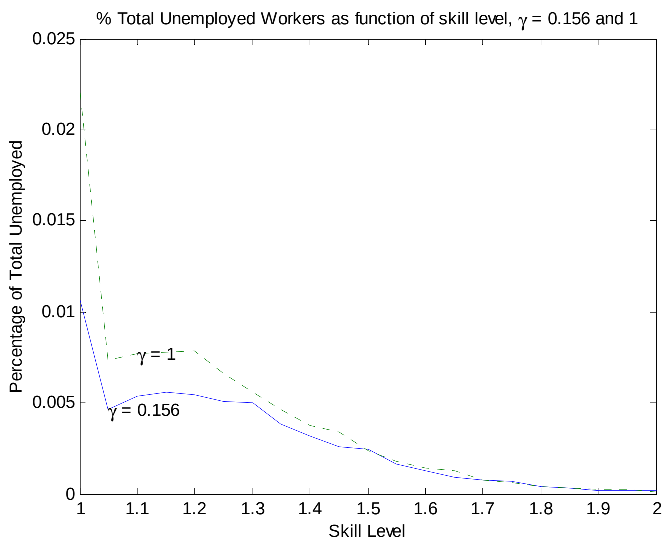
Figure 8: Average duration of unemployment by benefit level



By way of comparison the median duration of unemployment in Australia is about 13 weeks while the average duration of unemployment is closer to 45 weeks. Thus the model does well at getting the centre of tendency of unemployment durations but does not adequately match the skewness of the distribution towards longer durations. One interpretation of this is that the skewness in the Australian unemployment distributions are not equilibria phenomenon and are thus transient in the sense that they do not occur in the stationary equibria which is the focus of analysis in this model. However, here transient does not necessarily mean that the phenomenon is unimportant or quick to disipate.

As might be expected the Australian welfare system in which benefits are not related to past earnings, and thus are not related to skill, causes unemployment to be concentrated among the low skilled members of the population. Moreover, increasing the level of the unemployment benefit to the European level of generosity while maintaining the Australian practice of not relating the benefit to past earnings would increase the extent to which unemployment is concentrated among the low skilled. See Figure 9.

Figure 9: Unemployment by skill



It is of some interest to view the joint distribution of unemployment by skill level and previous salary as represented in Figure10 for the case where benefits are very low ($\gamma = 0.156$). New entrants who have no skills and zero last salary appear as a spike in the figure. Unemployment is concentrated among the low skilled who also happen to have had a low salary in their last job. This is caused, in the model, by the Australian system of unemployment benefits which are not related to salary in the previous job. While not wishing to claim too much here we view this as an important illustration of how the welfare system determines the distribution of income and (un)employment. Of course, there is nothing to suggest that this particular distribution is sub optimal.

Figure 10: Unemployment by skill and last salary for very low benefit levels

As is shown in Figure 11 Euoropean levels of generosity within an Australian benefit schedule (ie unrelated to past earnings) would raise unemployment and further concentrate it among the unskilled and low paid.

As is shown in Figure 12 when benefits are set at \$180 per fortnight almost all skill levels select the highest search intensity. The exception relates to the very lowest skilled workers who disproportionately comprise new entrants. As would be expected in a system where benefits are unrelated to past salary there is no effect of last salary on search intensity.

Introducing European levels of benefit generosity into the Australian system reduces the maximum search intensity (of the high skilled) by more than one half (see Figure 13; note the difference in the vertical axis scale when comparing figures 12 and 13). The reduction in the search intensity of low skilled workers is even more dramatic than that for high skilled workers under Euopean benefit levels. This disproportonate reduction in search intensity explains why European benefit levels within the Australian system would concentrate involuntary unemployment even more heavily among low skilled and low income individuals.

It is also of some interest to note in Figure **??** that because the "reasonable salary" criterion is related to past salary there is some relationship between last salary and search intensity. However, this effect is relatively minor even under European benefit levels.

Search intensity for the voluntarily unemployed workers is not affected by the level of benefits. This is because workers who become voluntarily unemployed in the model are not eligible for benefit payments. Thus there is no avenue through which the benefits regime can influence

Figure 11: Unemployment by skill and last salary with European levels of generosity

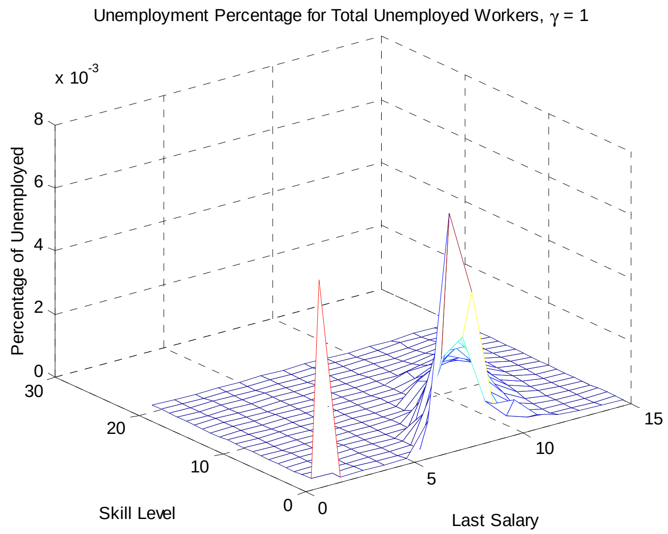


Figure 12: Search intensity for involuntary workers under least generous benefit levels

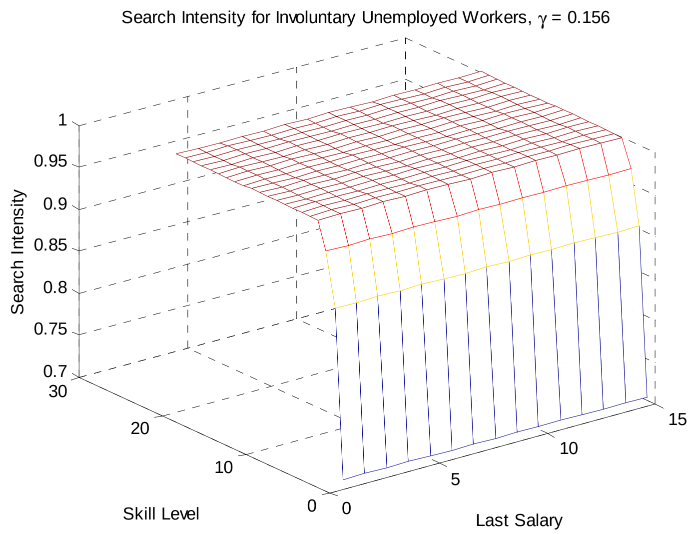
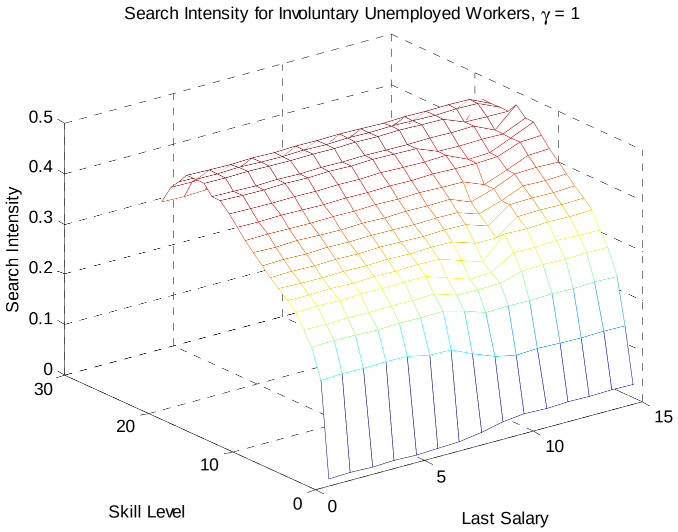


Figure 13: Search intensity of involuntary unemployed with European levels uf unemployment benefits



their job search decision. As might be expected the level of unemployment benefit does not greatly affect either the level of involunrary unemployment or the its distribution across skill levels. (See Figure 14).

In contrast, as is shown in Figure 15 the level of unemployment benefit has a very strong effect on the level of unemployment and the extent to which it is concentrated among the low skilled. Notice that for the low benefit scenario the distribution of involuntarily unemployed is hump-shaped. That is it is involuntary unemployment is not concentrated among new entrants. In contrast with European benefit levels involuntary unemployment is concentrated most heavily among new entrants and the low skilled.

This result becomes clearer if we also take into account the class of previous earnings of these unemployed workers. Notice that the large jump in the last figure corresponds to workers who have the lowest current skill levels whose last earnings correspond to a range which is around that of average earnings. This is shown in figures 16 and 17. So the large increment in involuntary unemployment rate is associated with these workers who were paid close to average earnings while employed but have the lowest current skill levels. As the unemployment benefit paid to such a group of people rises from a level below what they previously earned to that above it, the *cost* of being unemployed would have been turned into a *benefit* of being unemployed, in the true sense of the word.

Figure 14: Distribution of voluntary unemployment by skill for various benefit levels

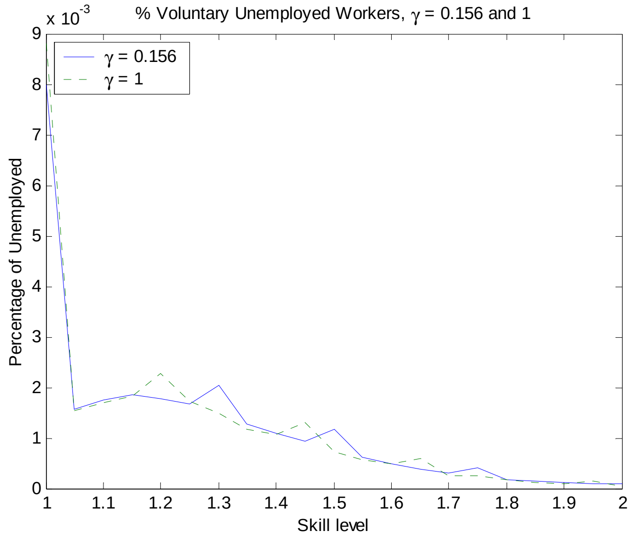


Figure 15: Involuntary unemployment by skill for various benefit levels

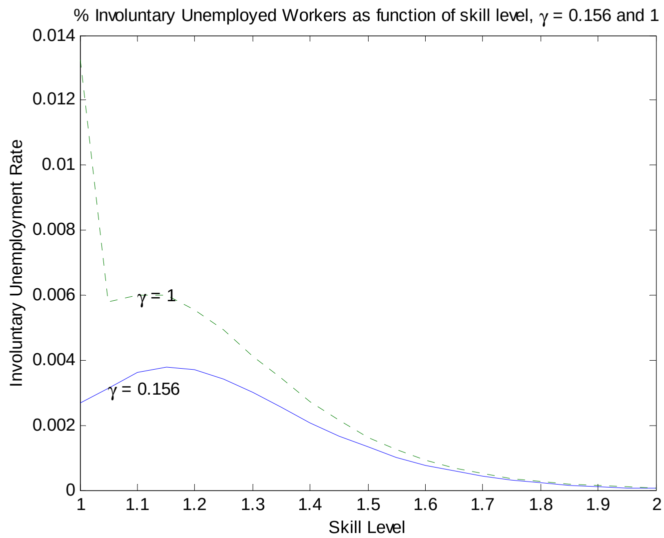
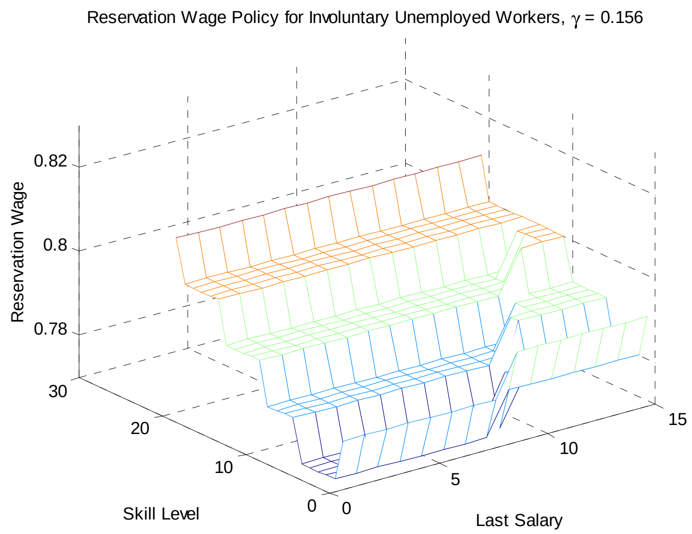


Figure 16: Distribution of unemployment by skill and last salary: lowest unemployment benefit scenario

Figure 17: Distribution of unemployment vy skill and last salary: European benefit levels scenario

In the model, choice behaviour is summarised by the reservation wage and search intensity rules. The differences in outcomes between benefit levels results from the effect of benefits on these two decisions. As can be seen by comparing figures 18 and 19 the level of benefits has a dramatic effect on the reservation wage. Increases in benefit levels raise the reservation wage. Specifically they raise the reservation wage by more for the low skilled and leave the reservation wage for the high skilled largely unchanged. The increase in the reservation wage is greatest for those who are low skilled but had high earnings in their previous jobs. This rotation upwards of reservation wages for the low skilled who had high wages in their previous jobs goes a long way towards explaining the distribution of involuntary unemployment in the European benefit levels scenario.

Figure 18: Reservation wage by skill and last salary: low benefit scenario

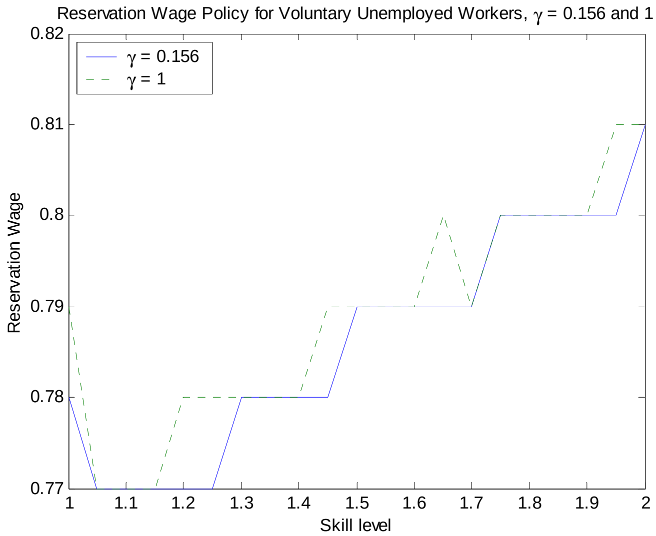


The intuition for this is as follows. For workers who have high current skills as benefits go up, the cost of remaining unemployed becomes less. This would have the effect of inducing a higher reservation wage, given that if they become employed next period, there is little room for skills improvement. But at the same time, there is some probability that their skill will deteriorate by more as they stay unemployed. And if this does happen they would expect less in terms of a wage offer. So the two countervailing effects on expected earnings or the reservation wage policy result in a fairly constant reservation wage level despite unemployment benefit increasing, for involuntarily unemployed workers with the highest current skills. As for the ones with the lowest skill levels, they do not have much to lose in terms of skills deterioration as they are already at the bottom of that measure. Thus they have more incentive to refuse low paid jobs as the level of unemployment compensation is increased. So we can see a general U-shaped function along the dimension of skill level.

Figure 19: Reservation wage by skill and last salary: European benefit levels

As might be expected the level of benefits does not greatly affect the reservation wage of the voluntary unemployed since they are not imediately eligible for benefits. The main avenue of influence is through effect on current behaviour of their future eligibility for benefits should they become involuntarily unemployed. As can be seen from Figure 20 these effects are small and there is not much difference by skill between the most generous and least generous benefit levels. The U-shape of the function along the dimension of skill level again is a result of skills accumulation and depreciation which follows the same argument above. From several figures above, we see that unemployed workers who are not eligible for benefits tend to choose the maximum intensity for job-search. Notice that the reservation wage of a voluntarily unemployed workers is always less than or equal to that of the involuntarily unemployed worker, for any given skill level. This is because unemployment episodes are always more costly for the unemployed who are not eligible for benefits. However, despite being ineligible for benefits, they would still take into account pontential future benefit payments if the fall into the involuntarily unemployed pool. Thus it is important for them to secure a job at a high wage rate as they would have more room to be picky about wage offers the next time they get laid off. Hence, as benefit is raised from the lowest level considered of \$180 per fortnight to the highest \$1080 per fortnight there is some shift upward in the reservation wage function for voluntarily unemployed workers, below.

Figure 20: Reservation wage by skill level for the voluntary unemployed



4.2 Experiment 2: Increased Economic Turbulence

Turbulance is measured as an increase in the variance of the skill-loss distribution, $\sigma^2_{\mu_l}$ from 0.02 to 0.03. We consider two benefit scenarios viz \$180 per fortnight ($\gamma = 0.156$) and \$760 per fortnight ($\gamma = 0.5$). Table 3 below reports the simulated steady state outcomes under alternative degrees of economic turbulence across the two benefit schemes. The marginal tax rates required to balance the government budget rise is about 1 per cent higher in the case of $\gamma = 0.5$. The fall in average productivity in both cases are similar. However, the economy does not weather an increase in the volatility of the environment well in terms of the unemployment rates. The total unemployment rate rises by 4 per cent when benefits are \$760 per fortnight ($\gamma = 0.5$) compared to a much smaller increase of 1 per cent in the same rate when $\gamma = 0.156$. A similar pattern happens in the sub-categories of the involuntary and voluntary unemployment rates. The increase of the spell of unemployment is also greatly increased when the economy is more volatile, under the case of $\gamma = 0.5$. Relative to the benchmark case, the percentage change in this stastistic is about 4 times larger. Thus with the Australian flat benefit schedule we are able to replicate the LS finding that increase economic turnulance can interact with more generous unemployment benefit regimes to produce substantially higher equilibrium unemployment rates.

Increasing turbulence in the economic environment results in an increase in unemployment rates for total and involuntary unemployments. Also average duration of unemployment rises. However, voluntary unemployment falls, beause the voluntary unemployed lower their reservation wage as a response to increased turbulance. This results in a fall in average productivity of labor and output. The result is worsened when unemployment benefits and corresponding balanced-budget marginal income tax rates are higher. That is the economy suffers more and becomes less resilient in terms of the unemployment when the welfare state is larger.

Table 3: Steady-state values for alternative welfare economies under different degrees of economic turbulence

	Degree of turbulence, $\sigma^2_{\mu_l}$		Percentage change
	0.02	0.03	
Tax rate, $\tau^* \times 100\%$:			
$\gamma = 0.156$	3.900	4.300	10
$\gamma = 0.5$	1.410	1.570	11
Average productivity (per 2 weeks):			
$\gamma = 0.156$	1.170	1.130	−3.4
$\gamma = 0.5$	1.168	1.130	−3.3
Unemployment rate (involuntary), %			
$\gamma = 0.156$	3.460	3.590	3.8
$\gamma = 0.5$	3.880	4.130	6.4
Unemployment rate (voluntary), %			
$\gamma = 0.156$	2.590	2.520	−2.8
$\gamma = 0.5$	2.590	2.580	−0.39
Unemployment rate (total), %			
$\gamma = 0.156$	6.050	6.110	0.99
$\gamma = 0.5$	6.470	6.710	3.7
Average duration of unemployment (weeks)			
$\gamma = 0.156$	12.700	12.820	0.94
$\gamma = 0.5$	13.620	14.188	4.17

5 Conclusion

We adapt the Ljungqvist and Sargent (1998) general equilibrium search model to the Australian tax and welfare system and use it to study the effects of benefit levels and economic turbulance on unemployment levels and durations. We conduct two simulation experiments. First, we studying the effect of varying the level of uneployment benefits on the level of unemployment and distribution across individuals with different skill levels. Second, we study the effect of turbulance as measured by the dispersion of the distribution of skill loss at layoff;

The results are encouraging. We can match the broad features of Australian unemployment. However the model does not capture the skewness of unemployment durations suggesting that they are not an equilibrium phenomenon. In the next stage of the paper we propose to model the effects of the changes in the progressivity of income tax rates on unemployment.

A Model

Both earnings from employment and benefits are taxed at the same rate, τ, provided the taxable income does not exceed a threshold level given by I_τ. Let Ω be the $n_\omega \times n_h$ matrix that collect a sample of gross earnings, $\omega_{ij} \in \Omega$.[12] Thus the tax structure is such that net earnings, $\omega_{ij}^{net} \in \Omega^{net}$, is given by

$$\omega_{ij}^{net} = \begin{cases} (1-\tau)\,\omega_{ij} & \text{if } \omega_{ij} \leq I_\tau \\ (1-\tau)\,I_\tau + (1-\rho\tau)\,(\omega_{ij} - I_\tau) & \text{if } \omega_{ij} > I_\tau \end{cases} \tag{4}$$

where τ is the marginal tax rate and ρ is the ratio of taxable income in a higher bracket to that below it. Note that if $\rho = 1$, all earnings are taxed at the flat marginal rate of τ, and the income threshold, I_τ, is redundant. If $\rho > 1$, earnings in the higher bracket will be taxed at the higher rate of $\rho\tau$. Given the normalization of $F(w)$ and skills $h \in \mathcal{I}_h$, net earnings would lie in the closed interval $[0, 2]$. For a specified level of benefits $\gamma \in [0, 2]$, the set of government policy functions $I_g(I)$ and τ, must be set such that the government budget is balanced. That is, in an equilibrium income tax revenue covers all unemployment benefits paid out.

We can formalize the decision problem which was informally described in section 2 via the Bellman functional equation. Let $V(w, h)$ be the value of the optimization problem of the employed worker with wage w and skill h at the beginning of a period. The value of the problem for the unemployed person who is eligible for unemployment benefits is $V_b(I, h)$ which is a function of the person's past earnings and current skill. The value function for the unemployed but ineligible for benefits is given by $V_o(h)$ which is just a function of skill alone. The Bellman equations are thus:

$$V(w,h) = \max_{accept,reject} \left\{ (1-\tau)\,wh + (1-\alpha)\,\beta \left[(1-\lambda) \sum_{h'} \mu_e(h,h')\,V(w,h') \right.\right.$$
$$\left.\left. \lambda \sum_{h'} \mu_l(h,h')\,V_b(wh,h') \right], V_o(h) \right\} \tag{5}$$

where

$$V_b(I,h) = \max_s \left\{ -c(s) + (1-\tau)\,\gamma + (1-\alpha)\,\beta \sum_{h'} \mu_u(h,h') \right.$$
$$\times\,[1-\pi(s)]\,V_b(I,h') + \pi(s) \left(\int_{w \geq I_g(I)/h'} V(w,h')\,dF(w) \right.$$
$$+ \int_{w < I_g(I)/h'} \max_{accept,reject} \left\{ (1-\tau)\,wh' + (1-\alpha)\,\beta \left[(1-\lambda) \sum_{h''} \mu_e(h',h'')\,V(w,h'') \right.\right.$$
$$\left.\left.\left.\left. +\lambda \sum_{h''} \mu_l(h',h'')\,V_b(wh',h'') \right], V_b(I,h') \right\} dF(w) \right) \right] \right\} \tag{6}$$

[12]Recall the definition of gross earnings as, $\omega = wh$, the product of wage/benefit and skill level. In the numerical simulations, we discretize the joint wage distribution, by forcing earnings conditional on skill type h to exist on a discrete grid, to speed up computation. That is we set $n_\omega = 51$.

and

$$V_o(h) = \max_s \left\{ -c(s) + (1-\alpha)\beta \sum_{h'} \mu_u(h,h') \times \left\{ [1-\pi(s)] V_o(h') + \pi(s) \int_{w \geq I_g(I)/h'} V(w,h')\, dF(w) \right\} \right\}. \quad (7)$$

By a dynamic programming argument, the maximization of the individual's lifetime utility is consistent with the maximization of the sum of a one-period utility and the expected utility of the remaining periods ahead. Thus, equation (5) says that for the employed worker, $V(w,h)$ is the value attained from maximizing the sum of current utility of post-tax earnings and the expected next period lifetime payoff in which there is a probability $(1-\lambda)$ of remaining in the same job but at some skill level h', and a probability λ of being laid off and thus being entitled to unemployment benefits. The value derived from the latter possibility is given in equation (6). Note that in equation (5), it also says that the currently employed person can resign, which then yields the value of $V_o(h)$ in the next period; and $V_o(h)$ is given by equation (7).

For an unemployed person eligible for benefits, equation (6) describes her utility maximization problem. The utility value to this person is $V_b(I,h)$ is the maximum of the sum of current earnings from benefits net of job-search disutility and the next period's lifetime payoff from either remaining involuntarily unemployed through no job offers or if some offer $w \geq I_g(I)/h'$ occurs and is accepted. Or if an offer $w < I_g(I)/h'$, comes along, it can either be accepted or rejected. If it is accepted, the remaining expected lifetime payoff will be conditioned on that lower wage offer (and there is a chance λ the person can be laid off again). If it is rejected the worker is back to being involuntarily unemployed with expected payoff of $V_b(I,h')$.

The voluntarily unemployed person, either by resignation from previous employment or refusal of an appropriate wage offer $w \geq I_g(I)/h'$ while unemployed, will not be entitled to benefits, and must maximize the lifetime payoff (7) which is the sum of current (dis)utility of job-search and discounted expected future payoff of possibly being offered a higher wage the next period or remaining voluntarily unemployed.

The solution to the dynamic problem in (5)-(7) are pairs of best response functions or decision rules for the two types of unemployed individuals. These are $\overline{s}_b(I,h)$ and $\overline{w}_b(I,h)$, yielding the optimal search intensity and reservation wage, respectively, for the unemployed person with last earnings I and skill-type h who is eligible for benefits. Note that there is a distribution for these two functions as they are taken over the joint distribution of the previous earnings and skills. Similarly the other pair of optimal decision rules are given by $\overline{s}_o(h)$ and $\overline{w}_o(h)$, for the unemployed person not eligible for benefits, which are also distributed according to the heterogeneity of skill types. These functions do not depend on previous earnings, I, as that is only relevant to paying out the benefit γ to the eligible. The reservation wage of an employed worker will also be $\overline{w}_o(h)$ since anyone who resigns from a current job will not be eligible for unemployment benefits.

We will compare simulation results from different stationary equilibria. A stationary equilibrium is defined as follows.

Definition A.1 *For a given constant unemployment benefit γ, a stationary equilibrium in this model is characterized by a set of government policy instruments $\{I_g(I), \tau\}$, optimal decision rules $\{\overline{s}_b(I,h), \overline{w}_b(I,h), \overline{s}_o(h), \overline{w}_o(h)\}$ and the allocations in time-invariant employment and unemployment distributions, consistent with individuals maximizing expected lifetime utility as given in (5)-(7) and a balanced government budget.*

This equilibrium is solved as a contraction mapping in the space of income tax rates. That is, starting with a fixed tax rate, τ, we solve the problem given for the worker in (5)-(7). We continue with the next value of τ and find the optimal decision rules for the workers again. Repeat this algorithm until $\tau = \tau^*$ solves both the workers' maximum problem and the problem of balancing the government budget. When the government budget is balanced we attain the fixed point τ^*. Note that this fixed-point is not unique. For instance $\tau = 1$ can also be a fixed point consistent with a time-invariant equilibrium, but one where no economic activity occurs.

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