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Unemployment Insurance and the Business Cycle

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Abstract

We develop a numerically solved equilibrium model of the labor market to study the effect of unemployment insurance (UI) over the business cycle. This model combines sequential job search, optimal job offer, layoff, and recall decisions, an aggregate productivity cycle, and details of an actual (namely, the Canadian) UI system. Optimal worker (firm) behavior is characterized by a dynamic programming problem conditional upon beliefs about the behavior of firms (workers). In equilibrium beliefs are consistent with the optimal decisions of other agents. The equilibrium beliefs are found using a nested algorithm in which simulations of the economy are used to iterate on beliefs while re-solivng for optimal decisions. Some of the model's parameters are used to match simulated moments to data on labor market outcomes for young Canadian men. Simulations of recent changes to the UI system suggest that they will raise average unemployment rates and increase short-term layoffs and recalls among young Canadians. Eliminating UI altogether would signficantly lower the unemployment rate among young men as well as lower average observed wages. Under the previous UI rules each month of UI is associated with .86 more months of unemployment than without UI. Under the new rules the ratio is 1.46: each two people on UI can be thought of as generating a third unemployed person not receiving UI through the changes in firm and worker decisions generated by the UI policy. In general, UI policy is found to have complicated effects on the timing of cycles in wages and other variables relative to the productivity cycle.

JEL Classification: L2, D2, J3, C4

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I. INTRODUCTION

In many developed countries the public unemployment insurance (UI) system introduces complex incentives for both individuals and firms. For firms, UI affects decisions to layoff and recall former workers and to offer jobs to outside workers. For individuals, UI affects decisions to quit or change jobs and to accept job offers while unemployed. While a large literature has studied UI both theoretically and empirically (see e.g. Atkinson and Mickelwright 1991), our understanding of UI has been limited in at least three respects. First, most models of UI have focussed on one side of the labor market or the other. Consequently, little is known about the equilibrium effects of UI. Second, most theoretical and empirical work has relied on stylized descriptions of UI eligibility rules. Therefore, the effect of specific changes in UI policies is difficult to predict either theoretically or empirically. Third, most theoretical models of the impact of UI adopt stationary (non-cyclical) environments, yet it is likely that UI programs with dynamic elements (such as mininum work requirements) have significant effects on the cyclical properties of the labor market.

This paper develops a labor market equilibrium model that combines sequential job search, optimal job offer, layoff, and recall decisions, an aggregate productivity cycle, and details of an actual (namely, the Canadian) UI system. Because of the nature and the number of extensions to theoretically tractable models, the model is solved numerically. We solve for the equilibrium through an iterative procedure that includes fully solving the dynamic programming problems for workers and firms given their beliefs and then simulating the resulting economy in order to reconcile outcomes with beliefs. Except for a simplifying assumption about wage determination, our framework builds on the matching model of Mortenson and Pissarides (1994). To set parameters of the model, we calibrate the aggregate productivity cycle to the Canadian economy, and we set the parameters of the UI system to match the system in place in Canada from 1981 to 1989. We fix time discount factors at realistic values, and the remaining parameters were set to yield simulated moments similar

to those found in data on the labor market outcomes of young Canadian men. While the computational burdens of the model make rigorous estimation of the model's parameters infeasible, we are able to find reasonable parameters with which to perform policy experiments. Furthermore, the computational burden of our equilibrium notion, which limits strategic interaction between workers and firms to a small set of consistent probabilities, is much smaller compared to that of the infeasible full Bayesian-Nash equilibrium.

We assess the effects of UI on young men by simulating the equilibrium response to two changes in the system, the complete removal of UI and the major changes made to UI in Canada since 1990. Our major results include the following. In comparison to the baseline of the 1980s, changes to UI in Canada since 1990 are found to raise unemployment rates and to exasperate the effect of a recession. Average wages are lowered slightly as well by the change in policies. Rates of unemployment are higher because there is more churning in the labor market. Higher rates of unemployment and lower wages are accompanied by more layoffs and more recalls of laid-off workers. These results are somewhat ironic, because changes to Canadian UI were motivated by a sense that the existing system made it too easy for firms and workers to use regular layoffs accompanied by UI benefits. Benefit rates were reduced and eligibility rules tightened. The unintended consequence is that these changes make it easier for firms to find workers and to recall laid off workers. The shorter wait for an acceptable job makes entering unemployment less costly for workers, thereby making it easier for firms to lay them off for short periods than under the older rules.

Simulations which eliminate the Canadian UI system altogether show that unemployment would fall uniformly over the business cycle. Under the previous UI rules, each person on UI is associate with a little less than one extra unemployed person relative to the no UI equilibrium. But under the new UI rules each person on UI is associated with 1.46 more unemployed. Thus, moving UI rules partially towards the elimination of UI does not necessarily lead to a partial movement towards the equlibrium without UI. We also show how unemployment durations, reservation wages, and other variables are affected in equilibrium by UI policy.

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In our framework the productivity of a job is subject to both aggregate and idiosyncratic shocks. The aggregate shocks are cyclical and generate a productivity (or business) cycle. Idiosyncratic shocks lead to simultaneous layoffs, quits, and recalls in each state of the business cycle. Firms respond to low productivity by laying off workers, and when productivity recovers they attempt to recall separated workers and possibly post a (costly) outside offer. Workers search both on and off the job, and they face state-dependent chances of layoff, recall, and job offers. Unemployment insurance directly alters the value workers place on layoffs, recalls, quits, and job offers. In equilibrium UI also indirectly alters optimal decisions made by firms through changes in beliefs about worker decisions. The combination of equilibrium beliefs and actions generate endogenous probabilities of match formation and destruction. The model also generates plausible predictions for many labor market phenomenon that other models ignore for the sake of simplicity, such as job-to-job transitions, temporary layoffs and recalls, quits into unemployment, and a non-degenerate distribution of wages.

Burdett and Mortensen (1980) first analyzed a model of sequential job search that included an implicit layoff probability as part of the endogenously determined labor contract. They consider the introduction of UI into the model, but leave several aspects of the labor market unexplained, including interfirm mobility for workers who have become attached to a firm. Hansen and İmrohoroğlu (1992) analyze the effect of UI in the presence of liquidity constraints and moral hazard. They find that plausible values of UI parameters may induce large efficiency losses in the economy. Their analysis includes potentially infinite duration of UI benefits and a single wage. More recently, Hopenhayn and Nicolini (1996) and Andolfatto and Gomme (1995) also develop general equilibrium models of stylized UI systems. Furthermore, differences in UI rules have been offered as an explanation for differences in unemployment patterns among Canada, the U.S., and European countries (Beach and Kaliski (1983), Atkinson and Micklewright (1991), and Bean (1994).). Mortensen and Pissarides (1994) and Mortensen (1994) study equilibrium models of job creation and destruction in

cyclical economies. These models include exogenously determined matching functions and job destruction rates. Andofatto (1996) includes labor market search in a business cycle model.

II. THE MODEL

The Labor Market

The labor market consists of a large number of *ex-ante* identical workers and *ex-ante* identical firms. The number of potential jobs in the labor market, filled and vacant, equals the number of workers. The economy is subject to autocorrelated aggregate shocks to productivity which generate a business cycle. The aggregate state s takes on three values, $s \in \{s_l, s_m, s_h\}$, that correspond to periods of low, medium, and high productivity. The common component of productivity in state s is denoted π_s. Over time s follows a Markov process with transition probabilities denoted $P_{ss'}$. Workers and firms observe the value of s and know the transition probabilities. For the numerical analysis, we set $\pi_m = 0$ and $\pi_l = -\pi_h$, leaving one free value, π_h, the average level of productivity in the high state, which we choose as part of the moment-matching described in section III.

In each period, a percentage l^d of workers die and are replaced by new workers who are unemployed and have no employment experience. A proportion λ^d of *unfilled* jobs are also destroyed each period and replaced with new unfilled jobs that have no workers to recall. (All probabilities of actions taken by workers are denoted with l, and all probabilities of actions taken by firms are denoted with λ.) Each period all workers and firms receive private information. Workers may receive an outside job offer, which is unobserved by their current firm. Firms observe a job-specific productivity shock drawn from a discrete distribution of values $\{\epsilon_1, \epsilon_2, \ldots, \epsilon_{N_\epsilon}\}$, indexed by i. Workers do not observe the value of ϵ_i. For the numerical analysis, we set the values of ϵ to be equally likely and to be spaced over the range $[-B, B]$, where $B > 0$ is chosen.

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Jobs are defined by a firm-worker match M, which is drawn from a discrete distribution of values $\{M_1, M_2, \ldots, M_{N_w}\}$, indexed by k, with corresponding wages w_k. We assume that the worker and firm share the match value, implying wages take the form

$$w_k \equiv \alpha M_k. \tag{1}$$

The worker's share $\alpha \in [0,1]$ of the match-specific product is fixed. Each wage and corresponding match value have the same probability $\frac{1}{N_w}$. For our numerical analysis the distribution of wages and match values depend on two parameters μ and σ^2:

$$w_k = w_{min} + \exp\left(\sigma\Phi^{-1}((k-0.5)/N_w)) + \mu\right) \tag{2}$$

where Φ^{-1} denotes the inverse of the standard normal distribution function and w_{min} is a wage that is just ineligible for unemployment insurance under the Canadian UI rules.

In a Nash bargaining model of wages (such as the one estimated by Eckstein and Wolpin 1995), the worker and firm would share the surplus value of the match not simply the current shared component of the match as we assume. Several features of a our model make the continued search while bargaining framework inappropriate and extensions of it too difficult. First, both the worker and the firm can leave the match at any time and possibly return later. So while the alternative to accepting a new match is simply further search, a bargaining model of this situation would have to contend with strategic interactions in all periods after the match begins. Our assumption of private information about productivity and outside alternatives is also consistent with our simple model of wages. Workers can capture the rent from their outside alternatives only by accepting them, and firms can only avoid large negative shocks by laying off the worker.

The firm's profit from employing a worker in one period equals the job's total productivity minus the wage, which using (1) can be written

$$\pi_s + \frac{1-\alpha}{\alpha} w_k + \epsilon_i. \tag{3}$$

There are a total of $3 \times N_w \times N_\epsilon$ distinct values for firm profits. The match does not end when the worker separates from the firm, because the firm can attempt to recall the worker. The

match ends when the job is vacant and either it is destroyed (exogenously) or the firm finds a new worker willing to form a new match.

Workers and firms form beliefs about the actions of other agents which take the form of probabilities contingent upon the aggregate state of the economy s. Workers form beliefs about whether firms will issue recalls (r), layoffs (l), job offers while unemployed (o), and outside job offers while on the job (j). We write the vector of worker beliefs about these events as:

$$\Lambda \equiv \left(\lambda_l^l, \lambda_m^l, \lambda_h^l, \lambda_l^r, \lambda_m^r, \lambda_h^r, \lambda_l^o, \lambda_m^o, \lambda_h^o, \lambda_l^j, \lambda_m^j, \lambda_h^j \right). \tag{3}$$

Firms form beliefs about whether workers will quit their job (q), accept recalls (r), and accept a new job offer (o):

$$L \equiv \left(l_l^q, l_m^q, l_h^q, l_l^r, l_m^r, l_h^r, l_l^o, l_m^o, l_h^o \right). \tag{4}$$

In equilibrium beliefs about the other side's actions are consistent with optimal behavior. Details of the solution method are given in Appendix 3.

The sequencing of firm and worker decisions and actions is represented in Figure 1 beginning in an arbitrary period, t. If a job is filled, production occurs and the worker is employed and paid. If the job is empty, no wages are paid, the firm incurs no costs, and the job disappears with (exogenous) probability l^d.[1] After production is completed, a worker may leave the labor market with (exogenous) probability λ^d and upon leaving is replaced by an unemployed worker with no employment experience. If an employed worker leaves the labor market, she also vacates her employment position. Her current firm begins period $t+1$ with an empty job.

At the end of period t new workers and jobs appear, the economy's new aggregate state is revealed, and each firm observes its next idiosyncratic shock, ϵ_i^{t+1}. Firms with a filled job decide whether or not to lay off its worker. Firms with a vacant job decide whether or not to recall the previous worker or whether to post an outside offer. Recall and layoff

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[1] We assume that l^d is constant over the business cycle, but jobs are more likely to be empty during a recession which generates an endogenous cycle in the job destruction rates.

announcements go out and unemployed workers respond to recall offers. Firms whose recalls fail or who did not issue recalls now post offers if they planned to do so. New firms also decide whether to post offers or to leave the job vacant again until next period. One randomly selected worker receives each job offer and the worker-firm match value is revealed to both sides. Workers decide to accept or reject each offer based on the wage associated with the match and their current situation. After all offers have been made and either accepted or rejected, workers inform their current employers whether they will quit or remain on the job for production period $t + 1$. Production in period $t + 1$ then begins and the within-period sequencing of events is repeated.

Unemployment Insurance

The UI regulations in the model mimic those in Canada in 1989.[2] It includes a longer entrance requirement for repeaters than for claimants who did not collect UI benefits in the previous year, duration of benefits that depends on the duration of the previous employment spell, a fixed replacement ratio, and minimum and maximum benefit levels. If currently employed, the duration of UI benefits for which one would be eligible upon becoming un-employed depends on the number of periods employed, p, and the number of periods since receiving UI, n. The minimum requirement is t_E periods for a new claimant ($n > 13$) and $t_E + t_{ER}$ periods for a repeater ($n \leq 13$). Once a worker qualifies for UI she may receive t_R periods of extended benefits. A qualified worker employed for half a year or less receives one additional period of benefits for each period worked and one additional period for each two periods employed after that, up to a maximum duration T of one year. ($T = 13$ since a period corresponds to four weeks). Therefore we can write the potential duration as

$$\begin{cases} 0 & \text{if } p < t_E \text{ or } (n \leq 13 \text{ and } p < t_E + t_{ER}) \\ p + t_R & \text{if } (p \geq t_E \text{ or } (n \leq 13 \text{ and } p < t_E + t_{ER})) \text{ and } t < T/2 \\ \min\{T/2 + p/2 + t_R, T\} & \text{otherwise} \end{cases} \quad (5)$$

Once unemployed the variable p begins tracking the periods until benefits are exhausted. The level of benefits depend on p and the index of the previous wage k. The proportion τ of

[2] Kidd and Shannon (1994) describe the UI system in detail.

the previous wage is insured up to the maximum insurable amount $w_{\max}$, as long as wages are above the minimum insurable $w_{\min}$. Therefore, UI benefits can be written

$$b(k,p) = \begin{cases} 0 & \text{if } w_k < w_{\min} \text{ or } p = 0 \\ \tau w_k & \text{if } w_{\min} \leq w_k \leq w_{\max} \text{ and } p > 0 \\ \tau w_{\max} & \text{if } w_k > w_{\max} \text{ and } p > 0. \end{cases} \tag{6}$$

Finally, the UI system is financed through a flat tax on wages. How this tax is incorporated into the policy simulations is discussed later on.

Worker's Problem

Workers maximize expected present value of income, discounted at rate β_w. While employed income equals the current wage w_k. While unemployed income equals $c_w + b_k$ where b_k denotes the level of UI benefits the person is eligible to collect based on the wage in the previous job, w_k. While a worker is unemployed, a recall offer from the previous job arrives each period with probability λ_s^r. The wage attached to a recall is the previous wage the worker received on the job, because the match value M_k survives the layoff period. If the worker accepts a recall, she enters the next period employed at the same wage as her previous employment. If she does not receive a recall, or receives a recall and rejects it, then an outside job offer arrives with probability λ_s^o and some match value $M_{k'}$. The worker can either accept or reject the offer. If no offer is accepted this period, the worker enters the next period unemployed. If the worker accepts an offer, she has made a new match, and enters the next period employed at the new wage $w_{k'}$.

While employed each worker expects to be laid off with probability λ_s^l each period and expects an outside job offer to arrive with probability λ_s^j.[3] Workers incur no cost when switching jobs and will take any outside job offer that is higher than the current wage or quit into unemployment.[4]

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[3] To capture differences in search intensity among unemployed and employed workers we assume that half of all job offers go to unemployed workers (given that they search harder), and half go to employed workers. Since there is a much larger number of employed workers than unemployed workers, employed workers will face a lower job offer probability than unemployed workers.

[4] A job offer can go to a worker just laid off in the same period, and if it is accepted the worker makes a job-to-job transition with no intervening unemployment.

The value of choices depends upon all aspects of the worker's situation. In the UI system described above a worker's state vector takes the form (m, k, p, n, s). The final element is the aggregate state of the economy, while the first four elements are specific to the worker:

m Labour Market Status:

$$m = \begin{cases} 0 & \text{if the worker is currently unemployed} \\ 1 & \text{if the worker is currently employed} \end{cases}$$

k Index of Current Wages or UI Benefits: $k \in [1, 2, \ldots, N_w]$ indexes the wage level if employed or previous wage (and hence the current UI benefit level) if unemployed.

p Periods Consecutively Employed or Periods until UI Benefit Exhaustion:

$$p \in \begin{cases} [1,2,\ldots,T] & \text{periods in the current employment spell} & \text{if m=1.} \\ [0,1,\ldots,T] & \text{periods until benefit exhaustion} & \text{if m=0.} \end{cases}$$

n Periods Since Receiving UI: $n \in [0, 1, \ldots, T]$. Values of $n > T$ are equivalent to $n = T$.

Let $V_w(m, k, p, n, s)$ denote the value to the worker of beginning a period in state (m, k, p, n, s). The value function V_w depends upon the current payoff of the state and the expected value of the next period's state, (m', k', p', n', s'). The transitions from the current state to the state next period depend upon the worker's decisions this period, whether she remains in the labor market next period, the decisions of firms, the draw of match values, the evolution of the aggregate economy, and the UI system. Using Bellman's equation, we write the value function for an unemployed person $(m = 0)$ as

$$
\begin{aligned}
V_w(0, k, p, n, s) = & c_w + b(k, p) \\
& + \beta_w(1 - \lambda^d) \sum_{s'=s_l}^{s_h} P_{ss'} \left\{ \left\{ (1 - \lambda_{s'}^o)(1 - \lambda_{s'}^r) V_w(0, k, p', n', s') \right\} \right. \\
& + \lambda_{s'}^o (1 - \lambda_{s'}^r) \left\{ \sum_{k'=1}^{N_w} P_{k'} \max\{V_w(0, k, p', n', s'), V_w(1, k', p', n', s')\} \right\} \\
& + \lambda_{s'}^r \left(\max\{V_w(1, k, 1, n', s'), (1 - \lambda_{s'}^o) V_w(0, k, p', n', s') \right. \\
& \left. \left. + \lambda_{s'}^o \sum_{k'=1}^{N_w} P_{k'} \max\{V_w(0, k, p', n', s'), V_w(1, k', p', n', s')\}\} \right) \right\}.
\end{aligned}
\tag{7}
$$

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The value function for an employed person $(m = 1)$ can be written

$$
\begin{aligned}
V_w\left(1, k, p, n, s\right) = & w_k + \beta_w \sum_{s'=s_l}^{s'=s_h} P_{ss'} \bigg\{ \left(1 - \lambda_{s'}^j\right)\lambda_{s'}^l V_w\left(0, k, p', n', s'\right) \\
& + \left(1 - \lambda_{s'}^j\right)\left(1 - \lambda_{s'}^l\right)\Big\{\max\big\{V_w\left(0, k, p', n', s'\right), V_w\left(1, k, p', n', s'\right)\big\}\Big\} \\
& + \lambda_{s'}^j \lambda_{s'}^l \Big\{ \sum_{k'=1}^{N_W} P_{k'} \max\big\{V_w\left(0, k, p', n', s'\right), V_w\left(1, k', p', n', s'\right)\big\}\Big\} \\
& + \lambda_{s'}^j \left(1 - \lambda_{s'}^l\right) \sum_{k'=1}^{N_W} P_{k'} \max\big\{V_w\left(1, k, p', n', s'\right), V_w\left(1, k', p', n', s'\right), V_w\left(0, k, p', n', s'\right)\big\} \bigg\}.
\end{aligned}
\tag{8}
$$

The optimal decision at each state is summarized by a reservation wage index $k^r = k^r(m, k, p, n, s)$ and an indicator function $I^R = I^R(k, p, n, s)$. If $m = 0$, then $k^r = k_u^r$ equals the index of the lowest wage offer w_k that the worker is willing to accept. If $m = 1$, $k^r = k_e^r$ equals the lowest wage for which the worker is willing to stay employed; for $k < k^r$ the worker quits the current job into unemployment or takes a new job if an acceptable one arrives this period. The function I^R indicates whether a currently unemployed worker is willing to accept a recall offer from the previous employer $(I^R = 1)$ or not $(I^R = 0)$. The decision to accept or reject a recall offer is different from the decision to accept an outside offer because of the value functions (7) and (8) as dictated by the timing of decisions if Figure 1. In particular, if a recall is accepted the worker cannot receive outside offers. This is consistent with the timing of decisions made by firms which we describe below. The transition functions for the state variables are defined in Appendix 1.

Firm's Problem

The firm's problem is simpler than the worker's problem because firms are not directly affected by the UI system.[5] If the firm's job is occupied at the beginning of the period, the firm can either lay off or retain the worker. Firms take as given a (state-contingent) probability l_s^q that a worker will quit a job before production begins. If the job is vacant at the beginning of the period, the firm can costlessly attempt to recall the worker who

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[5] The model assumes zero experience rating of UI claims attributable to a firm, which is the case in Canada. This assumption can be relaxed to allow for experience rating, although it increases the length of the firm's belief vector.

previously held the job. Firms take as given a probability l_s^r that a recall offer will be accepted. If the offer is rejected or the firm has chosen to forgo recalling the previous worker, the firm can then choose to post an outside offer with cost $c_f \geq 0$. The contacted worker will accept the job if k exceeds her reservation wage index k^r. Firms take as given the probability l_s^o that an outside worker will find an offer acceptable.

The state of the firm is described by the vector (m, h, k, i, s) where m is the previous employment status of the job (1=filled, 0=vacant), h indicates whether the job is new ($h = 1$) or existing ($h = 0$), k is the index of the match value, and i is the index of the current firm-specific shock. The firm chooses a vector of three binary values $d = (d^l, d^r, d^o)$: to lay-off a currently employed worker ($d^l = 1$), to put out a recall to the last worker who held the job ($d^r = 1$) or to post an offer to outside workers ($d^o = 1$).

The one-period expected profit for an existing firm ($h = 0$) can be written using the elements of the state vector and the decision vector d:

$$
\begin{aligned}
v_f(m, 0, k, i, s, d) =& m \times \left(\pi_s + (1 - \alpha)M_k + \epsilon_i \right) \left[(1 - l_s^q)(1 - d^l) \right] \\
&+ (1 - m) \times \left(\pi_s + (1 - \alpha)M_k + \epsilon_i \right) \left[d^r l_s^r \right] \\
&+ (1 - m) \times \left(\pi_s + (1 - \alpha)\mu/\alpha + \epsilon_i \right) \left[\left(d^r(1 - l_s^r) + (1 - d^r) \right) l_s^o d^o \right] \\
&- (1 - m) \times c_f \left[\left(d^r(1 - l_s^r) + (1 - d^r) \right) d_s^o \right].
\end{aligned}
\tag{9}
$$

where μ/α is the expected value of worker-firm matches. The first line equals the expected profit associated with a job remaining filled. The second and third lines are expected revenue and the fourth is the expected cost associated with the decision to fill a vacant job. If a job is destroyed, the expected profit is zero. For a new job ($h = 1$ and $m = 0$) expected profit is

$$
v_f(0, 1, k, i, s, d) = \left(\pi_s + (1 - \alpha)\mu/\alpha + \epsilon_i \right) \left[l_s^o d_s^o \right] - c_f \left[d_s^o \right].
\tag{10}
$$

The first term is the expected revenue from posting an offer and the second term is the expected cost.

A recall and new offer cannot be made simultaneously to prevent spurious creation of new jobs. The simulation of l_s^r in the model economy rules out the possibility that a worker

can receive a recall offer after accepting an outside offer. In effect, the firm loses track of the worker once she takes another job, and the firm must post an outside offer to fill the vacancy.

The value of a job given its current state is

$$V_f(m,h,k,i,s) = \max_d \quad v(m,h,k,i,s,d) + \beta E[V_f(m',h',k',i',s')|m,h,k,s,d]. \tag{11}$$

$\mathrm{Prob}(m',h',k',i',s'|m,h,k,s,d)$ is the probability transition function for the states of a firm and is defined in Appendix 1. With it we can write the firm's objective function

$$E[V_f(m',h',k',i',s')|m,h,k,s,d] \tag{12}$$
$$= \sum_{m'=0}^{1} \sum_{h'=0}^{1} \sum_{k'=1}^{N_w} \sum_{i'=1}^{N_\epsilon} \sum_{s'=1}^{3} \mathrm{Prob}(m',h',k',i',s'|m,h,k,s,d)V_f(m',h',k',i',s').$$

Optimal behavior is summarized by three reservation values of ϵ: $\epsilon_l^r = \epsilon_l^r(m,h,k,s)$, $\epsilon_R^r = \epsilon_R^r(m,h,k,s)$, and $\epsilon_o^r = \epsilon_o^r(m,h,k,s)$. For $\epsilon_i < \epsilon_l^r$ the firm lays off a currently employed worker. Similarly, if the job is vacant, the firm attempts to recall the worker if $\epsilon_i \geq \epsilon_R^r$, and if the recall is refused, the firm issues an outside offer if $\epsilon_i \geq \epsilon_o^r$. With costless recalls and costly outside offers, $\epsilon_o^r \geq \epsilon_R^r$.

Assuming that firms cannot keep track of how the job became vacant last period greatly simplifies the firm's value function. The firm also cannot keep track of the worker's availability for recall. This is similar to the assumption that workers cannot keep track of a firm's activity but instead perceive constant layoff and recall probabilities (conditional upon the aggregate state of the economy).

Equilibrium

Each vector of beliefs Λ and L determine probabilities of events occurring to agents on the other side of the market. That is, let $\Lambda^I(L)$ denote the aggregate state-contingent probabilities of layoffs, recalls, on-the-job job offers, and unemployed job offers implied by optimal firm behavior given firm beliefs L. Similarly, let $L^I(\Lambda)$ denote the aggregate state contingent probabilities of quits, recall acceptances, and job offer acceptances implied by

optimal worker behavior given worker beliefs Λ. Then an equilibrium is a fixed point in beliefs:

$$\Lambda^I(L) = \Lambda \qquad (13)$$

$$L^I(\Lambda) = L.$$

To find a set of consistent beliefs of this form, we simulate the labor market to compute probabilities of events given beliefs and optimal behavior based on those beliefs. The details of our simulation procedure are given in Appendix 3.

It may be instructive to compare this numerical model to the job matching model of Mortensen and Pissarides (1994). The probability of a layoff would become an exogenous parameter, the rate of match destruction in M&P. Existing but vacant jobs would be permanently destroyed with certainty ($l^d = 1$). Workers would never be recalled by the same firm ($\lambda^r_s = 0$). The UI system would be eliminated ($\tau = 0$) and quits would not be allowed ($l^q = 0$). Reservation wages of workers would equal the wage associated with the largest idiosyncratic shock (M&P's best-available-technology assumption). On the other hand, Mortensen and Pissarides solve a wage bargaining model that takes into account (constant, public) outside alternatives and the total (constant, public) surplus generated by the match. In this respect our assumption of constant sharing of the match-specific component alone is either *ad hoc* or requires the assumption that neither party can continue search during the bargaining process. It does, however, generate wage dynamics that are consistent with two stylized facts. In particular, the best-available-technology assumption in M&P avoids the possibility that workers would reject job offers, which simplifies the analysis, but it also implies that wages fall stochastically with tenure. Here, wages are constant with tenure, and our framework could be extended to allow for productivity that rises with tenure, although it would involve expansion of the firm's state space. Second, since the distribution of match values does not vary with the aggregate state in our model, wages of continuing jobs do not vary with the business cycle, although averages wages do vary because of selection processes. Observationally, a person's current wage does depend upon the state of the cycle in which the match

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was formed. This is consistent with Beaudry and Dinardo (1991) who find that, without correcting for selection of matches, a worker's current wage is more strongly related to the unemployment rate when the job began than the current or intervening unemployment rates.

III. PARAMETERS

The Business Cycle

The Markov transition probabilities for the aggregate productivity shocks are exogenous to the market equilibrium defined in the previous section. The values used throughout the analysis are reported in Table 1C. The mean duration of each state and the probability of movement between states is estimated using the autoregressive model suggested by Christiano (1991). We assume, as in Mortensen (1994), that the economy cannot move to a high state from a low state without passing through the middle state. The details of the procedure are provided in Appendix 2.

Based on $P_{ss'}$ in Table 1 the vector of ergodic probabilities for the Canadian data is (0.171,0.657,0.171), implying, for example, that the model economy is in the low state 17% of the time. If the economy is in a boom or a slump, there is a 97.7% probability that it will remain in that state during the next period (month). If it does not remain in the same state, the economy moves to the middle state. If the economy is in the middle state there is a 98.8% chance that it will remain in that state the next period. If it does not remain in the middle state, it is equally likely that next period's state will be low or high.

Unemployment Insurance

The values chosen for the unemployment insurance parameters appearing in the dynamic programming problem for individuals are also reported in Table 1D. They were chosen to match as closely as possible the Canadian UI system in place throughout the 1980's. This period is chosen for two reasons. The UI rules were not changed from 1980 to 1989, and this

period includes a complete business cycle. (The 7.5% unemployment rate in 1980 is identical to the unemployment rate in 1989.) While there were no major changes to UI rules during the 1980s, the particular entrance requirements and benefit duration faced by workers during this period varied with the unemployment rate over time and across regions of the country. The parameters are based on the mean unemployment rate over this period of 9.4%.[6]

For instance, the entrance requirement in Canada where the unemployment rate was 9.4% is 10 weeks; in the model, the entrance requirement is 3 periods, or 12 weeks. The penalty for repeat users of UI was six weeks, in the model it is 2 periods. Eligible workers were paid one week of benefits for each week worked up to 26 weeks, thereafter one week of benefits were paid for each two weeks worked. In the model, one period of benefits are paid for each period worked up to 6 periods, thereafter one period of benefits is earned for each two periods worked. Under an 9.4% unemployment rate, extended benefits lasted 24 weeks (6 periods).

In the 1980s the earnings replacement ratio, τ, was 60% of the previous wage up to the maximum insurable earnings and the minimum benefit is 20% of the maximum. The minimum and maximum benefit levels in Canada are calculated from a nominal maximum insurable weekly earnings level. To keep the real maximum insurable earnings level fairly stable, the government adjusts the nominal maximum insurable earnings each year. The maximum insurable weekly earnings in 1986 (the base year for calculating real wages) is $495.

Chosen Parameters

Three parameter values were not chosen by fitting them to aggregate data, government policy, or to match the model's simulated equilibrium to data. Their values are reported in Table 1B. The firm discount rate was set to $\beta_f = 0.997$, and as a four-week discount rate this

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[6] The feedback between the unemployment rate and UI eligibility is rightly considered an important element of the Canadian UI system (e.g. Milbourne et al. 1991). In our model this feature would require adding the unemployment rate in each aggregate state to the worker belief vector Λ.

implies a 4% annual real interest rate. The worker discount rate is set to $\beta_w = 0.97$ on the presumption that low-skill workers face a higher cost of borrowing than firms. The departure rate of workers from this market is set to $l^d = 0.0083$, which implies a mean duration until exit from the low skill market of 10 years.

Fitted Parameters

The remaining parameters were set following a (somewhat loose) matching of the moments generated from simulating the equilibrium of the model to moments derived from data on the labor market for Canadian men aged 20 to 24. Computational constraints, discussed in Appendix 2, kept us from truly matching the model's predictions to the chosen moments as well as possible. But this procedure did achieve its primary objective: to find values of the model's parameters that would yield simulations similar to actual outcomes in the Canadian labor market. This procedure increases confidence that the patterns found in our policy simulations are similar to those that would be found in a fully estimated version of the model.

We choose the young male demographic group for comparison based on three reasons. First, the business cycle is taken as exogenous, so our model is best thought of as a partial equilibrium model of one segment of the labor market. In a general equilibrium, changes in UI policy would induce responses in the pattern of aggregate shocks. Second, young men typically have relatively high rates of unemployment and receipt of UI benefits. Measuring how the market for their labor responds to the UI system is likely to provide an upper bound for the overall effect. Third, the Canadian UI system includes a large maternity leave component. Not including young women in our data avoids the difficulty of modeling the effect of maternity on reservation wages and decisions to quit jobs.

The fitted parameters include: the absolute value of the aggregate shock (π_h), the vacant job destruction rate (l^d), the firm's cost of hiring a new worker (c_f), the worker's value of being unemployed for one period (c_w), the worker share of the match value (α), the

mean (μ) and standard deviation (σ) of wage offers, and the absolute value of the largest idiosyncratic productivity shock (B). The moments chosen to match are the means and standard deviations of the unemployment rate, the proportion of people receiving UI within a period, and mean wages. Appendix 2 provides more details.

The parameters found by (partial) matching of simulated moments to data moments are presented in Table 1. The worker's value of remaining unemployed c_w is low relative to the mean wages because workers obtain most of the benefit from unemployment through UI payments and through the higher probability of finding a job when unemployed than when working. On the other hand, the firm's cost of hiring a worker c_f is slightly greater than the mean wage in the labor market. The worker receives about 80% of the match value. Comparing B to π_h, we see the range of the idiosyncratic shocks is much larger than that of wages and aggregate shocks. The model requires a lot of volatility within the life of a match to create an incentive for firms to lay workers off. On the other hand, if the market experiences a good aggregate shock, there is a high probability that it will experience a good aggregate shock next period. Therefore, a smaller value of the aggregate shock will suffice to have an effect on firm actions.

Parameter Values for Policy Experiments

The equilibrium under the *Baseline* policy that held in Canada during the 1980s is compared to two other policies: the elimination of UI altogether (*NoUI*), and the rules introduced since 1990 (*NewUI*). The simplest way to eliminate UI benefits payments to workers in the model is to change the replacement rate to zero. This is done for the first simulation. However, UI does not only affect the economy in terms of benefits. It also affects taxes paid by firms and workers. To incorporate this feature into the model, elimination of UI must also eliminate taxes paid on wages into the UI Fund. Since payroll taxes are paid on wages not match values, the share of the match retained by the firm now must be separated

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from the wages paid to the worker. Hence, under a system of no UI, the profit (3) becomes

$$\pi_s + \frac{w_k}{\alpha} - (1 + \zeta)w_k + \epsilon_i \tag{14}$$

where ζ represents the tax rate on wages which is *removed* under the alternative simulation. In the base simulation, $\zeta = 0$, meaning the match value in the firm's profit function includes all taxes. In the alternative simulation, $\zeta = -0.04$, which approximates the total proportion of wages paid into the Canadian UI Fund by firms and workers from 1980 to early 1993.[7]

In 1990, 1993 and 1994 the Canadian government introduced a series of significant changes to the UI system.[8] For a geographical area similar to the case assumed for the base simulation, the entrance requirement rose from 10 weeks to 16 weeks. Regional extended benefits were reduced from 24 weeks to 20 weeks, the maximum duration of benefits from 49 weeks to 44 weeks, lowered the replacement ratio to .50, disqualified persons who quit or were fired with cause completely, and increased the payroll tax rate by two percentage points.[9] Table 1D shows how these changes affect the model's UI policy parameters. The disqualification of quitters is approximated by changing the transition function governing the benefits of workers who leave employment to become unemployed.[10] The new transition function is given in Appendix 1.

IV. POLICY SIMULATIONS

Tables 2 and 3 and Figure 2 summarize simulations of the equilibrium response to the three policy regimes described in the last section using the parameter values (in Table 1) found by loosely matching the baseline case to empirical moments (in Table 2). First, the empirical moments and the moments simulated from the baseline policy show similar

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[7] The actual rate varied from 2.4% to over 6%.

[8] Yet another a set of changes to UI was introduced in 1996. These changes were not include in this analysis.

[9] The federal government originally introduced regional extended benefits as an add-on to UI payable out of federal coffers. The new extended benefits are payable by the UI Fund.

[10] To properly introduce the effect of the disqualification of quitters requires a separate reservation wage for employed workers who are laid off and those who are not.

patterns across the cycle with some differences in the levels of the moments. The average unemployment rates are matched closely. The rate of UI receipt is somewhat lower in the baseline simulations and mean wages are somewhat higher. The standard deviation of the moments within business cycle states are higher in the data than in the baseline simulation. This is perhaps not surprising since the aggregate producitivity in the model are constant within states, but in reality shocks are affecting the labor market at all time. It is worth noting again that the set of parameters in Table 1 are not the best possible fitting parameters due to the amount of time required to solve for equilibrium beliefs. However, the mean levels are similar enough to have confidence that the policy simulations yield patterns that are relevant for the actual labor market.

The other columns of Table 2 show how the moments respond to policies. Not suprisingly, eliminating UI leads to a lower unemployment rate in all aggregate states. In each case unemployment drops to about 60% of the baseline levels. Another way to look at this change is to attribute a share of this 'excess' unemployment under the Baseline to each person that receives UI under the Baseline. By aggregate state (low to high) each UI month is associated with .73, .93, and .74 of another unemployment month, respectively. Weighted by the long run probabilities of each state, each UI month is associated with .86 more months of equilibirum unemployment above the NoUI equilibrium. This response is higher that the actual proportion of people receiving UI in the Baseline model. The Baseline simulation itself underpredicts the rate of UI use among young Canadian men at these parameter values. This means the .86 value could overstate the impact of UI on unemployment since the denominator is smaller than in the data. On the other hand, parameter values that better fit the data might imply a lower unemployment rate without UI, so it is not known whether .86 is an understatement or overstatement. In any event, the UI system appears to have a potentially large effect on the unemployment when the equilibrium responses to the policy work themselves out. Mean wages also fall without UI, essentially because less productive match values are employed due to the incentive to work.

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What is surprising is that unemployment rates go up in each aggregate state under the New UI rules. The changes in the rules essentially move the UI system towards No UI 'on paper' but it does not move the economy unambiguously towards the No UI equilibrium. There is only a slight drop in rates of UI receipt. Since the rules cut benefit eligibility and duration, this lack of response must come through the changed labor market equilibrium. In terms of excess unemployment the effects is more dramatic. For each UI month the New UI rules generate 1.31, 1.61, and 1.06 months of unemployment across the business cycle states. The long-run average is 1.46: each two people on UI can be thought of as generating a third unemployed person not receiving UI through the changes in firm and worker decisions generated by the UI policy. The New UI rules move mean wages down, although the size of the change is small enough to be explain mainly by the increased payroll tax rate included in the New UI parameters.

Equilibrium Beliefs

Table 3 compares equilibrium beliefs held by workers (Λ) and firms (L) under each of the policies. First, consider the Baseline vectors. Some patterns are relatively straightforward. Layoff probabilities are monotonic (and counter-cyclical) across the business cycle (indicated by a '>' below the vector). Quit, recall offers, and unemployed job offer probabilities are all pro-cyclical. However, recall acceptances are counter-cyclical: laid off workers belief (rightly) that the probability of being recalled is higher during a recession than a boom. And two vectors of beliefs are not monotonic across the cycle. On-the-job offer probabilities reach a mininum and offer acceptance probabilities reach a maximum in the middle state, not in one of the two extreme states. While the existence of three aggregate states adds a great deal to the computational burden, these non-monotonic effects in the equilibrium beliefs indicate that a two-state model may mask some important asymmetries between booms and recessions due to the dynamic elements of job matching and the Canadian UI system.

Next, consider the equilibrium response of beliefs across the business cycle. Relative

to the Baseline simulation there are twelve vectors of beliefs across states to compare. In only half of these vectors is the change in beliefs monotonic across business cycle (indicated by either three or zero '^'s in each block of probabilities). Most of these monotonic changes occur when eliminating UI altogether. This would result in lower layoff and quit probabilities and greater job offer probabilities while unemployed. Offers on-the-job are less likely, which is driven by the greater employment levels in all three aggregate states. Recall offers are also lower without UI, presumably because the lack of UI leads more layoffs to be 'permanent', i.e. less affected by the time-varying idiosyncratic shocks. Two belief vectors do not respond monotonically to eliminating UI. Firms believe it more likely that offers and recalls are accepted during recession but less likely in the middle and boom states than in the Baseline.

The changes in beliefs induced by recent changes to the UI rules are not so straightforward and in several cases the opposite of those generated by removal of UI altogether. Recall from Table 2 that unemployment rates are higher under the (stricter) NewUI parameters than under the Baseline parameters. These changes lead to greater layoff and recall probabilities among workers. At the same time firms also expect workers to be more likely to accept recalls. Altogether, these changes indicate that tighter UI eligibility and lower benefits can lead to more short term layoffs based on the idiosyncratic shocks to revenue. Rather than discouraging use of the system, the changes can lead to more use.

The increase in temporary layoffs in the New UI equilibrium reflects the interface between firms and attached workers. These increases are accompanied by ambiguous effects on the interface between firms and unattached workers. For example, job offer probabilities are higher in recession despite the fact that there are more unemployed competing for offers in the NewUI equilibrium. In the other states outside offer probabilities go down. This pattern is a mirror reflection of the offer acceptance beliefs held by firms. They expect more offers to be accepted in booms under NewUI (relative to the Baseline) but fewer in the other states.

Finally, note the changes in monotonicity (marked by '>') across the business cycle across UI policy regimes. Three belief vectors are monotonic in all three policies: layoffs, recalls,

and recall acceptances. On-the-job offer probabilities are monotonic in none of the regimes. The remaining four beliefs exhibit different patterns across the policies. Perhaps the most interesting one is that job offer probabilities are pro-cyclical in the Baseline and NoUI but they reach a mininum in the middle state under the NewUI parameters. This indicates in yet another way that the dynamics within the UI system interact in a very complicated way with the dynamics of the business cycle.

Long Run and Cyclical Patterns in Labor Market Aggregates

Figure 2 shows the simulated time path of selected variables under the three policy regimes. The graphs cover more than a full business cycle. During the simulations the duration of the aggregate states is equal to their average durations. The boom ($s = h$) and recession ($s = l$) periods are shown along the timeline in Figure 2A. It shows that the three policy regimes have mainly a level effect on the unemployment rate. Under the New UI rules the rate is nearly the same by the end of a (average) boom as under the Baseline, but during middle states and recessions it is several percentage points higher. The pattern in mean duration of unemployment spells (below in Figure 2C) is more complex, since it is composed of both an incidence and a (pure) duration effect. At the beginning of a boom mean durations go up slightly in all three regimes, as the change in the aggregate state leads many firms to issue recalls, eliminating many layoffs due to idiosyncratic shocks. After that mean duration steadily falls as more and more workers take jobs, which arrive at a higher rate (Table 3). Since there are fewer vacant jobs there are fewer jobs totally destroyed, so fewer unemployed lose contact with their firms altogether. Interestingly, mean duration of unemployment is much less sensitive to cyclical conditions under NoUI. By the end of the average boom the mean duration under NoUI is higher than in the other two regimes. When the economy goes into recession there is a short-term drop in duration as many firms respond with layoffs. Then durations rise slowly under all three regimes. The peak in duration actually occurs when the economy moves back into the middle period, again generated by the recall of many

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short-term layoffs.

The pattern in mean wages (2B) is somewhat similar. During a boom mean wages fall, in part because lower-valued matches are now viable. At the start of the recession there is a corresponding increase in mean wages as low matches generate layoffs. This effect is not very pronounced under the Baseline and No UI regimes, and during the recession mean wages grow slowly. Under the New UI rules, however, mean wages increase more sharply and thereby peak at the end of the recession.

The patterns in wages and unemployment rates reflect, in part, a very complicated pattern in reservation wages among the unemployed (Figure 2D). This in turn is determined by the interplay of equilibrium beliefs across states. First, note that the pattern for NoUI is very abrupt, because under NoUI workers are spread over only a few states (primarily the wage of the previous match, which affects the value of a recall offer). Under NoUI reservation wages go up during a boom, driven primarily by the higher rate of job offers, making job search more productive. However, with a UI system in place reservation wages fall quickly during a boom. Job offer probabilities are very similar (Table 3), so this is caused by the unemployed wanting to get any job to establish a match and build up eligibility for UI while offers are available. This strategy is helped by the higher job offer rate during booms and leads to the higher quit rate than the NoUI case. These quits are mainly job-to-job transfers as employed workers can receive offers while holding a low-value match. During the recession reservation wages increase under the Baseline and (particularly) the NewUI regime. This reflects the combine effects of UI eligbility and altered layoff and recall policies of firms. Unemployed workers are less likely to accept outside offers under the NewUI rules because they are receiving UI benefits and are expecting recalls. Both of these effects are missing in the NoUI case. What is surprising is that the Baseline equilibrium falls between the two. In effect, the modest reduction in UI eligbility creates a greater response by firms (in terms of layoff and recall decisions) to outweigh the worker reaction.

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V. CONCLUSION

This paper has carried out experiments on the long run effects of changes in unemployment insurance policies based on an equilibrium model of the labor market in a cyclical economy. The model takes into account the details of the Canadian UI system. Our notion of equilibrium beliefs makes it feasible to compute how workers and firms respond to UI policy and the business cycle in terms of job search, job offers, layoffs, recalls, and quits. The equilibrium analysis shows that changes in policy parameters can have unintended effects on the long run equilibrium. In particular, we find that tightening eligiblity requirements leads to greater unemployment and only a small drop in UI incidence in the simulated economy. Our results also indicate that the new UI rules in Canada incorporated in our model create excess amounts of unemployment in equilibrium: each month nearly three people are unemployed for every two people on UI that would not be unemployed without UI. This is a higher ratio than under the Baseline policy in which fewer than one unemployed person is generated for every UI case each month.

The business cycle aspect of our analysis appears important. The equilibrium responses to the three policy regimes we simulate do differ across the business cycle. For example, the new UI regime tends to exasperate recessions more than the baseline regime. These asymmetries are caused in part by the dynamic element of the UI rules such as eligibility requirements and benefits that depending on past wages. Thus, the added cost of computing equilibria in the model with three aggregate states and several state variables for individuals appears to have proved worthwhile.

Our results are far from being precise estimates on the impact of UI on the Canadian economy. However, our results are highly suggestive and are only conceivable within an equilibrium model of the labor market that takes into account details of government policy. Evidence drawn from econometric studies of individual response to UI benefit levels (such as Meyer 1990) and from estimates of short run responses to policy changes (such Baker

and Rea 1993 or Green and Riddell 1993) are clearly important parts of policy analysis, but neither type of study can account for long run effects, which may either dampen or accentuate individual responses. Development of large-scale equilibrium models to simulate long run effects of policy changes should be seen as an important complementary element to traditional program evaluation.

APPENDIX 1:   TRANSITION FUNCTIONS

Workers

The transitions from the current state to the next for remaining workers depend upon the occurrence of offers, layoffs and recalls, the current wage, reservation wage and offered wage in each state, and the UI system. The occurrence of offers, layoffs and recalls and the level of the offered wage can be summarized by three random elements: λ^ϵ, λ^e, and k^o, where λ^e and $\lambda^\epsilon \sim U(0,1)$ and k^o are i.i.d. and drawn from a uniform distribution over the discrete values $1, 2, \ldots, N_w$. If the worker is unemployed, then a recall is received if $\lambda^\epsilon \leq \lambda_s^r$. If the worker is employed, then a new job offer is received if $\lambda^\epsilon \leq \lambda_s^j$. Similarly, an unemployed person receives a job offer if $\lambda^e \leq \lambda_s^o$, and an employed person is laid off if $\lambda^e \leq \lambda_s^l$.

Transition from $m = 0$

$$
m' = \begin{cases}
0 & \text{if } \left(\lambda^\epsilon > \lambda_s^r \text{ and } \left(\lambda^e > \lambda_s^o\right)\right. \text{ (no offer or recall)} \\
& \text{or } \left(\lambda^e \leq \lambda_s^o \text{ and } k_u^r > k^o\right) \text{ (offer, no recall, offered wage is too low)} \\
& \text{or } \left(\lambda^e > \lambda_s^o \text{ and } \lambda^\epsilon \leq \lambda_s^r \text{ and } k_u^r > k\right) \\
& \quad \text{(no offer, recall, recall wage is too low)} \\
& \text{or } \left(\left(\lambda^e \leq \lambda_s^o \text{ and } k_u^r > k^o\right) \text{ and } \left(\lambda^\epsilon \leq \lambda_s^r \text{ and } k_u^r > k\right)\right) \\
& \quad \text{(both offered wage and recall wages are too low)} \\
1 & \text{if } \left(\lambda^\epsilon \leq \lambda_s^r \text{ and } k_u^r < k\right) \text{ (recall is received and accepted)} \\
& \text{or } \left(\lambda^\epsilon > \lambda_s^r \text{ or } k_u^r > k\right) \text{ and } \left(\lambda^e \leq \lambda_s^o \text{ and } k_u^r \leq k^o\right) \text{ (no recall or recall wage} \\
& \quad \text{is too low, but new wage is offered and accepted}
\end{cases}
$$

Transition from $m = 1$

$$
m' = \begin{cases}
0 & \text{if } \lambda^e \leq \lambda_s^l \text{ and } \lambda^\epsilon > \lambda_s^j \text{ (layoff with no job offer)} \\
& \text{or } \lambda^e \leq \lambda_s^l \text{ and } \lambda^\epsilon \leq \lambda_s^j \text{ and } k_e^r > k^o \text{ (layoff with new offer, but offer too low)} \\
& \text{or } \lambda^e > \lambda_s^l \text{ and } \lambda^\epsilon \leq \lambda_s^j \text{ and } k_e^r > \max\{k, k^o\} \\
& \quad \text{(quit job and new offered wage is too low)} \\
1 & \text{if } \lambda^e \leq \lambda_s^l \text{ and } \lambda^\epsilon \leq \lambda_s^j \text{ and } k_e^r \leq k^o \text{ (layoff with new job offer accepted)} \\
& \lambda^e > \lambda_s^l \text{ and } \lambda^e ps > lambda_s^j \text{ (no layoff, no new job offer,} \\
& \lambda^e > \lambda_s^l \text{ and } \lambda^\epsilon \leq \lambda_s^j \text{ and } k_e^r < \max\{k, k^o\} \text{ (no layoff, new job is offered,} \\
& \quad \text{and either the offer or the existing wage is acceptable)}
\end{cases}
$$

Transitions for k, p, n

$$
k' = \begin{cases}
k & \text{if } m = 1 \text{ and } m' = 0 \text{ (leave job, wage index now denotes benefit level)} \\
& \text{or } ((m = 1 \text{ and } m' = 1) \text{ and } \lambda^\epsilon \leq \lambda_s^j \text{ and } k \geq k^o \\
& \text{(remain employed with job offer, reject new offer)} \\
& \text{or } m = 1 \text{ and } m' = 1 \text{ and } \lambda^\epsilon > \lambda_s^j \text{ (remain employed} \\
& \text{with no new job offer)} \\
& \text{or } \lambda^\epsilon \leq \lambda_s^r \text{ and } I^R = 1 \text{ (accept recall)} \\
k^o & \text{if } m = 0 \text{ and } \lambda^e \leq \lambda_s^o \text{ and } k_u^r < k^o \\
& \text{(accept new job offer when unemployed)} \\
& \text{or } m = 1 \text{ and } m' = 1 \text{ and } \lambda^\epsilon \leq \lambda_s^j \text{ and } k < k^o \\
& \text{(receive and accept outside job offer)}
\end{cases}
$$

$$
p' = \begin{cases}
1 & \text{if } m = 0 \text{ and } m' = 1 \\
p + 1 & \text{if } m = 1 \text{ and } m' = 1 \text{ and } p < y_p \\
p - 1 & \text{if } m = 0 \text{ and } m' = 0 \text{ and } p > 0 \\
0 & \text{if } m = 0 \text{ and } m' = 0 \text{ and } p = 0 \\
& \text{or } m = 1 \text{ and } m' = 0 \text{ and } p < t_E \\
& \text{or } m = 1 \text{ and } m' = 0 \text{ and } w_k < w_{min} \\
\min\{y_p/2 + p/2 + t_R, y_p\} & \text{if } m = 1 \text{ and } m' = 0 \text{ and } p \geq t_E \text{ and } w_k \geq w_{min}
\end{cases}
$$

$$
n' = \begin{cases}
\min\{n + 1, y_p\} & \text{if } m = 0 \text{ and } m' = 0 \text{ and } p = 0 \\
& \text{or } m = 0 \text{ and } m' = 1 \\
& \text{or } m = 1 \text{ and } m' = 1 \\
y_p & \text{if } m' = 1 \text{ and } p \geq t_{ER} \text{ (person qualifies for u.i. as a repeater)} \\
0 & \text{if } m' = 0 \text{ and } p > 0 \text{ (person is receiving u.i.)}
\end{cases}
$$

These are perhaps best illustrated by an example. Mary is unemployed with 12 periods UI remaining at a benefit level denoted by $k = 2$. The economy is in a recession $(s = s_l)$. The period is $t - 1$ and it is almost over. Her state in period $t - 1$ is $\{m, k, p, n, s\} = \{0, 2, 12, 0, s_l\}$. Now Mary is getting prepared for period t. The state of the economy in period t is revealed: $s = s_l$. Mary has not received a recall from her previous job. She receives a job offer at $k = 5$ for period t. Therefore Mary decides which is greater, $V(0, 2, 11, 0, s_l)$ or $V(1, 5, 1, 1, s_l)$. The value of k for which $V(0, 2, 11, 0, s_l) = V(1, k, 1, 1, s_l)$, is the reservation wage for the state $\{0, 2, 11, 0, s_l\}$. Mary's reservation wage in state $\{0, 2, 11, 0, s_l\}$ is $k_u^r = 4$. She accepts the job in period t, and is employed for that period. Her state in period t can be described by $\{1, 5, 1, 1, s_l\}$, which simply says she is employed at $k = 5$, for one period $(p = 1)$, has not received UI for one period $(n = 1)$ and the aggregate shock is low. Now period $t + 1$ is about

to begin. Mary now knows the economy is moving into a medium level of output, $s = s_m$ in period $t + 1$. She has not been laid off, but has received an outside job offer. She must now decide whether to remain employed at the current wage, quit, or accept the new job offer. If she quits, she does not qualify for UI. The value of k for which $V(1, k, 2, 2, s_m) = V(0, 5, 0, 0, s_m)$ is the reservation wage for state $\{1, 5, 2, 2, 0\}$. If $k_e^r <= 5$ Mary will continue to work. If $k^o > 5$ she will change jobs.

NewUI modifies the transition functions to

$$
p' = \begin{cases}
0 & \text{if } m = 1 \text{ and } m' = 0 \text{ and } \lambda^e > \lambda_s^l \text{ (not layed off)} \\
& \text{or } m = 1 \text{ and } m' = 0 \text{ and } p < t_E \\
& \text{or } m = 1 \text{ and } m' = 0 \text{ and } w_k < w_{min} \\
\min\{y_p/2 + p/2 + t_R, T\} & \text{if } m = 1 \text{ and } m' = 0 \text{ and } \lambda^e \leq \lambda_s^l \text{ and } p \geq t_E \\
& \text{and } w_k \geq w_{min}
\end{cases}
$$

where the first line takes account of the disqualification of quitters.

Firms

First define the probability of transition in the employment status of the job:

$$\mathrm{Prob}(1, 0, k | 0, 0, k, s, d) = \left(d^r l_s^r + \left(d^r(1 - l_s^r) + 1 - d^r\right) l_s^o d^o \frac{1}{N_w}\right)(1 - l^d)$$

$$\mathrm{Prob}(1, 0, k' \neq k | 0, 0, k, s, d) = \left(d^r(1 - l_s^r) + 1 - d^r\right) l_s^o d^o \sum_{k' <> k} P_{k'}\right)(1 - l^d)$$

$$\mathrm{Prob}(0, 1, k' | 0, 0, k, s, d) = l^d$$

$$\mathrm{Prob}(0, 0, k' | 0, 0, k, s, d) = 1 - \mathrm{Prob}(1, h', k' | 0, 0, k, s, d) - l^d$$

$$\mathrm{Prob}(1, k' | 1, 0, k, s, d) = \left(1 - l_s^q\right)\left(1 - d_s^l\right)\left(1 - \lambda^d\right)$$

$$\mathrm{Prob}(0, k' | 1, 0, k, s, d) = 1 - \mathrm{Prob}(1, k' | 1, k, s, d).$$

$$\mathrm{Prob}(1, h' = 0, k' | 0, 1, k, s, d) = d^o l_s^o$$

$$\mathrm{Prob}(0, h' = 1, k' | 0, 1, k, s, d) = 1 - \mathrm{Prob}(1, h' = 0, k' | 1, 1, k, s, d).$$

The complete transition probabilities then take the form

$$\mathrm{Prob}(m', h', k', i', s' | m, h, k, s, d) = \frac{1}{N_\epsilon} P_{ss'} \mathrm{Prob}(m', h', k' | m, h, k, s, d).$$

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APPENDIX 2: DATA SOURCES AND PARAMTER MATCHING

Data Sources

All data are from monthly seasonally adjusted (MSA) series. The last date used is March 1993, since major changes to UI regulations came into effect April 1, 1993. Data on wages of men 20 to 24 are not available in MSA series. To approximate the wages available in a low skilled labor market, the wages for service sector workers are used. These are transformed into real wages using the consumer price index. The unemployment rate for males 20 to 24 is available from CanSim. UI regular benefit claimants are available for the 20 to 24 year age group, but not by sex. The UI claimant series for the model is calculated according to:

$$uir_m = uic_{bs} \frac{ue_m}{ue_{bs} lf_m}$$

where

uir_m = UI claimant rate for men 20 to 24

uic_{bs} = Number of UI claimants both sexes 20 to 24

ue_m = Number of unemployed men 20 to 24

ue_{bs} = Number of unemployed persons both sexes 20 to 24

lf_m = labor force, men 20 to 24

CanSim Data Series Used in Model

VARIABLE NAME	SERIES NUMBER
Real GDP at Factor Cost	I37026
Consumer Price Index	P719500
Labor Force (both sexes, 20 - 24)	D774019
Labor Force (men, 20 - 24)	D774022
Number Unemployed (both sexes, 20 - 24)	D774036
Number Unemployed (men, 20 - 24)	D774039
Unemployment Rate (men, 20 - 24)	D774001
Unemployment Rate (both sexes, 15 +)	D767611
Number of UI Regular Claimants (20 - 24)	D730858
Wages in Service Sector	L95674

Markov Transition Functions for s

The continuous state of the business cycle is measured using Canadian monthly real GDP (at factor cost), denoted y_t. (See Appendix 2 for the details and for all data sources.) We let

$$y_t = \rho y_{t-1} + (1 - \rho)\mu_y + e_t$$

where

$$e_t = \gamma e_{t-1} + v_t, \quad Ev_t y_{t-1} = 0, \quad Ev_t = 0, \quad Ev_t^2 = \sigma_v^2 = \frac{z^2(1-\rho)}{\kappa}$$

Our estimate of ρ equals 0.977 and the kurtosis parameter κ is set to 3 as in the normal distribution. The variable z represents the size of the aggregate shock to the economy as a whole. It plays no role in calculating the transition matrix under the assumptions used in the current model. The elements of the Markov transition matrix $[P_{ss'}]$ can be found by solving the equations:

$$\rho = 2P_{ll} + P_{lm} - 1$$

$$\kappa = 1 + 0.5\frac{P_{lm}}{P_{ml}}.$$

Moment Matching

The other parameters besides $P_{ss'}$ in Table 1C where chosen to minimize the weighted sum of squared differences between simulated (SM) and empirical moments (EM). The

moments chosen to match between the data and simulations of the model are the means
($l = 1$) and standard deviations ($l = 2$) of the unemployment rate ($v = 1$), the proportion of
people receiving UI within a period ($v = 2$) and mean wages ($v = 3$). Since there are three
phases of the business cycle, there are $2 \times 3 \times 3 = 18$ moments. The distance between the
moment vectors,

$$\sum_{s=l,m,h} \sum_{v=1}^{3} \sum_{l=1}^{2} w_{lv} \big(SM_{svl} - EM_{svl} \big)^2 \tag{15}$$

was used as the objective while adjusting the parameters of the model. The weights (w_{lv})
and moments are reported in Table 2. Recall that calculation of the equilibrium beliefs
requires repeatedly solving the dynamic programming problems, simulating the economy,
and updating the belief vectors. While changing the parameter values we set the size of the
simulation small (in terms of the number of workers and firms and the number of discrete
shocks) and the precision of the simulation loose (in terms of the convergence criteria for the
belief vectors and the value functions). The values used in this stage are listed in Table 1A.
Furthermore, the objective function is not continuous in the choice variables which implies
that a non-gradient algorithm be used for minimizing the objective. These considerations
make it impractical to converge to the final minimizing values. The results reported are
based on values after approximately one month of time on an IBM SP-2 parallel processing
machine with eight nodes. Once this process was stopped the size and precision of the
simulations was increased considerably, as indicated in Table 1A, for the precise calculation
of beliefs under alternative policy regimes.

APPENDIX 3.   SOLUTION METHOD

To begin the iterative procedure, initial values are chosen for the vector of probabilities (beliefs) held by workers and firms about their labor market opportunities, denoted Λ_0 and L_0, bounded away from 0 and 1. There are then four steps in each iteration:

1 Solve the worker and firm maximization problems by iterating on the respective value functions V_w and V_f.

2 Based on the optimal behavior of firms and workers, simulate the labor market over a large number of periods for a large number of workers and firms.

3 From the simulated data, calculate the probabilities Λ_1 and L_1 that result from the joint behavior of workers and firms given their beliefs Λ_0 and L_0.

4 Adjust the beliefs to be a weighted average of the initial beliefs and the simulated probabilities.

Steps 1-4 are repeated until the vectors of new and initial beliefs converge. Then the model's parameters are adjusted to close the gap between simulated and empirical moments.

Details of step 1

Both the worker and firm maximization problems are solved by backward iteration on their respective Bellman's equations. The solution is achieved when the equation for each possible state the worker/firm can reach is stationary; that is to say, the value of making a decision in a given state is independent of the time period. For each state attainable by the worker, the solution to the worker problem yields a vector of reservation wages for both employed and unemployed workers, and an index which indicates whether an unemployed worker is willing to accept a recall to her previous job. For each state attainable by the firm, the solution to the firm problem yields a vector of yes/no decisions whether to post an offer for a newly created job, recall a previous worker for an existing vacant job, issue a recall and if refused post an outside offer for an existing vacant job, or layoff an employed worker.

Details of step 2

The first step in simulating the labor market is to specify a business cycle pattern set for the entire simulation. The model is simulated for a large number of workers and periods (see Table 1A). To reduce time to reach a solution, the business cycle follows a deterministic pattern based on the expected duration of each phase of the cycle. Next, initial values are chosen for the state of each simulated worker and firm. Each worker and firm is given an identification (id) number to keep track of them throughout the simulation. For simplicity (and without loss of generality), the worker begins the simulation attached to a firm with the same id number. Workers can begin the simulation employed or unemployed, with or without unemployment insurance. Whether employed or not, workers are assigned a wage index. This determines their wage if employed and their level of unemployment insurance premiums if unemployed and qualified for unemployment insurance. The wage index and employment status of the worker determines the initial wage index and vacancy status (filled or empty) of the corresponding firm's job. The percentage of workers employed and jobs filled in the first period is chosen, but the remainder of the assignments to states for both workers and firms are random.

After setting the initial values the simulation follows the sequence of actions illustrated in Figure 1. We will describe the process in terms of *last period*, *this period*, and *next period*. Both firms and workers enter *this period* in their final state from *last period*. All updating changes *this period*'s state. A worker or firm can be updated more than once if a worker refuses a recall and then accepts an outside job offer. Because only *last period*'s state is pertinent to all worker and firm decisions, only the *final* changes made to *this period*'s state carry forward into *next period*. Before *this period* ends, a percentage of firms with empty jobs are destroyed randomly with probability l^d and replaced by *new firms* with the same id numbers and vacant jobs. A percentage of workers also leave the labor market and are replaced by new workers who are unemployed and have no prior work experience. When employed workers leave the labor market, the corresponding firm's final state from *last period* is changed from job filled to job empty.

Before *this period* begins, two lists are created based on *last period*'s final state: the id numbers of employed workers and the id numbers of unemployed workers. When outside job offers are posted, the offer is issued randomly to a worker on the list of employed workers with probability l^e. Before any action is taken *this period*, the decision vectors for the new firms are examined, and if the firm wishes to make an offer its id number is added to a list of such firms. If the firm does not wish to make an offer, it is updated as a potential new job for the *next period*.

Recall and layoff decisions for all firms are completed before any outside offers are issued. The element of each firm's decision vector that determines whether the firm wants to recall its worker is examined and the following events occur:

No recall: the firm's state for *this period* is updated. If the worker is still attached to this firm, her state is also updated as remaining unemployed.

Recall: If the worker's job id no longer matches this firm's id, then the worker cannot be contacted and the firm can decide to post an outside offer. If the firm's decision is not to post an offer the job remains unfilled until the beginning of *next period*. If the firm wants to post an outside offer its id is added to a list of such firms for *this period*. If the worker is still attached to this firm, her recall index determines whether or not she will accept the recall. If the recall is accepted, the worker returns to work at the previous wage and the job is again filled. If the recall is rejected, the worker remains unemployed, and the firm's decision to post an outside offer is examined as if the worker had not been contacted.

For a filled job, the firm's decision vector indicates if the firm will layoff the worker. If yes, the firm is updated with the job now vacant, and the worker is updated as unemployed. If no, the worker's reservation wage is examined to see if she will quit. If the firm does not layoff the worker and the worker does not quit, the firm is updated with the job remaining filled and the worker is updated as still employed. If the worker quits, the firm is updated with the job now vacant and the worker is updated as unemployed going into *next period*. Note, at this point, the worker's state ending *last period* and coming into this one is still

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employed. Therefore, the worker is still included in the list of *employed* workers available for job offers.

After all firms have completed their layoff and recall processes, the list of firms that wish to issue offers is processed. First, the decision whether to send the offer to an employed or unemployed person is determined randomly based on the proportion of offers destined for each group. A second random assignment determines to which worker on the appropriate list the job offer will be directed. The process to determine whether the offer is accepted or rejected depends on whether the worker is employed or unemployed.

If the worker is unemployed (from *last period*) but has already accepted a recall, then the worker's id is removed from the list and the new job offer is directed to another unemployed worker. Once the offer reaches a still-available worker, the worker's reservation wage determines if she will accept the offer. If the worker accepts the offer she is updated as employed by the issuing firm and the firm is updated as employing the new worker. If the worker rejects the offer, the worker remains unemployed and the firm's job remains vacant going into *next period*.

If the worker is employed, it must be determined whether the worker has been laid off or not. If the worker has been laid off, the job is accepted if the offered wage matches or exceeds the worker's reservation wage. If the offer is accepted, the firm is updated with the job filled by the new worker and the worker is updated as employed by the new firm. If the worker has not been laid off, the job is accepted if the offered wage exceeds the worker's existing wage. If the offer is accepted, the firm is updated with the job filled by the new worker; the worker is updated as employed by the new firm; and the worker's previous firm is updated as having its job vacant. If the offer is rejected, the firm is updated as having its job remain vacant. The worker at this point does not need to be updated, since her state was determined during the first round of firm decisions.

Finally, all workers who are unemployed and who did not receive offers or recalls are updated as remaining unemployed.

Details of Step 3

For each simulated period, the recall, offer, on-the-job offer, and layoff probabilities facing the worker are calculated. The recall probability is calculated as the number of recalls issued, whether or not they reach the worker, divided by the number of unemployed workers. The offer probability is calculated as the number of offers issued to unemployed workers divided by the sum of the number of unemployed workers minus the number of unemployed workers who have accepted recalls *this period*. The on-the-job offer probability is the number of offers issued to employed workers divided by the number of employed workers. The layoff probability is the number of layoffs issued divided by the number of employed workers.

For each period, the probabilities for recall acceptances, job offer acceptances, and quits faced by firms are calculated. The probability that a recall is accepted equals the number of recalls accepted divided by the number of recalls issued, whether or not they reached the worker. The probability that an offer is accepted equals the number of offers accepted by both unemployed workers and employed workers divided by number offers issued. The probability that a worker quits a job equals the number of workers who quit their job, either to go into unemployment or to change job, divided by the number of employed workers.

At the end of each period, the vector of probabilities are assigned to the state of the economy in that period. These are averaged over all periods with the same state after discarding a number of periods to clear the effects of initial conditions.

Details of Step 4

Each of the new probabilities in Λ_1 and L_1 is compared to the corresponding initial belief in Λ_0 and L_0. There are 21 such probabilities, 12 in Λ and 9 in L. If the difference between any one element of the initial belief and simulated probability vectors falls outside the tolerance, the model is not yet solved.

The beliefs are adjusted according to:

$$\Lambda_0\prime = \Lambda_0 + (\Lambda_1 - \Lambda_0)r_v$$

$$L_0\prime = L_0 + (L_1 - L_0)r_v$$

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where $r_v \in (0,1]$ is the revision rate for the probabilities. Because the simulations are finite, the calculated probabilities are not continuous. Thus the belief vectors do not exhibit smooth convergence. Instead, they will continue to bounce around within some range that depends upon the size of the state spaces for workers and firms (which depend upon UI policies and other parameters) and the number of workers/firms in the simulation. When carrying out policy experiments (based on very large simulated economies) the iterations were simply run until none of the probabilities exhibited any trend over simulations. We ensured that at the end of the iterations the belief vectors had negligible variation (caused by the discreteness) compared to the difference in belief vectors across policies.

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Figure 1. Sequencing of actions and events within a Period

WORKER   FIRM

period t
production ends   period t
                                                                  production ends

some workers   jobs vacated by
leave market   departing workers

                                                                   some vacant
                                                                  jobs destroyed

new workers   potential new
enter market   jobs created

aggregate shock   aggregate shock
revealed   revealed

                                                              idiosyncratic shock
                                                               revealed to firms

                                                               layoffs announced

                                                               recalls announced

recalls accepted
or rejected

                                                                new and outside
                                                                 offers issued

match values   match values
revealed   revealed

outside offers
accepted or rejected

quits announced

period t+1   period t+1
production begins   production begins

A. Unemployment Rate

B. Mean After-Tax Wages

C. Mean Unemployment Duration
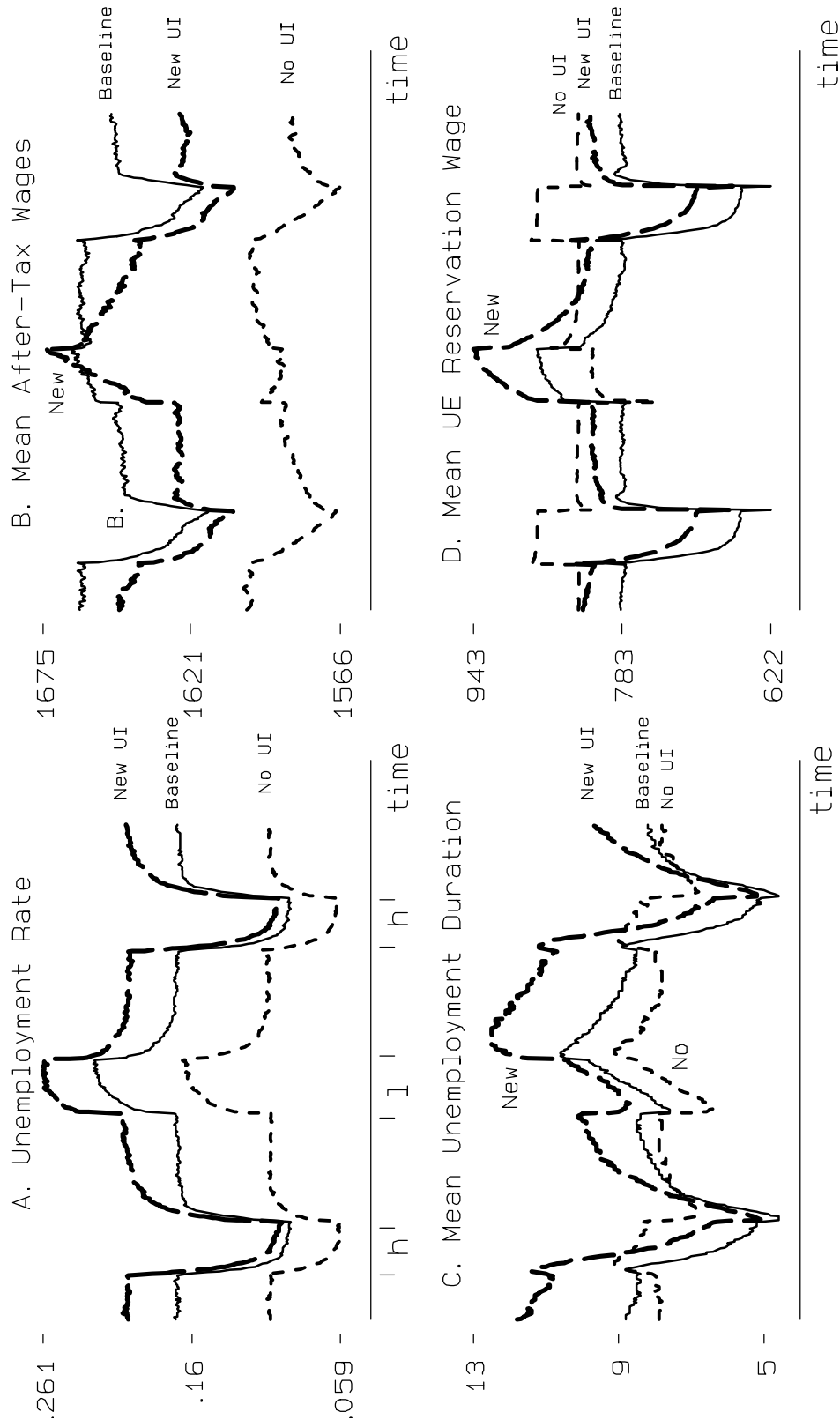
D. Mean UE Reservation Wage

Figure 2. Simulated Time Paths of Selected Variables

TABLE 1.
BASELINE AND POLICY EXPERIMENT PARAMETERS

Panel A: Size and Precision of the Simulated Equilibrium

Symbol	Description	Mom.Match	Exper.
N_w	Number of wage offers	10	25
N_ε	Number of firm-specific shocks	10	25
	Number of people/firms in simulations	4000	80000
	Number of periods in simulations	2000	5000
	Number of initial periods ignored	400	500
	Tolerance on belief convergence	0.001	*
	Tolerance on value function convergen	1E-05	1E-07

Panel B: Chosen (Fixed) Parameters

Symbol	Description	
β_w	worker discount factor	0.97
β_f	firm discount factor	0.997
λ_d	worker exit probability	0.0083

Panel C: Parameters Set to Match the Cdn. Business Cycle & Moments in Table 2.

Symbol	Description		Value
$P_{ss'}$	Aggregate state transition prob.		
		Low to Low	0.977
		Low to Medium	0.023
		Low to High	0
		Medium to Low	0.006
		Medium to Medium	0.988
		Medium to High	0.006
		High to Low	0
		High to Medium	0.023
		High to High	0.977
c_w	worker value of unemployment		10.906
μ	mean of log wages		6.285
σ	variance of log wages		0.634
c_f	firm cost of posting offer		2689.526
l_d	vacant job destruction prob.		0.126
α	worker share of match value		0.802
π_h	high state productivity		57.107
B	largest firm-specific shocks		9811.768

Panel D: Canadian Unemployment Insurance Parameters

Symbol	Description	Baseline	No UI	New UI
w_{min}	Mininum Insured Wage	400	-	400
τ	UI Replacement Rate	0.6	0	0.5
t_R	UI Regional Benefits	6	-	5
t_E	Regular Entrance Requirement	3	-	4
t_{ER}	Repeat UI Extra Entrance Req.	2	-	2
w_{max}	Maximum Insured Wages	1980	-	1980
ζ	Payroll tax rate	0	-0.04	0.02
T	maximum periods of UI receipt	13	-	12

* No specific tolerance was specified. Simulations were run until the beliefs were stationary

TABLE 2.

EMPIRICAL MOMENTS AND SIMULATED MOMENTS FROM BASELINE AND POLICY EXPERIMENTS

		Moment								
		Mean					Standard Deviation			
Variable	State	Weight	Empirical	Baseline	No UI	New UI	Weight	Empirical	Baseline	No UI	New UI
Unemployment Rate		3.00					1.00				
	low		0.20	0.22	0.16	0.25		0.020	0.009	0.011	0.007
	medium		0.14	0.17	0.11	0.20		0.028	0.012	0.010	0.015
	high		0.12	0.12	0.08	0.13		0.009	0.014	0.008	0.019
UI Receipt Rate		5.00					1.00				
	low		0.13	0.07	0	0.07		0.023	0.003	0	0.004
	medium		0.09	0.06	0	0.05		0.023	0.002	0	0.002
	high		0.09	0.05	0	0.05		0.014	0.005	0	0.004
Wages		2.00					1.00				
	low		1582.2	1666.0	1590.6	1658.4		8.67	2.63	2.94	9.37
	medium		1558.2	1659.6	1589.9	1644.0		14.74	4.21	8.75	9.37
	high		1547.4	1656.3	1579.5	1639.7		7.16	2.51	9.36	1.74

See Appendix 2 for data sources. Value of the objective at final parameter values: 5.94.   See section III for details.

TABLE 3.
EQUILIBRIUM BELIEFS UNDER ALTERNATIVE UI POLICIES

		Λ								L					
		Held by workers about firms								Held by firms about workers					
		r-Recall		o-UE Offer		j-Emp Offer		l-Layoff		o-Acc Offer		r-Acc Recall		q-Quit	
Policy	State	Value	Δ	Value	Δ	Value	Δ	Value	Δ	Value	Δ	Value	Δ	Value	Δ
Baseline	low	0.208		0.123		0.030		0.057		0.418		0.272		0.003	
	medium	0.150		0.140		0.027		0.032		0.442		0.185		0.004	
	high	0.083		0.198		0.028		0.011		0.429		0.050		0.006	
	Δ		>		>				>				>		>
No UI	low	0.194		0.130	^	0.021		0.047		0.447	^	0.318	^	0.0029	
	medium	0.062		0.178	^	0.022		0.015		0.406		0.124		0.0034	
	high	0.023		0.199	^	0.019		0.004		0.372		0.049		0.0031	
	Δ		>		>				>		>		>		
New UI	low	0.218	^	0.130	^	0.037	^	0.081	^	0.401		0.339	^	0.005	^
	medium	0.195	^	0.121		0.027		0.050	^	0.436		0.261	^	0.003	
	high	0.085	^	0.189		0.029	^	0.013	^	0.431	^	0.070	^	0.006	
	Δ		>						>				>		

^ indicates the probability to the left is higher than the corresponding value under the baseline policy.

> indicates that the vector of beliefs above are monotonic across the business cycle.