Cyclical Behavior of Unemployment and Job Vacancies: A Comparison between Canada and the United States

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Abstract

As long as workers do not value their leisure much, the Mortensen-Pissarides search and matching model implies that unemployment and job vacancies would be much less responsive to changes in labor productivity than what we observe in the business cycles of the Canadian labor market. These findings parallel the work of Shimer (2005) for the United States. The combined data from both countries present an additional difficulty for the model. Even if the unobserved value of leisure is allowed to be as high as required to fit the business cycle in the United States or in Canada, as proposed by Hagedorn and Manovskii (2007), another failure arises. The model cannot reconcile the similar labor cycles with the large policy differences in the UI benefits and income taxes in the two countries when the value of leisure is assumed to be the same in both countries.

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1 Introduction

The Mortensen-Pissarides (1994) search and matching model has become the standard model of the labor market presented in most macroeconomics textbooks.[1] One of the reasons for this popularity is that, with simple productivity shocks, the model correctly predicts the key empirical regularities in the cyclical fluctuations of unemployment and job vacancies.[2] Despite this success, however, recent work by Shimer (2005) has raised a serious question about the validity of this model by showing that, as long as unemployed workers care little about their leisure, the predicted variability of unemployment and job vacancies is much lower than that observed in the United States.

Although a large number of related studies has emerged to address this challenge, there has been little systematic work to check if this failure of the Mortensen-Pissarides model can be observed in other countries as well. This paper fills this gap by examining the business cycle in the Canadian labor market. Although the Canadian labor market is similar to that in the United States in many respects, Canadian data are particularly interesting given the differences in the generosity of unemployment insurance (UI) benefits and in tax rates between the two countries. These variables affect the opportunity cost of employment, which has proved to be a crucial variable to determine the cyclical predictions of the Mortensen-Pissarides model.

The dynamics of the Canadian labor market are found to be similar to those observed in the United States. Over the business cycle, both unemployment and job vacancies are volatile and persistent, and these two variables have a strong negative correlation (Beveridge curve). Workers find jobs more easily in booms than in recessions, while firms fill their vacancies more easily in recessions than in booms. Consistent with the way the matching is modelled in the Mortensen-Pissarides model, the job-finding and the vacancy-filling rates correlate closely, and with opposite signs, with the vacancy-unemployment ratio. Qualitatively, all these observations are correctly predicted by the standard Mortensen-Pissarides model with productivity shocks. However, as in the United States, when the model is calibrated assuming that workers do not value their time much while they are unemployed, the model predicts only a small fraction of the observed variation in unemployment and job vacancies in

[1] For example, see the graduate textbooks of Ljungqvist and Sargent (2004, 2nd edition, Chapter 26) and Romer (2006, 3rd edition, Chapter 9.8). The undergraduate textbooks, such as Mankiw (2007, 6th edition, Chapter 6), typically present a stripped-down version of the model. See Yashiv (2007) for further discussion.

[2] See Pissarides (2000) (pp. 26-33). Also, see Cole and Rogerson (1999); Mortensen and Pissarides (1994); and Rogerson, Shimer and Wright (2005).

Canada.

The empirical data also show that in both Canada and the United States shocks affecting the job-finding rate are the main driving force of cyclical fluctuations in unemployment. However, the relative importance of job separations differs in the two countries. In the United States, Shimer (2005) finds that the separation shocks account for a small fraction of the cyclical fluctuations in unemployment. In contrast, separations are important contributors in Canada. Yet, the introduction of separation shocks in the calibrations of the model does not significantly improve the model's ability to replicate the high fluctuations in unemployment and job vacancies observed in reality.

A comparison of the data from Canada and the United States uncovers an additional difficulty in explaining the observed cyclical variations in the labor market with the Mortensen-Pissarides model. Although it is easy to make the cyclical fluctuations in the vacancy-unemployment ratio as large in the model as observed in the United States or in Canada by simple parameterization of the opportunity cost of employment, no calibration permits the model to reconcile the similar labor cycles in both countries as long as workers in these two countries share the same value of leisure. More specifically, when the value of leisure in the United States obtained from targeting the American business cycle data is imposed on the model of the Canadian economy, the model generates unrealistic predictions for unemployment and job vacancies: the unemployment rate rises to 100 percent and the number of vacancies drops to zero. These results are driven by the fact that Canada provides much more generous UI benefits and has higher income taxes relative to the United States. This, together with the large common value of leisure, substantially raises the opportunity cost of employment and results in a negative match surplus. A similar failure presents when the value of leisure determined by matching the cyclical fluctuations in the Canadian labor market is imposed on the model of the American economy. The predicted standard deviation of the vacancy-unemployment ratio accounts for only about 20 (40) percent of its empirical unconditional (conditional) counterpart in the United States. An opposite intuition applies here: the lower income tax, and much more stingy UI benefits in the United States, accompanied by the low common value of leisure, greatly lower the worker's opportunity cost of employment, which enlarges the match surplus and destroys the amplification mechanism argued by Hagedorn and Manovskii (2007) (to be explained in Section 5). These findings are robust to several variations of the model, such as adding training costs, deviating from the Hosios rule to generate smoother real wages, and fitting conditional responses to productivity shocks instead of overall cyclical fluctuations.

Allowing for different preferences for leisure in the two countries proves crucial in resolving this failure. However, the value of leisure required to fit the United States cycles has to be about 1.6 times larger than the corresponding value of leisure in Canada after taking into account the difference in productivity between the two countries. Such a large gap is implausible. This finding is also robust to the variations of the model listed above. Although all these features allow for calibrations of the model with opportunity costs of employment not as high as those in Hagedorn and Manovskii (2007), they have little impact on the implied gap between the values of leisure in Canada and the United States.

The literature most related to this paper is Costain and Reiter (2008), which criticizes the Hagedorn and Manovskii's calibration by pointing out that if the non-market returns are high, the response of unemployment to changes in labor market policy, particularly unemployment insurance, is unrealistically large. Indeed, when the Canadian UI benefits and income taxes are introduced into the model of the American economy, the model predicts a dramatic rise in unemployment, to the point where all workers become unemployed. Similarly, when this exercise is reversed by imposing the American policies on the Canadian economy, the predicted unemployment declines by 50 percent. These predicted large reactions of unemployment suggest that the attempts to fix the volatility puzzle by simple parameterization of the opportunity cost of employment open up the door to other problems, such as unrealistic effects of changes in labor policy. Despite the similar results of Costain and Reiter (2008) and this study, the two papers differ in their methodology; Costain and Reiter examine the policy effect through reduced-form regressions, while this paper pursues this question by studying the data in two specific countries.

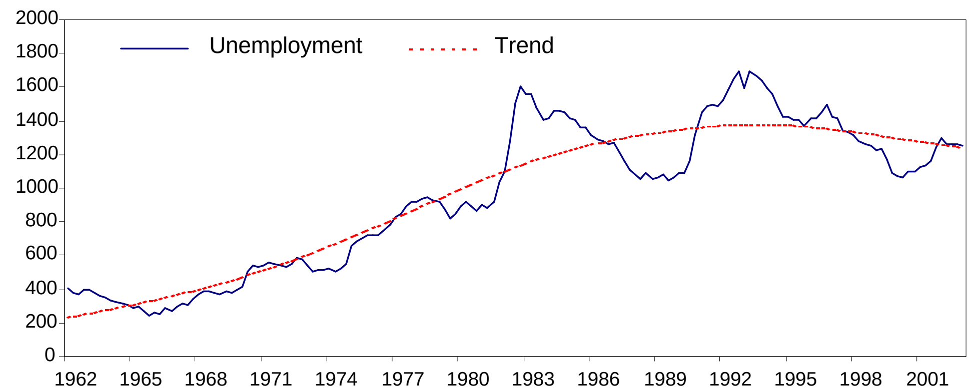
The rest of the paper is organized as follows. Section 2 documents the key facts characterizing the Canadian business cycle. Section 3 briefly describes the stochastic version of the Mortensen-Pissarides model with training costs and taxes. Section 4 calibrates the model using Canadian data, and discusses the performance of the model in explaining the observed business cycles in the Canadian labor market with a low opportunity cost of employment. Section 5 examines the model's empirical performance in simultaneously accounting for the cyclical variations in Canada and the United States with a high opportunity cost of employment. The additional difficulty is found by studying the effects of imposing one country's policy on the other. The role of the value of leisure in improving the model's fit is explored and the gap between the implied values of leisure in the two countries is discussed. Section 6 concludes with a summary and suggestions for further research.

2 Canadian Labor Market Facts

This section documents the movements of the main variables in the Canadian labor market: unemployment, vacancies, job-finding rate, separation rate, and labor productivity. For comparison purposes, the construction of these variables follows Shimer (2005).

The first variable of interest is unemployment, which is measured as the number of workers who are able to work, available for work, actively seeking jobs, and yet not working. To highlight the business-cycle fluctuations, the raw series in unemployment is detrended as in Shimer (2005), using the Hodrick-Prescott filter with a smoothing parameter of 10^5. (The same transformation is applied to the rest of the variables.) The evolution of unemployment in Canada is shown in Figure 1. Over the sample period of 1962 to 2003, unemployment climbed gradually and exhibited strong fluctuations; the cyclical component, the difference between the log of unemployment and its trend, has a standard deviation of 0.162. Hence, unemployment fluctuates as much as 32 percent above or below its trend over the cycles. Moreover, the cyclical component of unemployment also shows a large persistence as evidenced by its autocorrelation of 0.956.

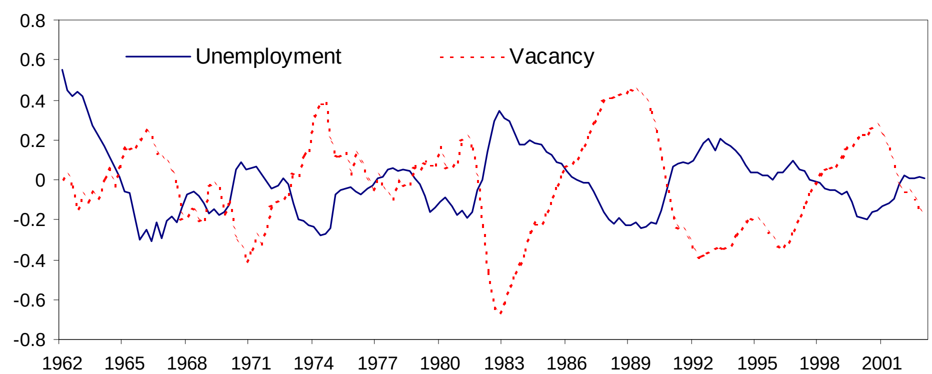
Figure 1: Quarterly Canadian Unemployment (In Thousands) and Trend, 1962 - 2003



The flip side of unemployment is job vacancies, reflecting the willingness by a firm to hire workers. The conventional measure of job vacancies is the help-wanted index elaborated from ads in major newspapers. Until recently, there was little question about the validity of this standard proxy for vacancies, but in the last few years many firms have increasingly relied on the Internet to post their vacancies. Therefore, the help-wanted index has become less useful, and Statistics Canada stopped compiling it in 2003 (but it has not yet introduced a substitute). For this reason, the whole set of time series in this study ends in that year. Similarly to unemployment, job vacancies display remarkable variations. The cyclical component of job vacancies has a standard deviation of 0.237, and it also exhibits a large persistence over the sample period with an autocorrelation of 0.956.

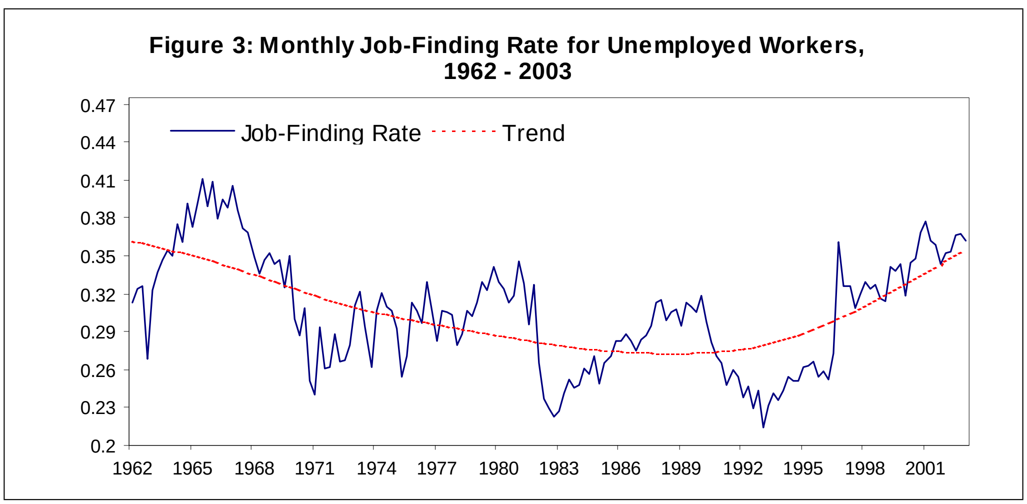
Figure 2 displays simultaneously the cyclical components of unemployment and vacancies. Throughout 1962 - 2003, the two series are negatively correlated with a correlation coefficient of -0.689. Since unemployment is countercyclical, while vacancies are procyclical, the vacancy-unemployment ratio is strongly procyclical. The empirical data show that the standard deviation for the cyclical component of the vacancy-unemployment ratio is 0.367. Figure 2 also shows that vacancies lead unemployment, and that the cycles of the former have slightly larger amplitudes.

Figure 2: Comparison of Cyclical Components of Unemployment and Job Vacancy, 1962 - 2003



NOTE: Both unemployment and vacancy in Figure 2 are expressed in logs as deviations from the Hodrick-Prescott trend with a smoothing parameter 10^5.

The job-finding rate, f_t, is a measure of the rate at which an unemployed worker finds a job. This rate plays a key role in the Mortensen-Pissarides model as it determines, together with the separation rate, the dynamics of unemployment. Assuming, as in Shimer (2005), a fixed labor force, unemployment at $t+1$ is the sum of the workers who lose their jobs from t to $t+1$ (short-term unemployed at $t+1$: u^s_{t+1}) plus the unemployed workers at t who remain unemployed at $t+1$. That is, $u_{t+1} = u^s_{t+1} + u_t(1 - f_t)$.[3] Using the number of workers who have been unemployed for less than 4 weeks to measure u^s_t, the resulting average monthly job-finding rate is 0.309.[4] That is, over the sample period, close to one third of the unemployed workers found jobs within one month. Figure 3 plots the evolution of the quarterly average of the monthly job-finding rate and its trend from 1962 to 2003. The job-finding rate displayed considerable variations as evidenced by the standard deviation of 0.105 for its cyclical component. Compared with its counterpart in the United States (see Figure 5 in Shimer 2005), the rates in Canada showed similar trends except for the period of 1990-2000, when they steadily rose in Canada while remaining fairly stable in the United States. Figure 4 displays simultaneously the cyclical components of both the vacancy-unemployment ratio and the job-finding rate, revealing a strong positive relationship between these two variables, with a correlation of 0.753. This high correlation is consistent with a fairly stable matching function, as assumed by the Mortensen-Pissarides model.

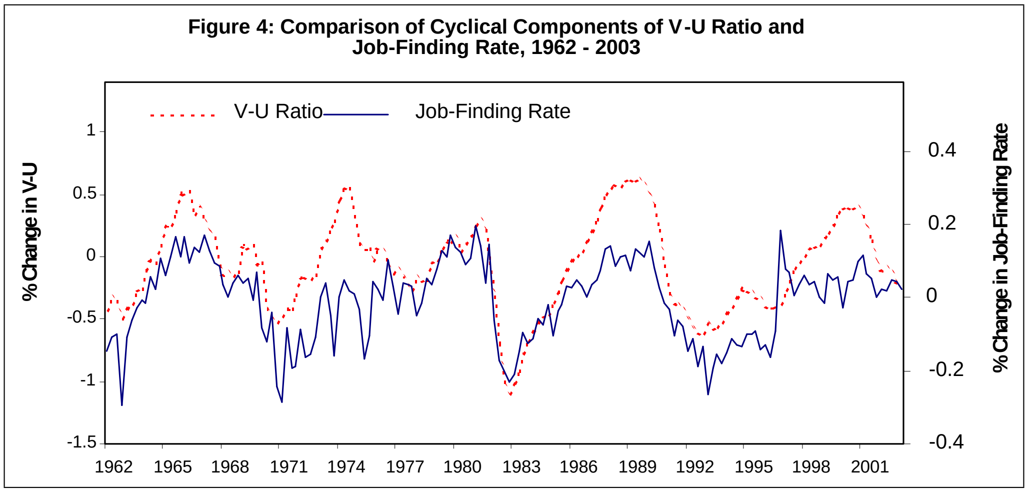


Another important determinant of fluctuations in unemployment is job separation. The separation rate, s_t, measures the departure rate of workers from their employing firms when it is no longer in their mutual interest to continue their relationship. With a constant labor force, short-term unemployment at $t+1$, u^s_{t+1}, is the group of workers who have separated from their job at t.

[3]A limited cyclical fluctuation of the Canadian labor force is observed over the sample period as evidenced by its low standard deviation of 0.016.

[4]The alternative measure used in Hall (2005b), based on job-duration data, yields a monthly job-finding rate of 0.302.

That is, $u^s_{t+1} = e_t s_t(1 - \frac{1}{2}f_t)$ where e_t is employment in period t. The term in parenthesis reflects the fact that unemployment is measured in a survey date (middle of each month in Canada), so a newly unemployed worker has, on average, half a month to find a new job before he or she is recorded as unemployed. Using the job-finding rate constructed above, the average monthly separation rate is about 0.03. That is, over the sample period, an average of three percent of workers separated from their jobs each month, so jobs lasted on average 2.8 years.



NOTE: Both the V-U ratio and job-finding rate in Figure 4 are expressed in logs as deviations from the Hodrick-Prescott trend with a smoothing parameter 10^5.

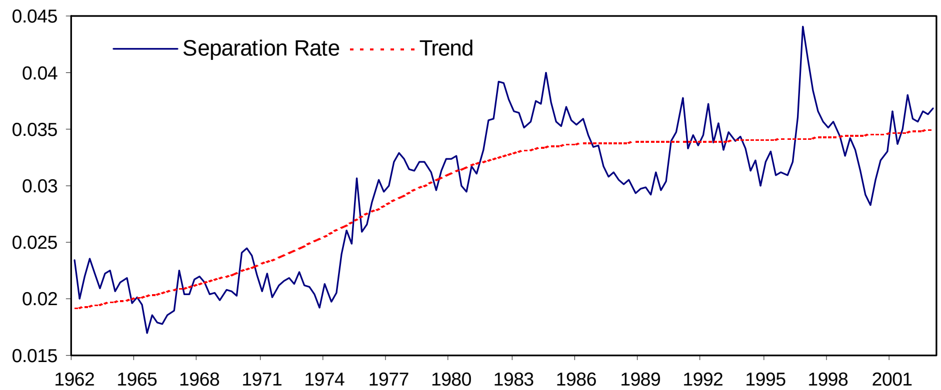
Figure 5 shows the evolution of the quarterly average of the monthly separation rate and its trend. The difference between the log of the separation rate and its trend has a standard deviation of 0.096.[5] Of particular note is that the trends of the separation rates in Canada and the United States after 1980 were different: the trend in Canada was roughly stable, but it declined substantially in the United States (see Figure 7 in Shimer 2005). This difference can be partly explained by the fact that Canada, since the 1971 liberalization of the UI program, provides much more generous UI benefits relative to the United States.[6] Because UI benefits essentially subsidize unemployment,

[5] An alternative measure in Hall (2005b), using the job tenure data, yields a monthly separation rate of 0.031.

[6] The 1971 liberalization of Unemployment Insurance broadened coverage to most (93 percent) of the labor force, compared to 42 percent in 1940 when it was created. Program changes also included easier work requirements; increased level (two-thirds of insurable

they increase the worker flows from employment to unemployment, thus raising the job separation rate. Green and Riddell (1997) examine the response of employment durations to the change in the UI entitlement requirement in 1990 in Canada. They find strong evidence of the moral hazard effect: the labor market participants tailor their behavior to adjust to the change in the eligibility requirement, and many jobs terminate when workers approach the duration that would permit a UI entitlement.[7]

Figure 5: Monthly Separation Rate for Employed Workers, 1962 - 2003



It is time to examine the relative contributions of the finding rate and the separation rate to the cyclical fluctuations in the unemployment rate. For this purpose, it is useful to notice that over the sample period the actual unemployment rates almost coincided with the implied "steady-state unemployment rates" constructed by using the time series of the separation and the finding rate: u_t^{ss} ($u_t^{ss} = \frac{s_t}{s_t+f_t}$) (see Figure 6).[8] Therefore, the contributions of variations in the job-finding rate and in the separation rate to the fluctuations in

earnings replacement rate), duration and range of benefits (adding sickness, maternity and retirement benefits).

Five criteria are widely used to assess the generosity of UI, namely, the replacement rate, the maximum duration of benefits, the fraction of the work force covered by the UI program, the weeks of employment required to qualify for UI, and the categories of unemployed workers who qualify for UI. The Canadian UI system is far more liberal by any of these criteria. See Table 2 in Moorthy (1989) for more details.

[7] See also Andolfatto and Gomme (1996), Christofides and Mckenna (1996) and Moorthy (1989) for the discussion of the effects of the UI system on job duration and unemployment.

[8] At steady state, the flows out of unemployment equal the flows into unemployment. That is $e_t s_t = u_t f_t$. In Figure 6, the actual rates were observed to be lower than the

the unemployment rate can be easily decomposed by constructing two theoretical unemployment rates: one with the actual separation rate and the mean job-finding rate, denoted as u_t^1 ($u_t^1 = \frac{s_t}{s_t+E(f_t)}$), and the other with the actual job-finding rate and the mean separation rate, denoted as u_t^2 ($u_t^2 = \frac{E(s_t)}{E(s_t)+f_t}$).

Figure 6: Quarterly Unemployment Rate vs. Steady-State Unemployment Rate, 1962 - 2003

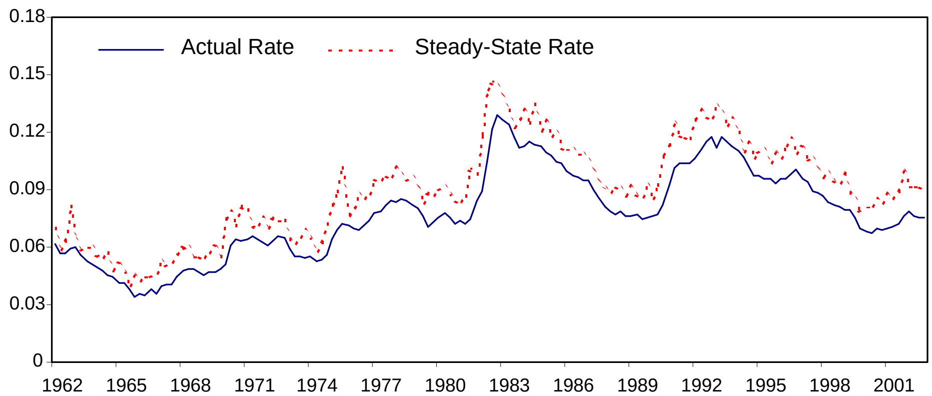
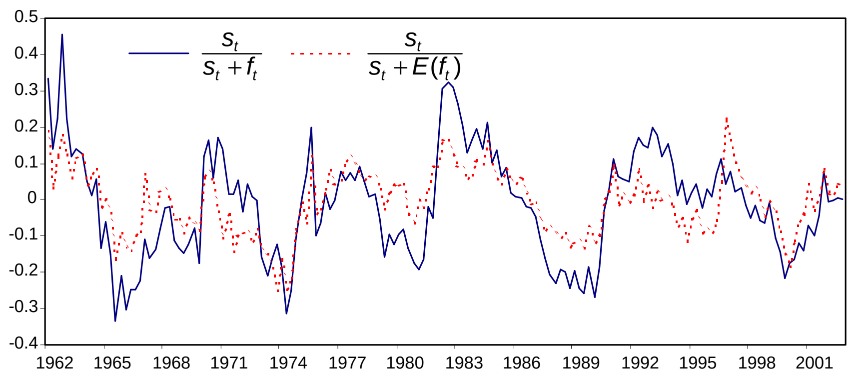


Figure 7: The Impact of the Separation Rate on Fluctuations in Unemployment, 1962 -2003

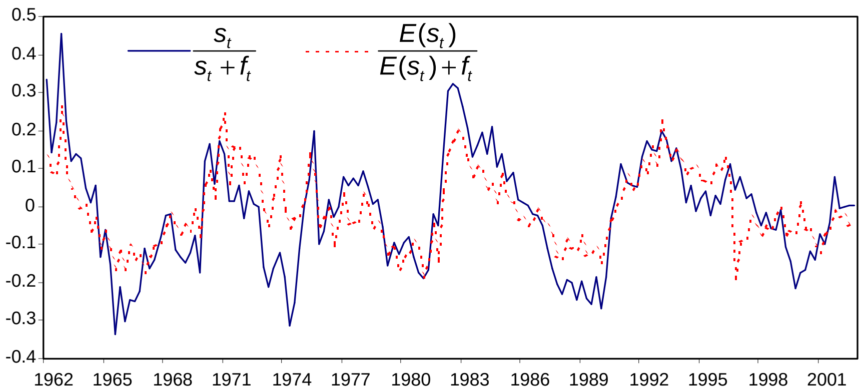


Figures 7 and 8 compare the cyclical components of u_t^1 and u_t^2, respectively, with the cyclical component of u_t^{ss}. Unlike what Shimer observes in the United

constructed steady-state ones. One possible explanation is that in constructing the steady-state unemployment rate, I rule out the possibility of staying out of the labor force, which leads to overestimation of the unemployment rates.

States labor market, both figures show pronounced co-movements between the two series, suggesting that not only the job-finding rate but also the separation rate is an important determinant of the cyclical behavior of unemployment. In particular, the job-finding rate accounts for 62 percent of the observed fluctuations in unemployment, while the separation rate accounts for 54 percent of those fluctuations. These two percentages add up to more than 1 since the finding rate and the separation rate are correlated.

Figure 8: The Impact of the Job-Finding Rate on Fluctuations in Unemployment, 1962 - 2003

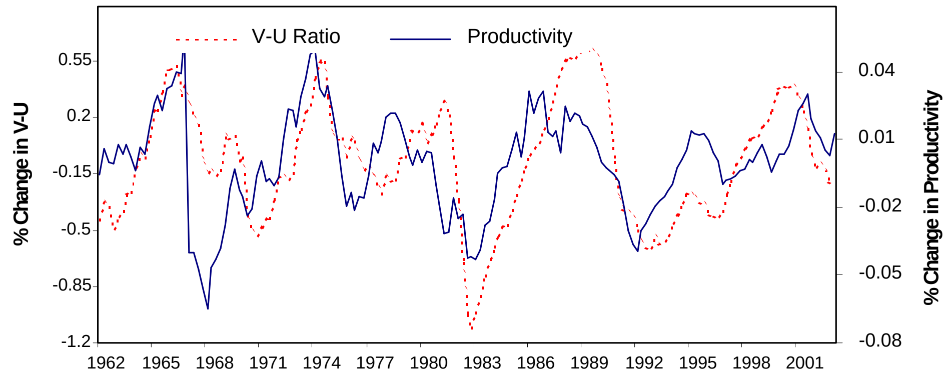


NOTE: All the unemployment rates in Figures 7 and 8 are expressed in logs as deviations from the Hodrick-Prescott trend with a smoothing parameter 10^5.

Labor productivity is the last variable examined in this section. It is measured as real output per worker in all industries excluding agriculture and the public sector. Figure 9 depicts the cyclical components of labor productivity and the vacancy-unemployment ratio. The vacancy-unemployment ratio is procyclical throughout the whole sample period, with a correlation of 0.52 with labor productivity. The most important message in this figure, however, is that the vacancy-unemployment ratio fluctuates much more than labor productivity. The vacancy-unemployment ratio displays remarkable variation, deviating above or below its trend by more than 0.5 log points eight different times, and reaching 1 log point below the trend in the recession of 1982. In contrast, labor productivity is relatively stable, never fluctuating beyond 6 percent. The overall fluctuations in the vacancy-unemployment ratio are over ten times larger than those of labor productivity in the period from 1962 to 2003.[9]

[9] When labor productivity is defined as output per hour worked, the resulting standard

Figure 9: Quarterly Cyclical Components of Canadian V-U Ratio vs. Labor Productivity, 1962 - 2003



NOTE: Both the V-U ratio and productivity in Figure 9 are expressed in logs as deviations from the Hodrick-Prescott trend with a smoothing parameter 10^5.

TABLE 1 Summary Statistics
Quarterly Canadian Data, 1962 - 2003 and Quarterly U.S. Data, 1951 - 2003

		u	v	v/u	f	s	p
Standard deviation		0.162	0.237	0.367	0.105	0.096	0.021
		0.190	*0.202*	*0.382*	*0.118*	*0.075*	*0.020*
Quarterly autocorrelation		0.956	0.956	0.959	0.791	0.795	0.876
		0.936	*0.940*	*0.941*	*0.908*	*0.733*	*0.878*
	u	1	−0.689	−0.851	−0.660	0.682	−0.322
		1	*−0.894*	*−0.971*	*−0.949*	*0.709*	*−0.408*
	v	–	1	0.958	0.712	−0.475	0.568
		–	*1*	*0.975*	*0.897*	*−0.684*	*0.364*
	v/u	–	–	1	0.753	−0.595	0.520
Correlation matrix		–	–	*1*	*0.948*	*−0.715*	*0.394*
	f	–	–	–	1	−0.155	0.232
		–	–	–	*1*	*−0.574*	*0.396*
	s	–	–	–	–	1	−0.396
		–	–	–	–	*1*	*−0.524*
	p	–	–	–	–	–	1
		–	–	–	–	–	*1*

NOTE: All variables in Table 1 are expressed in logs and deviations from the Hodrick-Prescott trends. The numbers in the upper line are the empirical data moments in the Canadian labor market, while the ones in the lower line are the counterparts in the United States. The U.S. data are from Shimer (2005).

deviation is still low, equal to 0.041 at the annual frequency, close to the standard deviation of output per worker, which is 0.034 at the annual frequency.

Table 1 collects the key statistical moments describing the Canadian labor market and compares them to their analogs from the United States. In summary, this table documents the following facts: 1) Unemployment and job vacancies display considerable variations over the sample period, and both are about 10 times more volatile than labor productivity. Moreover, the vacancy-unemployment ratio is strongly procyclical, with a standard deviation almost 20 times larger than that of labor productivity. 2) All variables show remarkable persistence. 3) Both job creation and job destruction are critical factors in explaining the cyclical movements in unemployment. 4) The cycles of job vacancies slightly lead those of unemployment. Finally, of particular note in Table 1 is the similar data moments in the United States and Canada, which implies that the labor markets in these two countries share similar dynamics over the business cycles.

3 The Mortensen-Pissarides Search and Matching Model with Training Costs and Taxes

In this section, I lay out a variation of the discrete time version of Shimer's (2005) model with the following three extensions. A general linear income tax is introduced in a way that labor income (wages and UI compensations) and corporate income (sales minus wages) are taxed at a common rate τ. The value of the opportunity cost of employment z is decomposed into three components: UI benefits b, taxes t and leisure l. Lastly, a one-time training cost k is introduced. Workers and firms pay a respective tax-deductible training cost k^w and k^f upon forming a match. The total training cost, $k = k^w + k^f$, is split between the two parties in a match according to the generalized Nash bargaining solution. This cost captures in a simplified fashion the fact that firms incur hiring and training costs when they recruit new employees, while workers typically suffer human capital losses when they undergo a spell of unemployment. Earlier studies have found that this cost is important to improve the fit of the model to the business cycle data.[10] Moreover, an additional benefit from this consideration is that it increases the opportunity cost of the match without resorting to a high value of the opportunity cost of employment for the worker, which will be shown in Section 5. To facilitate comparability, I use Shimer's notation whenever possible.

[10] See Mortensen and Nagypál (2007), Silva and Toledo (2007), and Yashiv (2006) for discussions about the importance of training costs (or, more generally, turnover costs) for the dynamics of unemployment.

In the model, both workers and firms are identical, infinitely-lived, risk-neutral and discount the future income at a common rate r. In each period, an employed worker earns an endogenous wage net of taxes, $w_t(1-\tau)$, which is contingent on the realization of labor productivity (the aggregate state of the economy), while an unemployed worker receives a utility value from both the after-tax UI benefits and leisure, $b(1-\tau)+l$, and searches for a job at no cost. Each firm has access to a constant returns to scale production technology, producing output p_t with one unit of labor in each period. There is free entry of firms. In each period, after the realization of the productivity shock, firms decide whether to post a vacancy or not. The firm that desires to hire a worker posts a vacancy at a tax-deductible cost c (units of output). When the vacancy is filled, the firm yields a net profit $(p_t - w_t)(1-\tau)$.

Unemployed workers and firms are brought together pairwise by a matching technology, which is assumed to be Cobb-Douglas in unemployment u_t and vacancies v_t: $m(u_t, v_t) = \mu u_t^{1-\eta} v_t^{\eta}$. Symmetry across the workers implies that the job-finding rate f_t at which each worker finds a job at t is equal to the matches formed in that period divided by unemployment. Likewise, the vacancy-filling rate q_t at which a vacancy is filled at t is equal to the matches formed in that period divided by the measure of vacancies:

$$f(\theta_t) = \frac{m(u_t, v_t)}{u_t} = m(1, \theta_t) = \mu\theta_t^{\eta} = \theta_t q(\theta_t), \tag{1}$$

where θ_t is the vacancy-unemployment ratio (also called market tightness).

Once a vacancy is taken by an unemployed worker, the match remains until an exogenous separation occurs (no job-to-job transition), which takes place at a rate s_t. The match surplus is split up between the worker and the firm according to a generalized Nash bargaining rule in each period, through which the wage is determined and continuously updated. The bargaining power for the worker is $\beta \in (0,1)$.

For the time being, the only shock in the economy generating business cycles is a productivity shock. Labor productivity p_t is assumed to be stochastic and follows a first-order Markov process. Contingent on productivity being p, the values of being an employed worker and an unemployed worker, W_p and U_p, and the values of a firm matched with a worker and posting a vacancy, J_p and V_p, are recursively defined by the following discrete-time Bellman equations:

$$
\begin{aligned}
W_p &= w_p(1-\tau) + \frac{1}{1+r}[sE_pU_{p'} + (1-s)E_pW_{p'}], && (2)\\
U_p &= b(1-\tau) + l \\
&\quad + \frac{1}{1+r}\left\{f(\theta_p)\left[E_pW_{p'} - k^w(1-\tau)\right] + \left[1 - f(\theta_p)\right]E_pU_{p'}\right\}, && (3)\\
J_p &= (p - w_p)(1-\tau) + \frac{1}{1+r}(1-s)E_pJ_{p'}, && (4)\\
V_p &= -c(1-\tau) + \frac{1}{1+r}q(\theta_p)\left[E_pJ_{p'} - k^f(1-\tau)\right] = 0, && (5)
\end{aligned}
$$

where the expression $E_pX_{p\prime}$ denotes the expected value of a variable X (W, U, J, or V) conditional on the aggregate state p' next period. The free entry condition drives V_p to zero for all values of p.

The total surplus from the match is defined as:

$$\gamma_p = (J_p + W_p - U_p) / (1-\tau). \tag{6}$$

The Nash bargaining rule implies that the firm pays a fraction $(1-\beta)$ of the total training cost and obtains a fraction $(1-\beta)$ of the total surplus:

$$k^f = (1-\beta)\, k. \tag{7}$$

$$J_p / (1-\tau) = (1-\beta)\, \gamma_p. \tag{8}$$

The opportunity cost of employment is defined as:

$$z = b + \frac{l}{1-\tau}. \tag{9}$$

Notice that since leisure is not taxed, income taxes can be considered as part of the opportunity cost of employment. Defining $t = \tau l / (1-\tau)$, the opportunity cost of employment can then be decomposed into three components: the value of leisure, the value of UI benefits, and a term that captures the effect of taxes ($z = l + b + t$).

The equilibrium values of J_p, W_p, U_p, γ_p, w_p, and θ_p are determined by the system of equations (2) to (9). As pointed out by Mortensen and Nagypál (2007), this system of equations can be easily solved by finding first γ_p and then the remaining equilibrium functions. Substituting (2) to (4) into (6) and using (7) to (9), it yields:

$$\gamma_p = p - z + \frac{1}{1+r}\left[(1 - s - \beta f(\theta_p))\, E_p \gamma_{p'} + \beta f(\theta_p) k\right]. \qquad (10)$$

This equation determines the dynamic behavior of the surplus from a match. Intuitively, the total value of a match is the net surplus in the current period, $p - z$, plus the expected discounted value of the match next period. The match survives next period with probability $1 - s$, but (10) contains the term $[1 - s - \beta f(\theta_p)]$ to take into account that when the match dissolves, the value of unemployment is not zero due to the expected gains received by the worker from forming an employment elsewhere next period. The term $\beta f(\theta_p)k$ captures the training costs paid by the worker in the future employment.

Combining (1) with (5), (7) and (8), the stochastic equilibrium of the vacancy-unemployment ratio must satisfy:

$$\theta_p = \left[\frac{\mu(1-\beta)}{c(1+r)} \max\left\{0, E_p \gamma_{p'} - k\right\}\right]^{\frac{1}{1-\eta}}. \qquad (11)$$

The *max* operator in (11) represents the firm's optimal behavior in the job creation activity. When the training costs are too large compared to the realized productivity in downturns, firms would optimally choose not to open up vacancies in those periods.

The equilibrium values of γ_p and θ_p are the solution to equations (10) and (11). Once θ_p is obtained, the dynamics of unemployment follow from the law of motion: $u_{t+1} = [1 - f(\theta_p)]\, u_t + s(1 - u_t)$. As long as p does not change, this unemployment (rate) converges to a conditional steady-state unemployment (rate): $u_p^{ss} = \frac{s}{s + f(\theta_p)}$, which is contingent on p.

4 The Cyclical Behavior of Unemployment and Job Vacancies in Canada

This section calibrates a simplified version of the previous model, where the training costs, the income taxes and the value of leisure are all set to be zero, to match the Canadian business cycle facts. Given this simplicity, the opportunity cost of employment equals the UI benefits. The purpose is, in the same setup as Shimer (2005), to gauge to what extent the model explains the observed volatilities in unemployment and job vacancies with a low opportunity cost of employment. Labor productivity is assumed to follow a stochastic process that satisfies: $p = z + e^y(p^* - z)$, where p^* is a parameter normalized to one. The total net surplus $(p^* - z)$ is assumed to be positive, which implies

$p > z$. So, for all values of p, there are bilateral gains from the match. The underlying variable y is an exogenous random variable with a zero mean. It follows an eleven-state Markov process in which transitions only occur between contiguous states. As detailed in the Appendix, the transition matrix governing this process is fully determined by two parameters: Δ (the step size in a transition) and λ (the probability that a transition occurs).

To capture the fact that job destruction is also an important determinant of the fluctuations in unemployment, a second simulation extends the model of Section 3.1 by adding separation shocks. In this case, the separation rate, instead of being a constant, follows a first-order Markov process that satisfies: $s = e^{\phi y} s^* + \epsilon$, where s^* is calibrated to the average monthly separation rate, and ϵ is an *i.i.d.* truncated normal random variable with a zero mean and a σ_ϵ^2 variance.[11]

TABLE 2
Calibration Targets for the Canadian Model

Average monthly separation rate (s)	0.03
Average monthly finding rate (f)	0.309
Elasticity of the finding rate with respect to market tightness (η)	0.54
Opportunity cost of employment (z/w)	0.6
Annual real interest rate (r)	0.048
Standard deviation of labor productivity *(quarterly in logs)*	0.021
Autocorrelation of labor productivity *(quarterly in logs)*	0.876
Normalization units of θ	1
Correlation between productivity and separation *(quarterly in logs)*	−0.396

In the simulations of the model, the period frequency is set to be one month, although consecutive periods are aggregated to match productivity and real wage data, which are only available at quarterly frequencies. Table 2 summarizes the calibration targets and their values. The separation and the finding rates are those constructed in Section 2. The elasticity of the finding rate with respect to market tightness η is estimated using the same method as Mortensen and Nagypál (2007) explained in the Appendix.[12] The Hosios condition is used to pin down the worker's bargaining power, so $\beta = 1 - \eta$.

[11] Since the distribution functions of p' and s' depend only on y (and so p), equations (10) and (11) describing an equilibrium remain the same with the qualification that s is now the realization of an stochastic process.

[12] Shimer (2005) proposes regressing the log of the finding rate on the log of the vacancy-unemployment ratio to find η. However, this yields a value of η, which is outside the plausible range proposed by Petrongolo and Pissarides (2001).

The opportunity cost of employment z is chosen to fit the Canadian statutory replacement rate of UI benefits (see the Appendix for details), and this sets $z/w = 0.6$. Finally, following Shimer (2005), the monthly real interest rate r is set to be consistent with an annual rate of 4.8 percent; the standard deviation and the autocorrelation of p are aimed to be consistent with the observed moments of quarterly productivity; and the mean of market tightness θ is normalized to one, which implies that the value of μ in the matching function equals the monthly finding rate. In the second simulation with separation shocks, the correlation between s and p is targeted to their empirical counterpart at a quarterly frequency, and following Shimer (2005), the standard deviation of s is aimed to be the same as the standard deviation of quarterly productivity.[13]

TABLE 3
Parameter Values for the Canadian Model

	Source of Shocks	
Parameters	*Productivity*	*Productivity and Separation*
Productivity (p)	Stochastic	Stochastic
Separation rate (s)	0.03	Stochastic
Step size (Δ)	0.032	0.032
Probability parameter (λ)	0.312	0.329
Variance of ϵ (σ_ϵ^2)	–	0.00086
Parameter (ϕ)	–	−0.184
Cost of posting a vacancy (c)	0.404	0.414
Matching function (μ *and* η)	$0.309u^{0.46}v^{0.54}$	$0.309u^{0.46}v^{0.54}$
Bargaining power of workers (β)	0.46	0.46
UI benefits (z)	0.573	0.578
Real interest rate (r)	0.004	0.004

The values of $\{s,\ r,\ \eta,\ \beta,\ \mu\}$ directly follow from the stated targets in Table 2, and the values of $\{z,\ c,\ \Delta,\ \lambda,\ \phi,\ \sigma_\epsilon^2\}$ are obtained by simulating the model and revising their values until the targets in Table 2 are matched. The outcome of this calibration process is summarized in Table 3.

Table 4 compares the predicted standard deviations of unemployment, vacancies, and the vacancy-unemployment ratio with those observed in the Canadian economy. The unconditional standard deviations are those calculated from the cyclical components of these variables constructed in Section 2. The

[13] When the observed standard deviation of separation is chosen as the target, similar to the results in the model with only separation shocks shown in Shimer (2005), the model predicts a positive correlation between unemployment and the vacancies, which is counterfactual.

conditional standard deviations are obtained using the formula: *conditional* $stdv(X) = stdv(X) \cdot corr(p, X)$, where X is the variable of interest. As argued by Mortensen and Nagypál (2007), this conditional criterion allows for the evaluation of the performance of the Mortensen-Pissarides model in predicting the response to productivity shocks without having to make the strong assumption that other shocks are not affecting labor market fluctuations. In any case, as the table reports, the standard deviations obtained from the simulations of the model are far from those observed in the Canadian economy, both conditional and unconditional. For example, the model with only productivity shocks generates standard deviations of unemployment and the vacancy-unemployment ratio that are only 12 percent and 13 percent of their respective empirical unconditional counterparts. Even using the conditional criterion, the model can explain only 37 percent and 24 percent of the observed conditional standard deviations. Adding separation shocks increases the standard deviation of unemployment moderately, but it has almost no effect on the standard deviations of vacancies and the vacancy-unemployment ratio.[14]

TABLE 4

Simulation Results for the Canadian Model

	Standard Deviations			
	Model		Canada	
	One Shock	*Two Shocks*	*Unconditional on p*	*Conditional on p*
u	0.019	0.029	0.162	0.052
v	0.034	0.035	0.237	0.135
v/u	0.046	0.047	0.367	0.191

5 The Model's Implications from a Comparison between Canada and the United States

The above results depend on the opportunity cost of employment z being low. As argued by Hagedorn and Manovskii (2007), the Mortensen-Pissarides model generates such low standard deviations of unemployment and job vacancies as found in Shimer (2005) because it is calibrated to match a relatively large net surplus from the match $(p - z)$. They also show that for values of z around 97 percent of the marginal product of labor (p), the model fits the cyclical labor market movements well.[15] The important channel through which this

[14] When the elasticity of finding rate with respect to market tightness η is estimated using the method in Shimer (2005), the model's explanatory power is even lower.

[15] A similar point was made by Costain and Reiter (2008).

amplification operates is the percentage changes in a firm's net profits: When $(p - z) \simeq 0$, even a small percentage change in labor productivity p induces a very large percentage change in the net profit $p - z$, which provides the firm with incentives to hire more workers. In the case of Canada, z has to be 0.953 for the unconditional standard deviation of the vacancy-unemployment ratio to match its empirical counterpart in the model with zero training costs.

The similarity between Canada and the United States in the value of z brings up another question: what would happen if the different policy changed in the two countries? Since the UI policy and taxation would alter the value of z, it is of interest to study: 1) how workers and firms respond to the policy changes; 2) when the Canadian policy is introduced into the United States, whether the model can generate the cyclical variations observed in the labor market in Canada, and vice versa. The findings in this section uncover an additional difficulty with the Mortensen-Pissarides model: Simple parameterization for z can fix the volatility puzzle with the model in the United States or in Canada, as argued by Hagedorn and Manovskii (2007), but as long as workers value leisure in the same way in both countries, it cannot fix the model's failure in reconciling the similar cyclical variations and the large policy disparities in UI benefits and income taxes between the two economies. In addition, this section shows that the above failure can be resolved by relaxing the assumption of the common value of leisure, but the required value of leisure in the United States would need to be 1.6 times larger than the level in Canada. Such a gap is too large to be plausible.

5.1 Effects of Imposing the Canadian (U.S.) Policies on the U.S. (Canadian) Model

In this part, the model in Section 3 is calibrated to fit the data from Canada and the United States. The main purpose is to evaluate the effects of imposing one country's policy on the other. I set out by examining the impact of the Canadian policy on the United States economy. To this end, the model is first calibrated to fit the data in the United States, including the labor market variability, under the American policies. Then the Canadian policies are introduced into the calibrated model of the American economy to find out: if the model is able to generate the cyclical fluctuations of the vacancy-unemployment ratio observed in Canada, and how unemployment in the American model economy reacts to the policy changes? Motivated by the recent literature, the exercise is conducted in several different ways, such as adding training costs (Mortensen and Nagypal 2007, Silva and Toledo 2007), departing from the Hosios rule to targeting the cyclical fluctuations in real wage (Hagedorn and Manovskii 2007), and matching the conditional variability in the labor market (Mortensen and Nagypal 2007).

The calibration strategy is similar to the one employed in Section 4, except for the separation rate s and the opportunity cost of employment z. In the model of the American economy, the separation rate s is calibrated to match the average monthly unemployment rate over the period of 1962-2001, which is $u_{US} = 0.0567$.[16] With respect to the value of z, instead of targeting the statutory replacement rate of UI benefits as in Shimer (2005), it is set to be composed of the values of leisure, UI benefits, and taxes, with the value of leisure as a free parameter. The tax rate is chosen to match the average general tax burdens relative to GDP, so $\tau_{US} = 0.30$.[17] With respect to UI benefits b, the statutory UI benefits replacement rate tends to overstate the generosity of UI benefits because not all unemployed workers are paid UI benefits, and not all recipients of UI get the statutory replacement benefits. To adjust for these factors, b is calibrated to fit the actual replacement rate, which is measured as the ratio of the average weekly UI benefits paid to unemployed workers to the average weekly earnings paid to employed workers. This yields: $(b/w)_{US} = 0.111$ (see the Appendix for details). Lastly, the value of leisure l is picked to match the standard deviation of the vacancy-unemployment ratio in the United States. The model of Section 3 introduces one-time training costs k. In the calibrations where these are positive, they are calibrated as follows. As in Silva and Toledo (2007), the training costs in the United States are measured using data from the 1982 Employer Opportunity Pilot Project (EOPP). According to these data, the total average cost of the training in the first three months is approximately equivalent to 55 percent of the quarterly wage of a newly-hired worker.[18] This implies a calibration target of $(k/w)_{US} = 0.55$. It is worth noting that the value of η in the United States happens to be the same as that in Canada by using the calibration method in Mortensen and Nagypál (2007). In the model of the Canadian economy, the counterpart targets for the policy parameters τ and b are $\tau_{CA} = 0.35$ and $(b/w)_{CA} = 0.265$.

[16] If the average monthly separation rate constructed in Section 2 is used, the predicted average unemployment rate is slightly larger than the average rate observed in the United States, which makes it inappropriate to conduct the experiment regarding the reaction of unemployment to policy changes.

[17] See Figure 1 in "The Economic and Fiscal Update 1999" by the Department of Finance Canada for rates in Canada and the United States.

[18] The 1992 Small Business Administration Survey (SBA) suggests that 70 percent of training spells are finished in the first three months. Using also the 1982 EOPP project, Barron, Berger and Black (1997) and Dolfin (2006) provide a detailed discussion of the measure of training costs.

The calibration targets in the United States are summarized in Table 5 (the first column). In the simulations that serve the purpose as mentioned earlier, all parameters except the UI benefits b and tax rate τ are calibrated to fit the targets in the United States and are forced to be the same in the two countries. In a baseline calibration, the value of leisure is calibrated to match the unconditional standard deviation of θ_{US}, using the Hosios rule to determine β, and no training costs. In subsequent calibrations, these targets are changed to match the standard deviation of θ_{US} conditional on p, the standard deviation of the real wage conditional on p and the observed training costs in the United States.

Table 5
Calibration Targets for the U.S. and the Canadian Models

	U.S.	*Canada*
Monthly real interest rate *(r)*	0.004	0.004
Monthly finding rate *(f)*	0.452	0.309
Average monthly unemployment rate *(u)*	0.0567	0.0778
Actual UI benefits replacement rate *(b/w)*	0.111	0.265
Average income tax rate (τ)	0.30	0.35
Standard deviation of labor productivity *(quarterly in logs)*	0.020	0.021
Autocorrelation of labor productivity *(quarterly in logs)*	0.878	0.876
Elasticity of the finding rate with respect to θ (η)	0.54	0.54
Normalization units of θ	1	1
Normalization of labor productivity (p^*)	1	1
Standard deviation of θ *(quarterly in logs)*	0.382 or 0.151	0.367 or 0.191
Conditional standard deviation of real wage w *(quarterly in logs)*	*free* or 0.012	*free* or 0.016
Ratio of training costs to quarterly wage rate (k/w)	0 or 0.55	0 or 0.37

The calibration results in the model of the American economy under the American policies are reported in Section A of Table 6. The upper part describes the targets in the calibrations. Model 1 is the baseline model. Model 2 adds training costs to this model. Models 3 and 4 target the conditional standard deviation of θ with and without training costs, respectively. Finally, Model 5 targets the standard deviation of the real wage (conditional on p) instead of using the Hosios rule to determine β. The lower part shows the parameter values that fit the American model to the observed target values before the policy changes take place. When the Canadian UI benefits and income taxes are introduced, the policy parameters b and τ adjust to fit the Canadian targets while the rest of the parameters remain the same. Section B of Table 6 decomposes the calibrated value of the opportunity cost of employment z into its three components: l (value of leisure), t (taxes), and b

(UI benefits) under the American and Canadian policies, respectively. The predicted response of unemployment to the policy changes is reported at the bottom of Section B.

TABLE 6
Effects of the Canadian Policies on the U.S. Model

A. U.S. Policy

	Model 1	Model 2	Model 3	Model 4	Model 5
Calibration Targets in the U.S.					
$s.d.(\theta)$	0.382	0.382	0.151	0.151	0.151
$s.d.(w)$	*free*	*free*	*free*	*free*	0.012
β	0.46	0.46	0.46	0.46	0.25
k/w	0	0.55	0	0.55	0.55
Parameter values in the U.S.					
c	0.051	0.054	0.131	0.130	0.621
s	0.026	0.026	0.027	0.027	0.027
k	0	1.605	0	1.594	1.513
λ	0.284	0.295	0.297	0.300	0.300
Δ	0.263	0.131	0.104	0.074	0.082

B. U.S. vs Canadian Policy

	Model 1		Model 2		Model 3		Model 4		Model 5	
	U.S.	*CA*	*U.S.*	*CA*	*U.S.*	*CA*	*U.S.*	*CA*	*U.S.*	*CA*
Decomposition of opportunity cost of employment z										
l	0.591	0.591	0.556	0.556	0.536	0.536	0.503	0.503	0.518	0.518
t	0.253	0.318	0.238	0.299	0.230	0.289	0.216	0.271	0.222	0.279
b	0.111	0.292	0.108	0.285	0.110	0.280	0.107	0.271	0.102	0.284
z	0.955	1.201	0.902	1.140	0.876	1.105	0.826	1.045	0.842	1.081
Predicted response of u										
u (%)	–	100	–	100	–	100	–	100	–	100

The targets listed in Section A are exactly matched by the model if the policies are set to the American values, and the remaining variables take the values shown in the second part of Section A (some parameter values are omitted to conserve space). Notice that prior to the policy changes, the calibrated values of l are robustly large, over 50 percent of labor productivity in all cases, and the resulting values of z are close to 1. However, since the values of z are still smaller than 1, the current profits received by the firms $(p - z)$ remain positive in all models. When the much more generous UI benefits and the higher income taxes prevalent in Canada replace their counterparts in the United States, Section B shows that the model economy reaches a corner solution where all workers become unemployed and firms post no vacancies. The results are robust to the introduction of training costs, the adoption of the conditional criterion, and the alternative calibration for the critical parameter β. Intuitively, given the large value of leisure, in response to the pronounced rises in the UI benefits and income tax rate, the opportunity cost of employment increases considerably and surpasses labor productivity. The resulting negative match surplus makes the market activity no longer attractive, which induces both firms and workers to stay inactive in the labor market.

In the simulations presented in Table 6, the observable parameters $\{\lambda, \Delta, k\}$ and the unobservable parameters $\{c, \mu\}$ are picked by targeting the United States data moments and assumed to be the same before and after the policy changes.[19] Can the model's fit be improved if these parameters are calibrated to match the Canadian targets after the introduction of the Canadian policies? I explore the answer in what follows. When the parameters $\{\lambda, \Delta, k\}$ are allowed to be different, they are targeted to the stochastic process of labor productivity and the ratio of training costs to wages observed in Canada. As to the training costs in Canada, based on the "Learning and Development Outlook 2005" by the Conference Board of Canada, Goldenberg (2006) estimates that in Canada the training costs as a fraction of wages are around two-thirds of those in the United States, which implies $(k/w)_{CA} = 0.37$. When the parameters $\{c, \mu\}$ are allowed to be different, they are calibrated to the fit the normalized mean of θ_{CA}, and the average monthly finding rate f_{CA}, respectively. Given the intuition explained above, one can easily see that as long as the high value of leisure obtained in the United States is imposed in Canada, recalibrating the parameters $\{\lambda, \Delta, k, c, \mu\}$ does not alter the model's prediction for unemployment; the corner solution still remains.

What would happen if the above exercise is reversed? To find out the answer, following the same strategy, the model is calibrated to fit the Canadian targets. In particular, the value of leisure l_{CA} is determined by targeting the standard deviation of θ_{CA}, and the separation rate is set to fit the average unemployment rate u_{CA}. The Canadian targets are summarized in Table 5 (see the second column). In the second step, the policies and stochastic process for productivity observed in the United States are imposed on the preferences estimated for the Canadians.[20] A similar failure appears! In all models considered above, the bottom part of Table 7 shows that the predicted standard devia-

[19] When the values of μ and η are the same before and after the policy changes, the matching function is implicitly assumed to be the same in both countries. This assumption is relaxed when the value of μ is set to match its Canadian target.

[20] If the values of parameters λ and Δ calibrated to the stochastic process of productivity observed in Canada are retained in the model of the American economy, the simulated productivity is about 4 times more volatile than what is observed in the United States, which gives rise to a much larger predicted standard deviation of θ.

tion of θ accounts for only about 20 (40) percent of its empirical unconditional (conditional) counterpart in the United States.[21] Not surprisingly, the policy changes also evoke sharp reactions of the unemployment rates (drop of about 50 percent) in the model of the Canadian economy. An opposite intuition applies here: the lower tax rate and the much more stingy UI benefits, along with the low common value of leisure, significantly lower the non-market returns, which not only enlarges the net profit $p-z$, destroying the amplification channel argued by Hagedorn and Manovskii, but also reduces the attractiveness of unemployment.

TABLE 7
Effects of the U.S. Policies on the Canadian Model

A. Canadian Policy

	Model 1	Model 2	Model 3	Model 4	Model 5
Calibration Targets in Canada					
$s.d.(\theta)$	0.367	0.367	0.191	0.191	0.191
$s.d.(w)$	*free*	*free*	*free*	*free*	0.016
β	0.46	0.46	0.46	0.46	0.25
k/w	0	0.37	0	0.37	0.37
Parameter values in Canada					
c	0.051	0.053	0.099	0.100	0.214
s	0.025	0.025	0.026	0.026	0.026
k	0	1.089	0	1.083	1.063

B. Canadian vs the U.S. Policy and Stochastic Productivity Process

	Model 1		Model 2		Model 3		Model 4		Model 5	
	CA	*U.S.*	*CA*	*U.S.*	*CA*	*U.S.*	*CA*	*U.S.*	*CA*	*U.S.*
λ	0.290	0.300	0.300	0.300	0.301	0.300	0.302	0.300	0.303	0.300
Δ	0.260	0.052	0.159	0.046	0.135	0.044	0.102	0.040	0.106	0.041
Decomposition of opportunity cost of employment z										
l	0.447	0.447	0.427	0.427	0.415	0.415	0.396	0.396	0.402	0.402
t	0.241	0.192	0.230	0.183	0.223	0.178	0.213	0.170	0.217	0.173
b	0.265	0.110	0.260	0.108	0.263	0.109	0.258	0.107	0.254	0.104
z	0.953	0.749	0.917	0.718	0.901	0.702	0.867	0.673	0.873	0.679
Predicted response of u and variability of θ										
$s.d.(\theta)$	0.367	0.077	0.367	0.077	0.191	0.064	0.191	0.065	0.191	0.064
u (%)	7.78	3.13	7.78	3.23	7.78	4.25	7.78	4.30	7.78	4.10

These negative findings show that the model with a high opportunity cost of employment cannot simultaneously explain the data in the two countries

[21] Allowing the parameters $\{c, \mu, k\}$ to take their American values does not affect the results for the standard deviations of θ.

that are observed over the business cycles and in the long run. More precisely, the observed differences in the various features of environments and the policy disparities in UI benefits and taxes do not help the model explain the average behavior of unemployment and job vacancies in the two countries.

5.2 Independent Calibrations for Canada and the United States

TABLE 8
Value of Leisure for the Canadian and the U.S. Models

	Model 1		Model 2		Model 3		Model 4		Model 5	
	CA	*US*	*CA*	*US*	*CA*	*US*	*CA*	*US*	*CA*	*US*
Calibration Targets										
$s.d.(\theta)$	0.367	0.382	0.367	0.382	0.191	0.151	0.191	0.151	0.191	0.151
$s.d.(w)$	*free*	*free*	*free*	*free*	*free*	*free*	*free*	*free*	0.016	0.012
β	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.25	0.10
k/w	0	0	0.37	0.55	0	0	0.37	0.55	0.37	0.55
Parameter values										
c	0.051	0.051	0.053	0.054	0.099	0.131	0.100	0.130	0.214	0.621
s	0.025	0.026	0.025	0.026	0.026	0.027	0.026	0.027	0.026	0.027
k	0	0	1.089	1.605	0	0	1.083	1.594	1.063	1.513
λ	0.290	0.284	0.300	0.295	0.301	0.297	0.302	0.300	0.303	0.300
Δ	0.260	0.263	0.159	0.131	0.135	0.104	0.102	0.074	0.106	0.082
Decomposition of opportunity cost of employment z										
z	0.953	0.955	0.917	0.902	0.901	0.876	0.867	0.826	0.873	0.842
t	0.241	0.253	0.230	0.238	0.223	0.230	0.213	0.216	0.217	0.222
b	0.265	0.111	0.260	0.108	0.263	0.110	0.258	0.107	0.254	0.102
l	0.447	0.591	0.427	0.556	0.415	0.536	0.396	0.503	0.402	0.518
Value of l_{US}/l_{CA}										
	Model 1		Model 2		Model 3		Model 4		Model 5	
$p^{*CA} = p^{*US} = 1$	1.32		1.30		1.29		1.27		1.29	
$p^{*CA}/p^{*US} = 0.8$	1.65		1.63		1.61		1.59		1.61	

The explanation behind the difficulty shown in Section 5.1 suggests that an easy fix would be to allow for different preferences of leisure in the two countries. Then, two questions arise immediately: How different would the values of leisure in these two countries have to be in order to be in line with the observed business cycles data and the big policy disparities? How plausible is the gap in the implied values of leisure in the two countries? To pursue the answer, I undertake two independent calibrations for Canada and the United States. That is, in the following simulations, all the parameters in the United States (Canadian) model economy, regardless of whether they are observable or not, are determined to fit the United States (Canadian) targets listed in

Table 5. Since labor productivity in Canada is around 80 percent of that in the United States, the values of l_{CA} are calculated both taking or not taking into account these productivity differences.

Table 8 displays the calibration results in both countries that correspond to the various models discussed above. The ratios of l_{US}/l_{CA} are reported at the bottom of the table to facilitate the comparison. The main message delivered by Table 8 is that in all cases the values of leisure in Canada are much lower than those in the United States. Without taking into account the productivity differences between the two countries, the value of leisure in the United States is around 30 percent higher than the value of leisure in Canada. Once the productivity differences are considered, this gap climbs to over 60 percent. Fitting conditional responses to productivity shocks, adding training costs, and deviating from the Hosios rule to generate less volatile real wages help reduce the required values of z relative to those in Hagedorn and Manovskii (2007), but these changes have little impact on the implied gap between the values of leisure in the two countries.

6 Concluding Remarks

This paper aims to investigate how well the standard Mortensen-Pissarides search model explains the business cycle fluctuations observed in the Canadian labor market. Although the model is successful in predicting many of the observed qualitative features, a key quantitative implication is unrealistic. As in Shimer (2005), the simulation results reveal that the model lacks the ability to reproduce the observed high variability in unemployment and job vacancies with low values of leisure. In particular, using a similar calibration methodology to the one used by Shimer, the response of the vacancy-unemployment ratio to labor productivity shocks is less than 1/3 of the estimated response in the Canadian data.

The similar performance of the model in both Canada and the United States, and the large differences in the UI generosity and in taxation between the two countries uncover an additional difficulty for the model. For example, when the value of the opportunity cost of employment z is allowed to be as high as needed to duplicate the observed large variations in the vacancy-unemployment ratio in the United States, the implied large value of leisure (the unobserved component of z), together with the relatively high UI benefits and income taxes in Canada, induces the non-market returns to surpass labor productivity, which results in counterfactual predictions about unemployment and job vacancies in the model of the Canadian economy. This failure can be resolved by allowing for different values of leisure in the two countries. To examine how different the values of leisure between these two countries have to be, this paper calculates the values of leisure in Canada and the United States that would be required to generate a realistic variability of the vacancy-unemployment ratio, and finds that the value of leisure in Canada would have to be around 60 percent of the value of leisure in the United States. It is an unrealistically large disparity between the two countries. Moreover, this paper represents the Costain and Reiter criticism by showing the exaggerated response of unemployment when the Canadian UI benefits and income tax rate are put in place in the model of the American economy. All the negative findings in the paper imply that simple parameterization cannot fix the volatility puzzle with the standard version of the Mortensen-Pissarides model.

Although some authors have successfully resolved the volatility puzzle along the line of wage rigidity (see Hall 2005a, Hall and Milgrom 2008), there are some problems with this approach. Mortensen and Nagypál (2007) point out that a rigid wage per se is not enough to fix the puzzle. To this end, the level of wages must also be close to productivity (the opportunity cost of employment z is implicitly required to be sufficiently large). To show the importance of this point, they demonstrate that given a small value of z, the model still lacks the ability to produce the observed large cyclical variations even if the worker's bargaining power is set to be zero.[22] Intuitively, firms' incentive to post vacancies is driven by the net profits $(p-w)$ or net match surpluses $(p-z)$. With wage or opportunity cost of employment close to productivity, the net profits or net match surpluses respond strongly to changes in productivity, which gives rise to larger amplitudes in the job creation behavior over the cycles and, therefore, to larger cyclical labor market movements. More recently, a similar point has been made by Pissarides (2007), who emphasizes that it is the expected wage rather than the volatility of wages over the spells of employment that motivates job creation. He also advocates that a better proxy for the Nash wages in the model would be the wages in the new matches, while the microeconometric evidence shows that wages for the new hires are indeed procyclical in the United States and main countries in Europe.[23] Moreover, the empirical data on real wages in Canada and the United States do not support this solution. Although Canada has stronger union power and a more generous social security system (such as unemployment insurance, health

[22] With zero bargain power for workers, the model is simplified into the one with fixed wages equal to the opportunity cost of employment z.

[23] See also Bils et al. (2007), and Haefke, Sonntag and van Rens (2007) for the empirical evidence for procyclicality of wages in the new hires.

care, and pension plan), the standard deviation of the real wage conditional on productivity in Canada is about 0.016, even larger than its counterpart in the United States, which is 0.012.

The additional difficulty uncovered in this paper suggests that it would be useful to explore some features of UI institutions that might simultaneously explain the observed cycles in these two countries. In particular, it would be interesting to examine the effects of the rules of the UI provisions, such as the length of employment required to gain UI eligibility, the duration of benefits, and the rating of UI contributions, which affect the labor market flows over the cycles yet differ in the two countries. Also, given that job separation, another important factor for unemployment fluctuation, is insufficiently explored in the literature, it would be worthwhile endogenizing job separation by considering that some workers quit (or are temporarily laid-off) in order to collect UI benefits, or do not search while they are collecting UI benefits.

Appendix

Calibration Strategy and Methodology

The Stochastic Process of Productivity (Separation)

With respect to the random variable y, the initial value of y lies on a finite-ordered (11 states) set of points, which is called the feasibility set Y.

$$y \epsilon Y \equiv \{-5\Delta, -4\Delta, ..., 0, ..., 4\Delta, 5\Delta\}, \ \Delta > 0,$$

where Δ is the step size, measuring the change in the cyclical components of labor productivity in logs.

At the beginning of each period, the economy is hit by an exogenous labor productivity shock. The value of y responds by either taking a new value, y', with probability λ or staying unchanged otherwise. The new value y' moves up or down by one step Δ, but still remains within the feasibility set Y.

$$y' = \begin{cases} y + \Delta, \ with \ prob \ \frac{\lambda}{2}(1 - \frac{y}{5\Delta}), \\ y - \Delta, \ with \ prob \ \frac{\lambda}{2}(1 + \frac{y}{5\Delta}). \end{cases}$$

The probability of moving up is decreasing in the current value of y, which ensures the mean reversion. The parameters Δ and λ are calibrated to match the empirical moments of the quarterly productivity, namely the standard deviation and autocorrelation.

Elasticity of Finding Rate with respect to the Market Tightness

Following Mortensen and Nagypál (2007), η is estimated using the law of motion of unemployment at steady state: the flows out of unemployment (also the number of successful matches) equal the flows into unemployment. It gives that:

$$m(u,v) = s(1-u). \tag{12}$$

Taking logarithms on both sides of equation (12) and combining with the specification of the matching function, it follows that

$$\ln \mu + \eta \ln v + (1-\eta) \ln u = \ln s + \ln(1-u).$$

Thus, the coefficient in an OLS regression of $ln(v \mid u)$ on lnu can be derived as

$$\frac{\partial E \ln(v \mid u)}{\partial \ln u} = -\frac{1}{\eta}(\frac{u}{1-u} + 1 - \eta).$$

The data moments stated in Table 1 imply that

$$\frac{\partial E \ln(v \mid u)}{\partial \ln u} = \rho_{vu} \frac{\sigma_v}{\sigma_u}.$$

Using the data on the average monthly unemployment rates over the period of 1962-2001, which are 7.78 percent in Canada and 5.67 percent in the United States, the estimated value of η turns out to equal 0.54 in both countries.

	σ_v	σ_u	ρ_{vu}	u	η
Canada	0.237	0.162	-0.689	0.0778	0.54
U.S.	0.202	0.190	-0.894	0.0567	0.54

Statutory UI Benefits Replacement Rate (Section 4)

According to the 1955 Employment Insurance Acts and the subsequent amendments, the Canadian statutory UI replacement rate averaged, over the period of 1962-2003, 55 (60 for claimants with dependents) percent of the average yearly insurable earnings in the qualifying period. The simulations in Section 4 use $z/w = 0.6$ (the median for the whole sample of claimants).

Actual UI Benefits Replacement Rate (Section 5)

The actual UI benefits replacement rate is measured as the ratio of the average weekly UI benefits paid to an unemployed worker to the average weekly earning paid to an employed worker (term (1) in the table below). To facilitate the measure, the indicator of interest is decomposed into two parts shown as terms (2) and (3). Term (2) is the ratio of the average weekly benefits paid to an UI recipient to the average weekly insurable earnings paid to an employed worker on a gross basis. Term (3) is the eligibility rate, the ratio of the average weekly number of UI recipients to the average weekly number of unemployed workers.

Actual UI Benefits Replacement Rate, 1972-2003

	$\frac{\text{Average UI benefits (the unemployed)}}{\text{Average earnings (the employed)}} =$	$\frac{\text{Average UI benefits (UI recipients)}}{\text{Average earnings (the employed)}} \times$	Eligibility rate
	(1) =	(2)×	(3)
Canada	0.265	0.406	0.653
U.S.	0.111	0.357	0.310

Data Source

Variables in the Labor Market

1. Unemployment: Statistics Canada, CANSIM II, V2062814 over the period of 1976-2005; the Historical Labour Force Statistics, Catalogue, Vol.1971-1974 over the period of 1962-1974; and Statistics Canada, Labour Force, Catalogue 71-001, Vol. 1975 for the year 1975.

2. Vacancy: Statistics Canada, CANSIM II, V3687 (1981=100) over the period of 1962-1988 and V3759 (1996=100) over the period of 1981-2003.

3. Job-finding rate: The job-finding rate is computed by equation (1) in Shimer (2005). The data required are from Statistics Canada, CANSIM II, V2064893 and V3433878 over the period of 1976-2003; the Historical Labour Force Statistics, Catalogue 71-210, Vol. 1971-1974 over the period of 1962-1974; and Statistics Canada, Labour Force, Catalogue 71-001, Vol. 1975 for the year 1975.

4. Separation rate: The separation rate is constructed by equation (2) in Shimer (2005). The data required are from Statistics Canada, CANSIM II, V 2064890 over the period of 1976-2005; the Historical Labour Force Statistics, Catalogue 71-210, Vol. 1971-1974 over the period of 1962-1974; and Statistics Canada, Labour Force, Catalogue 71-001, Vol. 1975 for the year 1975.

5. Labor productivity: Labor productivity is measured as real output per worker in industries excluding agriculture and public sector, 1992=100. The

data source for GDP is Statistics Canada, CANSIM II, V328916, V328932, V329123, V329126, V329144, V329155, V329156, V329157, V329170, V329217, V329218 over the period of 1961-1996, and V2035520, V2035521, V2035524, V2035541, V2035545, V2035549, V2035736, V2035737, V2035738, V2035758, V2035773, V2035783, V2035794 over the period of 1997-2003. The data source for employment is Statistics Canada, CANSIM II, V2057606, V2057607, V2057608, V2057609, V2057611, V2057612, V2057613, V2057614, V2057615 over the period of 1987-2003; Statistics Canada, Labour Force, Catalogue 71-001, Vol. 1960-1966 over the period of 1962-1966; and the Historical Labour Force Statistics, Catalogue, 71-201, Vol. 1971-1974 and Vol. 1986-1987 over the period of 1966-1986.

6. Unemployment rate: In Canada, the data required are from Statistics Canada, CANSIM II, V2062815 over the period of 1976-2003. In the United States, they are from the Bureau of Labor Statistics, Series LNS14000000 over the period of 1951-2003.

7. Real wage: Measured as the average nominal wage per worker in all industries divided by the implicit GDP deflator. The implicit GDP deflator is measured as nominal dollar GDP divided by real GDP. In Canada, the data required are from Statistics Canada, CANSIM II, V500266 and V1996471 for the nominal wage, V498943 for the real GDP and V498086 for the nominal GDP over the period of 1962-2003. In the United States, the data are from the Bureau of Labor Statistics, Series PRS85006063 for the nominal compensation, PRS85006013 for employment, PRS85006043 for the real GDP and PRS85006053 for the nominal GDP.

Indicators of Generosity of Unemployment Insurance System

1. UI benefits replacement rate (for UI recipients): Measured as the ratio of the average weekly regular UI benefits paid to UI recipients to the average weekly earnings paid to employed workers on a gross basis. In Canada, the data required are from Statistics Canada, CANSIM II, V384494 for the average weekly regular UI benefits, and V75249, V729405, V1597104 for the average weekly earnings over the period of 1972-2003. In the United States, this ratio is directly from the U.S. Department of Labor Employment and Training Administration Annual Report and Financial Data (Taxable and Reimbursable Claim, Column 27) over the period of 1972-2003.

2. UI eligibility rate: Measured as the ratio of the monthly number of regular UI recipients to the monthly number of unemployment. In Canada, the data on the monthly regular UI recipients are from Statistics Canada, CANSIM II, V384652 and V2062814 over the period of 1976-2003. In the

United States, this ratio is directly from Table C.1 in Wayne Vroman (2004) over the period of 1967-2003.

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