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# UNEMPLOYMENT INSURANCE: A GENERAL EQUILIBRIUM MODEL FOR THE CHILEAN ECONOMY

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# Unemployment Insurance: A General Equilibrium Model for the Chilean Economy*

Carola Moreno†

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**Abstract**

Ackowledging that a non-zero level of benefits is socially optimal, and may even be considered efficient, this paper implements a labor search model that distinguishes between unemployed with and without benefits to quantify the effects on the Chilean labor market that result from increasing unemployment benefits as well as the pool of potential beneficiaries. Simulations show that both policies result in higher average unemployment, longer mean unemployment duration (MUD) and a tighter labor market, although having a larger mass of eligible workers has on average a lower impact than increasing the replacement rate. Because we do not measure possible efficiency gains nor the effects of having these benefits being financed in part by the own worker's savings, elements that may amiliorate the negative effects of the policy changes, the magnitudes discussed should be considered as upper bounds. Simulations show that mean unemployment increases 0.1 percent points when either average benefits increase by 8.3 percent points (from an initial level of 30%) or the proportion of eligible workers increases by 10 percent points (from 45 to 55% of the labor force). MUD in turn increases aproximately 1% and the measure of market tightness by 4%. The effects on these three measures are similar when we either assume that workers' bargaining power is lower or that the separation rate is higher. Nevertheless, when workers are assumed to have other sources of non-labor income, the impact of both policies is more pronounced.

JEL classification: E32, J64 and J65

Keywords: Real Business Cycles, matching function, unemployment insurance

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# 1 Introduction

A new unemployment insurance (UI) system was introduced in Chile in October 2002. Compared to the old system, the new one reduced the duration of the benefits while increasing the average monthly amounts received by the unemployed worker.[1] In terms of the way the benefits are financed, the new one is fully funded as opposed to the pay-as-you go system that was in place before. Also, eligibility requirements are explicitly defined. The objective of this paper is to quantify the effect of some of these changes on average unemployment duration, unemployment rate volatility and average tightness of the labor market, measured as the ratio of vacancies over unemployment. In particular, we quantify the effect of increasing benefits and increasing the potential pool of beneficiaries.

The new unemployment insurance system was designed in order to minimize the distortionary effects on the labor market while being able to exploit the well-known benefits that result from giving financial help to those that are momentarily unemployed. Moral hazard is one of the issues that are usually associated with insurance, and unemployment insurance is no exception. The Chilean system deals with it in at least two ways. First, benefits are given in a finite horizon of time, and so the worker knows that after that period he will be on his own. Second, the amount of money that the unemployed worker receives each month is lower that the amount received the previous month. This decreasing benefits mechanism creates an incentive to increase search efforts. The fiscal burden problem that may arise from implementing a system like this is also taken care of by incorporating a saving component. The worker finances part (or whole in some cases) of its unemployment benefits with money saved in an individual account while he was employed. This element also helps minimize the passive behavior during unemployment because it is the workers own resources that are being used to finance his non-working state. As a result, the new system allows the unemployed to receive a substantially higher benefit compared to the old system, while still motivating them to search for a new employment opportunity.

The approach that we follow is that of setting up a stochastic general equilibrium model in which the economy is perturbed by random shocks to labor productivity, calibrate it so as to match the features of the Chilean labor market, and then use it to simulate time series for unemployment, vacancies and real wages. The advantage is that these series can be simulated assuming different values for the relevant policy parameters that characterize the UI system, such as the average replacement rate. The period under study is 1986-2006

[1] It is worth mentioning that the old system in practice did not provide material assistance. Workers were not properly informed about its existence and only few unemployed applied to it.

during which the average unemployment rate was 8.6%. The series is very volatile, with the lowest level registered in February 1998 (5.1%) and the highest in February 1986 (13.5%). A period of high unemployment followed the Asian crises, reaching 11.9% in August 1999. At the moment in which the new UI system was put in place -Oct.02- the unemployment rate was 10.5%. Also, the series is highly persistent and countercyclical.

To study unemployment in a general equilibrium setting the model needs to incorporate a friction in the labor market such that unemployment persists even when other markets, for instance the goods market, clear. The model summarized in Pissarides (2000) achieves this goal by incorporating the concepts of search and matching. The main idea is that both employers and employees take time before finding each other and so both engage in a search process. Upon meeting a match is created, meaning that an unemployed worker becomes employed and a vacant job is filled. We will use this model as the basic framework. The main modification we propose is the inclusion of three states of nature for workers: employed, unemployed with benefits and unemployed without benefits. The proportion of workers in each state is given by a combination of the (exogenous) separation rate and the parameter that describes eligibility to benefits. We are able to incorporate some, but not all, of the elements that were incorporated as part of the new design. For instance, we do not model the fact that benefits are mostly self-financed, and therefore, we do not capture this positive aspect of the new system. As a results, the negative effects that we quantify could be considered as an upper bound to those that might actually materialize if changes of these type were to ever take place.

Considering that unemployment insurance entails positive and negative effects on the economy, the literature concludes that an economy should consider an optimal level of benefits, different from zero. In this context, the Chilean system was implemented taking into account that a minimum level of protection is socially optimal, and in fact, it may even be efficient, as Acemoglu and Shimer (1999) propose. In terms of the negative effects, the literature on optimal unemployment insurance establishes a positive relationship between the generosity of unemployment benefits ($b$ in the model) and the duration of unemployment.[2] The argument is that larger benefits diminish the cost of being unemployed and so unemployment spells are larger. At the macro level, this implies that more generous unemployment benefits increase unemployment. We confirm this positive relationship for the Chilean market: when the assumed replacement rate increases from 30 to 40 percent, unemployment increases from an average initial level of 8.6% to approximately 8.7%. In

[2] See Atkinson and Mickelwright (1991) and Holmlund (1998) for a literature review on unemployment insurance and unemployment.

turn, mean unemployment duration (MUD) experiences a 1.7% increase. As expected, the market becomes tighter (5.5% more) and therefore after increasing benefits it becomes harder for an unemployed to find a job. In addition, our results show that the simulated series of unemployment, vacancies and the vacancy-unemployment ratio do not become more volatile as benefits increase although they do become more persistent. For instance, the autocorrelation coefficient of unemployment increases from 0.64 to 0.65 for the same 10 percent points increase in the replacement rate.

The sensitivity of the results was studied by carrying out the same exercise (increasing $b$) while maintaining either a higher level of non-labor income, or having the duration of contracts be lower, or reducing the workers' power to negotiate wages, or even under a scenario in which wages are completely rigid. We found that when workers have other income, different from labor income, to cope with unemployment the previously reported effects are magnified. For instance, increasing the replacement rate by 10 percent points (from 30 to 40%) results in a 0.7 percent points increase in unemployment (up from a level of 12%) when non-labor income is calibrated to 60% of labor income rather than zero. When the duration of contracts is lower, even though the level of unemployment is much higher the reaction to this policy change is very similar to the base case. In a setting in which worker's bargaining power is lower, the equilibrium average unemployment level is also lower, but the impact of the policy is similar since the unemployment rate increases 1.3% (from 7.2 to 7.3%). Nevertheless, there is a big difference in terms of the autocorrelation of the series: for the same level of benefits, unemployment is less persistent, and a 10 percent points increase in benefits results in a 47% increase in persistence. Finally, when rigid wages are introduced in the model we find that for the same level of benefits, volatility of unemployment and vacancies is much higher when wages are not renegotiated. In this setting, as benefits increase the series become less volatile (2% less volatile) and more persistent (1% more).

The second policy parameter that we study, $\phi$, represents the proportion of workers who are eligible for benefits when becoming unemployed. We found that a policy directed at increasing this proportion would result -at first- in similar distortions in the labor market than one that increases benefits. Starting from a level of $b = 30\%$ and $\phi = 45\%$, increasing $b$ by 8.3 percent points or $\phi$ by 10 percent points results in an increase of unemployment of approximately 0.1 percent points. After this point, both elasticities increase, but unemployment shows to be much more responsive to adjustments in the level of benefits than to the proportion of eligible unemployed. In fact, the base simulations show that starting from a level of 8.6% unemployment, a 9.1% would be reached only when $\phi \approx 1$, while the same level would be reached after increasing $b$ to 60%.

The exercise carried out in this paper allows policy makers to compare alternative scenarios by isolating the effect of one policy versus another one. As it will become clearer when the model is introduced later, we make several simplifying assumptions, like assuming perfect insurance markets, risk neutral agents and no cost of searching, among others. These assumptions are likely to emphasize the negative effects of the policy changes. Therefore, as stated above, the discussed magnitudes should be interpreted as upper bounds to the likely outcomes.

The rest of the paper is organized as follows: Section 2 describes the data and the new unemployment insurance system. Section 3 presents the model. Section 4 explains the values chosen for the calibration of the parameters of the model and section 5 presents the results of the simulation, including results for the case in which wages are assumed rigid. In section 6 we present sensitivity results for the base and alternative scenarios. Finally section 7 concludes.

# 2 Stylized Facts

## 2.1 Chilean Labor Market

The variables we consider as most relevant in terms of showing the behavior of the labor market are unemployment, vacancies, real wages, and labor productivity, which we measure as real GDP per hour. The period under study is 1986-2006 and we use quarterly data.

The unemployment rate is measured on a monthly basis by the National Institute of Statistics (INE) using the National Employment Survey. Vacancies are measured by the INE on a monthly basis as an index that leads the evolution of employment. It is elaborated using job advertising in the Sunday newspaper. The average of 1995 is set equal to 100. Real wages are measured by the INE on a monthly basis as a general index which is equal to 100 in January 2006, deflated using the CPI. This series is the only one not available for the whole sample period, but only beginning on 1993:Q2. All monthly series are converted by calculating quarterly averages of the seasonally adjusted monthly series.

The productivity series is calculated as real average output per hour. Hours worked are reported by the INE on a monthly basis as average weekly hours per worker. In order to obtain total hours worked in the economy on a given quarter we first multiply the series by four as an approximation to obtain the average hours worked during a month, and then add these for the three months of the corresponding quarter. Finally, average hours worked during a quarter are multiplied by the number of employed in such quarter. Real GDP is

Figure 1: Descriptive Statistics for the Chilean Labor Market: 1986-2006

| | *Y* | *P* | *W* | *U* | *V* | *V/U* |
|---|---|---|---|---|---|---|
| Real GDP | 1 | 0.7295 | 0.3341 | -0.6634 | 0.6212 | 0.6845 |
| Productivity | | 1 | 0.6969 | -0.1917 | 0.1882 | 0.202 |
| Real Wages * | | | 1 | 0.0667 | -0.2699 | -0.1642 |
| Unemployment Rate | | | | 1 | -0.7691 | -0.9501 |
| Vacancy Index | | | | | 1 | 0.93 |
| Vacancy-Unemployment Ratio | | | | | | 1 |

| | *Y* | *P* | *W* | *U* | *V* | *Theta* |
|---|---|---|---|---|---|---|
| Standard deviation | 0.0403 | 0.0331 | 0.0199 | 0.1624 | 0.1378 | 0.2825 |
| Quarterly autocorrelation | 0.9332 | 0.8974 | 0.8774 | 0.8884 | 0.8649 | 0.9055 |

*Note: All variables are expressed in logs as deviations from an HP trend wih smoothing parameter 10^5*

*(*) The correlation between real wages and the v-u ratio is not statistically significant*

reported by the Central Bank of Chile in millions of Pesos of 2003, on a quarterly basis. The series is seasonally adjusted.

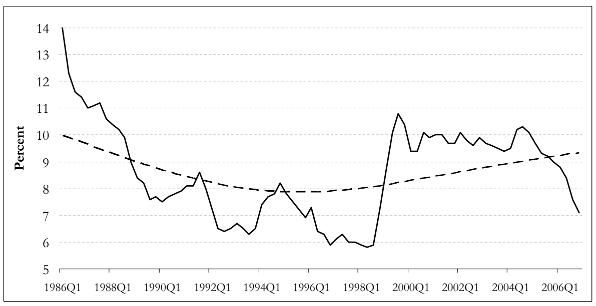
In order to study the cyclical behavior of the series, a very low frequency trend is extracted so that both short and medium term cycles remain after applying the Hodrick-Prescott filter.[3] Figure 1 presents summary statistics for the cyclical component of each variables, expressed as log deviations around their trend. It considers the period 1986:1-2006:4. When discussing the features we will compare with those of the US labor market given that most of the work in this literature has been done for the US economy, and so it will be interesting to discuss differences and similarities (see Shimer, 2004 and 2005).

Unemployment is the most volatile of the series (except for the vacancy-unemployment ratio) with likely observed values fluctuating 32% around the trend. It is more volatile than the vacancies series, a feature that is not observed in the US labor market where vacancies are more volatile than unemployment. During the period 1986-2006 the average unemployment rate was 8.6%, with the lowest level registered in February 1998 (5.1%) and the highest in February 1986 (13.5%).[4] A period of high unemployment followed the Asian crises, reaching 11.9% in August 1999, and maintaining an average of 10% between May-99 and Oct-02. At

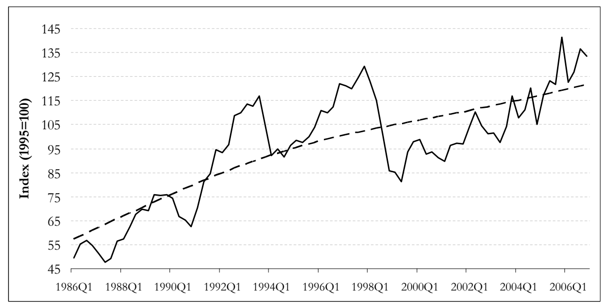
[3] We use a smoothing parameter equal to 100,000 although the smoothing parameter most frequently used for quarterly data is 1600. In this choice we follow Shimer (2004,2005) as well as Mortensen and Nagypal (2005) and Hagedorn and Manovskii (2005) who discuss similar models so that we can have comparable results.

[4] Note that the figure shows the behavior of the unemployment series by quarters, and so the minimum and maximum levels for the months of Feb-98 and Feb-86, respectively, cannot be seen in the graph.

the moment in which the new UI system was put in place -October 2002- the unemployment rate was 10.5%. The series appears to be very persistent, with an autocorrelation coefficient of 0.89, higher than that of the vacancies series, while in the US labor market both series are almost equally persistent. Finally, unemployment is highly countercyclical, although after the Asian crisis the correlation with real output becomes positive.[5]




Unemployment Rate and trend, 1986-2006



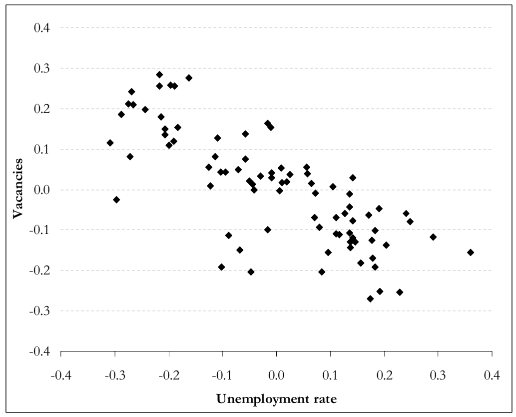

Vacancy Index and trend, 1986-2006

The vacancies series on the other hand is procyclical but shows a weaker relationship with real output compared to unemployment. With regards to labor productivity, neither unemployment nor vacancies show a strong correlation, in fact, both are more or less of the same magnitude, but with opposite signs. Vacancies and unemployment are negatively correlated at business cycle frequency, a feature that is known as the Beveridge curve. This negative relationship is observed as well in the US data, but it is much stronger ($-0.896$ versus $-0.77$ in the Chilean labor market.)

The behavior of unemployment and vacancies is summarized by the vacancies to unemployment ratio (the $v$-$u$ ratio.) The volatility of the $v$-$u$ ratio is about eight times higher than that of labor productivity. We anticipate at this point that one of the criticism that the stochastic search model faces is the difficulty to replicate the high observed volatility of

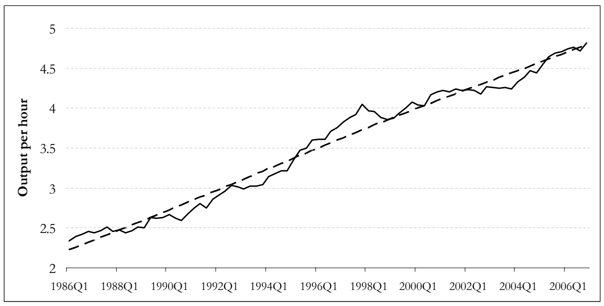
[5] The correlation between unemployment and real output in the subsample 1991:I-2006:1 is not statistically significant. It is worth noting that when unemployment behaves acyclical, real wages correlate positively (statistically significant) with unemployment, as expected.

the $v$-$u$ ratio for reasonably calibrated productivity shocks.

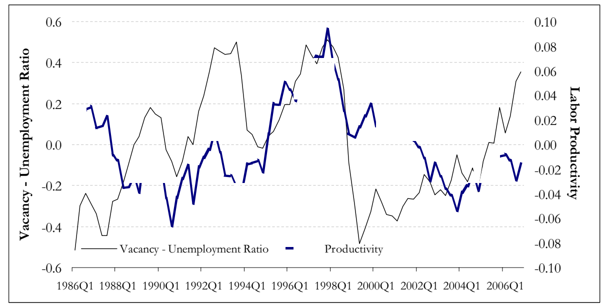



Beveridge Curve, 1986:I-2006:IV

Productivity appears as strongly persistent, with relatively low volatility (only $\pm 3\%$ around its trend) and highly correlated with real wages -even more so if we only consider the subsample 1986:Q1-1998:Q4- as opposed to a much weaker correlation of these variables in the US labor market (0.362). It is also positively correlated with the $v$-$u$ ratio, but this relationship is not stable during the sample. In fact, the series are negatively correlated prior to 1990, and then again in the subsample 1986:Q1-1998:Q4. It is worth noting that this change in the relationship is not a particularity of the Chilean market. Shimer (2005) reports a similar change: positive correlation between 1951-1985, and then negative between 1986 and 2003. The change in the sign of this correlation reflects a change with respect to each of the components of the v-u ratio. In the first subsample, $\rho(p, u) = -0.3$ while it increases to 0.46 in the second one. With vacancies the opposite holds: $\rho(p, v) = 0.28$ and decreases to $-0.42$ after 1998:Q4.




Productivity and trend, 1986-2006




Productivity and v-u ratio, 1986-2006

In terms of the correlation between real wages and unemployment, vacancies, and the $v$-$u$ ratio, we find the opposite signs compared to the US. Considering the whole sample, $\rho(w, u) > 0$, a relationship that seems counter intuitive but that probably has to do with the high degree of indexation of wages. It is confirmed as positive in the second sub-sample, but not in the first one, although this negative correlation is not statistically significant (probably because there are too few data points.[6]) The most striking difference with the US market is given by the correlation with the v-u ratio, that appears strongly negative in the second sub-sample, and still negative (even though weak) in the entire sample. In contrast, this correlation is positive (0.175) in the US market.

The main features on which we will concentrate in order to test the model will be the negative correlation between unemployment and vacancies, the sign and magnitude of the correlation between productivity and wages, unemployment, vacancies and the $v$-$u$ ratio respectively, and the volatility measures of unemployment, vacancies and the $v$-$u$ ratio. The calibration will consider the statistics calculated for the entire sample.

## 2.2 The New Unemployment Insurance System

The new system is designed in such a way that it benefits unemployed workers regardless of the reasons why they became unemployed, subject to eligibility requirements. This is possible because unemployment benefits are withdrawn from a savings account (individual account or IA) that belongs to the worker. There is also a solidarity fund (SF), that "belongs" to all contributors. The IA of all workers plus the SF are administered by a private entity.

[6]Recall the real wages are only observed from 1993:Q2 onwars.

The sources of financing depend on the type of contract that the worker has. On the one hand, if he has an indefinite contract, the employee contributes through payroll taxes 0.6% of his wage to the IA, while the employer contributes the equivalent to 1.6% of the employee's wage to his IA plus the equivalent to 0.8% of the wage to the SF. On the other hand, if the worker has a fixed duration or by task contract, only the employer contributes to the IA an amount equivalent to 3% of the worker's wage. If the wage is higher than US$3,100, approximately, the contribution is calculated over this amount only.[7] In addition, the government contributes a fixed annual amount to the SF which is defined by law and is approximately equivalent to US$13,562,199.[8] An employed worker has to contribute to his IA for a maximum of 11 years with the same employer, after which the funds increase only by the return on the investments. If there is a positive balance in the IA at the moment in which the worker retires, the funds can be added to his pension funds.

Upon becoming unemployed the worker needs to meet some eligibility requirements in order to withdraw from his IA and from the SF. One requirement refers to the type of contract the worker had while employed: indefinite versus fixed duration or by task contracts. Only those who had indefinite contracts will be able to withdraw from the SF. Another requirement has to do with the number of contributions to the IA. In order to withdraw from the IA the worker needs to contribute at least twelve times if his contract is indefinite, or six times if his contract was of fixed duration or by task. These monthly contributions need to be continuos in order to be eligible to access the SF. In addition, only those whose contract was terminated involuntarily can access the SF.

The duration of the benefits is determined by the number of contributions. The unemployed worker will receive one month of benefits for every 12 contributions, for a maximum of 5 months. The amount received in benefits depends on the balance of the IA, and also on whether the unemployed worker is eligible to access the SF. On the one hand, if the worker can only access his IA, then the replacement rate will depend on the amount accumulated in the IA and on the number of periods over which this balance will be distributed. The first withdrawal is always equal to the balance in the account divided by a factor that changes depending on the benefit schedule.[9] The remaining monthly withdrawals, if any, are calculated as a decreasing percent of the first month's withdrawal: 90%, 80%, 70% and 60%. The last month's withdrawal is always equivalent to the remainder balance in the IA. As a

[7] The maximum amount over which the contribution is calculated is 90UF. UF stands for Unidad de Fomento which is a monetary unit indexed to inflation so its value changes on a daily basis.

[8] By law it is fixed to UTM 225,792. UTM is a monetary unit used for tax purposes that varies on a monthly basis (and so it is indexed to inflation).

[9] The factor is equal to 1 for one withdrawal, 1.9 for two, 2.7 for three, 3.4 for four and 4 for five withdrawals

Figure 2: Examples of Benefit Schedules

| N Withdrawals | Factor | Month 1 | Month 2 | Month 3 | Month 4 | Month 5 | Total |
|---|---|---|---|---|---|---|---|
| 1 | 1 | 1,000,000 | 0 | 0 | 0 | 0 | 1,000,000 |
| 2 | 1.9 | 526,316 | 473,684 | 0 | 0 | 0 | 1,000,000 |
| 3 | 2.7 | 370,370 | 333,333 | 296,296 | 0 | 0 | 1,000,000 |
| 4 | 3.4 | 294,118 | 264,706 | 235,294 | 205,882 | 0 | 1,000,000 |
| 5 | 4 | 250,000 | 225,000 | 200,000 | 175,000 | 150,000 | 1,000,000 |

result, whether the unemployed worker is allowed to receive benefits for one or five months, at the end of the period his IA will have a zero balance (unless he finds a job in between). On the other hand, if the worker does not have enough funds accumulated in his IA, and is eligible to access the SF, his replacement rate on the first month will be equivalent to 50% (with a minimum and maximum amount defined in pesos). The replacement rate for the following months decreases by 5% with respect to the previous month. Whatever cannot be covered by the funds accumulated in the individual account is withdrawn from the common fund.

As an example, figure 2 shows the benefit flows for the case in which the balance in the IA is one million pesos and the unemployed worker only withdraws from the IA. It shows the benefit schedule depending on the number of withdrawals that the worker is allowed to do, which as explained earlier depends on the number of contributions done to the IA.

Data regarding contributors and beneficiaries was obtained from the Superintendency of Pension funds, on a monthly basis. We observe that 47% of contributors have fixed duration or by task contracts and thus they will not be eligible to access the SF in case they become unemployed. In terms of beneficiaries, 90% received benefits for only one month. This is probably a result of the system being so new. These beneficiaries had an average replacement rate of approximately 30%.

The new unemployment insurance system was designed to minimize the moral hazard problem as well as other potential negative effects on the labor market. The next section introduces the model, which is a simplification of the real like scheme. It captures some, but not all, of the features of the new system. As a result, our analysis tends to magnify the potential negative effects of policy changes such as increasing the amount of benefits. In this regard, the results should be interpreted as upper bounds.

# 3 The Model

## 3.1 Search and the Matching Function

The matching function is the outcome of the investment of resources by firms and workers in the trading process as a function of the inputs. Vacant jobs and unemployed workers become matched to each other and move from trading to production activities gradually, according to the prevailing matching technology. The separation between jobs and workers, resulting in movements into unemployment, follow a Poisson process with exogenous rate $s$.[10] This can be understood to occur as a result of job-specific shocks, real ones, associated with a shift in either tastes or technology. When separation occurs, the firm can either withdraw from the market or reopen a job as a new vacancy (in equilibrium the firm is indifferent between these two options). Following the basic model of Pissarides (2000) we will describe a full rational expectations equilibrium.

In order to obtain an equilibrium condition for unemployment, we consider a continuum of workers and a normalized labor force equal to one. Because of the normalization, the number of unemployed and the unemployment rate will be given by the same variable, $u$. The number of vacant jobs, $v$, is also understood as a fraction of the labor force. The number of job matches will be given by a function that depends both on $u$ and $v$. We consider a matching function which is assumed increasing in both arguments, concave and homogenous of degree one, and more over, it is assumed to be a Cobb-Douglas with the following form:[11]

$$m = \chi v^{1-\eta} u^{\eta} \tag{1}$$

where $m$ is the number of matches and $\chi$ is a measure of efficiency of the matching process.

We define $\theta = v/u$ , the vacancy-unemployment ratio, as a measure of the relative number of traders in each side of the market, also known in the literature as a measure of market "tightness".

The probability that a job is filled will be determined endogenously by $q(\theta) \equiv m/v = \chi\theta^{-\eta}$. The mean duration of a vacant job is $1/q(\theta)$.

The rate (of a Poisson process) at which unemployed workers find a job and move into employment is given by $\theta q(\theta) \equiv m/u = \chi\theta^{1-\eta}$. Therefore, the mean duration of unemployment is $1/\theta q(\theta)$.

[10] When the rate of separation is constant, no externalities arise through job losses (Pissarides 1984, pg 98).

[11] From Shimer 2004: Blanchard and Diamond 1989 estimate a CES matching function and they cannot reject a unit elasticity of substitution, the Cobb-Douglas case. There is not much analysis though of the Cobb-Douglas assumption.

Because of the mismatches and creation of new vacancies, the unemployment rate tomorrow is given both by the stock of workers that lost their jobs today $(s(1-u))$ minus the flow of new employed that result from successful matches today. We assume that new matches become productive after one period. Then, the evolution of mean unemployment is given by,

$$\dot{u}(t) = s(1-u(t)) - m(t) = s(1-u(t)) - \chi\theta_{p(t)}^{1-\eta}u(t) \tag{2}$$

Since in steady state the mean rate of unemployment is constant, we have that

$$s(1-u) = \theta q(\theta)u$$

or

$$u = \frac{s}{s+\theta q(\theta)} \tag{3}$$

The latter equation is known as the *Beveridge curve*, a downward sloping curve and convex to the origin in the $v$-$u$ space.

## 3.2 Firms and Job Creation

There is a continuum of small firms, each offering one job. The production technology for the single good uses labor as the only input and the value of output is given by $p$. We follow the discretization procedure in Shimer (2005), that defines productivity as a function of an underlying process $h$ in the following way:

$$p = z + \phi b + \exp(h)(p^* - z - \phi b)$$

where $h$ is dictated by the following law of motion (in continuos time)[12]:

$$dh = -\gamma h dt + \sigma dx$$

The above process can be described as a Brownian motion with mean reversion coefficient $\gamma$ and standard deviation $\sigma$, except that $x$ is not Gaussian because it is constrained to a discrete space.

Following the literature, we define $J_p$ as the state-contingent present value to the firm of a filled job and $V_p$ the state-contingent present value of a vacant job. Accordingly, $rJ_p$ is the flow capital cost of the job, $[V_p - J_p]$ is the net capital gain (in this case it is negative,

[12]The discrete time counterpart of the above process is $h_t = \exp(-\gamma)h_{t-1} + \sigma\left(\frac{1-\exp(-2\gamma)}{2\gamma}\right)\varepsilon_t$.

and so it is in fact a loss) that is realized if the filled job becomes vacant, which occurs with probability $s$, and $[E_p J_{p'} - J_p]$ is the net capital gain from a change in the aggregate state, that happens at a rate $\lambda$. The expression that defines $J_p$ is:

$$rJ_p = p - w_p + s\left[V_p - J_p\right] + \lambda\left[E_p J_{p'} - J_p\right] \quad ,\forall\ p \tag{4}$$

Likewise, we define $V_p$ analogously in recursive form as (4), and so $rV_p$ is the net capital cost of the vacant position. Before the job is filled, the firm incurs in a cost of recruiting which is reflected in the cost of maintaining an open vacancy, $c$. Also, a net capital gain occurs when the vacant job is filled, given by $J_p - V_p$, which happens with probability $q(\theta_p)$. Finally, a net capital gain (or loss) occurs when there is a change in the aggregate state of the economy, given by $E_p V_{p'} - V_p$, which occurs at rate $\lambda$. Then, $V_p$ can be formulated as,

$$rV_p = -c + q(\theta_p)\left[J_p - V_p\right] + \lambda\left[E_p V_{p'} - V_p\right] \ ,\forall\ p \tag{5}$$

Assuming free entry for vacancies, a firm will decide to create job openings until the value of a vacancy is zero, [13]

$$V_p = 0 \quad ,\forall\ p \tag{6}$$

## 3.3 Workers

The behavior of workers in the model tries to reflect some of the features of the Chilean unemployment benefit system. We begin by formulating the simplest model where employed workers are assumed to be risk neutral, earn a wage, and lose their job at the exogenous rate $s$.[14] Unemployed agents do not work in the current period and search for a new production opportunity for the next period. As is standard in the literature, we assume that search is effortless, search intensity does not affect job prospects, and on-the-job search is ruled out. In addition, eligible unemployed workers collect unemployment insurance benefits for an amount $b$, expressed as ratio to average past wages (replacement rate). This means that at any period of time only a proportion of unemployed workers will receive benefits, which will last for a finite period of time. In order to model the fact that not all agents qualify, we denote by $\phi$ the probability that the unemployed worker is eligible for unemployment benefits. The fact that benefits are finite will be modeled by assuming that with probability

[13] Because we assumed that each firm has a single job, the profit maximization condition is equivalent to the zero-profit condition for firm entry (Pissarides, 2000).

[14] Being risk neutral, agents don't value the insurance component.

$\delta$ the benefits will continue the next period. The duration of benefits is then given by $1/\delta$ .[15] We denote by $z$ be the value of leisure.

The transition probabilities for the different states a worker can be in are given by

| | $W$ | $U^b$ | $U^{nb}$ |
|---|---|---|---|
| $W$: Working | $1-s$ | $s\phi$ | $s(1-\phi)$ |
| $U^b$: Unemployed, with benefits | $\theta q(\theta)$ | $(1-\theta q(\theta))\delta$ | $(1-\theta q(\theta))(1-\delta)$ |
| $U^{nb}$: Unemployed, no benefits | $\theta q(\theta)$ | $(1-\theta q(\theta))\delta$ | $(1-\theta q(\theta))(1-\delta)$ |

Let $W_p$ represent the state-contingent present value for an employed worker who earns $w$, defined in a recursive form $\forall\ p$,

$$rW_p = w_p + s\phi\left[U_p^b - W_p\right] + s(1-\phi)\left[U_p^{nb} - W_p\right] + \lambda\left[E_p W_{p'} - W_p\right] \tag{7}$$

Likewise, $U_p^{nb}$ is the state-contingent present value of an unemployed worker who does not receive unemployment benefits but still "earns" $z$ from household activities (value of leisure),

$$rU_p^{nb} = z + \theta_p q(\theta_p)\left[W_p - U_p^{nb}\right] + (1-\theta_p q(\theta_p))\delta\left[U_p^b - U_p^{nb}\right] + \lambda\left[U_{p'}^{nb} - U_p^{nb}\right] \tag{8}$$

Finally, $U_p^b$ is the state-contingent present value of an unemployed worker who receives unemployment benefits $b$,

$$rU_p^b = z + b + \theta_p q(\theta_p)\left[W_p - U_p^b\right] + (1-\theta_p q(\theta_p))(1-\delta)\left[U_p^{nb} - U_p^b\right] + \lambda\left[U_{p'}^b - U_p^b\right] \tag{9}$$

## 3.4 Wages

We assume that firm and worker engage in an asymmetric Nash bargaining, a common assumption in this literature. In this type of bargaining, workers and employers get to divide the total surplus that results from this negotiation. The worker's surplus is defined as the difference between the value of being employed and unemployed, while the surplus for the employer is the difference between the value of a filled and a vacant job. When there is no differentiation between types of unemployed, the resulting wage is unique. Nevertheless, given that we have different states for an unemployed worker we need to make some further assumptions so that we still have a unique wage in equilibrium.

[15] We do not rule out the possibility that unemployed workers who do not have benefits today may have benefits tomorrow. This is an empirical possibility since not all unemployed who are eligible withdraw from their fund immediately. In this setting, $\delta$ is understood as the probability of an agent having unemployment benefits tomorrow, regardless of whether he has benefits today or not. In terms of solving the model, we assume $\delta = \phi$. This means, that the condition for the agent to have benefits at time $t$ is the same as the condition for the agent to maintain those benefits for an additional month.

We assume that eligibility occurs randomly at the moment in which separation occurs, and not at the moment of matching. Therefore, at the moment in which wages are negotiated, all prospective employees have equal probability of being unemployed with benefits or without benefits if separation occurs in the future. As a result, since the negotiated wage incorporates this fact, we do not need to distinguish between employed with benefits and employed without benefits, and there is a unique wage. A similar assumption is used by Costain and Reiter (2005). In terms of defining the worker's surplus, we define the overall value of being unemployed as the weighted average of the value functions when unemployed with and without benefits. The weight is given by the probability of having benefits, $\phi$.[16]

Given this assumption, the solution to the asymmetric Nash bargaining is given by

$$\frac{W_p - (1-\phi)\,U_p^{nb} - \phi U_p^b}{\beta} = \frac{J_p - V_p}{1-\beta} \quad ,\forall\ p \tag{10}$$

The above expression is the first order maximization condition from the program

$$w_p = \arg\max \left(W_p - (1-\phi)\,U_p^{nb} - \phi U_p^b\right)^{\beta} (J_p - V_p)^{1-\beta}$$

where $0 \leq \beta \leq 1$ is interpreted as labor's share of the total surplus that an occupied job creates; Pissarides (2000).

Given this negotiation setting we should expect that higher replacement rates result in higher negotiated wages because it implies that the reservation wage of the worker is higher, which is reflected in a higher value of being unemployed with benefits ($U_p^b$). Likewise, we should expect a higher wage when the coefficient $\phi$ is larger.

### 3.5 Solution of the model

The model outlined has seven endogenous variables, namely $W_p, U_p^b, U_p^{nb}, J_p, V_p, w_p, \theta_p$. We will obtain the first equation by taking advantage of the fact that equations (4)-(10) are linear in $W_p, U_p^b, U_p^{nb}, J_p, V_p, w_p$. Therefore we can eliminate these variables to get a forward-looking nonlinear difference equation for the $v$-$u$ ratio (or $\theta$) as well as an expression for the wage as a function of the $v$-$u$ ratio. [17]

$$\frac{(r+s+\lambda)}{\chi\theta_p^{-\eta}} + \beta\theta_p = (1-\beta)\left(\frac{p - \phi b - z}{c}\right) + \lambda E_p\left(\frac{1}{\chi\theta_{p'}^{-\eta}}\right) \tag{11}$$

[16] Note that we assume this probability to be exogenous, something that in reality depends on a series of conditions briefly discussed above.

[17] The equations are very similar to those obtained by Shimer (2004). The derivation can be found in the appendix.

$$w_p = \beta(p + c\theta_p) + (1-\beta)(\phi b + z) \tag{12}$$

Given the parameters included in these equations, we can solve for $\theta_p$ and $w_p$ numerically. Once we obtain a solution for $\theta_p$ and $w_p$ we can recover the unemployment rate from (2), and then given this value and $\theta_p$, pin down one for vacancies.

# 4 Calibration

The parameters that we need to calibrate are the real rate of return $r$, the separation rate $s$, the constant of the matching function $\chi$, the elasticity of matches with respect to unemployment $\eta$, the coefficient that determines the worker's bargaining power $\beta$, the proportion of the labor force that is eligible for unemployment insurance $\phi$, the replacement rate $b$, the value of leisure $z$ and the cost of vacancy $c$. The values are summarized in the table below. In addition, we need the productivity state vector $p$.

| Symbol | Value | Explanation |
|---|---|---|
| $r$ | 0.0194 | Annual real rate of return of 8% |
| $s$ | 0.125 | Job duration of 2 years |
| $\chi$ | 1.3285 | $\overline{\theta} = 1$, and $\bar{u} = 8.6\%$ |
| $\eta$ | 0.7 | Belani et al. 2002 |
| $\beta$ | 0.7 | Hosios 1990 (optimality condition: $\eta = \beta$) |
| $\phi$ | 0.45 | Contributors as % of labor force |
| $b$ | 0.3 | Average replacement rate |
| $z$ | 0 | Arbitrary |
| $c$ | 0.3226 | $\overline{\theta} = 1$, and $\bar{p} = 1$ |

The discount rate $r$ is calibrated at 0.02 given the quarterly frequency of the model. It corresponds to an annual real rate of return of 8% for the period 1986-2006. This is in line with other work done for the Chilean economy (Bergoeing and Soto 2005 calibrate their model using 9.1% annual rate of return, but their period of study is 1986-2000). For the US economy, Shimer (2004,2005) calibrates it to 0 and 0.012. As Bergoeing and Soto (2005) note, the higher real interest rate of the Chilean economy compared to the US economy implies that intertemporal effects are less important in Chile because the future is more heavily discounted.

The rate of separation $s$ is calibrated at 0.125 which is a quarterly rate such that jobs last for about 2 years. The 2 years figure is based on Cowan et al (2004) who report that is the approximate duration of contracts in Chile. During the sensitivity analysis section, $s$ is also calibrated at 0.25, which implies that the duration of contracts is one year. For the US Andolfatto (1996) calibrates it as 0.15 and Shimer (2004) as 0.10,the latter corresponding to an average duration of jobs of 2.5 years.

The two parameters from the matching function are calibrated as follows. First, $\chi$ is calibrated to 1.3285 so as to be consistent with (i) the average unemployment rate during the period 1986-2006 (8.6%) and (ii) the normalization of the average vacancy unemployment ratio to 1. This normalization follows Shimer (2004, 2005) who chooses to target a mean $v$-$u$ ratio of 1, which for the case of the US economy requires $\chi = 1.355$. Second, $\eta$, the elasticity of job matches with respect to unemployment, is calibrated using the results of Belani et al (2002) who estimate that the parameter can take values in the range $0.7 - 0.85$. We set $\eta = 0.7$ given that the plausible values discussed in the literature range between $0.5 - 0.7$ (Petrongolo and Pissarides, 2001).

The coefficient $\beta$ is defined as the bargaining power of workers, or their share of the total surplus that results from the expected gains from trade that are split according to the Nash bargaining solution. We calibrated it as 0.7 following Hosios (1990) who shows that in order for the decentralized equilibrium to be efficient it has to be that $\beta = \eta$. We also use $\beta = 0.55$ in the sensitivity analysis. Andolfatto (1996) imposes the condition and so does Shimer (2004). It is also common to assume symmetric Nash bargaining setting $\beta = 0.5$.

In order to calibrate the parameter $\phi$ we approximated the probability of being eligible for unemployment benefits at the time that the worker becomes unemployed to the proportion of the labor force who is currently contributing to the new UI system. As of June 2005 there were approximately 3 million contributors and the labor force was $6,333,980$, so the parameter is calibrated at 0.45.

The parameter $b$ is the unemployment benefit and is calibrated as to reflect the average replacement rate of the new UI system. Data for November 2004 obtained from the AFC shows that the average replacement rate is $b = 0.3$. For the US it is usually calibrated as 0.4.

The value of leisure $z$ is calibrated as 0 because we are interested in the actual difference of income received in different states of employment/unemployment. For instance, Costain and Reiter (2005) simply calibrate the difference between unemployment income in the two states being equal to unemployment benefits. Nevertheless, we acknowledge that the calibration of this parameters needs to be studied further since it may actually be very relevant in terms of the estimated volatility of the series of unemployment and vacancies. In fact, recent research by Hagedorn and Manovskii (2005) discusses the value of non-market activity as one of the "key parameter" (together with the bargaining coefficient $\beta$). In our sensitivity analysis we also use the value $z = 0.6$.

The parameter that reflects the cost per advertising a vacancy, $c$, is fixed and is calibrated so as to target an average vacancy unemployment ratio equal to 1. It will therefore be different in the alternative specifications, because the equations that determine the $v$-$u$ ratio change. For the model with risk neutral agents and flexible wages, $c = 0.3226$.

Finally, the stochastic process for labor productivity was approximated using a discrete state space such that it closely replicates the behavior of the Chilean labor productivity; Shimer (2005). The discrete version used in the solution of the model considers that a random shock from a Poisson distribution arrives at a rate $\lambda$, and when this happens, $h$ either moves "up" or "down" by a step $\Delta$, in the $2n + 1 \geqslant 3$ points grid defined by $H$,

$$H = (-n\Delta, -(n-1)\Delta, ..., 0, ..., (n-1)\Delta, n\Delta)$$

with probabilities:

$$h' = \begin{cases} h + \Delta \text{ with probability } \frac{1}{2}\left(1 - \frac{h}{n\Delta}\right) \\ h - \Delta \text{ with probability } \frac{1}{2}\left(1 + \frac{h}{n\Delta}\right) \end{cases}$$

As $h$ increases, the probability of an "upward" jump decreases, to the point where the probability is equal to zero when $h$ reaches the upper boundary. Likewise, the probability of decreasing is zero when the lower boundary is reached. The parameters are defined as $\gamma \equiv \lambda/n$ and $\sigma \equiv \sqrt{\lambda\Delta}$, and calibrated as $\gamma = 0.004$ and $\sigma = 0.1$, such that we replicate the behavior of productivity at the business cycle frequency. We chose the value $n = 100$ so that we have a grid of 201 points.

# 5 Simulation Results

An initial condition for the productivity state and the unemployment rate is chosen in order to start the simulation. The associated $v$-$u$ ratio and wage are obtained using equations (11) and (12), respectively. Then, a random number is drawn from a Poisson distribution with arrival rate $\lambda$ to determine whether a shock hits the economy. If it does, the new productivity state is obtained following the process described above and the unemployment level is calculated from the law of motion of unemployment. The model is simulated 1000 times, each time generating series for unemployment, vacancies, $v$-$u$ ratio, wages and productivity of length equal to $10,084$ quarters. After dropping the first $10,000$ quarters, the series are transformed in the same way as the data -that is, log differenced from an HP trend- and summary statistics are calculated.

The model is relatively successful in replicating the correlation between unemployment and vacancies ($-0.69$ versus $-0.77$ in the data), the correlation between unemployment and the $v$-$u$ ratio ($-0.83$ versus $-0.95$ in the data) as well as that of vacancies and the v-u ratio (0.97 versus 0.93 in the data). It nevertheless overestimates the correlations between productivity and the rest of the variables. The estimated autocorrelation coefficients are lower than those observed in the data, in particular those of unemployment (0.64 versus 0.89 in the data) and vacancies (0.68 versus 0.86 in the data) .

| Correlation | p | w | u | v | v/u |
|---|---|---|---|---|---|
| Productivity | 1 | 1 | −0.8261 | 0.9764 | 1 |
| Real Wages | | 1 | −0.8261 | 0.9764 | 1 |
| Unemployment | | | 1 | −0.6869 | −0.8261 |
| Vacancies | | | | 1 | 0.9764 |
| V−U Ratio | | | | | 1 |

| | p | w | u | v | v/u |
|---|---|---|---|---|---|
| Standard Deviation | 0.0331 | 0.0333 | 0.0118 | 0.0307 | 0.0399 |
| Autocorrelation | 0.8318 | 0.8318 | 0.6434 | 0.6823 | 0.8318 |

Base model (calibration in section 4)

By construction, in this model the correlation between wages and productivity is 1, because wages are negotiated every time productivity changes. As a consequence, wages absorb all the effect of the productivity shock and so the volatility of wages is also the same as the volatility of labor productivity. For the same reason, unemployment and vacancies appear to have a very low volatility around its trend (0.012 and 0.03 log points respectively). The volatility of the $v$-$u$ ratio, although higher than that of unemployment and vacancies, is still very low compared to the data, summarizing the problem that the model is not able to replicate the observed business cycle volatility.[18] We address this issue later by adding wage rigidity although Hagedorn and Manovskii (2005) argue that the low volatility of unemployment and vacancies is not due to a wrong specification of the model itself but rather to the way it is typically calibrated and they propose a new calibration strategy for what they call the "central parameters" of the model - the worker's value of non-market activity and the worker's bargaining power.

[18] See Shimer 2005 for a discussion on this issue.

## 5.1 A positive value of leisure

We calibrate the value of leisure as $z = 0.6$ with the advantage that it helps improve the estimated autocorrelation coefficient of unemployment series, making it more persistent than vacancies as it is in the data, and it also improves the estimated correlation between unemployment and vacancies. Nevertheless, it does not improve the low volatility of unemployment and vacancies. In addition, the volatility of productivity and wages is even lower than in the $z = 0$ case.

| Correlation | | | | | |
|---|---|---|---|---|---|
| Productivity | 1 | 1 | −0.8636 | 0.9845 | 0.9989 |
| Real Wages | | 1 | −0.8636 | 0.9845 | 0.9989 |
| Unemployment | | | 1 | −0.7674 | −0.8647 |
| Vacancies | | | | 1 | 0.9855 |
| V–U Ratio | | | | | 1 |
| Standard Deviation | 0.0103 | 0.01 | 0.011 | 0.0325 | 0.0417 |
| Autocorrelation | 0.8432 | 0.8433 | 0.8351 | 0.751 | 0.8443 |

Case of $z = 0.6$

## 5.2 Rigid Wages

As discussed in Cowan et al. (2004), the Chilean labor market features very rigid wages. In response to a negative real shock wages fall slightly. Also real wages have a very low response to changes in unemployment. Therefore, incorporating rigid wages to the model seems like a reasonable step to take. Its incorporation can also be justified by the fact that, as discussed earlier, the volatility of unemployment and vacancies in the model is too low compared to the one observed in the data. The low volatility is a problem that the model faces even when calibrated to match the features of the US labor market. One of the solutions proposed in the literature is to modify the way in which wages are negotiated, and in the extreme, assume rigidity of wages (see Shimer 2004). Costain and Reiter (2005) also incorporate sticky wages and find that it helps because they make the firm's share more procyclical, allowing hiring to vary more at business cycle frequencies without greatly changing the long run effects of policies.

Following Shimer (2004) we assume rigid wages in all matches which means that a matched worker and the firm have no incentive to renegotiate the wage as productivity changes. We therefore replace the Nash bargaining solution with a fixed wage that is calibrated in such a way that average unemployment is equal to 8.6%. The resulting wage is $\bar{w} = 0.5$. To solve the model we chose the same benchmark parameterization, except for the value of the bargaining coefficient $\beta$, which is not part of the model, and the cost of vacancies $c$ that is adjusted so as to be consistent with $\bar{\theta} = 1$. These parameters are such that $J_p > 0$ and $W_p > \phi U_p^b + (1-\phi)U_p^b$. We use equations (4)-(9) and the fixed wage $\bar{w}$, to find the equation that defines the vacancy unemployment ratio for each productivity state:

$$\frac{(r+s+\lambda)}{\chi\theta_p^{-\eta}} = \left(\frac{p-\bar{w}}{c}\right) + \lambda E_p\left(\frac{1}{\chi\theta_{p'}^{-\eta}}\right)$$

The improvement of the model can be found in the estimated volatility of the two main variables -unemployment and vacancies. The standard deviation of unemployment increased from 0.0118 to 0.03 (lower than the actual volatility in the data, 0.1624). Likewise, the volatility of the vacancies series increased from 0.03 to 0.07. Still we face the problem that in the model, vacancies are more volatile than unemployment, as opposed to what happens in the data. Finally, the estimated series are again less persistent than in the data.

| Correlation | p | w | u | v | v/u |
|---|---|---|---|---|---|
| Productivity | 1 | -- | −0.8133 | 0.9708 | 0.9976 |
| Real Wages | | -- | -- | -- | -- |
| Unemployment | | | 1 | −0.6656 | −0.8147 |
| Vacancies | | | | 1 | 0.9734 |
| V–U Ratio | | | | | 1 |

| | p | w | u | v | v/u |
|---|---|---|---|---|---|
| Standard Deviation | 0.0328 | 0 | 0.0292 | 0.0742 | 0.0943 |
| Autocorrelation | 0.8286 | -- | 0.6126 | 0.6681 | 0.829 |

Rigid Wages

## 5.3 Other parameters of interest: s and $\beta$

The rate of separation, $s$, and the coefficient that reflects the worker's bargaining power, $\beta$, are two parameters that were calibrated to rather questionable values given that there is not much information about them. Therefore, we modify their values to see how the simulated series react.

In the case of the separation rate, it could well be the case that the duration of contracts is lower than 2 years as assumed in the base case. We therefore increase this rate to reflect this fact, holding all other coefficients at the value suggested in section 4. We found that a separation rate of 0.25 (which implies that contracts last for 1 year, or 4 quarters) causes average unemployment to raise from 8.6% in the base model, to 16.4%.

Regarding the bargaining coefficient, we reduce the value of the parameter to reflect a lower negotiation power of workers. Allowing for an (almost) symmetric wage bargaining ($\beta = 0.55$) has two main effects. First, the volatility of unemployment increases from 1.2% to 1.4%, and second, both unemployment and vacancies present a lower autocorrelation coefficient, in particular unemployment (0.224 versus 0.637 in the base simulation).

# 6 Sensitivity analysis

In this section we carry out sensitivity analysis for the two chosen policy parameters, $b$ and $\phi$, and study their effect on mean unemployment duration, average tightness of the labor market (given by the $v$-$u$ ratio), as well as on equilibrium average unemployment in the simulated economy. We consider alternative scenarios: the base model whose calibration is described in section 4, the case in which non-labor income is higher ($z = 0.6$), an economy in which the bargaining coefficient is lower ($\beta = 0.55$), another one in which the separation rate is higher ($s = 0.25$) and finally an economy that has rigid wages and does not renegotiate them when the policy change occurs.

## 6.1 Replacement rate ($b$)

First we discuss changes in the replacement rate for the base model as seen in figure 4, that is the one calibrated following section 4. Mean unemployment duration (MUD) increases as $b$ increases, a result that is in accordance to what has been found in the literature for the US market. The coefficient that measures average tightness of the labor market decreases, which means that tightness increases. The reason is that as the ratio of vacancies to unemployment decreases it becomes more difficult for unemployed workers to find a vacant position. Average tightness is approximately equal to 1 when $b = 0.3$ because of the calibration done to normalize average tightness $\bar{\theta}$.

In terms of magnitude, if the replacement rate were to increase from 30 to 40 percent average unemployment would increase 0.1 percent points (from 8.6 to 8.7%), while MUD increases 1.7% (from 0.75 to 0.76). Market tightness, on the other hand, increases 5.5%

# Figure 3: Sensitivity Results

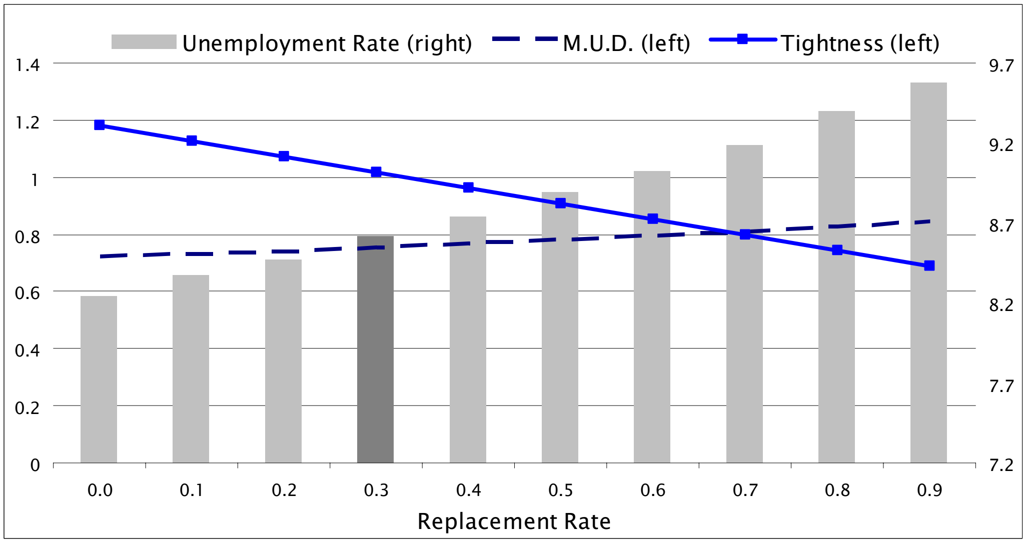
Changes in the replacement rate

| | | u rate | mud | tightness | | σv | ρu | ρv |
|---|---|---|---|---|---|---|---|---|
| base | b=0.3 | 8.62 | 0.75 | 1.02 | 0.012 | 0.031 | 0.637 | 0.678 |
| | b=0.4 | 8.74 | 0.76 | 0.96 | 0.012 | 0.031 | 0.654 | 0.686 |
| | b=0.5 | 8.90 | 0.78 | 0.91 | 0.012 | 0.030 | 0.661 | 0.680 |
| | b=0.6 | 9.03 | 0.79 | 0.85 | 0.012 | 0.031 | 0.681 | 0.689 |
| z=0.6 | b=0.3 | 12.0 | 1.09 | 0.29 | 0.011 | 0.032 | 0.818 | 0.721 |
| | b=0.4 | 12.7 | 1.16 | 0.24 | 0.011 | 0.032 | 0.834 | 0.727 |
| | b=0.5 | 13.5 | 1.25 | 0.19 | 0.010 | 0.032 | 0.841 | 0.719 |
| | b=0.6 | 14.6 | 1.37 | 0.14 | 0.010 | 0.032 | 0.860 | 0.731 |
| β=0.55 | b=0.3 | 7.2 | 0.62 | 1.91 | 0.014 | 0.030 | 0.224 | 0.547 |
| | b=0.4 | 7.3 | 0.63 | 1.83 | 0.013 | 0.030 | 0.328 | 0.589 |
| | b=0.5 | 7.5 | 0.64 | 1.73 | 0.013 | 0.032 | 0.425 | 0.638 |
| | b=0.6 | 7.5 | 0.65 | 1.62 | 0.013 | 0.032 | 0.436 | 0.648 |
| s=0.25 | b=0.3 | 16.3 | 0.78 | 0.91 | 0.012 | 0.034 | 0.589 | 0.707 |
| | b=0.4 | 16.5 | 0.79 | 0.86 | 0.011 | 0.032 | 0.594 | 0.695 |
| | b=0.5 | 16.8 | 0.81 | 0.80 | 0.011 | 0.032 | 0.596 | 0.683 |
| | b=0.6 | 17.3 | 0.82 | 0.75 | 0.011 | 0.034 | 0.654 | 0.713 |
| fixed w | b=0.3 | 8.7 | 0.75 | 1.07 | 0.028 | 0.072 | 0.604 | 0.670 |
| | b=0.4 | 9.0 | 0.76 | 1.05 | 0.027 | 0.069 | 0.610 | 0.668 |
| | b=0.5 | 8.7 | 0.75 | 1.06 | 0.025 | 0.065 | 0.617 | 0.669 |
| | b=0.6 | 8.7 | 0.75 | 1.05 | 0.023 | 0.060 | 0.609 | 0.666 |

Changes in the elegibility parameter

| | | u rate | mud | tightness | | σv | ρu | ρv |
|---|---|---|---|---|---|---|---|---|
| base | . | 8.6 | 0.75 | 1.02 | 0.012 | 0.031 | 0.633 | 0.676 |
| | . | 8.7 | 0.76 | 0.98 | 0.012 | 0.030 | 0.638 | 0.673 |
| | . | 8.8 | 0.77 | 0.94 | 0.012 | 0.031 | 0.650 | 0.678 |
| z=0.6 | . | 12.1 | 1.09 | 0.29 | 0.011 | 0.031 | 0.812 | 0.711 |
| | . | 12.4 | 1.13 | 0.26 | 0.011 | 0.032 | 0.833 | 0.733 |
| | . | 12.9 | 1.18 | 0.22 | 0.011 | 0.032 | 0.843 | 0.733 |
| β=0.55 | . | 7.2 | 0.62 | 1.93 | 0.014 | 0.031 | 0.263 | 0.553 |
| | . | 7.3 | 0.63 | 1.86 | 0.014 | 0.031 | 0.334 | 0.615 |
| | . | 7.3 | 0.64 | 1.78 | 0.013 | 0.030 | 0.363 | 0.611 |
| s=0.25 | . | 16.2 | 0.78 | 0.91 | 0.011 | 0.033 | 0.572 | 0.690 |
| | . | 16.4 | 0.79 | 0.87 | 0.011 | 0.032 | 0.566 | 0.682 |
| | . | 16.7 | 0.80 | 0.84 | 0.011 | 0.032 | 0.627 | 0.710 |
| fixed w | . | 8.8 | 0.75 | 1.07 | 0.028 | 0.073 | 0.612 | 0.670 |
| | . | 8.7 | 0.75 | 1.06 | 0.027 | 0.069 | 0.606 | 0.662 |
| | . | 8.7 | 0.75 | 1.06 | 0.026 | 0.066 | 0.603 | 0.662 |

Figure 4: Base model: changes in the replacement rate

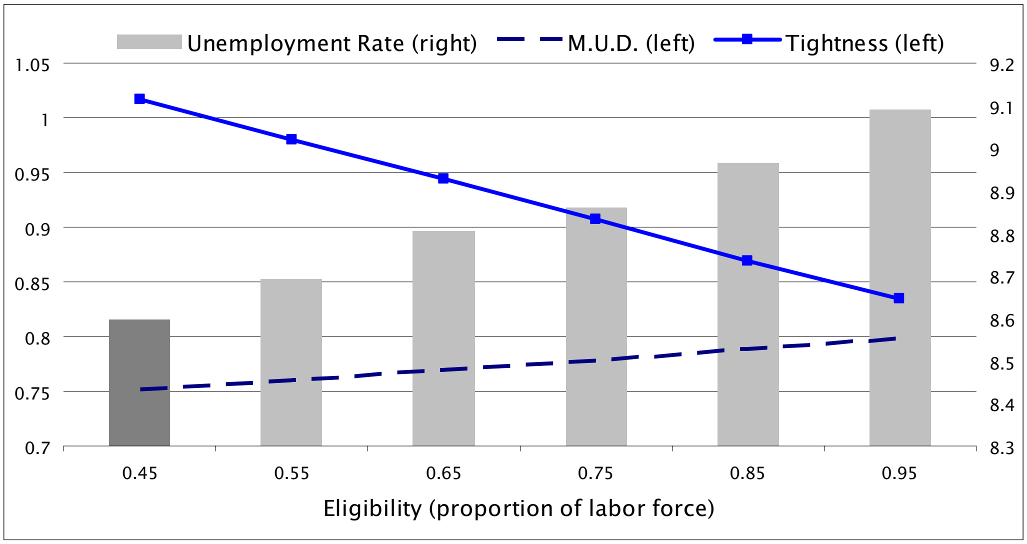



(recall that when the coefficient of market tightness falls, market tightness increases) as a result of that same change in benefits. These results are larger in magnitude if income from non-labor activities were higher. We find that the same 10 percent points increase in the replacement rate (from 30 to 40 percent) results in an increase of 0.7 percent points in unemployment (from 12 to 12.7%) and a 6% increase in MUD, when z=0.6 instead of zero. Likewise, market tightness increases almost 18% given this higher level of non-labor income.

Even though higher separation rates imply higher levels of unemployment as in the case of higher non–labor income (16.3% when s=0.25) the response of unemployment to changes in $b$ is less strong, more comparable to that of the base case. In fact, increasing $b$ from 30 to 40 percent increases unemployment by 0.2 percent points. The response of MUD and market tightness are also similar to the base case.

In terms of volatility of unemployment, Costain and Reiter (2005) find that a larger $b$ implies higher volatility of unemployment and higher volatility of vacancies in the US data. We didn't find this increase in volatility as benefits become more generous, but we did find that unemployment becomes more persistent. This result is in line with what Holmlund (1998) reports, and so a transitory labor productivity shock leads to prolonged unemployment when replacement rates are higher. To have a sense of magnitude, if UI benefits were to increase 10 percent points, from 30 to 40 percent, the autocorrelation coefficient would

Figure 5: Base model: changes in the eligibility parameter




rise from 0.64 to 0.65.

In a scenario in which workers have less power to negotiate wages ($\beta = 0.55$ instead of 0.7), average unemployment is higher than in the base case (7.2 versus 8.6% when b=0.3) and it increases by 0.1 percent points to 7.3% when benefits increase to 40%. That is, the response is the same.

When wages are rigid, and they are not renegotiated as the policy change takes place, changes in the replacement rate result in no significant changes in the average unemployment rate. Nevertheless, the volatility of the unemployment and vacancies series is almost twice as high as the one estimated in the base model. These volatilities, as opposed to what we found in the flexible-wage case, decrease as benefits increase. Meanwhile persistence stays roughly the same.

## 6.2 UI Eligibility ($\phi$)

The proportion of the labor force who is eligible for unemployment benefits, $\phi$, was calibrated at a base value of 0.45 and so again, at this value, $\bar{\theta} \approx 1$. Figure 5 shows how MUD and average tightness of the labor market respond as the proportion of eligible workers increases, as well as the evolution of the average unemployment rate. We do not run the sensitivity analysis for values lower than 0.45 percent because we assume that coverage will only increase, and so an exercise than involves reducing this parameter was not of policy relevance.

Mean unemployment duration increases and the coefficient of market tightness decreases (which means that the market becomes tighter) as the proportion of eligible workers increase. The trends are the same as in the case of changes in the replacement rate, but in the case of eligibility, the magnitude of the changes is different. For instance, an increase in the proportion of eligible unemployed workers of 10 percent points, from 45 to 55 percent, results in an increase in unemployment of aproximately 0.1 percent points from the base level of 8.6%.

The response of the market under different scenarios for non-labor income, separation rate and fixed wages are also similar to those of changes in the replacement rate. One difference is that having z=0.6 does results in a 0.3 percent points increase in mean unemployment when $\phi$ increases 10 percent points, versus the 0.7 percent points increase when $b$ increased 10 percent points.

The effects on average unemployment when increasing $\phi$ by 10 percent points (from 45 to 55%) are similar to those of increasing $b$ by approximately 8 percent points (from 30 to 38.3%). After this point, both elasticities increase, but unemployment shows to be much more responsive to adjustments in the level of benefits than to the proportion of eligible unemployed. In fact, the base simulations show that starting from a level of 8.6% unemployment, a 9.1% would be reached only when $\phi \approx 1$, while the same level would be reached after increasing $b$ to 60%. As can be seen in figure 5 a level of approximately 9.1% unemployment is reached when $\phi \approx 1$, while a similar level of unemployment is reached when $b \approx 0.6$ (see figure 4).

# 7 Conclusions

We build on the search literature to construct a stochastic general equilibrium model for the Chilean economy that incorporates some of the features of a recently implemented unemployment insurance system. The new system introduced several elements that allow unemployed workers to receive benefits that represent on average 30% of their previous wage, for a limited period of time, while minimizing the moral hazard problems as well as other negative effects on the labor market such as increased unemployment duration. For instance, benefits are in part, and in some cases completely, financed by the own worker's savings. Also, benefits are given out in a decreasing schedule and for a finite period of time. The model developed in this paper incorporates some, but not all, of the design elements, and quantifies the effects on the labor market that result from increasing the amount of benefits and the pool of beneficiaries.

The main model outlined in Pissarides (2000) is extended to consider three states of nature for workers: employed, unemployed with benefits and unemployed without benefits. The proportion of workers in each state is given by a combination of the (exogenous) separation rate and the parameter that describes eligibility to, as well as finiteness of, benefits. The base model replicates fairly well some key features of the Chilean labor market at business cycle frequency, such as the negative correlation between unemployment and vacancies. In addition, we present sensitivity analysis after proposing alternative values for relevant parameters such as non-labor income, the bargaining power of workers, the separation rate, and also after allowing wages to be rigid.

The policy parameters chosen are those related to the unemployment insurance system, namely the replacement rate ($b$) and the proportion of the labor force that is eligible for benefits once unemployed ($\phi$). In our base model in which workers are assumed to be risk neutral and wages are flexible, average unemployment and mean unemployment duration (MUD) increase as the replacement rate increases, and this reaction is about four times stronger when the value of leisure is calibrated at a higher value. Average tightness of the labor market increases as well. The reason is that as the ratio of vacancies to unemployment decreases it becomes more difficult for unemployed workers to find a vacant position. Alternative scenarios given by either a higher separation rate or a lower parameter value of the worker's bargaining power confirm the response of unemployment to changes in the policy parameter. The simulated series nevertheless are less persistent, especially the unemployment series simulated with a lower $\beta$. After incorporating rigid wages, we find that the series become more volatile, but still not as volatile as they are in the data, and this volatility decreases as either policy parameter increases. In this scenario, the average values of unemployment, MUD and labor market tightness are almost not affected by the policy changes.

The sensitivity results for the second coefficient, $\phi$, the proportion of workers who are eligible for benefits when unemployed, tell us that this parameter has on average a much lower impact in the labor market than the replacement rate. It has, nevertheless, a similar impact at the beginning, meaning that when $b = 30\%$ and $\phi = 45\%$, the same increase in unemployment would result either if we experience an 8 percent points increase in $b$ or a 10 percent points increase in $\phi$. After this point, both elasticities increase, but unemployment shows to be much more responsive to adjustments in the level of benefits than to the proportion of eligible unemployed. In fact, the base simulations show that starting from a level of 8.6% unemployment, a 9.1% would be reached only when $\phi \approx 1$, while the same level would be reached after increasing $b$ to 60%.

Alternative calibration scenarios involve a higher separation rate and lower power for workers to negotiate wages. When the duration of contracts is lower, even though the level of unemployment is much higher the reaction to this policy change is very similar to the base case. In a setting in which worker's bargaining power is lower, the equilibrium average unemployment level is also lower, but the impact of the policy is similar since the unemployment rate increases 1.3% (from 7.2 to 7.3%). Nevertheless, there is a big difference in terms of the autocorrelation of the series: for the same level of benefits, unemployment is less persistent, and a 10 percent points increase in benefits results in a 47% increase in persistence. Finally, when rigid wages are introduced in the model we find that for the same level of benefits, volatility of unemployment and vacancies is much higher when wages are not renegotiated. In this setting, as benefits increase the series become less volatile (2% less volatile) and more persistent (1% more).

The analysis carried out in this paper does not take into account the insurance motive because we assumed workers to be risk neutral. Eventhough it is a very common assumption in the literature (see Pissarides, 2000) risk neutrality precludes any need for consumption smoothing via insurance when faced with aggregate productivity shocks. In addition, for simplicity we ignored the fact that benefits are mostly self-financed and that, in turn, eligibility is endogenous as it depends on the balance accumulated in the individual account. As a result, the new system designed to minimize the distortions in the labor market is not completely interpreted by our model. The most direct implication is that the magnitudes discussed above are larger than those expected in reality were these policies implemente and should therefore be considered as an upper bound. We leave the extensions of the model for future research.

# 8 Appendix

In this appendix we show how to obtain the wage equation as a function of the vacancy-unemployment ratio, and the forward non-linear equation for the vacancy-unemployment ratio.

Begin by replacing equation (6) in (5)

$$J_p = \frac{c}{q\left(\theta_p\right)} \quad \forall p \tag{i}$$

Replacing (6) in (10)

$$W_p - (1-\phi)\, U_p^{nb} - \phi U_p^b = \left(\frac{\beta}{1-\beta}\right) J_p \tag{ii}$$

Replacing (i) in (ii)

$$W_p - (1-\phi)\, U_p^{nb} - \phi U_p^b = \frac{\beta}{1-\beta}\left(\frac{c}{q(\theta_p)}\right) \tag{iii}$$

In order to form $W_p - (1-\phi)\, U_p^{nb} - \phi U_p^b$ in (iii) we use (7), (8) and (9)

$$\begin{aligned}
r\left(W_p - (1-\phi)\, U_p^{nb} - \phi U_p^b\right) &= w_p + s\phi\left[U_p^b - W_p\right] + s(1-\phi)\left[U_p^{nb} - W_p\right] \\
&\quad + \lambda\left[E_p W_{p'} - W_p\right] \\
&\quad - (1-\phi)\left\{\begin{array}{c} z + \chi\theta_p^{1-\eta}\left[W_p - U_p^{nb}\right] \\ + \left(1-\chi\theta_p^{1-\eta}\right)\delta\left[U_p^b - U_p^{nb}\right] \\ + \lambda\left[E_p U_{p'}^{nb} - U_p^{nb}\right] \end{array}\right\} \\
&\quad - \phi\left\{\begin{array}{c} z + b + \chi\theta_p^{1-\eta}\left[W_p - U_p^b\right] \\ + \left(1-\chi\theta_p^{1-\eta}\right)(1-\delta)\left[U_p^{nb} - U_p^b\right] \\ + \lambda\left[E_p U_{p'}^b - U_p^b\right] \end{array}\right\}
\end{aligned}$$

$$\begin{gathered}
r\left(W_p - (1-\phi)\, U_p^{nb} - \phi U_p^b\right) = w_p + \phi\left(s + \chi\theta_p^{1-\eta}\right)\left(U_p^b - W_p\right) \\
+ (1-\phi)\left(s + \chi\theta_p^{1-\eta}\right)\left(U_p^{nb} - W_p\right) \\
- (z + \phi b) - \left(1 - \chi\theta_p^{1-\eta}\right)\left(\phi(1-\delta) - \delta(1-\phi)\right)\left(U_p^{nb} - U_p^b\right) \\
+ \lambda\left[E_p W_{p'} - W_p\right] - \phi\lambda\left[E_p U_{p'}^b - U_p^b\right] - (1-\phi)\,\lambda\left[E_p U_{p'}^{nb} - U_p^{nb}\right]
\end{gathered}$$

$$\begin{aligned}
r\left(W_p - (1-\phi)\, U_p^{nb} - \phi U_p^b\right) &= (w_p - \phi b - z) \\
&\quad - (s+\lambda)\left(W_p - (1-\phi)\, U_p^{nb} - \phi U_p^b\right) \\
&\quad - \chi\theta_p^{1-\eta}\left(W_p - (1-\delta)\, U_p^{nb} - \delta U_p^b\right) \\
&\quad + (\delta - \phi)\left(U_p^{nb} - U_p^b\right) \\
&\quad + \lambda E_p\left(W_{p'} - (1-\phi)\, U_{p'}^{nb} - \phi U_{p'}^b\right)
\end{aligned}$$

$$\begin{aligned}
(r + s + \lambda)\left(W_p - (1-\phi)\, U_p^{nb} - \phi U_p^b\right) &= (w_p - \phi b - z) \\
&\quad - \chi\theta_p^{1-\eta}\left(W_p - (1-\delta)\, U_p^{nb} - \lambda U_p^b\right) \\
&\quad + (\delta - \phi)\left(U_p^{nb} - U_p^b\right) \\
&\quad + \lambda E_p\left(W_{p'} - (1-\phi)\, U_{p'}^{nb} - \phi U_{p'}^b\right)
\end{aligned} \tag{iv}$$

If $\delta = \phi$ equation (iv) becomes:

$$\left(W_p - (1-\phi)\, U_p^{nb} - \phi U_p^b\right) = \frac{(w_p - \phi b - z) + \lambda E_p\left(W_{p'} - (1-\phi)\, U_{p'}^{nb} - \phi U_{p'}^b\right)}{\left(r + s + \lambda + \chi\theta_p^{1-\eta}\right)} \tag{iv'}$$

Using (iii)

$$\left(r+s+\lambda+\chi\theta_p^{1-\eta}\right)\left(\frac{\beta}{1-\beta}\right)\frac{c}{\chi\theta_p^{-\eta}}=(w_p-\phi b-z)+\lambda\left(\frac{\beta}{1-\beta}\right)E_p\left(\frac{c}{\chi\theta_{p'}^{-\eta}}\right)$$

$$\left(r+s+\lambda+\chi\theta_p^{1-\eta}\right)\frac{1}{\chi\theta_p^{-\eta}}=\left(\frac{1-\beta}{\beta}\right)\left(\frac{w_p-\phi b-z}{c}\right)+\lambda E_p\left(\frac{1}{\chi\theta_{p'}^{-\eta}}\right)$$

$$\frac{(r+s+\lambda)}{\chi\theta_p^{-\eta}}+\theta_p=\left(\frac{1-\beta}{\beta}\right)\left(\frac{w_p-\phi b-z}{c}\right)+\lambda E_p\left(\frac{1}{\chi\theta_{p'}^{-\eta}}\right) \tag{v}$$

**Wage Equation** Start with equation (4) and use equations (6), (i) and (v)

$$rJ_p=p-w_p+s\left[V_p-J_p\right]+\lambda\left[J_{p'}-J_p\right]$$

$$(r+s+\lambda)\frac{c}{\chi\theta_p^{-\eta}}=p-w_p+\lambda E_p\left(\frac{c}{\chi\theta_{p'}^{-\eta}}\right)$$

$$w_p=p-(r+s+\lambda)\frac{c}{\chi\theta_p^{-\eta}}+\lambda E_p\left(\frac{c}{\chi\theta_{p'}^{-\eta}}\right) \tag{vi}$$

$$\begin{aligned} w_p &= p-(r+s+\lambda)\frac{c}{\chi\theta_p^{-\eta}} \\ &\quad +c\left(\frac{(r+s+\lambda)}{\chi\theta_p^{-\eta}}+\theta_p-\left(\frac{1-\beta}{\beta}\right)\left(\frac{w_p-\phi b-z}{c}\right)\right) \end{aligned}$$

$$w_p=\beta\left(p_j+c\theta_p\right)+(1-\beta)\left(\phi b+z\right)$$

**Forward-looking nonlinear difference equation for the vacancy/unemployment ratio** Replace (vi) in (v)

$$\begin{aligned} &\frac{(r+s+\lambda)}{\chi\theta_p^{-\eta}}+\theta_p \\ = &\left(\frac{1-\beta}{\beta}\right)\left(\frac{p}{c}-(r+s+\lambda)\frac{1}{\chi\theta_p^{-\eta}}+\lambda\frac{1}{\chi\theta_{p'}^{-\eta}}-\frac{\phi b+z}{c}\right)+\lambda E_p\left(\frac{1}{\chi\theta_{p'}^{-\eta}}\right) \end{aligned}$$

$$\frac{(r+s+\lambda)}{\chi\theta_p^{-\eta}}\left(\frac{1}{\beta}\right)+\theta_p=\left(\frac{1-\beta}{\beta}\right)\left(\frac{p-\phi b-z}{c}\right)+\left(\frac{1}{\beta}\right)\lambda E_p\left(\frac{1}{\chi\theta_{p'}^{-\eta}}\right)$$

$$\frac{(r+s+\lambda)}{\chi\theta_p^{-\eta}}+\beta\theta_p=(1-\beta)\left(\frac{p-\phi b-z}{c}\right)+\lambda E_p\left(\frac{1}{\chi\theta_{p'}^{-\eta}}\right)$$

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