

# The cost of business cycles and the stabilization value of unemployment insurance

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## Abstract

This paper offers a new perspective on why labor market policies aimed at reducing the cost of business cycles may be warranted and how such policies can be designed in order to improve welfare. To this end, we develop a quantitative dynamic equilibrium model to illustrate how the contractual structure of the labor market may hide significant undiversified wage risk induced by aggregate fluctuations. The environment analyzed is such that the only imperfectly diversified risk workers bear is the risk of losing their job when the market for new contracts is depressed. When we fit the model to replicate the amount of wage variation estimated from micro-data, we obtain estimates of the potential value of stabilization policies that are substantially larger than those found in the literature. We use this framework to examine several policy issues and, in particular, to show why state-contingent unemployment insurance may dominate non-contingent unemployment insurance schemes. © 2001 Elsevier Science B.V. All rights reserved.

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## 1. Introduction

When analyzing policies aimed at reducing the cost of business cycles, the ultimate goal is to evaluate these policies in terms of their effectiveness in generating welfare gains. However, ever since Lucas (1987) placed in doubt the intrinsic value of eliminating aggregate fluctuations, it has become contentious to claim that any stabilization policy is worth pursuing. In his influential study, Lucas presents a simple estimation of the cost of aggregate instability. His estimate computes the uniform percentage increase in consumption that is needed to leave a consumer indifferent between a consumption stream with the U.S. consumption variability, and a smooth consumption path. This calculation indicates that the business cycle generates an almost negligible welfare cost – less than one-tenth of a percentage point of consumption. Lucas thus concludes that the potential gains attainable from stabilizing the economy may be negligible.

Lucas's computation is based on the assumption that markets are complete and hence all but aggregate risk is diversifiable. Although this is a questionable assumption, Lucas's work clearly shows that stabilization policies generate substantial welfare gains only if they help to reduce some undiversifiable components of business cycle risk.<sup>1</sup> Following this observation, Imrohorglu (1989) and Atkeson and Phelan (1994) have examined the potential gains associated with reducing economic instability in economies where markets are incomplete.<sup>2</sup> Both papers argue that employment fluctuations are not shared evenly among different individuals. Instead, the burden of recessions falls disproportionately among those few who lose their jobs in recessions. Based on this premise, both papers focus on unemployment risk as the principal undiversified risk associated with the business cycle.

For example, Imrohorglu measures the welfare cost of the business cycle in an economy where individuals have access to a storage technology but limited access to credit and insurance. She compares a cyclical and a stabilized economy that differ only in the transition probabilities between employment and unemployment. In the cyclical economy, the probability of becoming unemployed and the probability of remaining unemployed is more likely during a recession than it is during a boom. Imrohorglu's estimates of the cost of aggregate fluctuations in this environment are also small, on the order of 0.3% of

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<sup>1</sup>In this view, stabilization policies bring welfare gains only to the extent that they can reduce the volatility of consumer marginal utility. Thus, this view dismisses any effect of stabilization policy on the average level of employment or output. For a discussion of how stabilization policies can affect the mean of output and employment see Delong and Summers (1988).

<sup>2</sup>Imrohorglu and Hansen (1992) is a closely related paper.

consumption.<sup>3</sup> The reason for this result is the relatively small time variation in the average duration of U.S. unemployment. Thus, the risk of being unemployed longer in a recession is relatively small and smoothing out the cycle in order to have a constant expected duration of unemployment does not lead to big welfare gains.<sup>4</sup>

We also premise our analysis on the view that the burden of the business cycle is borne mainly by those who are laid off in recessions. However, we claim that focusing only on the time variability of unemployment duration may underestimate the welfare gains of stabilization policies and bias policy analysis. Indeed, the main purpose of this paper is to emphasize that the mild variability of the aggregate wage may hide important business cycle fluctuations in individual wages and that this source of risk induces substantial welfare costs. We argue that there may be significant welfare gains from stabilization policies even when abstracting from unemployment risk (or risk associated with variation in asset returns, as in Atkeson and Phelan (1994)). The second aim of this paper is to examine different economic policies designed to reduce wage risk. We find that simple unemployment insurance schemes may be inefficient at diversifying the risk associated with economic fluctuations, and we indicate how and why alternative programs may be preferable.

Our model builds on evidence suggesting that the labor market may be better characterized as a market for contracts than as a spot market. In particular, we rely on the work of Bilal (1985), Beaudry and DiNardo (1991,1995) and Jacobson et al. (1993), which present empirical evidence that labor market outcomes exhibit a pattern of history-dependence suggestive of dynamic enforcement-constrained implicit contract theory. In our model, capital market imperfections and different commitment possibilities for workers and firms, give rise to risk-sharing contracts between workers and firms that are similar in nature to those examined by Harris and Holmstrom (1982). The environment considered assumes two types of shocks: aggregate and allocative. In this environment, it is optimal for an employer to insure workers against deteriorating labor market conditions induced by aggregate shocks. However, if a job is subject to a reallocation shock, the worker is laid off and must endure the burden associated with labor market conditions. Hence, the risk in our model is the result of the interaction between allocative and aggregate shocks and the undiversifiable risk is that of being laid off when the market for new contracts is depressed. We fit

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<sup>3</sup> Imrohorglu's largest estimate corresponds to a welfare cost equivalent to 1.5% of consumption. However, obtaining this number requires a very high degree of risk aversion (coefficient of relative risk aversion equal to 6.2), and a substantial loss of income due to unemployment (75%). Imrohorglu's conservative estimate of 0.3% is based on a coefficient of relative risk aversion of 1.5.

<sup>4</sup>Note that Imrohorglu's calculations do not imply that unemployment is not socially costly. They only imply that stabilizing unemployment-duration risk at its mean, as opposed to allowing it to vary over time, is unlikely to have great social benefits.

our model to replicate the amount of wage risk estimated from micro-data and use it to assess the cost of the business cycle in an environment where workers receive unemployment subsidies (UI) when unemployed. This calibration exercise relies heavily on the estimates of cyclical wage movements estimated by Beaudry and DiNardo (1991).

The first finding in this paper is that accounting for contractual wage risk leads to estimates of the costs of business cycles that are considerably larger than those found in the literature. Intuitively, the reason why contractual wage risk leads to estimates of the value of stabilization policies that are substantially larger than estimates based on unemployment-duration risk is that wage risk has a very significant time-varying dimension. Moreover, this risk induces changes in workers' income that are very persistent and thus difficult to smooth away with personal savings. The second finding is that recognizing the importance of contractual wage risk has implications for the design of policy. In particular, we find that in an environment characterized by substantial variations in contract wages, unconditional UI may be an inefficient way of reducing the cost of economic fluctuations.<sup>5</sup> In contrast, we find that state-contingent UI can generate substantial welfare gains. In fact, by increasing wages during recessions and mildly decreasing wages during booms, such a policy improves risk-sharing and reduces the cost of aggregate fluctuations.

The paper is structured as follows. Section 2 presents the model. Section 3 discusses how the model is calibrated and uses it to assess the potential welfare gains associated with stabilization policy. Section 4 evaluates the extent to which different policies may achieve these welfare gains. Finally, Section 5 draws some conclusions.

## **2. The model**

The aim in this section is to construct a simple dynamic general equilibrium model that can replicate several observed micro and macroeconomic features of the labor market. More precisely, the model is aimed at capturing the idea that aggregate movements in real wages do not properly reflect either variations in the marginal product of labor or individual variations in labor income. In accordance with this objective, this paper examines an economy where imperfections in the capital market lead firms to offer risk-sharing contracts.

Although a typical feature in the implicit contract literature is that contract wages do not reflect the marginal productivity of labor, the assumptions that are

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<sup>5</sup> Our results in terms of welfare and unemployment are surprisingly similar to those obtained by Mortensen (1994), even though the environments are completely different. In particular, in Mortensen's analysis workers are assumed to be risk neutral.

made regarding workers' mobility or firms' commitment possibilities matter for the determination of the optimal wage policy. Empirical evidence presented in Beaudry and DiNardo (1991,1995) suggests that environments where there are constraints on contract enforcement are more consistent with the observed comovements between wages and unemployment than environments where contracts are perfectly enforceable. In light of these observations, the environment we consider will make explicit the enforcement constraints that restrict perfect risk sharing.

### 2.1. Preferences and technology

The environment considered is composed of a continuum of workers and a continuum of firms owned by well-diversified entrepreneurs. These entrepreneurs are international investors who operate firms as to maximize the present discounted value of future profits. Aggregate production possibilities for firms are represented by  $f(l, \theta_t)$ , where  $l$  is the measure of workers employed by firms, and  $\theta_t \in \Theta$  is the state of technology at time  $t$ .<sup>6</sup> The total measure of workers is normalized to 1. The economy is subject to two kinds of shocks: aggregate shocks and allocative shocks. Aggregate shocks are captured by changes in  $\theta$ , where  $\theta$  follows a Markov chain. Allocative shocks are shocks that reallocate a fraction  $1 - \delta$  of jobs in each period to other firms, keeping aggregate production possibilities the same but destroying  $1 - \delta$  of existing employment relationships.

Consumers in this economy are each endowed with one indivisible unit of labor and have preferences over goods that are represented by a time-separable utility function, with per-period utility  $U(C_t)$ .<sup>7</sup> Firms and workers discount the future at the same rate, where  $\beta < 1$  is the common discount factor and  $1/\beta$  is the return on an internationally diversified portfolio. Workers are assumed to derive no direct utility from leisure but have the choice of either working for a firm or working in the informal/household sector. The production of goods in the informal/household sector is given by  $g(1 - l)$ , with  $g'(\cdot) > 0$ ,  $g''(\cdot) < 0$ .<sup>8</sup> This means of modeling the informal/household sector is a convenient way of allowing for an aggregate upward sloping labor supply curve. We will generally refer to a worker in the informal/household sector as being unemployed.

<sup>6</sup> We assume that  $f(l, \theta_t)$  is increasing in both of its arguments, and concave with respect to labor.

<sup>7</sup>  $U(C_t)$  is assumed to be increasing and concave.

<sup>8</sup> In order to prove existence of an equilibrium, we will also assume that  $g'(0) = \infty$  and that  $f_l(0, \theta) = \infty$ . However, neither of the assumptions is necessary for existence of equilibria as our calibration exercise will show.

## 2.2. Institutional structure

Markets in this economy are incomplete due to the presence of contractual enforcement problems. In effect, if all contracts in this economy were fully enforceable, risk would be perfectly diversified and workers would not bear any of the risk associated with business cycle fluctuations. In order to coherently motivate the existence of risk-sharing employment contracts based on enforcement problems, we assume that workers cannot bind themselves to either financial or employment contracts. This implies that workers can save through the financial market but cannot borrow. The interest workers receive on their savings is denoted  $R$ , with the restriction that the return on savings available to consumers is less than the return on the internationally diversified portfolio (i.e.  $1 + R < 1/\beta$ ).<sup>9</sup> The lack of workers' commitment also implies that workers cannot commit to staying in a job if they receive a better offer. Therefore, employment contracts must be self-enforcing from the workers' point of view. In contrast, employers are assumed to have better but still imperfect commitment possibilities. They can bind themselves to an employment contract with a worker as long as the job is not subject to an allocation shock.<sup>10</sup> These different commitment possibilities motivate firms to make contract offers that protect workers from deteriorating labor market conditions and that increase wages when the labor market improves. This type of enforcement problem is the central idea behind Harris and Holmstrom (1982) work on implicit contracts and it appears more consistent with empirical observation than contract models that predict constant wage payments.

Although firms in this environment offer risk-sharing employment contracts, risk will remain imperfectly diversified because firms cannot insure workers against allocative shocks. Therefore, to the extent that contracts differ at different stages of the business cycle, workers bear the risk of being laid off. It is the importance of this risk, when calibrated to match observed movement in wages, that we want to quantify using the model. Finally, we introduce a government that collects taxes from employed workers in order to pay for unemployment subsidies. We also assume that the government can use the international financial market to diversify and balance expenditures and receipts across time.

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<sup>9</sup> This assumption is consistent with the observation that most individuals do not save through the stock market. For example, in 1992 in the U.S. only 29.3% of households had stock holdings greater than \$2000, and only 58% of these households owned publicly traded stocks or mutual funds. Moreover, 95% of non-pension equity was held by the top 10% richest households (Poterba and Samwick, 1995).

<sup>10</sup> In particular, we are excluding the possibility of severance payments to laid-off workers. This assumption is natural if we interpret the allocation shock as one that makes  $1 - \delta$  firms bankrupt and creates  $1 - \delta$ , since bankrupt firms cannot offer severance payments to laid-off workers.

### 2.3. Equilibrium

An equilibrium in this environment is composed of a set of rules that specify for each possible history, (1) contract offers stating how workers are to be paid in different contingencies, (2) employment decisions, and (3) saving decisions. The equilibrium requirements for these rules are that the rules be sequentially rational and that in each period the supply of workers wanting to accept new contracts equals the demand for new (or additional) hires.

In principle, it would be desirable to provide a complete characterization of equilibria for this environment. However, at this level of generality, a complete characterization is rather intractable, since the relevant state space can be infinite. This problem is common in models with heterogeneous agents. In our environment, the heterogeneity arises because workers have different employment histories and wealth levels. This complexity is substantially reduced in the case where there is sufficient job reallocation and returns on savings are relatively low. Therefore, this is the case we focus upon. As we will show in Proposition 1, in this case there exist equilibria that have a tractable history dependence. In such an equilibrium, employment levels only depend on the current state of technology; contractual wages depend only on the state of technology at the time a worker is hired and on subsequent states; and savings decisions are not history dependent and are equal to zero, since contracts exploit all the relevant consumption-smoothing opportunities. Note that although Proposition 1 only characterizes equilibria for a sub-set of the possible parameterizations, our calibration exercise shows that it probably captures the most quantitatively relevant cases.

We define  $w(\theta_t, \theta^{t+i})$  as the wage paid at time  $t + i$  to a worker hired at time  $t$  in state  $\theta_t$ , where wages are allowed to vary with the history of shocks, denoted  $\theta^{t+i} = \{\theta_t, \dots, \theta_{t+i}\}$ , that arose since the worker was first employed. Also,  $l(\theta_{t+i})$  represents the fraction of workers employed in state  $\theta_{t+i}$ , and  $s$  represents the saving decision. In order to later consider the possibility of state-contingent unemployment insurance, we define  $\varphi(\theta_{t+i})$  as an unemployment subsidy contingent on state  $\theta_{t+i}$  and  $\tau$  as a constant tax on employed workers. We assume that the duration of unemployment insurance eligibility is of the length of at least one period long. Finally,  $N$  represents the number of states in  $\Theta$ .

*Proposition 1. If  $\delta$  and  $R$  are sufficiently small, there exists an equilibrium of the form  $\{l(\theta_t), w(\theta_t, \theta^{t+i}), s\}$ , where  $s = 0$  and  $l(\theta_t)$  and  $w(\theta_t, \theta^{t+i})$  satisfy the following five conditions.*

(i) *Contract wages are downwardly rigid but always pay at least the current entry wage. That is,*

$$\forall \theta_t, \theta^{t+i}, \quad w(\theta_t, \theta^{t+i}) = \text{Max}\{w(\theta_t, \theta^{t+i-1}), w(\theta_{t+i}, \theta_{t+i})\}.$$

(ii) *Contracted wage payments equal the present discounted value of marginal productivity*

$$\forall \theta_t, \quad E_{\theta_t} \sum_{i=0}^{\infty} (\beta\delta)^i f_l(l(\theta_{t+i}), \theta_{t+i}) = E_{\theta_t} \sum_{i=0}^{\infty} (\beta\delta)^i w(\theta_t, \theta^{t+i}).$$

(iii) *Unemployed workers are indifferent between remaining unemployed or accepting a job offering the optimal contract. That is,*

$$\forall \theta_t, \quad E_{\theta_t} \sum_{i=0}^{\infty} (\beta\delta)^i U(w(\theta_t, \theta^{t+i}) - \tau) = E_{\theta_t} \sum_{i=0}^{\infty} (\beta\delta)^i U(g'(1 - l(\theta_{t+i})) + \varphi(\theta_{t+i})).$$

(iv) *There is gross hiring every period*

$$\forall \theta_t, \theta_{t+1}, \quad l(\theta_{t+1}) - \delta l(\theta_t) \geq 0.$$

(v) *The marginal rate of substitution between consumption in this period and consumption in the next period is no less than the return to savings. That is,*

$$\begin{aligned} &\forall \theta_{t-i}, \theta^t, \\ &\frac{U_c(w(\theta_{t-i}, \theta^t) - \tau)}{\beta E_{\theta_t} (\delta U_c(w(\theta_{t-i}, \theta^{t+1}) - \tau) + (1 - \delta) U_c(g'(1 - l(\theta_{t+1})) + \varphi(\theta_{t+1})))} \\ &\geq (1 + R) \end{aligned}$$

*Proof.* See Appendix A.  $\square$

We first describe the type of equilibrium behavior implied by Proposition 1 and then we discuss how such behavior is reflected by the above conditions. Proposition 1 characterizes an equilibrium in which firms offer contracts with state-contingent payments. The precise pattern of these payment varies depending on the state of technology at the period the worker is hired. In the best state, employers offer contracts that perfectly insure workers as long as their jobs are not subjected to an allocation shock. In bad states, employers offer contracts that first pay low wages but wages increase when a better state of technology arises. In effect, ongoing contractual relationships always pay at least as much as new contracts offered on the market. Employment is higher in good states because contracts are more attractive than they are in bad states. Loss of employment in this economy is associated with wage risk rather than with unemployment risk. A laid-off worker obtains the same expected discounted utility from being unemployed for a period as from accepting a new contract immediately. Wage risk arises because new contracts pay wages conditional on the new state of productivity, whereas workers in continuing job are insured against possible falls in productivity. Finally, even though layoffs are associated with risk, workers in equilibrium do not find it in their interest to save as a precaution against being laid off.

To be more precise, Condition (i) states that contracts wages are downwardly rigid and upwardly flexible. This upward flexibility stems from the lack of enforcement on the part of workers since, with perfect enforcement, optimal contracts would pay constant wages. In effect, in order to keep workers from quitting gross wages increase in ongoing relationships when times get better. Condition (ii) states that equilibrium employment is set not by equating wages to the current value of the marginal product of labor but by equating the present discounted value of the marginal product of labor to the present discounted value of contracted wages. Condition (iii) is the equilibrium supply condition for the market of new contracts. This condition states that wages must be such that a worker is indifferent between accepting a job today and holding on to it or remaining unemployed and collecting unemployment insurance over the same period. This condition holds with equality when Condition (iv) is met (which requires a sufficiently small  $\delta$ ), and holds even though any worker is eligible for unemployment insurance only for one period. Condition (v) states that no saving on the part of workers is optimal, since the marginal rate of substitution between consumption now and expected consumption in the future is greater than the return on saving  $1 + R$ .

#### *2.4. Alternative equilibrium configurations*

Proposition 1 is restrictive in that it only characterizes equilibria for sufficiently small values of  $\delta$  and  $R$ . Although this may seem to undermine the usefulness of the proposition, the next section will show that an equilibrium satisfying Conditions (i)–(v) exists for empirically reasonable parameter values. While this observation is an essential condition for this equilibrium to be of interest, it is not sufficient to justify our focus. In effect, it is relevant to go one step further and ask whether there may be alternative equilibrium configurations which co-exist under reasonable parameter values with the one characterized in Proposition 1. In particular, if such a situation cannot be ruled out, we need to justify our interest in the specific equilibrium configuration given by Proposition 1. In order to discuss this issue, we consider three potential cases in which an equilibrium defined by Proposition 1 may co-exist with an equilibrium that does not satisfy some of the conditions stated in Proposition 1. Case (1) is the situation where there exists an alternative equilibrium that does not satisfy Condition (v). Case (2) is the situation where an alternative equilibrium does not satisfy Condition (iv), and Case (3) is the situation where an alternative equilibrium satisfies Conditions (iv) and (v) but does not satisfy at least one of Conditions (i)–(iii).

In Case (1), the conjectured alternative equilibrium is one in which labor contracts do not exhaust all the attainable gains of consumption-smoothing and individuals choose to save along the equilibrium path. At first glance, it may seem more insightful to focus on this alternative equilibrium configuration if it

happened to co-exist with the one defined in Proposition 1. However, we believe there are two reasons that justify our focus on an equilibrium defined by Proposition 1. The first reason concerns the observed behavior of personal savings over the business cycle. Although it is well-known that consumption is less variable than output, it is less known that this phenomenon is mainly driven by business rather than personal savings. In fact, using HP-filtered data, we calculated the volatility of personal consumption expenditures on goods and services relative to the volatility of labor income and found this ratio to be almost exactly equal to 1 (using quarterly US data for 1959–96). Moreover, when we detrend these data using a quadratic trend, we found the volatility of consumption to be slightly greater than the volatility of labor income. Thus it seems reasonable that, for business cycle purposes, we focus on an equilibrium where employment contracts provide sufficient consumption smoothing to employed workers. These findings, however, do not rule out that workers save outside the employment relationships for reasons such as retirement or protection against idiosyncratic shocks not related to the business cycle.

The second reason to focus on an equilibrium configuration where workers choose not to save is that, by doing so, we are in effect being conservative in our evaluation of the cost of business cycle and thereby advancing a stronger case for the question at hand. In particular, by examining an equilibrium that satisfies Condition (v), we are constraining ourselves to a situation where individual consumption does vary too much over the business cycle. In effect, if for the same  $\delta$  and  $R$ , there exists an alternative equilibrium in which individuals choose to save, it must be that the marginal utility of consumption varies more in this latter case. Hence, the cost of business cycles and the value of stabilization would be greater in the positive savings case than in the zero savings equilibrium.<sup>11</sup>

Case (2) arises if there exists an alternative equilibrium configuration in which occasionally there is no gross hiring. Although we cannot rule out such a case, focusing on the continuous gross hiring case is empirically more relevant given the magnitude of employment flows in most countries.

Finally, the third case concerns the existence of an alternative equilibrium configuration in which Conditions (iv) and (v) are satisfied but Conditions (i)–(iii) are not met. However, such case cannot arise. As can be inferred from the proof of Proposition 1, if an equilibrium satisfies Conditions (iv) and (v), it must satisfy Conditions (i)–(iii), since Conditions (i) and (ii) are the firms optimal wage and employment decisions given Conditions (iv) and (v), and Condition (iii) is the optimal labor supply decision conditional on (iv). Hence, when Conditions (iv) and (v) are met, the only possible equilibrium configuration is the one defined by Proposition 1.

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<sup>11</sup> This comparison would be reversed if workers could not (instead of chose not to) save in the first place.

In summary, even if we have not ruled out the possibility of multiple equilibria, focusing on the equilibrium defined by Proposition 1 appears to provide an empirically relevant and conservative means of exploring the potential cost of business cycles in the absence of a full set of risk markets.

### 3. Quantifying the welfare cost of business cycles

#### 3.1. Calibrating the model

The aim in this section is to quantify the welfare cost of aggregate fluctuations in our modeled economy. The first step is to choose functional forms and a number of possible states for  $\theta$ . These choices are based mainly on simplicity. We assume  $U(C) = C^{1-\sigma}/(1-\sigma)$ ,  $f(l, \theta) = A_1 l - \frac{1}{2}\theta l^2$ ,  $g(1-l) = A_2(1-l)^\gamma$ . We also assume that the process governing  $\theta$  is represented by a two-dimension Markov chain with symmetric transition matrix  $P$ , where  $p$  is defined as the probability of remaining in state  $\theta_1$  or state  $\theta_2$ . This produces a model with 13 parameters:  $\beta, \sigma, \delta, R, A_1, A_2, \gamma, \theta_1, \theta_2, p, \tau, \varphi(\theta_1)$  and  $\varphi(\theta_2)$ . In general, for arbitrary parameter values, we can find wage contracts and employment decisions that satisfy Conditions (i)–(iii) of Proposition 1.<sup>12</sup> However, in order to constitute an equilibrium, we must also verify that these wage and employment decisions satisfy Conditions (iv) and (v). Therefore, throughout our calibration exercises, we begin by using Conditions (i)–(iii) to find a candidate equilibrium and then check whether this candidate equilibrium satisfies Conditions (iv) and (v).

Our strategy for choosing values for these parameters is as follows: A first set of parameters, namely  $R, \delta, \varphi(\theta_1)$  and  $\varphi(\theta_2)$ , are chosen to directly match empirical counterparts. A second set of parameters, namely  $\sigma$  and  $\beta$ , is allowed to vary in order to give us information on how results depend on these two parameters. Finally, the remaining set of parameters is chosen to allow the equilibrium of the model to replicate a set of empirical observations.

Our calibration is based on U.S. observations. The length of time represented by a period is six months since this period corresponds to the number of months a U.S. worker may collect unemployment insurance. The interest rate available to consumers,  $R$ , is set at 1% in order to match the observed real returns on a savings account over the post-war period.<sup>13</sup> The size of the allocative shock

<sup>12</sup> For the specific functional forms described in this section and in a two-state economy, the candidate wages and employment levels are characterized by the solution to the set of equations described in Appendix B.

<sup>13</sup> For comparison, Imrohorglu (1989) calibrates the interest rate on individual savings accounts at zero.

$(1 - \delta)$  is set to match the average yearly job destruction rate reported by Davis and Haltiwanger (1992).<sup>14</sup> Thus, the average job tenure is 8.6 years, only slightly higher than the 8 years of tenure reported by Hall (1982). The unemployment subsidies,  $\varphi(\theta_1)$  and  $\varphi(\theta_2)$  are set to a constant value such that the low-wage replacement ratio is 50%, leaving the average replacement to be determined endogenously.<sup>15</sup>

The values for the remaining parameters ( $A_1, A_2, \gamma, \theta_1, \theta_2, p, \tau$ ) are such that, for given values of  $\beta$  and  $\sigma$ , the equilibrium values of  $w(\theta_t, \theta^{t+i})$  and  $l(\theta_{t+i})$  defined by Proposition 1 replicate the following set of observations:

- (1) Unemployment varies between 4% and 9% over the business cycle.<sup>16</sup>
- (2) The yearly autocorrelation in unemployment is 0.78.
- (3) The elasticity of the labor demand is 0.5.<sup>17</sup>

(4) Wages for new hires vary more over the cycle than aggregate wages. This observation relies on two sources. First, several studies, including Bils (1985), Beaudry and DiNardo (1991) and Barsky and Solon (1989) show that, after controlling for selectivity bias, aggregate wages decrease by approximately 1.5% for each percentage increase in unemployment. Second, Beaudry and DiNardo (1991) using a procedure consistent with a Harris and Holmstrom contracting framework, show that wages for new hires decrease by approximately 3–4.5% for every percent increase in unemployment. Since this latter figure is important in our calculations we report results corresponding to both the lower and the upper bound of these estimates.

- (5) Finally,  $\tau$  is set so that, in average, the government budget balances.

In order to allow the model to replicate observed movements in average wages, we derive average wages in our framework. We let  $w(\theta_i, \theta_j)$  represent the wage received by a person hired when  $\theta = \theta_i$ , and the current period state is  $\theta = \theta_j$ . In addition, we let  $k_{ij}$  be the steady-state share of employed workers that receive wages  $w(\theta_i, \theta_j)$  in a given period,  $i, j = 1, 2$ . The average net wage,

<sup>14</sup>The annual destruction rate used to calibrate the model is calculated from the annual data and therefore is not likely to reflect temporary layoffs.

<sup>15</sup>The mandated U.S. replacement ratio is 50%, however limits in the maximum perception reduce the high-wage replacement ratio. In our baseline case, this average is 0.41, only slightly lower than the 44% average observed in the United States.

<sup>16</sup>Over the last 20 years, the fluctuation in the U.S. unemployment rate for males 20 years and older is as follows: In 1979, it was 4%; in 1983, 10%; in 1989, 4%; in 1992, over 7%; and at the end of 1998, approximately 3.5%. Therefore, a spread of 5 percentage points in unemployment over the cycle appears as a reasonably conservative approximation, given that the unemployment rate for groups other than prime-age males fluctuates even more. Also note that this 5 percentage points (p.p.) spread is substantially less than the 8 p.p. spread used by Imrohorglu (1989).

<sup>17</sup>Estimates of labor demand elasticities vary widely. However, most values cluster around 0.5 or less (Hamermesh, 1993).

Table 1  
Baseline parameter values

Time period = 6 months	$p = 0.8^{1/2}$
$R = 0.01$	$\theta_1 = 62.7$
$\varphi(\theta_1) = 13.8$	$\theta_2 = 48.39$
$\varphi(\theta_2) = 13.8$	$\gamma = 0.155$
$\beta = 0.92^{1/2}$	$A_1 = 85.6$
$\sigma = 2$	$A_2 = 1.81$
	$1 - \delta = 0.0581$

conditional on the realization of  $\theta_j$ , can then be defined as:

$$\forall \theta_j \quad \bar{w}(\theta_j) = \sum_{i=1}^2 \frac{k_{ij}}{k_{1j} + k_{2j}} (w(\theta_i, \theta_j) - \bar{\tau})$$

whereas the unconditional average wage is given by  $E(\bar{w}(\theta_j))$ . The actual computation of  $k_{ij}$ ,  $i = 1, 2, j = 1, 2$ , requires finding the invariant distribution of a Markov chain with transition matrix  $\Pi$ . The number of states of this Markov chain is 5, representing the five possible statuses in the labor market. Hence  $\{e_1, e_2, e_3, e_4, e_5\} = \{\text{Be employed with } w(\theta_1, \theta_1), \text{ be employed with } w(\theta_2, \theta_1), \text{ be unemployed when } \theta_t = \theta_1, \text{ be employed with } w(\theta_2, \theta_2), \text{ be unemployed when } \theta_t = \theta_2\}$ .<sup>18</sup> An element of the transition matrix, such as  $\{\pi_{mn}\}$ , represents the probability of being in state  $e_n$  next period, given the realization of state  $e_m$  in the current period. The complete description of the matrix  $\Pi$  is given in Appendix C. The matrix  $\Pi$  has a unique ergodic set, since  $\pi_{mn}^{(h)} > 0, \forall m, n$  and for  $h \geq 2$ , where  $h$  indicates the powers of  $\Pi$ . Hence  $\Pi$  has a unique invariant distribution  $q^*$  and therefore the model's implications for averages can readily be calculated.

In summary, in order to calculate the cost of business-cycle fluctuations associated with a given value of  $\beta$  and  $\sigma$ , we set parameter values that allow us to match cyclical aggregate wage and employment behavior, as well as individual wage behavior. Table 1 reports parameter values for the particular case where  $\beta = 0.92$  (per year) and  $\sigma = 2$ . Note that a  $\beta = 0.92$  per year implies that the alternative cost of funds for firms is 8% annually, close to the historical average return on an internationally diversified portfolio. We refer to this case as the baseline case.

### 3.2. Computing the cost of business cycles

The aim of this section is twofold. First, it seeks to quantify the welfare cost of economic instability in an economy where workers are subjected to contractual

<sup>18</sup> The state corresponding to being employed at a low-wage when productivity is high, does not exist. In equilibrium, wages in ongoing contracts are bid up when a better state of productivity arises.

wage risk. Second, it aims to show that a computation of the welfare cost of business cycles based on the variability of the aggregate wage may yield very biased estimates. In particular, most studies of the cost of business cycles simply assume that the aggregate variability in real wages is a good reflection of the wage risk individuals face. Then conclude that this risk can be disregarded based on the low variability of the aggregate. The results in this section help quantify the extent to which this approximation may be misleading.

In order to assess the cost of the business cycle, we compare the workers' steady-state utility generated by the equilibrium wages and employment allocations defined in Proposition 1, with the utility obtained in an alternative 'stable' economy. We consider two counter-factual stable economies in order to better understand our results. In the first economy, in every period and for any realization of  $\theta$ , all workers turn their income to an insurance company, with the explicit promise of obtaining the expected workers' income. In this comparison, allocations are held constant and we assume that insurance companies can transfer resources intertemporally given an interest rate equal to the discount rate.<sup>19</sup> The lifetime utility in this environment is the discounted value of a constant stream of consumption. The cost of the cycle, represented by  $\varepsilon_1$ , can then be measured as the maximum tax on this stable income that a worker would be willing to pay in all periods to avoid income fluctuations.

Our second measure of the cost of fluctuations,  $\varepsilon_2$ , is obtained by comparing workers' utility in our baseline economy to the utility attained in an economy that is subject only to allocative shocks. In this alternative stable economy, consumption in every period is constant and is given by the new equilibrium wage, net of a lump-sum transfer (positive or negative) from workers to firms. The purpose of this transfer is to avoid contaminating  $\varepsilon_2$  with any redistribution of income between workers and shareholders. Thus, when comparing the fluctuating economy with the economy without cycles, we keep expected profits constant and pass on to workers all welfare gains obtained from stabilizing the economy. Thus,  $\varepsilon_2$  measures the tax that a representative worker in this stable economy is ready to accept in any period in order to avoid aggregate fluctuations. In the economy without cycles, wages equate the marginal product of labor with the returns in the household sector.<sup>20</sup>

Both  $\varepsilon_1$  and  $\varepsilon_2$  provide a measure of the risk workers bear at the individual level. These measures differ from the cost captured using only the variability in

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<sup>19</sup>Given the distinction between workers and entrepreneurs or shareholders, workers do not obtain any share of profits. The expected workers' income is obtained as the mean of workers' income when employed and when unemployed weighted by the steady states probabilities (see Appendix C for details).

<sup>20</sup>See Appendix C for the set of equations that characterizes equilibrium wages and employment allocations in this case.

Table 2  
The cost of the business cycle as a percentage of average consumption

		$\sigma = 1.01$	$\sigma = 2$	$\sigma = 3$	$\sigma = 4$
$\beta = 0.88$	$\varepsilon_1$	2.56	3.16	3.79	4.42
	$\varepsilon_2$	2.61	3.13	3.65	4.14
	$\varepsilon_3$	0.06	0.13	0.19	0.25
$\beta = 0.90$	$\varepsilon_1$	2.24	2.82	3.42	–
	$\varepsilon_2$	2.29	2.78	3.27	–
	$\varepsilon_3$	0.06	0.13	0.19	–
$\beta = 0.92$	$\varepsilon_1$	1.90	2.45	3.02	–
	$\varepsilon_2$	1.96	2.41	2.87	–
	$\varepsilon_3$	0.06	0.13	0.19	–
$\beta = 0.94$	$\varepsilon_1$	1.37	1.87	–	–
	$\varepsilon_2$	1.42	1.82	–	–
	$\varepsilon_3$	0.06	0.12	–	–

workers' aggregate consumption. In order to quantify this difference, we compute a third measure,  $\varepsilon_3$ , which reflects the (mis)perceived welfare cost based only on aggregate wage variability. This measure is the amount (in percentage terms) that a fictitious individual is willing to give up to receive the unconditional mean of the aggregate wage rather than receiving the fluctuating aggregate wage.

Table 2 reports estimates of these different measures of the cost of economic fluctuations for different values of  $\sigma$  and  $\beta$ . Note that  $\beta$  is always reported in yearly rates. The appendix gives the details of the calculations.

The results in Table 2 are quite striking. First,  $\varepsilon_1$  and  $\varepsilon_2$  yield approximately the same numerical values and indicate costs of aggregate fluctuations that range from approximately 1.37% to 4.42% depending on the assumed values of time preference and risk aversion. Second, the risk borne at the individual level is significantly higher than the risk inferred from average wages or average consumption variation. Thus,  $\varepsilon_1$  and  $\varepsilon_2$  reflect estimates that are, on average, about 20 to 30 times larger than  $\varepsilon_3$ .

Third, the relative size of  $\varepsilon_1$  and  $\varepsilon_2$ , indicates that the benefits of having an insurance system that is able to deliver a constant income to workers are comparable to the benefits of completely eliminating aggregate fluctuations from the economy. This result is interesting in itself, since it indicates that our cost estimates reflect mainly inefficient risk-sharing rather than allocative distortions induced by the contractual structure of the economy.

Fourth,  $\varepsilon_1$  or  $\varepsilon_2$  increase with the degree of risk aversion and the discount rate, whereas  $\varepsilon_3$  only varies with  $\sigma$ . These difference suggests that an economy populated with workers that are not particularly risk averse but are very

impatient, can still largely benefit from stabilization. The reason for this pattern is that in a contractual labor market, the more impatient workers are, the more tempted they are to choose a labor market option – either accepting a long-term contract or remaining in the household sector – as a function of short-term returns. As a consequence, a mean preserving spread in wages shows up in the calculation of  $\varepsilon_1$  or  $\varepsilon_2$ , but it is not reflected in  $\varepsilon_3$ .

Finally, focusing our analysis on parameters that satisfy the premise of Proposition 1 is not very constraining. In effect, Table 2 indicates that for an important range of values of  $\beta$  and  $\sigma$ , the values we have set for  $R$  and  $\delta$  (that is,  $R = 1\%$  and  $\delta = 0.9419$ ) are sufficiently small for an equilibrium of the type described by Proposition 1 to exist. The empty boxes in Table 2 are cases where these values of  $R$  and  $\delta$  are not sufficiently small for a candidate equilibrium defined by Conditions (i)–(iii) to satisfy Conditions (iv) and (v); hence, these are cases where we do not know how to characterize an equilibrium.

Our cost estimates, represented by  $\varepsilon_1$  and  $\varepsilon_2$ , are large in comparison to those obtained in previous literature and are, in particular, substantially higher than those found by Imrohorglu (1982) when the focus is unemployment-duration risk rather than wage risk.<sup>21</sup> Her estimate of the cost of the business cycle, calculated as a percentage of average consumption, is 0.3% when  $\sigma = 1.5$  and  $\beta = 0.92$ .<sup>22</sup>

What does explain this difference in estimated costs? In Imrohorglu's model, unemployment-duration risk arises because unemployment spells last longer in recessions and the temporary loss of income due to unemployment is undiversifiable beyond personal accumulation of wealth. In our contractual economy, the risk associated with aggregate fluctuations arises because, in recessions, entry-level wages are lower than wages paid to workers in ongoing contracts. This difference in the type of risk – unemployment duration versus wage risk – causes our model to yield very different estimates of the cost of business cycles. In the U.S., employment-duration risk is quite small since the duration of unemployment does not greatly vary with the cycle and the transitory nature of unemployment allows workers to smooth consumption by asset holding. In addition, the risk associated with being unemployed during recessions is compensated with a lower duration of unemployment during expansions. Therefore, it is not surprising that stabilizing unemployment duration over the business cycle does not yield large welfare gains.

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<sup>21</sup> Lucas's estimates of the cost of economic instability range from 0.072% to 0.38% for risk aversion parameters of 1 or 5 and standard deviation of the log of consumption comparable to the one obtained in our model. Notice, that these estimates are of the same order of magnitude as our reported  $\varepsilon_3$  measure, which quantifies the welfare cost associated with consuming the fluctuating aggregate wage.

<sup>22</sup> To obtain this estimate, Imrohorglu assumes that unemployed workers lose 75% of their income when working. For replacement ratios closer to the ones used in our calculations (about 50%) her cost estimates would have been even lower.

Table 3  
The cost of the business cycle. Lower wage variability

		$\sigma = 1.01$	$\sigma = 2$	$\sigma = 3$	$\sigma = 4$
$\beta = 0.92$	$\varepsilon_1$	1.2	1.5	1.8	2.0
	$\varepsilon_2$	1.3	1.5	1.7	1.9
	$\varepsilon_3$	0.03	0.06	0.09	0.1

In contrast, the wage risk examined in this paper leads to rare but persistent changes in income that are difficult to smooth away by saving. Since unemployment is highly autocorrelated, and wages for workers laid off in recessions return to their pre-recession levels only after unemployment returns to its pre-recession level, a fall in wages in the model is very persistent, lasting an average of four to five years. Note that this amount of persistence in wage movements is consistent with most empirical observations.<sup>23</sup> Therefore, even though individuals in our model find this risk quite substantial, they do not find savings an attractive way to reduce this risk. In fact, the reason why individuals do not self-insure against such risk is closely related to the reason why individuals do not save to smooth consumption when income follows a random walk process. Although income shocks in our model are not infinitely persistent, they are sufficiently persistent to make it unattractive for individuals to accumulate assets in order to smooth rare, but persistent, periods of low wages. This lack of willingness to save in the face of wage risk is particularly likely to arise when individuals are impatient relative to the returns they can get on their savings.

The above calibration exercise relies on the estimates obtained by Beaudry and DiNardo (1991) on wage movements over the business cycle. As it can be expected, the amount of wage variation that the model is forced to replicate matters in determining the cost of business cycles. In order to see how sensitive our estimates are to changes in the assumed wage variation, we also report estimates for the case in which the wage variation corresponds to the lower bound of Beaudry and Dinardo's estimates. We fit our model to match a semi-elasticity of wages to unemployment of  $-1\%$  for average wages and  $-3\%$  for the starting ones. Table 3 shows the cost of the business cycle for this smaller wage variability. Although these alternative estimates are lower than those reported in Table 2, they are still substantially higher than those obtained by either Lucas (1987) or Imrohoroğlu (1989) using similar degrees of risk aversion. Also, the relative size of these measures indicates that the risk borne at the individual level induces a business cycle cost that is still about 20 to 40 times greater than the cost that is inferred from aggregate wage fluctuations.

<sup>23</sup> For example, see Abowd and Card (1987) and Beaudry and DiNardo (1991).

Finally, we assess the extent to which our results are sensitive to changes in the amount of variability in unemployment the model is calibrated to reproduce. For example, we set  $\beta = 0.92$  and  $\sigma = 2$  and calibrate the model so that unemployment varies from 4% to 7.5% over the business cycle, as opposed to from 4% to 9%. We obtain  $\varepsilon_1 = 1.68\%$ ,  $\varepsilon_2 = 1.78\%$  and  $\varepsilon_3 = 0.08\%$ . These costs are again very sizable relative to the estimates found in the literature.

#### 4. Evaluating different stabilization policies

Tables 2 and 3 report estimates of potential gains from stabilization policies that are not trivial. The aim of this section is to examine the effectiveness of particular stabilization policies in achieving these gains. In order to do so, we evaluate the effects of policies on the risk faced by workers as well as the allocative distortions that these policies may introduce. In particular, we compare a worker's expected utility in the initial baseline economy to the utility attained in an economy where a policy has already been implemented. However, since policy experiments are likely to change the distribution of income between workers and firms, we make sure firms' profits are kept constant by virtue of a lump-sum transfer between workers and firms. Therefore, if a policy generates an increase (decrease) in workers' utility, it also generates an allocation that is Pareto superior (inferior) to the one obtained in the baseline economy.

To be more precise about our means of evaluating stabilization policies, we let  $EV_0$  and  $EV$  represent a worker's expected discounted utility before and after the policy is introduced. We let  $x$  represent the constant stream of consumption that yields a discounted utility equivalent to  $EV_0$  and define  $t$  as the percentage increase in  $x$  that generates a constant consumption path equivalent, in utility terms, to  $EV$ . Then, under CRRA preferences,

$$t = \left( \left( \frac{EV}{EV_0} \right)^{(1/(1-\sigma))} - 1 \right) 100.$$

A positive (negative)  $t$  implies that  $EV > EV_0$  ( $EV < EV_0$ ). Therefore the policy generates a Pareto superior (inferior) assignment with respect to the baseline economy. The assignment of resources implied by the baseline economy is inefficient on two grounds. First, optimal risk-sharing conditions do not hold, since workers have to bear the wage risk of being laid off. Second, the contractual environment induces an inefficient allocation of employment between firms and the household, since marginal productivities in both sectors are not equated.

A policy that generates a positive  $t$  does not necessarily improve the risk-sharing properties of the economy. Even in an economy where consumers are, on average, better off than in the baseline economy, the value of having further

stabilization policies or social insurance may increase. In order to evaluate such possibilities, we use a complementary measure to distinguish the overall gains or losses in efficiency from the gains or losses on the risk-sharing side. We define  $\lambda$  as the percentage change in the cost of the business cycle that is generated by a stabilization policy. That is,

$$\lambda = (\varepsilon_1/\varepsilon_{1^0} - 1)100$$

where  $\varepsilon_1, \varepsilon_{1^0}$  are the costs associated with the cycle in the post-policy and baseline economies, respectively. By construction, this measure abstracts from changes in average consumption and focuses instead on the increase or decrease in consumption variability generated by the policy. According to this measure, a policy that yields  $\lambda < 0$  is a policy that reduces the variability of the representative worker's marginal utility and hence, it improves the risk-sharing properties of the original economy.

#### 4.1. *The value of unemployment insurance*

An extensive literature seeks to assess the effects of UI systems on unemployment incidence, unemployment duration, and welfare. In particular, and closely related to our work, Mortensen (1994) uses an equilibrium matching model to examine the effects on unemployment and welfare of eliminating the UI system. His results suggest that eliminating UI would generate a 0.9% increase in average consumption and a 3.48% fall in steady-state unemployment. Therefore, according to Mortensen's estimates, UI generates significant efficiency losses that might justify eliminating the system. However, in his model workers are risk-neutral, and there are no aggregate fluctuations. Hence, his results do not account for possible risk-sharing gains generated by an UI system.

In this section, we examine the advisability of eliminating UI within our framework. We examine whether welfare would increase, decrease, or remain unchanged if the unemployment subsidies were reduced or taken away. However, this policy experiment takes place in a model in which unemployed individuals face wage risk but not unemployment duration risk (since unemployment in this model is purely voluntary). For this reason, the relevance of such an experiment to actual policy must be interpreted with care, as we will discuss later in this section.

Table 4 shows the effects on efficiency, risk sharing and employment of eliminating, in part or altogether unemployment subsidies using different labor demand elasticities.<sup>24</sup> In particular, for an elasticity of 0.5, we find that eliminating the UI system altogether would generate a welfare gain equivalent to a 1.9%

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<sup>24</sup>The replacement ratios of 50%, 27% and 0% correspond to values of the unemployment subsidy of  $\bar{\varphi} = 13.8$ ,  $\bar{\varphi} = 7.1$  and  $\bar{\varphi} = 0$ , respectively.

Table 4

The effects of changing the unemployment insurance replacement ratio relative to the baseline economy

Replacement ratio	50%	27%	0%
Labor demand elasticity = 0.5	$t = 0$	$t = 1.26$	$t = 1.9$
	$\lambda = 0$	$\lambda = 16$	$\lambda = 25$
	$l(\theta_1) = 0.91$	$l(\theta_1) = 0.94$	$l(\theta_1) = 0.956$
	$l(\theta_2) = 0.957$	$l(\theta_2) = 0.968$	$l(\theta_2) = 0.974$
Labor demand elasticity = 0.25	$t = 0$	$t = 0.7$	$t = 1.1$
	$\lambda = 0$	$\lambda = 25.9$	$\lambda = 46.3$
	$l(\theta_1) = 0.91$	$l(\theta_1) = 0.934$	$l(\theta_1) = 0.951$
	$l(\theta_2) = 0.957$	$l(\theta_2) = 0.967$	$l(\theta_2) = 0.974$

increase in average certain consumption. In this case, unemployment would fall by 4.6 percentage points in low-productivity states and by 1.7 in the high-productivity states. Yet the positive value of  $\lambda$  indicates that the current UI system reduces the welfare cost of aggregate fluctuations.

Table 4 also shows that the welfare gains of eliminating the UI system fall as labor demand becomes more inelastic. The explanation is simple: the lower the elasticity of labor demand, the smaller the allocative distortions generated by the UI system. Moreover, the welfare cost associated with aggregate fluctuations becomes larger, since a lower elasticity of demand implies greater ex-post variability in wages. The equivalent loss in consumption that can be attributed to the UI system is reduced to 1.1% whereas the value of stabilizing the economy increases 46% with respect to the baseline economy.

Overall, these results show that a UI system partially reduces the cost of the business cycle, although not enough to eliminate all the risk associated with aggregate fluctuations. Moreover, unemployment subsidies generate allocative distortions beyond those generated by the contractual arrangements of the economy. The importance of these distortions and the equivalent loss in consumption grows with the elasticity of labor demand. However, the reason why UI is only moderately effective in reducing the costs of the business cycle is that it does not directly address the main risk: the time variation in the contract wage.

#### 4.2. State-contingent UI policies

The previous results indicate that a simple UI program that is not state contingent is not very efficient in reducing the wage risk associated with aggregate fluctuations. Therefore, it is natural to ask whether other policies are more likely to achieve welfare gains.

Table 5  
The effects of state contingent UI relative to the baseline economy

Replacement ratio low state	52% ( $\varphi(\theta_1) = 14.5$ )	50% ( $\varphi(\theta_1) = 13.8$ )
Replacement ratio high state	34% ( $\varphi(\theta_2) = 12$ )	24% ( $\varphi(\theta_2) = 8.5$ )
Labor demand elasticity = 0.5	$t = 0.13$ $\lambda = -5.27$ $l(\theta_1) = 0.905$ $l(\theta_2) = 0.960$	$t = 0.58$ $\lambda = -5.5$ $l(\theta_1) = 0.905$ $l(\theta_2) = 0.960$
Labor demand elasticity = 0.25	$t = 0.23$ $\lambda = -8.4$ $l(\theta_1) = 0.906$ $l(\theta_2) = 0.960$	$t = 0.65$ $\lambda = -10.2$ $l(\theta_1) = 0.91$ $l(\theta_2) = 0.965$

In this section we examine UI policies that are specifically designed to reduce the time variation in the contract wage. In particular, we analyze the risk-sharing and allocative efficiency properties of a state-contingent UI program that offers more generous subsidies during recessions than during expansions. The reason such a policy may bring welfare gains is found in the generated changes in wages and employment allocations. By increasing wages paid in recessions and mildly decreasing wages paid in expansions, a state-contingent UI reduces wage variability. However, such a policy induces further allocative distortions, since it reduces employment in recessions when employment is already too low. Therefore, we explore quantitatively whether the positive effect on the risk-sharing side offsets the allocative distortion generated by the policy.

Table 5 reports the results associated with implementing state-contingent UI.<sup>25</sup> To be precise, we examine the welfare effects of two alternative UI policy reforms: first, a policy that pays higher subsidies in low states than in high states but keeps the average tax collection constant (column 2); and second, a policy that reduces payments in one of the states and thereby lowers the tax collected (column 3). Table 5 shows that marginally reducing the high state payments, generates gains in both risk-sharing ( $\lambda < 0$ ) and overall welfare ( $t > 0$ ). Moreover, these gains become more important as labor demand elasticity falls.<sup>26</sup>

<sup>25</sup> The fact that we restrict our analysis to equilibrium configurations where there is new hiring in every period places a lower bound in the unemployment subsidies that we can consider. In particular for  $\varphi(\theta_2) = 0$  the size of the reallocation shock is not enough to guarantee positive hiring in the low state.

<sup>26</sup> A state-contingent UI targeted at low states generates a reduction in the wage spread similar to what could be achieved by a minimum wage or a progressive tax on income. This analogy suggests that such policies may also lead to potential welfare gains.

Overall, the results in Table 5 suggest that state-contingent UI subsidies are a more effective means of reducing the cost of business cycles and improving welfare than constant subsidies. Moreover, we have shown that such a change in the UI program can be introduced in ways that simultaneously reduce costs and improve welfare. How do the insights of this section apply to a world in which there are wage and unemployment duration risks? For example, unemployment duration risk could be introduced in our model by adding search frictions which cause some individuals to be involuntarily unemployed. In our view the results drawn from Table 4, which indicates that non-contingent unemployment insurance is inefficient, may not be robust to changes in the model that introduce involuntary unemployment. In such case, UI would be more directly relevant to reducing the risk at hand. Nonetheless, we believe that our results regarding the desirability of state-contingent UI (over constant UI) is likely to be maintained if we introduce search frictions. Although an explicit analysis of such a case is beyond the scope of this paper, we conjecture that state-contingent UI would also mitigate the cost of unemployment duration risk. State-contingent UI would be providing extra income in periods in which individuals' savings aimed at self-insuring against unemployment duration risk are more likely to run out. Thus, this type of policy can potentially address both wage and unemployment-duration risk.<sup>27</sup>

#### 4.3. *Wage subsidies as a complement to UI policies*

To finish our analysis on stabilization policies, we examine whether it is desirable to introduce wage subsidies in recessions. Such a possibility has often been advanced in the literature. For example, Phelps (1994) justifies the introduction of a low-wage subsidy as a means to reduce unemployment and raise the pay of the disadvantaged poor. A wage subsidy can also counteract some of the harmful allocation effects of the UI system. Mortensen (1994) examines this issue and finds that a hiring subsidy – that is, a wage subsidy to new workers – has a positive effect on job creation. In addition, hiring subsidies increase average consumption and welfare in his framework.

Our analysis focuses on the effectiveness of wage subsidies as a means of stabilizing individual consumption along the business cycle. Incorporating wage subsidies in our model is quite simple. We let  $\phi_1$  represent the subsidy to low-wage workers that is paid to firms whenever  $\theta = \theta_1$ . In order to not introduce further distortions in the economy, we assume that the policy is

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<sup>27</sup>The policy prescription implied by Table 5, which argues for state-contingent UI, is closely related to the U.S. practice of varying the length of UI eligibility depending on the state of the economy. We believe that the above results give support for such a practice and show the value of pursuing reforms along this line.

Table 6  
Effects of a wage subsidy as a complement to UI

Subsidy: % of the low wage	0%	13%	24%
$t$	0	1.7	2.8
$\lambda$	0	– 55.1	– 95
$l(\theta_1)$	0.91	0.929	0.942
$l(\theta_2)$	0.957	0.951	0.945

financed via lump-sum taxes on firms' profits. The equilibrium wages and employment allocations are still defined by Proposition 1, however equation (ii) is slightly modified to account for the state-contingent wage subsidy.<sup>28</sup>

Table 6 shows the effects of introducing a conditional wage subsidy to our baseline economy for values of the subsidy ranging from 0% to 24% of the low-state wage. For any size of the subsidy, the numerical results show that subsidizing the wage paid to workers hired in recessions leads to allocations that are Pareto superior to the one obtained from the baseline economy. These gains in efficiency reflect improvements in both allocative efficiency and risk-sharing. The subsidy generates more hiring during the low states and thus reduces underemployment. At the same time, it increases the equilibrium low wage, and mildly decreases the wage paid during expansions. By making the wage spread smaller, subsidies improve the insurance properties of the economy. In addition, wage subsidies not only smooth workers' marginal utility at different stages of the cycle but also stabilize the economy in the traditional sense, since employment fluctuations become smaller.

All these results correspond to the case in which firms' expected profits are kept constant by virtue of a lump-sum transfer. If the transfer were not in place, a wage subsidy would induce a redistribution of income from workers to firms and therefore reduce workers' welfare.

## 5. Conclusion

In this paper we present a quantitative dynamic general equilibrium model aimed at replicating several observed micro and macroeconomic features of wage and employment behavior. The objective has been to highlight how the

<sup>28</sup> Relative to the set of equations in Appendix B, the only change is that Eq. (6.5) becomes

$$w(\theta_1, \theta_1) - \phi_1 = A_1 - \theta_1 l(\theta_1). \quad (4.1)$$

According to this formulation, a wage subsidy is not exactly equivalent to a hiring subsidy. In this model, the firm receives a subsidy for all workers employed at the low-wage, regardless of the period in which they are hired.

contractual structure of the labor market can hide a significant degree of undiversified wage risk associated with aggregate fluctuations. Our estimates show that this source of risk may be substantial. It leads to an evaluation of the welfare cost of economic fluctuations that is much larger than previous estimates which have been based on aggregate consumption or unemployment duration risk. The intuition behind our result is simple: whereas unemployment risk induces temporary shocks in current income, contractual wage risk induces persistent changes in workers' income and therefore creates risk that cannot easily be smoothed away by personal savings.

We also find that the identification of what might be an important component of undiversified business cycle risk has clear policy implications. The first obvious one is rehabilitating the potential role for stabilization policies as policies that can bring about important welfare gains. The second is that by identifying one reason business cycles may be socially costly, we can recommend stabilization policies that are more directly focused on reducing this risk borne at the individual level. To this end, we have examined the risk-diversification role of UI and find that a simple non-contingent UI system is not a well-targeted policy for addressing this risk. Furthermore, we show why a state-contingent UI program can be a more efficient way of reducing the cost of the business cycle. We have also investigated the role of wage subsidies in improving allocative and risk-sharing efficiency. Overall, we have attempted to explain why labor market policies aimed at mitigating the cost of business cycles may be warranted and how such policies can be designed in order to improve welfare.

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### Appendix A

The proof of Proposition 1 is rather long and therefore in this appendix we only outline the steps used in the proof, which is available from the authors upon request.

*Proof of Proposition 1.* The proof of Proposition 1 can be broken into two major parts. First, we show that for a sufficiently small  $\delta$  and  $R$ , there exists a pair of functions,  $l(\theta_t)$  and  $w(\theta_t, \theta^{t+i})$ , that satisfies Conditions (i)–(v). Second, we show that given a pair of functions  $l(\theta_t)$  and  $w(\theta_t, \theta^{t+i})$  that satisfy (i)–(v), and given the decision rule  $s = 0$ , this together constitutes an equilibrium. Our strategy in

proving the later statement consists of taking advantage of the infinitesimal aspect of a hiring decision to break the proof down into four further steps. In the first step (Lemma 1), we show that, given wage contracts satisfying Condition (i) and positive gross hiring every period (Condition (iv)), it is optimal for firms to employ workers up until the point that Condition (ii) is met. The second step (Lemma 2) consists of showing that an efficient relationship between a worker and a firm requires wage payments to satisfy condition (i) when conditions (ii), (iv) and (v) are satisfied. The third step is to show (Lemma 3) that workers will find it optimal to supply  $l(\theta_t)$  when Condition (iii) is met and when there is new hiring in every period (condition (iv)). The fourth step is to recognize that Condition (v) implies that workers do not find it optimal to save using their own savings technology. Together, these steps constitute a proof of the statement, since they imply that firms and workers are satisfied by the employment outcomes, that contract offers are bilaterally efficient, and that the decision not to save is individually rational.

### Appendix B

The following set of equations characterizes the equilibrium candidate wages and employment allocations in the two-state case.

$$(w(\theta_1, \theta_1) - \bar{c})^{1-\sigma} = (g'(1 - l(\theta_1)) + \bar{\varphi})^{1-\sigma},$$

$$A_1 - \theta_1 l(\theta_1) = w(\theta_1, \theta_1),$$

$$w(\theta_1, \theta_2) = w(\theta_2, \theta_2) = w(\theta_2, \theta_1),$$

$$(g'(1 - l(\theta_2)) + \bar{\varphi})^{1-\sigma} - ((w(\theta_2, \theta_2) - \bar{c})^{1-\sigma})$$

$$= \frac{\beta(1 - p)}{1 - \beta p} ((w(\theta_2, \theta_1) - \bar{c})^{1-\sigma} - (w(\theta_1, \theta_1) - \bar{c})^{1-\sigma}),$$

$$\frac{w(\theta_2, \theta_2)}{(1 - \beta\delta)} = \frac{(1 - \beta\delta p)}{D} (A_1 - \theta_2 l(\theta_2)) + \frac{\beta\delta(1 - p)}{D} (A_1 - \theta_1 l(\theta_1)),$$

$$\bar{c} = \bar{\varphi} \frac{((1 - l(\theta_1)) + (1 - l(\theta_2)))}{l(\theta_1) + l(\theta_2)},$$

where  $D$  is the determinant of the matrix  $(I - \beta\delta P)^{-1}$ .

### Appendix C

#### Dynamics

The stochastic matrix  $\Pi$  that defines the transition probabilities from one labor market status to another is defined by

$\Pi =$

$$\begin{pmatrix} p(\delta + (1 - \delta)^2 \frac{1-l_1}{\delta l_1}) & 0 & p(1 - \delta) \frac{1-l_1}{1-\delta l_1} & (1 - p)(\delta + (1 - \delta) \frac{1-l_1}{\delta l_1}) & (1 - p)(1 - \delta) \frac{1-l_1}{1-\delta l_1} \\ p(1 - \delta)^2 \frac{1-l_1}{1-\delta l_1} & p\delta & p(1 - \delta) \frac{1-l_1}{1-\delta l_1} & (1 - p)(\delta + (1 - \delta) \frac{1-l_1}{\delta l_1}) & (1 - p)(1 - \delta) \frac{1-l_1}{1-\delta l_1} \\ p(1 - \delta) \frac{1-l_1}{1-\delta l_1} & 0 & p \frac{1-l_1}{1-\delta l_1} & (1 - p) \frac{1-l_1}{1-\delta l_1} & (1 - p) \frac{1-l_1}{1-\delta l_1} \\ (1 - p)(1 - \delta) \frac{1-l_2}{1-\delta l_2} & (1 - p)\delta & (1 - p)(1 - \delta) \frac{1-l_2}{1-\delta l_2} & p(\delta + (1 - \delta)^2 \frac{1-l_2}{\delta l_2}) & p(1 - \delta) \frac{1-l_2}{1-\delta l_2} \\ (1 - p) \frac{1-l_2}{1-\delta l_2} & 0 & (1 - p) \frac{1-l_2}{1-\delta l_2} & p(1 - \delta) \frac{1-l_2}{1-\delta l_2} & p \frac{1-l_2}{1-\delta l_2} \end{pmatrix}$$

where the states of the system are;  $e_1 =$  be employed with  $w(\theta_1, \theta_1)$ ,  $e_2 =$  be employed with  $w(\theta_2, \theta_1)$ ,  $e_3 =$  be unemployed and  $\theta_t = \theta_1$ ,  $e_4 =$  be employed with  $w(\theta_2, \theta_2)$ , and  $e_5 =$  be unemployed and  $\theta_t = \theta_2$ .  $\Pi$  converges to a stochastic matrix  $Q$ , with identical rows, given by the vector  $q'$ . Then,  $q_i$  defines the steady state probability of being in labor market status  $i$ ,  $i = 1, 2, 3, 4, 5$ . Thus, for example,  $q_1$  is the invariant probability of being employed with the low wage, when the state of nature is  $\theta_1$ . By renaming the vector  $q$ , we obtain the  $k_{ij}$  described in the dynamics section of the main text.

#### Computation of the cost of the business cycle

We compare the stochastic economy subjected to aggregate fluctuations to two different stable economies. In the first, we assume the presence of an insurance system that allows every worker to obtain the unconditional average income,  $\bar{\eta}$ , which is computed as  $E_\theta(\bar{\eta}(\theta_j))$  and

$$\begin{aligned} \bar{\eta}(\theta_j) &= \sum_{i=1}^2 \frac{k_{ij}}{k_{1j} + k_{2j} + k_{uj}} (w(\theta_i, \theta_j) - \bar{w}) \\ &+ \frac{k_{uj}}{k_{1j} + k_{2j} + k_{uj}} (A_2(1 - l(\theta_j))^{\gamma-1} + \bar{\varphi}) \end{aligned}$$

where  $k_{uj}$  is the invariant probability of being unemployed and  $\theta_t = \theta_j$ .  $\bar{\eta}$  is just an average of the income received when employed – at either the high or the low-wage – and when unemployed, weighted by the steady-state probabilities. Hence  $\varepsilon_1$  is such that

$$E_t \sum_{i=0}^{\infty} \beta^i U(C_{t+i}(\theta_{t+i})) = \frac{U(\bar{\eta}(1 - \varepsilon_1))}{1 - \beta}.$$

In this case,  $\varepsilon_2$  is obtained by comparing the workers' welfare in the baseline economy with what they could attain in an economy that is subjected only to allocative shocks. However, in order to insure that we are obtaining a proper measure of the equivalent loss in average consumption due to aggregate fluctuations, we have to assume that (1) expected profits in the stable economy are kept constant at the baseline level, and (2) in the stable economy a UI system is also in place. Without these assumptions,  $\varepsilon_2$  would be contaminated by the redistribution of income between workers and firms and from the potential welfare gains induced by the removal of the UI system. Define  $w^s$  as the wage received by employed workers in the stable economy, let  $\tau^s$  be the tax per worker to finance the UI program and  $\varphi^s$  the subsidy received when unemployed, and let  $l^s$  be the measure of workers employed by firms in the stable economy. In the absence of aggregate fluctuations, and for  $\varphi^s = \bar{\varphi}$ , the equilibrium wage, employment allocation, and taxes are given by the solution of the following set of equations:

$$A_1 - E(\theta)l^s - \tau^s = A_2(1 - l^s)^{\gamma-1} + \varphi^s, \tag{C.1}$$

$$f(l^s, E(\theta)) - w^sl^s - transfer = E[profits], \tag{C.2}$$

$$transfer = w^s - (A_1 - E(\theta)l^s - \tau^s), \tag{C.3}$$

$$\tau^s = \varphi^s \frac{1 - l^s}{l^s}. \tag{C.4}$$

Eq. (C.1) states that the market clears and that workers are indifferent between working at the contract sector or remaining unemployed and receiving the UI subsidy plus the average return in the home sector. Eq. (C.2) guarantees that firms' expected profits are kept at the level of the baseline economy by virtue of a lump-sum transfer between firms and all workers. Eq. (C.3) states the value of the transfer, and Eq. (C.4) guarantees that the UI budget is balanced.

Finally, we compute  $\varepsilon_3$  as the percentage reduction on the unconditional average wage, that is equivalent in utility terms to a fluctuating stream of consumption, such that workers consume  $C(\theta_j) = \bar{w}(\theta_j)$  whenever  $\theta_t = \theta_j$ , where  $\bar{w}(\theta_j)$  is the conditional average net wage. Therefore,

$$E_t \sum_{i=0}^{\infty} \beta^i U(\bar{w}(\theta_{t+i})) = \frac{U((E_t(\bar{w}(\theta_{t+i}))) (1 - \varepsilon_3))}{1 - \beta}.$$

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