Job Displacement Risk and the Cost of Business Cycles

October, 2006

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Abstract

This paper analyzes the welfare costs of business cycles when workers face uninsurable job displacement risk. The paper uses a simple macroeconomic model with incomplete markets to show that cyclical variations in the long-term earnings losses of displaced workers can generate arbitrarily large cost of business cycles even if the variance of individual income changes is constant over the cycle. In addition to the theoretical analysis, this paper also conducts a quantitative study of the cost of business cycles using empirical evidence on the long-term earnings losses of U.S. workers. The quantitative analysis shows that realistic variations in job displacement risk generate sizable costs of business cycles even though a second-moment analysis implies negligible costs.

JEL Classification: D52, E21, E32, J24
Keywords: Cost of Business Cycles, Job Displacement Risk, Incomplete Markets

*I would like to thank for many useful comments a co-editor, three anonymous referees, Chris Carroll, Larry Katz, Chris Phelan, Richard Rogerson, Kjetil Storesletten, and seminar participants at Arizona State, Brown, ECB, Heidelberg, Johns Hopkins, UC-Irvine, Mannheim, MIT, UPenn, Syracuse, the NBER Monetary Program Meeting, Fall 2004, the SED-Meeting, Summer 2005, and the ET-Meeting, Summer 2005. All remaining errors are mine.

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I. Introduction

In a highly influential contribution, Lucas (1987) argues that standard macroeconomic theory implies that the welfare cost of business cycles is negligible. In other words, Lucas (1987) argues that from a welfare point of view, business cycle research and counter-cyclical stabilization policy are irrelevant. His argument is based on a representative-agent model with no production and “standard” preferences. More specifically, Lucas (1987) assumes that i) there is no uninsurable idiosyncratic risk (complete markets), ii) there is no link between business cycles and economic growth, and iii) preferences allow for a time-additive expected utility representation with moderate degree of (relative) risk aversion. In principle, any one of these three assumptions could be questioned, and an extensive literature has subsequently studied how weakening these assumptions could change Lucas’ surprisingly strong conclusion. In his recent survey, Lucas (2003) summarizes the findings of this literature in the following way: “But I argue in the end that, based on what we know now, it is unrealistic to hope for gains larger than a tenth of a percent from better countercyclical policy”.

There is considerable empirical evidence that workers face a substantial amount of uninsurable idiosyncratic labor market risk.\(^1\) This paper asks to what extent cyclical variations in such labor market risk can generate non-negligible cost of business cycles. In accordance with the previous literature, this paper assumes that macroeconomic stabilization policy can eliminate the cyclical fluctuations in idiosyncratic labor market risk without affecting the average amount of idiosyncratic risk. In contrast to the previous literature, however, this paper focuses on the long-term earnings losses of displaced workers, that is, income losses that persist even after the displaced worker is re-employed. An extensive empirical literature has shown that such earnings losses are substantial. Moreover, there is also evidence that these long-term earnings losses display a strong cyclical component. In other words, job displacement leaves permanent scars that persist even after the displaced worker finds a new job, and this scarring effect is more pronounced for workers that are laid off during weak

\(^1\)The empirical literature on idiosyncratic labor market risk is surveyed in Section V.
labor market conditions. This paper shows that cyclical variations in this type of scarring effect are likely to generate sizable cost of business cycles.

The analysis conducted in this paper proceeds in two steps. First, this paper uses a simple macroeconomic model with incomplete markets to show that the cost of business cycles can be arbitrarily large even if the variance of individual income shocks is constant over the cycle. Put differently, cyclical variations in the long-term earnings losses of displaced workers can go a long way towards generating sizable cost of business cycles even if, as suggested by the recent empirical evidence, the variance of individual income shocks has no cyclical component.\(^2\) Intuitively, if job displacement is a rare event with devastating long-term consequences for workers that are laid off during recessions, then the cost of business cycles might be very large even if the variance of individual income shocks barely changes over the cycle.

In addition to the theoretical analysis, this paper also provides a quantitative analysis of the welfare effect of cyclical variations in job displacement risk. More specifically, this paper uses evidence about the long-term earnings losses of displaced U.S. workers obtained by the empirical literature to calibrate the model economy, and then computes the cost of business cycles for the calibrated version of the model. The quantitative analysis shows that realistic variations in the long-term earnings losses of displaced workers generate sizable welfare cost of business cycles. Moreover, the cyclical variations in the variance of individual income shocks implied by the model economy are so small that a second-moment analysis would imply negligible cost of business cycles. Thus, any comprehensive welfare analysis of macroeconomic stabilization policy that either disregards idiosyncratic labor market risk or confines attention to second-moment analysis is likely to produce very misleading results.\(^3\)

\(^2\)See section II, and in particular footnote 5, for a discussion of the empirical evidence.

\(^3\)Note that this paper follows Lucas (1987) by disregarding any link between business cycles and economic growth, that is, it assumes that stabilization (monetary) policy is neutral in the long-run. See, for example, Barlevy (2004) and Manuelli, Jones, Siu, and Stacchetti (2005) for papers that emphasize long-run output effects of stabilization policy. Similarly, Gali, Gertler, and Lopez-Salido (2005) argue that price- and wage-rigidities introduce sizable efficiency cost of business cycles.
At this stage, two comments regarding modeling strategy seem in order. First, to focus on the main economic issues, this paper uses a simple and highly tractable incomplete-market model along the lines of Constantinides and Duffie (1996) and Krebs (2004). In this model, the earnings losses of displaced workers are fully permanent. However, Section VI.5 considers an extension of the baseline model in which these earnings losses are persistent, but not fully permanent, and shows that the cost of business cycles remain substantial. In other words, even though the baseline model assumes permanent income shocks for tractability reasons, the quantitative results are robust to the more general assumption of persistent income shocks. Second, following the bulk of the literature, this paper takes the job displacement process as exogenously given and uses an abstract “integration principle” (Lucas, 2003, Krebs, 2003a, Krusell and Smith, 1999) in order to model the effect of macroeconomic stabilization policy on job displacement risk. Clearly, a more detailed analysis of the economic forces behind the cyclical variations in job displacement risk in conjunction with an explicit model of macroeconomic stabilization policy would yield additional insights into the cost of business cycles. However, despite these limitations, this paper shows one important result: contrary to the results reported by the previous literature, there are good reasons to believe that the costs of business cycles are substantial.

II. Previous Literature

Atkeson and Phelan (1994), Imrohoroglu (1989), and Krusell and Smith (1999) all study models of worker unemployment, and focus on cyclical fluctuations in unemployment rates and unemployment durations. However, these papers assume that the earnings of a displaced worker fully recovers after the worker has found a new job. Thus, they rule out by assumption

4Long-term earnings losses of displaced workers may increase during recessions for at least two reasons. First, workers’ skills depreciate during periods of unemployment, and this depreciation effect is more pronounced during recessions when unemployment durations are long. Second, displaced workers may lose occupation-specific human capital when they are forced to accept jobs in a new occupation, and these losses are likely to increase during recessions when job offers are rare. The development and analysis of a model incorporating these effects is left for future research.
the type of scarring-effect studied here. Gomes, Greenwood, and Rebelo (2001) extent the analysis of unemployment risk and allow for endogenous search. In this case, business cycles may have a positive effect on welfare (option value of search).

Krebs (2003a) and Storesletten, Telmer, and Yaron (2001) discuss the cost of business cycles when individual workers face earnings shocks that are highly persistent and (log)-normally distributed. These papers assume that the variance of earnings shocks depends on business cycle conditions, but they do not condition on the job displacement event. Thus, they assume that mean earnings changes of displaced and non-displaced workers are the same. In contrast, the model analyzed in this paper assume that log-earnings changes are only normally distributed after we condition on the individual job displacement event (and business cycles conditions). In a certain sense, the models considered by Krebs (2003a) and Storesletten et al. (2001) are mis-specified.5

Beaudry and Pages (2001) consider a model of unemployment in which the wage of new hires varies over the business cycle, and argue that these cyclical variations are much more persistent and stronger than the cyclical variations in the aggregate wage. Thus, the analysis conducted in Beaudry and Pages (2001) is close in spirit to the current paper, but there are also important differences. First, this paper provides a general theoretical analysis of extreme events, and shows that a second moment analysis can produce very misleading results. Second, the quantitative analysis conducted in this paper is based on a wide range of empirical evidence on the long-term earnings losses of displaced workers, whereas the results reported in Beaudry and Pages (2001) are solely based on the empirical finding by Beaudry and DiNardo (1991) that wages of new hires are strongly cyclical. Finally, and perhaps most importantly, the current paper follows Lucas (2003) and most of the work in the literature

5Notice that the costs of business cycles reported in Krebs (2003a) and Storesletten et al. (2001) are based on estimates obtained by Storesletten, Telmer, and Yaron (2004), who find strong fluctuations in the variance of the persistent component of individual labor income shocks. However, Barlevy and Tsiddon (2004) have recently argued that the data do not support the view that earnings inequality increases during recessions once long-run trends are taken into account. Similarly, once we de-trend the estimates of the variance of permanent income changes reported in Meghir and Pistaferri (2004), we cannot reject the hypothesis that this variance is constant over the cycle (results are available on request).
by assuming that the elimination of business cycles only eliminates the cyclical variations in idiosyncratic risk keeping the average amount of idiosyncratic risk constant. That is, stabilization policy improves the bad times (recessions), but also takes away from the good times (booms). In contrast, Beaudry and Pages (2001) argue that stabilization policy can improve recessions without affecting the boom-times, which amounts to removing the cyclical variations in idiosyncratic risk and reducing the average amount of idiosyncratic risk to its minimum level. In this paper, we also calculate the cost of business cycles using the method proposed in Beaudry and Pages (2001), but here we call it the cost of recessions (see table 2).

III. Model

The model provides a formal approach to the intuitive idea that consumption equals permanent income. It features ex-ante identical, long-lived households with homothetic preferences that make consumption/saving choices in the face of uninsurable income shocks. There is no production (exchange economy), the interest rate is endogenous (general equilibrium), and income shocks are permanent, which implies that self-insurance is an ineffective means to smooth out income fluctuations. Indeed, the economy is set up in a way so that in equilibrium households will not self-insure at all, that is, income shocks translate one-to-one into consumption changes.

There is a significant body of empirical work providing strong evidence that individual labor income risk, as measured by the variance of individual income changes, has a substantial component that is highly persistent. However, the same literature also provides clear evidence in favor of a substantial transitory component of labor income risk. Similarly, the empirical literature on job displacement risk has shown that job displacement has both short-term and long-term effects on earnings. Thus, the current model is not consistent with

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Krebs (2003a,b) considers an extension of this approach to production economies with positive aggregate saving.
one dimension of the data. However, for the particular issue addressed here, this feature of the model is unlikely to be a major drawback. First, an extensive literature has shown that households can self-insure against transitory income shocks through borrowing or own saving, and the effect of these types of shocks on consumption and welfare is therefore small. Hence, it seems reasonable to abstract from transitory income shocks as a first approximation. Second, introducing these types of shocks can only increase the cost of business cycles and therefore strengthen this paper’s main result. More specifically, for the quantitative analysis conducted in Section V we calibrate the model economy so that the implied size of the earnings losses of displaced workers matches the estimates of the long-term component of the earnings losses. Similarly, the process that describes the non-cyclical component of labor market risk is calibrated so that the model matches the empirical estimates of the variance of permanent income changes (see Section V.1 for details). In other words, the quantitative analysis assumes that workers can fully self-insure against transitory income shocks.

III.1. Economy

Time is discrete and open ended. Labor income of worker \( i \) in period \( t \) is denoted by \( y_{it} \). Labor income is uncertain and defined by an initial level \( y_{i0} \) and the law of motion

\[
y_{i,t+1} = (1 + g)(1 + \theta_{i,t+1})(1 + \eta_{i,t+1}) y_{it},
\]

where \( g \) is the (constant) aggregate growth rate of labor income and the random variables \( \theta_{i,t+1} \) and \( \eta_{i,t+1} \) describe shocks to the labor income of worker \( i \). We assume that the sequence of random variables \( \{\theta_{it}\} \) is i.i.d. over time with log-normal distribution function:

\[
\log(1 + \theta_{i,t+1}) \sim N(-\sigma^2/2, \sigma^2).
\]

The sequence of random variables \( \{\eta_{it}\} \) is also independently distributed over time, but it is not identically distributed over time. More specifically, we assume that there is an aggregate i.i.d. state process \( \{S_t\} \) with stationary probabilities \( \pi_S \), and that the distribution of \( \eta_{i,t+1} \)

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7See, for example, Heaton and Lucas (1996) and Aiyagari (1994) for a quantitative analysis and Levine and Zame (2002) for a theoretical argument.
depends on the aggregate state $S_{t+1}$ in the following way:

$$
\eta_{i,t+1} = \begin{cases} 
-d_S & \text{with probability } p_S \text{ if } S_{t+1} = S \\
\frac{p_S d_S}{1-p_S} & \text{with probability } (1-p_S) \text{ if } S_{t+1} = S 
\end{cases},
$$

(3)

The random variable $\eta_{it}$ is the cyclical component of labor income risk, and we interpret this component as describing job displacement risk. The number $d_S$ is the long-term income loss of a worker who is displaced when the aggregate state is $S$, and the number $p_S$ is the corresponding displacement probability. The income losses of displaced workers, and in particular its persistent component, have been extensively studied by the empirical literature, and we survey this literature in Section V.1. Notice that we have assumed that all displaced workers experience the same income loss $d_S$, but our analysis extends to the case in which earnings losses of displaced workers are log-normally distributed with mean $d_S$ and constant variance (see Section VI.2). Note also that a worker gains income $\frac{p_S}{1-p_S}d_S$ if he is not displaced, an assumption only made to ensure that the random variable $\eta_{it}$ has mean zero. Finally, the i.i.d. assumption means that income changes associated with the displacement event are unpredictable, which implies that the corresponding income losses are permanent.

The random variable $\theta_{it}$ is the non-cyclical component of labor income risk, and we interpret it as containing any labor income risk beyond job displacement risk. To relate this variable to the empirical literature, let us take logs in equation (1):

$$
\log y_{i,t+1} = \log y_{i,t} + \log (1+g) + \log (1+\theta_{i,t+1}) + \log (1+\eta_{i,t+1}).
$$

(4)

Equation (4) says that log-labor income approximately follows a random walk with drift and heteroscedastic error term $\epsilon_{i,t+1} = \log (1+\theta_{i,t+1}) + \log (1+\eta_{i,t+1})$, which is yet another way of saying that income shocks are permanent. An extensive empirical literature, to be discussed in Section V.1, has estimated the parameters of the permanent component of income shocks under the log-normal distribution assumption. The estimates obtained by this literature are used in Section V.2 to find a value of $\text{var}(\log (1+\theta_{i,t+1})) = \sigma^2$.

Each worker begins life with no initial financial wealth. Workers have the opportunity to
borrow and lend (dissave and save) at the risk-free rate $r_t$. There are no insurance markets for idiosyncratic labor income risk. In other words, there are no assets with payoffs that, conditional on the aggregate state $S$, are correlated with either $\theta_{it}$ or $\eta_{it}$. Thus, the sequential budget constraint of worker $i$ reads:  

$$
a_{i,t+1} = (1 + r_t)a_{it} + y_{it} - c_{it} $$

$$
a_{i,t+1} \geq -D, \; a_{i0} = 0. $$

Here $c_{it}$ denotes consumption of household $i$ in period $t$ and $a_{it}$ his asset holdings (wealth excluding current interest payments) at the beginning of period $t$. The real number $D$ represents an explicit debt constraint that rules out Ponzi schemes.

Workers have identical preferences that allow for a time-additive expected utility representation:

$$
U(\{c_{it}\}) = E \left[ \sum_{t=0}^{\infty} \beta^t u(c_{it}) \right].
$$

Moreover, we assume that the one-period utility function, $u$, is given by $u(c) = \frac{c^{1-\gamma}}{1-\gamma}$, for $\gamma \neq 1$ and $u(c) = \log c$ for $\gamma = 1$. That is, we assume that preferences exhibit constant degree of relative risk aversion $\gamma$. For given interest rate, households choose a consumption-saving plan that maximizes (6) subject to the budget constraint (5).

In Appendix 1, we derive an equilibrium for the economy outlined so far under the assumption that condition (A5) is satisfied. In this equilibrium, the interest rate is constant, $r_t = r$, and workers consume their income: $c_{it} = y_{it}$. Further, equilibrium welfare is given by

$$
U = \frac{y_{i0}^{1-\gamma}}{(1-\gamma) \left( 1 - \beta E \left[ \left( (1+g)^{1-\gamma} (1+\theta_i)(1+\eta_i) \right)^{1-\gamma} \right] \right)} \quad \text{if } \gamma \neq 1
$$

$$
U = \frac{1}{1-\beta} \log y_{i0} + \frac{\beta}{(1-\beta)^2} E[\log ((1+g)(1+\theta_i)(1+\eta_i))] \quad \text{if } \gamma = 1.
$$

Notice that the analysis remains unchanged if we assume that agents have the opportunity to trade assets whose payoffs depend on the aggregate state $S$ (Krebs, 2004). Our assumption that there are no insurance markets means that one should interpret $y_{it}$ as income after transfer payments from the government.
Using the distributional assumption (2) and (3), we can evaluate the expectations in (7) and find the following welfare formula:

\[
U = \frac{y_0^{1-\gamma}}{(1 - \gamma) \left(1 - \beta (1 + g)^{1-\gamma} e^{\frac{\sigma^2}{2} \sum S \pi_S \left[p_S (1 - d_S)^{1-\gamma} + (1 - p_S) \left(1 - \frac{p_S d_S}{1 - p_S} \right)^{1-\gamma}\right]}\right)}
\]

\[
U = \frac{1}{1 - \beta} \log y_0 \\
+ \frac{\beta}{(1 - \beta)^2} \left(\log(1 + g) - \sigma^2/2 + \sum S \pi_S [p_S \log(1 - d_S) + (1 - p_S)\log(1 + p_S d_S/(1 - p_S))]\right).
\]

**IV. Cost of Business Cycles: Qualitative Analysis**

In this section, we use the welfare formula (8) to analyze the cost of business cycles. We begin with a discussion of how to eliminate business cycles, and then derive an explicit formula for the cost of business cycles (equation (16)). Using this formula, we will prove propositions 1 and 2.

**IV.1. Eliminating Business Cycles**

In our model, the elimination of business cycles amounts to eliminating the variations in business cycle conditions \(S\), that is, replacing the \(S\)-independent income shocks \(\theta_i\) and \(S\)-dependent income shocks \(\eta_i\) by \(S\)-independent income shocks \(\bar{\theta}_i\) and \(\bar{\eta}_i\). The question that arises is how to find the distributions of \(\bar{\theta}_i\) and \(\bar{\eta}_i\) given the distributions of \(\theta_i\) and \(\eta_i\). Following Lucas (1987) and the subsequent literature, we will answer this question without an explicit model of the interaction between macroeconomic stabilization policy and the business cycle.

For economies without uninsurable idiosyncratic risk (complete markets), Lucas (1987) postulates that the elimination of business cycles amounts to replacing all \(S\)-dependent economic variables by their expected value. One way of extending this approach to economies with uninsurable idiosyncratic risk is to postulate that eliminating business cycles amounts...
to replacing all $S$-dependent economic variables by their expected value with respect to $S$
conditional on the idiosyncratic state of an individual worker (the “integration principle”, see
Lucas (2003), Krebs (2003a), and Krusell and Smith (1999)). For the a-cyclical component
of individual income shocks this principle implies $\bar{\theta}_i = \theta_i$, and therefore

$$\log(1 + \bar{\theta}_i) \sim N \left( -\sigma^2/2, \sigma^2 \right).$$

(9)

For the cyclical component of income shocks, $\eta_i$, the integration principle reads:

$$\bar{\eta}_i = E \left[ \eta_i | s_i \right],$$

(10)

where $s_i$ is the individual state of worker $i$, which can take on two values: $s_i = 0$ if worker $i$
is not displaced and $s_i = 1$ if worker $i$ is displaced. Taking the expectations in (10) yields:

$$\bar{\eta}_i = \left\{ \begin{array}{ll}
-\bar{d} & \text{with probability } \bar{p} \\
\bar{d}/\bar{p} & \text{with probability } (1 - \bar{p})
\end{array} \right.,$$

(11)

where the job displacement rates and earnings losses in the economy without business cycles
are given by

$$\bar{p} = \sum_s \pi_S p_S$$

(12)

$$\bar{d} = \sum_s \frac{\pi_S p_S}{\bar{p}} d_S.$$

Equation (12) shows how the application of the integration principle to the current case
requires that we use the conditional probabilities $\text{prob}(S | s_i = 1) = \frac{p_S}{\bar{p}} \pi_S$ to calculate the
mean of the income losses $d_S$. Alternatively, we could use the unconditional probabilities $\pi_S$
to calculate this mean, that is, we could replace (12) by

$$\bar{p} = \sum_s \pi_S p_S$$

(13)

$$\bar{d} = \sum_s \pi_S d_S.$$

Equation (13) seems plausible if earnings losses $d_S$ are a linear function of aggregate GDP and
if, as in Lucas (1987), the elimination of business cycles amounts to replacing stochastic GDP
by its (unconditional) mean. Notice that (12) and (13) coincide if either job displacement rates are a-cyclical, \( p_S = p \), or earnings losses are a-cyclical, \( d_S = d \). Thus, the theoretical results derived in this paper (propositions 1 and 2) are valid regardless of which of the methods we use to eliminate business cycles. However, for the quantitative analysis it makes a difference, and we therefore report the cost of business cycles for both methods in Section V.

Following Beaudry and Pages (2001), one could also assume that there is a non-linear (asymmetric) relationship between business cycle conditions and the long-term earnings losses of displaced workers, which would imply that stabilization policy can also affect the mean of \( d \).\(^{9}\) Depending on the nature of this non-linearity, \( \bar{d} \) may take on any value between \( d_H \) and \( d_L \). Thus, the lower bound on \( \bar{d} \) is \( \bar{d} = d_H \), in which case the cost of business cycles (15) achieves its maximum. Intuitively, \( \bar{d} = d_H \) means that stabilization policy can reduce idiosyncratic risk during recessions without affecting idiosyncratic risk during booms. The corresponding welfare cost will be called the cost of recessions. Note that this cost is similar to the cost of recession computed in Hall (1995), but not the same. Hall (1995) computes the cost of one recession, whereas in this paper we are concerned with the cost of all (future) recessions.

**IV.2. Cost of Business Cycles**

We define the welfare cost of business cycles as the number \( \Delta \) that solves

\[
E_0 \left[ \sum_{t=0}^{\infty} \beta^t u((1 + \Delta)c_{it}) \right] = E_0 \left[ \sum_{t=0}^{\infty} \beta^t u(\bar{c}_{it}) \right],
\]

where \( c_{it} \) is consumption in the economy with business cycles and \( \bar{c}_{it} \) is consumption in the economy without business cycles. That is, we define the welfare cost of business cycles as the percentage of consumption in each date-event that workers have to receive in order to be fully compensated for the cyclical variations in labor income risk. Using the definition

\[^{9}\text{Beaudry and Pages (2001) argue that implicit contracts provide a theoretical foundation for this type of approach.}\]
(14) in conjunction with the welfare formula (7), we find the following formula for the cost of business cycles:

$$\Delta = \left( \frac{1 - \beta (1 + g)^{1-\gamma} E[(1 + \theta_i)^{1-\gamma} (1 + \eta_i)^{1-\gamma}]}{1 - \beta (1 + g)^{1-\gamma} E[(1 + \theta_i)^{1-\gamma} (1 + \bar{\eta}_i)^{1-\gamma}]} \right)^{\frac{1}{1-\gamma}} - 1 \quad \text{if } \gamma \neq 1 \quad (15)$$

$$\Delta = \frac{\beta}{1 - \beta} (E[\log (1 + \bar{\eta}_i)] - E[\log (1 + \eta_i)]) \quad \text{if } \gamma = 1.$$

We can evaluate the expectations in (15) and find:

$$\Delta = \left( \frac{1 - \beta (1 + g)^{1-\gamma} e^{\frac{\gamma}{2}(\gamma-1)\sigma^2} \sum_S \pi_S \left[ p_S (1 - d_S)^{1-\gamma} + (1 - p_S) \left( 1 + \frac{p_S d_S}{1 - p_S} \right)^{1-\gamma} \right]}{1 - \beta (1 + g)^{1-\gamma} e^{\frac{\gamma}{2}(\gamma-1)\sigma^2} \left[ \bar{p} (1 - \bar{d})^{1-\gamma} + (1 - \bar{p}) \left( 1 + \frac{\bar{p} d}{1 - \bar{p}} \right)^{1-\gamma} \right]} \right)^{\frac{1}{1-\gamma}} - 1$$

$$\Delta = \frac{\beta}{1 - \beta} \left( \bar{p} \log(1 - \bar{d}) + (1 - \bar{p}) \log \left( 1 + \bar{p} \bar{d}/(1 - \bar{p}) \right) \right) - \frac{\beta}{1 - \beta} \left( \sum_S \pi_S \left[ p_S \log(1 - d_S) + (1 - p_S) \log \left( 1 + p_S d_S/(1 - p_S) \right) \right] \right),$$

where the bar-variables are defined through equation (12), respectively (13).

Several facts about (16) are noteworthy. First, the cost of business cycles is the same for all workers. This is a result of the joint assumption of homothetic preferences and permanent income shocks with a distribution that is independent of workers’ characteristics. Second, in the case of log-utility preferences, the non-cyclical component of idiosyncratic risk, $\theta$, does not affect the cost of business cycles. Hence, in this case one can disregard non-cyclical labor market risk, an approach taken in Beaudry and Pages (2001). If $\gamma > 1$, then there is an interaction effect between $\theta$ and $\eta$, and in Section V we will investigate the quantitative importance of this effect. Third, if we use the integration principle (equation 10) to eliminate business cycles, then the welfare cost of business cycles is non-negative: $\Delta \geq 0$. This fact immediately follows from the concavity of the utility function in conjunction with the fact that $\eta_i$ is a mean-preserving spread of $\bar{\eta}_i$. Moreover, and more importantly, the cost of business cycles is nil if the earnings losses of displaced workers have no cyclical component, $d_S = d$, and this result holds for both methods (equation (12) or equation (13)) of removing business cycles. Similar neutrality results have been derived in Atkeson and Phelan (1994) and Krebs (2003a).
Proposition 1. If earnings losses of displaced workers are constant over the cycle, $d_S = d$, then the welfare cost of business cycles is nil: $\Delta = 0$. That is, cyclical variations in job displacement rates by themselves do not generate welfare cost of business cycles.

Proposition 1 suggests that in the current set-up, there is not much hope for generating cost of business cycles by confining attentions to cyclical variations in job displacement rates, at least as long as the mean of $p$ is not affected by stabilization policy. Matters are different, however, if the earnings losses of displaced workers have a cyclical component. Inspection of (16) suggests that we have $\Delta \to \infty$ when $d_S \to 1$ for some $S$ if $\gamma \geq 1$. That is, for high enough degree of risk aversion, the cost of business cycles becomes arbitrarily large when the income losses of displaced workers become arbitrarily large during recessions. In the Appendix, we show that this result still holds even if job displacement rates and the second moments of the distribution of income changes are (almost) constant.

Proposition 2. Suppose the degree of relative risk aversion is large enough: $\gamma \geq 1$. Then there is a process of job displacement risk with constant displacement rates so that i) the cost of business cycles is arbitrarily large and ii) the second moments of the distribution of individual income shocks are (almost) constant over the business cycle. More precisely, for any real numbers $\epsilon > 0$ and $\bar{\Delta} > 0$, we can find numbers $p_S$ and $d_S$ with $p_S = p$ so that i) $\Delta = \bar{\Delta}$ and ii) $|\sigma_y^2(S) - \sigma_y^2(S')| < \epsilon$ for all $S, S'$, where $\sigma_y^2(S) \equiv var(y_{i,t+1}/y_{it}|S_{t+1})$.

V. Cost of Business Cycles: Quantitative Analysis

In this section, we analyze the quantitative importance of proposition 2. To this end, we first discuss the calibration of the model economy (Section V.1) and then report the quantitative results (Section V.2).

V.1. Calibration

Following the previous literature (Imrohoroglu, 1989, Krebs, 2003a, Krusell and Smith, 1999, and Storesletten et al., 2001), we assume now that there are two aggregate states,
\( S = L, H \), corresponding to low economic activity (economic contraction) and high economic activity (economic expansion). We further follow the literature and disregard any asymmetry in the business cycle, that is, we assume that on average both aggregate states have the same likelihood of occurrences. In our setting without persistence in the aggregate state process, this means that \( \pi_L = \pi_H = .5 \). We choose the period length to be one year to be consistent with the empirical work on labor market risk (see below). Thus, the choice of \( \pi_L = \pi_H = .5 \) implies an average duration of both good and bad times of two years, which is also the value considered in Imrohoroglu (1989), Krebs (2003a), and Krusell and Smith (1999). We choose an average growth rate of labor income of \( g = .02 \).

The process of job displacement risk is defined by the parameters \( p_S \) and \( d_S \). We choose these parameters so that the model economy matches the first and second moments of the job displacement rates and long-term earnings losses of U.S. workers. Note that by using the empirical estimates of the long-term component of earnings losses we effectively disregard any transitory effect of job-displacement.

**Long-Term Earnings Losses of Displaced Workers**

There are many studies of the long-term consequences of job displacement for U.S. workers. One of the most thorough studies is Jacobsen, LaLonde, and Sullivan (1993), who use longitudinal data on the earnings of high-tenure workers (workers with at least six years of tenure) in Pennsylvania from 1974 to 1986 to estimate the earnings losses of displaced workers. In their restricted sample, they confine attention to workers that are separated from distressed firms (employment contraction of at least 30%). For these workers, they find an initial drop of earnings of around 50% of pre-displacement earnings. Moreover, even though earnings recover for the first three years after displacement, this recovery is far from perfect. Indeed, six years after displacement earnings are still 25% below pre-displacement earnings. Long-term earnings losses of around 25% for high-tenure workers are also consistent with

---

\[^{10}\text{Long-term earnings losses experienced by displaced workers have two components: the direct decline in earnings and the forgone increase in earnings experienced by non-displaced workers. The numbers cited here refer to the total long-term earnings losses.}\]
estimates obtained by Topel (1990). In a similar vein, Kambourov and Manovskii (2002) find that ten years of occupational tenure increase wages by at least 19 percent.

The preceding discussion dealt with high-tenure workers, but low-tenure workers also experience substantial long-term earnings losses after job displacement. For example, Lorie and Farlie (2003) study the earnings losses of young adult workers based on the National Longitudinal Survey of Youth (NLSY), and find that the long-term earnings losses of male young adults are around 10% (for female young adults they find significantly larger losses). Farber (1997, 2005) and Ruhm (1991) provide further evidence that long-term earnings losses for all types of displaced workers are substantial. Ruhm (1991) uses earnings data from the Panel Study of Income Dynamics (PSID) for the years 1969-1982 and finds that for a sample of displaced workers of all tenure levels (low and high tenure) the earnings losses are between 11% and 15% four years after job separation. Analyzing data drawn from the Displaced Workers Survey (DWS) between 1984-2004, Farber (2005) estimates for a sample of displaced workers of all tenure levels earnings losses of around 13%.11

In sum, the empirical literature suggests that job displacement leads to long-term earnings losses of up to 25% for high-tenure workers and around 10% for low tenure workers. Empirical studies that do not distinguish between low- and high-tenure workers tend to find long-term earnings losses of around 13% of pre-displacement earnings. None of the studies takes into account that job displacement often leads to a reduction in health and pension benefits. If we assume that these benefits are around 15% of reported earnings, then a benefit loss of 2% of pre-displacement earnings should be added to the estimated long-term earnings losses. Guided be these considerations, for the baseline economy we choose a value of 15% for the average earnings losses of displaced workers. That is, we choose the parameters $d_L$ and $d_H$ so that the restriction $0.5d_L + 0.5d_H = 0.15$ is satisfied.

---

11The fact that the DWS has no panel dimension can lead to mis-estimation of the long-term earnings losses of displaced workers. It leads to an over-estimate since some of the earnings losses are transitory. It leads to an under-estimate since it misses the pre-displacement earnings losses, which can be substantial (Jacobson et al., 1993).
Jacobson et al (1993) also find strong evidence that the long-term earnings losses of displaced high-tenure workers exhibit pronounced cyclical variations. More specifically, they define a variable “cyclical labor market condition” by the unemployment rate and the deviation from trend employment, and estimate that workers who become displaced during the worst cyclical condition experience a permanent income loss of 37%, whereas this income loss is only 13% for those workers who experience job displacement during the best cyclical condition (see table 2 and the corresponding discussion in Jacobson et al., 1993). In other words, the spread is $37\% - 13\% = 24\%$.\(^{12}\) Weinberg (2001) considers a sample of displaced workers of all tenure-levels (low- and high-tenure workers), and finds that a one-standard deviation increase in industry growth increases post-displacement wages by 4%. Thus, the spread between good and bad cyclical conditions is 8% if we focus on one-standard deviations from the mean and 16% if we consider two-standard deviations from the mean. In a similar vein, Farber (2005) finds that earnings losses of displaced workers have a strong cyclical component (again for a sample of workers of all tenure levels). For example, during the most recent cycle earnings losses increased from a level of 7% in the period 1996-1997 (economic expansion) to a level of 17% in the period 2002-2003 (economic contraction), which implies a spread of 10%.

Beaudry and DiNardo (1991) show that wages of new hires decrease on average by approximately $3 - 4.5\%$ for every percent increase in the unemployment rate. Thus, assuming a spread of the unemployment rate of 5 percent between economic contractions and economic expansions, the last finding implies a variation of income losses over the cycle of somewhere between 15% and 22.5%.\(^{13}\) Clearly, this type of evidence is silent about the persistence of income losses, but work by Devereux (2002) has shown that 60% of the initial wage losses are still present four years after starting the new job. That is, the combined evidence reported in

\(^{12}\)Note that the empirical results reported by Jacobson et al. (1993) are derived exploiting the differences across local labor markets, and the aggregate time-series inference drawn in this paper is therefore somewhat tentative. A similar comment applies to the work by Weinberg (2001).

\(^{13}\)Notice that a 5 percent spread in the unemployment rate is consistent with the fluctuations in the U.S. unemployment rate over the last 30 years. Note also that Imrohoroglu (1989) and Krusell and Smith (1999,2002) use a spread in the unemployment rate that is even larger.
Beaudry and DiNardo (1991) and Devereux (2002) suggests a variations of persistent income losses over the cycle somewhere between 9% and 13.5%.

Finally, we note that Keane and Wolpin (1997) estimate that the skill-level of white-collar workers depreciates by 30% for each year of unemployment. Combined with the fact that unemployment durations increase during recessions, this finding provides additional evidence for the view that cyclical conditions affect the long-term losses of displaced workers. For example, the most commonly cited measure of unemployment duration is “average weeks unemployed”, which is released each month by the BLS. This measure exhibits pronounced cyclical swings, rising from around 11-12 weeks at the business cycle peak to above 20 weeks at the end of a typical recession (Valletta, 2002). In short, the increase in unemployment duration moving from boom to recession is almost 3 months, which translates into an increase in the permanent income losses due to skill depreciation of around 7.5%. Clearly, this number is an under-estimate of the variation of the long-term earnings losses of displaced workers since the BLS statistics include all unemployed workers, which are likely to experience shorter spells of unemployment than the displaced workers who are the focus of the current study.

To sum up, the empirical literature suggests that long-term earnings losses of displaced workers increase by somewhere between 8% and 20% when the economy is moving from the peak to the trough of the business cycle. As mentioned before, these numbers do not include the loss of health and pension benefits (and their associated cyclical variation), and in this sense represent an under-estimate of the true variation in long-term earnings losses. Guided by this evidence, for the baseline economy we choose the parameter values $d_L$ and $d_H$ so that the spread, $d_L - d_H$, is equal to .12. Combined with the condition $.5d_L + .5d_H = .15$, this yields $d_L = .21$ and $d_H = .09$.

**Job Displacement Rates**

Using the DWS data, Farber (1997) reports an average annual job displacement rate of .0384 for workers of age 35-44, which is in accordance with the job displacement rates reported by Stevens (1997) using the PSID data. Guided by these results, we choose a mean
of the annual job displacement rate of .04, that is, we require \( .5p_L + .5p_H = .04 \). Note that the job displacement rates reported in the DWS and the PSID are likely to be under-estimates of the true job displacement probabilities because of recall bias (Topel, 1991). With respect to the cyclicality of job displacement rates, Farber (1997, 2005) reports job displacement rates that increase by around .02 when the economy moves from peak to trough of the business cycle, and Stevens (1997) finds similar variations. In the baseline model, we therefore require \( p_L - p_H = .02 \), which combined with the condition \( .5p_L + .5p_H = .04 \) leads to \( p_L = .05 \) and \( p_H = .03 \).

Note that standard measures of total rates of job separation are much larger than the job displacement rates used here. For example, Shimer (2005) estimates a monthly job separation rate for the U.S. of .034. This translates into an annual job separation rate of .49, which is an order of magnitude larger than the average job displacement rate of .04 used in this paper. Note also that Shimer’s finding that job separation rates are only somewhat cyclical is not inconsistent with our baseline calibration of the model. More specifically, the job separation rates estimated in Shimer (2005) display cyclical variations that in absolute terms by far exceed the .02 variation of annual job displacement rates assumed in our calibration (see in particular figure 7 in Shimer, 2005). However, to see the effect of non-cyclical job displacement rates, we will also report the cost of business cycles for the case \( p_H = p_L \).

**Non-Cyclical Labor Market Risk**

For the non-cyclical component of income risk, we follow Carroll (1997) and set \( \sigma^2 = .01 \). To understand the meaning of this choice, notice first that the average variance of log-income changes is (see equation 4)

\[
\sigma^2_{\log y} = \sum_S \pi_S \text{var} \left( (\log y_{i,t+1} - \log y_{it})|S \right)
\]

\[
= \sigma^2 + \sum_S \pi_S \text{var} \left( \log(1 + \eta_{i,t+1})|S \right).
\]

The variance term \( \sigma^2_{\log y} \) has been estimated by an extensive empirical literature. More specifically, the empirical literature on labor income risk has often used a random walk...
specification for the permanent component of labor income (Carroll and Samwick, 1997, Gottschalk and Moffitt, 1994, and Meghir and Pistaferri, 2004), or has used an AR(1) specification and then estimated a serial correlation coefficient close to one (Hubbard, Skinner, and Zeldes, 1994, and Storesletten et al., 2004). Thus, this literature provide a direct estimate of $\sigma_{log y}^2$. All the empirical studies use annual income data drawn from the PSID data set, and estimate an average variance of permanent income shocks between .022 and .033 for the pooled household/worker sample (a standard deviation between .15 and .18). The choice of $\sigma^2 = .01$ in conjunction with the job displacement process specified above yields $\sigma_{log y}^2 = .01042$ (averaged over business cycle conditions), which is somewhat lower than the estimated value obtained by the empirical literature. That is, our choice of $\sigma^2 = .01$ is a conservative one.

The view that labor income risk has a substantial permanent (highly persistent) component has a long tradition in labor economics (see, for example, MaCurdy (1982), Deaton and Paxson (1994), Meghir and Pistaferri (2004), and Storesletten, Telmer, and Yaron (2004)). However, Guvenen (2005) has recently argued that the empirical evidence on individual income and consumption can also be explained by an alternative view that postulates moderately persistent income shocks and learning about individual-specific income profiles. Though it seems too early to judge if this alternative explanation will replace the dominant view of labor income dynamics, we will also report our results for the case in which $\sigma^2 = 0$ (perfect self-insurance against the non-cyclical component of labor income risk). Note that the empirical results reported by Guvenen (2005) do not apply to the process of job displacement (3) since his work heavily relies on second-moment analysis.

Preference Parameters

We follow the bulk of the business cycle literature and choose an annual discount factor of $\beta = .96$. In comparison, Imrohoroglu (1989) also chooses $\beta = .96$, but Storesletten et al. (2001) pick $\beta = .95$. Krusell and Smith (1999) assume a stochastic discount factor with a mean of .95. For the degree of relative risk aversion, a choice of $\gamma = 1$ (log-utility) is often
made, but one could also argue that a somewhat higher degree of risk aversion is reasonable. In this paper, we therefore report all results for the values \( \gamma = 1, 2, 3, \) and 4. In comparison, Krusell and Smith (1999) use log-utility, Storesletten et al. (2001) focus on \( \gamma = 4, \) and Imrohoroglu considers the two cases \( \gamma = 1.5 \) and \( \gamma = 6. \)

**V.2. Results**

Table 1 presents the results of our quantitative study. The first column (method 1) shows the cost of business cycles for different preferences parameters when business cycles are eliminated according to equation (13). If \( \gamma = 1 \) (log-utility), we have a welfare cost of business cycles of \( \Delta = .53\% \). Moreover, this cost increases to \( \Delta = .98\% \) if the degree of risk aversion is two, and reaches \( \Delta = 4.09\% \) if \( \gamma = 4. \) Thus, the costs of business cycles found here are sizable. In particular, they are at least one order of magnitude larger than the costs of business cycles found by Lucas (1987,2003) for comparable degrees of risk aversion using a representative-agent model. For example, for the log-utility case, Lucas (2003) finds \( \Delta = .05\% \), and he uses a linear approximation that implies a cost of business cycles of \( \Delta = .20\% \) for \( \gamma = 4. \) Note also that the cost of business cycles exhibits a strong non-linearity in the degree of risk aversion \( \gamma \), something that is missed when using a linear approximation. This point has been emphasized by Storesletten et al. (2001). Finally, note that in the current model there are no fluctuations in aggregate income, so that the cost of business cycles is nil when markets are complete (column CM in table 1).

The next column (method 2) shows the costs of business cycles when equation (12) is used to eliminate business cycles. In this case, the costs of business cycles are lower than in the previous case, but they are still quite sizable. Moreover, they are similar to the costs of business cycles that occur when job displacement rates in the economy with business cycles are constant (third column). Thus, introducing cyclical variations in job displacement rates amplifies the effect of cyclical variations in long-term earnings losses by a sizable amount only if equation (13) is used to eliminate business cycles.

The fourth column shows the costs of business cycles when, incorrectly according to the
current paper, the researcher assumes that log-income changes are normally distributed. More precisely, according to the model, the variance of log-income changes, $\sigma_{\log y}^2$, varies between $\sigma_{\log y}(L) = 0.01074$ and $\sigma_{\log y}(H) = 0.01009$. In the fourth column of tables 1 and 2, we consider a labor income process that has, conditional on the aggregate state $S$, a symmetric two-state support, and choose the support so that we match the given $S$-dependent standard deviations. The results reported in the fourth column show that the costs of business cycles become negligible once the log-normal approach is taken since the implied cyclical variations in the variance of log-income changes, $\sigma_{\log y}(L) - \sigma_{\log y}(H)$, are very small.

Table 2 reports the cost of recessions, that is, in table 2 we follow Beaudry and Pages (2001) and assume that macroeconomic stabilization policy can remove recessions without affecting economic boom times: $\bar{d} = d_H$. Clearly, the cost of recessions is very large indeed. For example, in the baseline economy with time-varying job displacement rates (column 1), we have $\Delta = 1.35\%$ for log-utility and $\Delta = 2.41\%$ for a degree of relative risk aversion of two. As noted before, this cost is not the cost of one recession, but the cost of all (future) recessions.

VI. Robustness

The previous section has shown that the baseline model implies sizable cost of business cycles. We now provide an extensive sensitivity analysis demonstrating that this result is robust to empirically reasonable changes in parameter values and modeling assumptions.

VI.1. Parameter Values of Job Displacement Risk

Figure 1 shows the cost of business cycles as a function of the average long-term earnings losses of displaced workers, $E[d] = 1/2d_L + 1/2d_H$, keeping fixed the cyclical variations in $\sigma_{\log y}^2$. This is the two-state approximation of the normal distribution using the Gauss-Hermite quadrature (Judd, 1998). The welfare results barely change if a four-state approximation is used, which suggests that the two-state approximation is already very good. See Krebs (2003a) for a more detailed discussion of the cost of business cycles in economies with (log)-normally distributed income shocks.
these losses, as measured by the spread $d_L - d_H$. If the degree of relative risk aversion is two, then a reduction in $E[d]$ from its baseline value of .15 to a value of .13 decreases the cost of business cycles from .98 percent of lifetime consumption to .86 percent. If we decrease the mean further to a value of .10, the cost of business cycles becomes .70 percent of lifetime consumption. As our previous discussion has indicated, a value of $E[d] = .10$ lies at the lower end of the estimates of the empirical literature (for a mixed sample of low and high-tenure workers).

In figure 2 we show the dependence of the cost of business cycles on cyclical variations in the long-term earnings losses of displaced workers, measured by the spread $d_L - d_H$, keeping the mean level of these losses fixed. Not surprisingly, the cost of business cycles is sensitive to changes in the cyclical component of long-term earnings losses. For example, if the degree of risk aversion is two, then a reduction in the spread from its baseline value of .12 to a value of .10 decreases the cost of business cycles from .98 percent of lifetime consumption to .75 percent. A further reduction in the spread to .08 decreases the cost of business cycles to a value of .54 percent of lifetime consumption. The empirical literature surveyed in the previous section suggests that a value of .08 constitutes a lower bound on the true degree of cyclical variations in the long-term earnings losses of displaced workers.

To sum up, the result that job displacement risk generates sizable cost of business cycles is robust to empirically reasonable changes in the mean and spread of the long-term earnings losses of displaced workers. However, reasonable changes in the parameter values have a non-negligible effect on the cost of business cycles, and more empirical work on the long-term earnings losses of displaced workers is required to derive precise estimates of the cost of business cycles.

VI.2. Generalizing the Job Displacement Process

The model developed in Section III makes the extreme assumption that the job displacement process has a two-state support, that is, earnings losses after displacement only occur in discrete jumps. We now show that this simplifying assumption is not crucial for our
Suppose that the income process is given as before by equation (1), where \( \{ \theta_{it} \} \) is a sequence of i.i.d. random variables and \( \{ \eta_{it} \} \) is a sequence of independently distributed random variables. We further assume that \( \theta_{it} \) is distributed as specified in (2): \( \log(1 + \theta_{it}) \sim N(-\frac{\sigma_\theta^2}{2}, \sigma_\theta^2) \). In contrast, we assume that equation (3) is replaced by:

\[
\eta_{i,t+1} \sim \begin{cases} 
N \left( \log(1 - d_S) - \frac{\sigma_\eta^2}{2}, \frac{\sigma_\eta^2}{2} \right) & \text{with probability } p_S \text{ if } S_{t+1} = S \\
N \left( \log \left( 1 + \frac{psd_S}{1-p_S} \right) - \frac{\sigma_\eta^2}{2}, \frac{\sigma_\eta^2}{2} \right) & \text{with probability } (1-p_S) \text{ if } S_{t+1} = S ,
\end{cases}
\]

(18)

Clearly, the new income process can also be written as

\[
y_{i,t+1} = (1 + g)(1 + \tilde{\theta}_{i,t+1})(1 + \tilde{\eta}_{i,t+1}) y_{it} ,
\]

(19)

where \( \{ \tilde{\theta}_{it} \} \) is i.i.d over time with distribution

\[
\log(1 + \tilde{\theta}_{i,t+1}) \sim N \left( -\frac{\sigma_\theta^2}{2} + \sigma_\eta^2, \frac{\sigma_\theta^2 + \sigma_\eta^2}{2} \right)
\]

(20)

and \( \{ \eta_{it} \} \) is a sequence of independently distributed random variables with

\[
\tilde{\eta}_{i,t+1} = \begin{cases} 
-d_S & \text{with probability } p_S \text{ if } S_{t+1} = S \\
\frac{psd_S}{1-p_S} & \text{with probability } (1-p_S) \text{ if } S_{t+1} = S .
\end{cases}
\]

(21)

Thus, the new income process is equivalent to our original income process, with the only difference that \( \sigma^2 \) is now replaced by \( \sigma_\theta^2 + \sigma_\eta^2 \). This shows that none of the results derived in this paper depends on the simplifying two-state assumption.

**VI.3. Non-Cyclical Component of Labor Market Risk**

Equation (15) shows that for degrees of risk aversion larger than one, there is an interaction effect between cyclical job displacement risk and a-cyclical labor market risk in the sense that \( \sigma^2 \) affects the cost of business cycles. To study the magnitude of this effect, we now report the cost of business cycles when \( \sigma^2 = 0 \) (cyclical job displacement risk is the only source of labor market risk). For a degree of relative risk aversion of two, the interaction effect is non-negligible, but not very large: \( \Delta = .98 \) vs \( \Delta = .81 \). However, for a degree
of risk aversion of four, the difference becomes quite large: $\Delta = 4.09$ vs $\Delta = 1.33$. Thus, for degrees of risk aversion below two, the specification of non-cyclical labor income risk is relative unimportant, but for higher degrees of risk aversion the cost of business cycles heavily depends on $\sigma^2$. However, for all values of risk aversion the cost of business cycles is sizable even if we have $\sigma^2 = 0$.

VI.4. Finite Lifespan of Workers

Suppose that each household faces a constant probability, $1 - q$, of death in any period ($q$ is the survival probability). Clearly, one interpretation of the event “death in period $t$” is that the worker retires in that period. Assuming that the continuation utility of a dead (retired) worker is independent of the business cycle, it is straightforward to show that the welfare formula (15) still applies to the modified model if the discount factor $\beta$ is replaced by the effective discount factor $\tilde{\beta} = \beta * q$. In other words, the modified model with finitely-lived households and discount factor $\beta$ is equivalent to the baseline model with infinitely-lived household and a discount factor $\tilde{\beta} = \beta * q < \beta$. We choose the value of the survival probability, $q$, so that the implied expected lifespan of any household is equal to 40 years, which yields $q = .976$. The implied effective discount factor is therefore $\tilde{\beta} = .96 * .976 = .937$.

Since the modified model with finitely-lived households is equivalent the baseline model with infinitely-lived households and lower discount factor, the introduction of a finite lifespan effectively makes households more impatient. Thus, the implied equilibrium interest rate increases. Indeed, for log-utility preferences ($\gamma = 1$), the implied interest rate is now $r = 7.66\%$. For higher degrees of risk aversion, this interest rate decreases, and for $\gamma = 3$ the implied interest rate is roughly in line with the standard choice in the macro literature: $r = 6.04\%$. This suggests that as long as we confine attention to finitely-lived workers, the degree of relative risk aversion should probably be around three.

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$^{15}$The lifespan of individual households is geometrically distributed with a probability of $(1 - q)q^t$ that any household lives exactly $t$ years. Thus, the expected value of the lifespan of households (the average life expectancy) is equal to $q/(1 - q)$.
The costs of business cycles for the case of finitely-lived workers are \( \Delta = .33\%\), \( .65\%\), \( 1.15\%\), and \( 2.25\%\) for degrees of risk aversion of \( \gamma = 1, 2, 3, 4\), respectively. In comparison, the numbers for the corresponding case when workers are infinitely-lived are \( \Delta = .53\%\), \( .98\%\), \( 1.79\%\), and \( 4.09\%\). Thus, even though the introduction of finite lifetimes has a significant effect on the costs of business cycles, these costs still remain substantial.

VI.5. A model with tenure-heterogeneity and earnings recovery after job displacement

We now discuss an extension of the basic model that allows for tenure heterogeneity and earnings shocks that are persistent, but not fully permanent. We assume that earnings depend on the level of occupation-specific human capital, which in turn is an increasing function of occupational tenure.\(^{16}\) Thus, earnings losses of displaced workers depend on occupational tenure. For simplicity, we do not model the occupational choice by workers, and in this sense the model is quite mechanical. Moreover, we assume that there are only two types of workers, low-tenure workers and high-tenure workers. If worker \( i \) is a high-tenure worker in period \( t \), then he faces income risk given by:

\[
y_{i,t+1} = (1 + g)(1 + \theta_{i,t+1})(1 + \eta_{i,t+1}^h) y_{it},
\]

where \( \theta_{it} \sim N(-\sigma^2/2, \sigma^2) \) and \( \eta_{i,t+1}^h \) is distributed as follows:

\[
\eta_{i,t+1}^h = \begin{cases} 
-d_{hS} & \text{with probability } p_{hS} \text{ if } S_{t+1} = S \\
p_{hS}d_{hS} & \text{with probability } (1 - p_{hS}) \text{ if } S_{t+1} = S.
\end{cases}
\]

Equation (23) assumes that a high-tenure worker who becomes displaced always experiences an earnings loss of \( d_{hS} \). Thus, the current model assumes that displaced high-tenure workers always have to change occupation, and that therefore a high-tenure worker always becomes a low-tenure worker after job displacement. We further assume that a non-displaced high-tenure worker becomes a low-tenure worker with probability \( q_h \), so that the transition

\(^{16}\)The interpretation of human capital as occupation-specific as opposed to firm-specific is in line with evidence reported in Neal (1995) and Kambourov and Manovskii (2002). It also provides a natural explanation for the increase in the earnings losses of displaced workers during recessions, something that is not easily explained by firm-specific human capital.
probability from the high-tenure state to the low-tenure state is \( p_{hS} + q_h \). The introduction of the event \( q_h \) will allow us to generate any stationary tenure-distribution for given job displacement rates \( p_{hS} \). In order to avoid introducing additional earnings risk, we assume that this event is not associated with any earnings losses.

We assume that low-tenure workers have no occupation-specific human capital. Thus, they face no displacement risk. However, whenever a low-tenure workers becomes a high-tenure worker, an event that occurs with probability \( q_l \), he recovers the previously lost human capital, and therefore experiences an increase in earnings by \( E[d_h] = \pi_L d_{hL} + \pi_H d_{hH} \). Thus, the income change for a worker \( i \) who is a low-tenure worker in period \( t \) is:

\[
y_{i,t+1} = (1 + g)(1 + \theta_{i,t+1})(1 + \eta_{i,t+1}) y_{it},
\]

where \( \theta_{it} \sim N(-\sigma^2/2, \sigma^2) \) and \( \eta_{i,t} \) is distributed according to:

\[
\eta_{i,t+1} = \begin{cases} 
E[d_h] & \text{with probability } q_l \\
\frac{-E[d_h]}{1-q_l} & \text{with probability } (1-q_l).
\end{cases}
\]

Notice that the second term in (25) has only been introduced to ensure that \( \eta_{i,t+1} \) is a random variable with mean zero.

Workers face a sequential budget constraint that allows them to save at the interest rate \( r \). In contrast to the basic model, workers cannot borrow (equation A16). Preferences over lifetime consumption are specified as before (equation 6). The Appendix shows that no-trade is an equilibrium for this economy if condition (A5) is satisfied and the interest rate is given by (A17). Moreover, the cost of business cycles of a worker of type \( s \), \( s = l, h \), is specified in (A20), and the social cost of business cycles is given by (A21).

We calibrate the model economy as follows. As in the baseline economy, we choose \( \pi_L = \pi_H = .5 \), \( g = .02 \), \( \sigma^2 = .01 \), and \( \beta = .96 \). The empirical literature surveyed in Section V.1 suggests that for high-tenure workers, average long-term earnings losses of displaced workers might be up to 25 percent of pre-displacement earnings. As a conservative choice, we assume average earnings losses of 20 percent for high-tenure workers: \( .5d_{hL} + .5d_{hH} = .20 \).
For the spread of earnings losses over the business cycle we assume \( 0.5d_{hL} - 0.5d_{hH} = 0.16 \), which lies below the estimate of Jacobson et al. (1993) for their sample of high-tenure workers. We set the probability that a low-tenure worker becomes a high-tenure worker, \( q_l \), so that it takes on average 10 years for a low-tenure worker (who is not displaced) to become a high-tenure worker, which yields \( q_l = 0.091 \). Note that this calibration implies that it takes on average 10 years for displaced workers to fully regain their initial earnings losses. In this sense, earnings losses are persistent, but not fully permanent. We set the probability that a non-displaced high-tenure worker becomes a low-tenure worker, \( q_h \), so that the implied stationary probability of being a low-tenure worker is equal to \( \pi_l = 1/2 \). This yields \( q_h = 0.051 \). Note that in the model, the average value of earnings losses of displaced workers is \( 0.5 \times 0 + 0.5 \times 0.20 = 0.10 \) (averaged across worker-types and business cycle conditions), and that the average spread of earnings losses is \( 0.5 \times 0 + 0.5 \times 0.14 = 0.07 \). Both values lie at the very low end of the spectrum of estimates obtained by the empirical literature for the mixed sample of workers of all tenure levels (see Section V.1), and in this sense the model calibration is conservative.

For a degree of risk aversion of two, our calibration implies an equilibrium interest rate of \( r = 4.46\% \), which is calculated using the consumption Euler equation (A17) for high-tenure workers. In contrast, the consumption Euler equation for low-tenure worker implies an interest rate of \( r_l = 4.99\% \) (again for a degree of risk aversion of two). Clearly, in the model discussed here, the latter interest rate is not observed in equilibrium since the borrowing constraint for low-tenure workers is binding. But this calculation shows that any model with financial intermediation that creates an interest rate differential of at least \( 4.99\% - 4.46\% = 0.53\% \) between borrowing and lending rate would also support the no-trade allocation \( c_{it} = y_{it} \). Compared to observed differences between borrowing and lending rate, this differential seems moderate, which suggests that abstracting from trade might be a good first approximation.

Tables III and IV show the welfare results using (A20). Not surprisingly, the costs of business cycles for low-tenure workers are lower than what they are in the baseline model (compare tables I and III). However, even though low-tenure worker face no cyclical risk,
their costs of business cycles are non-negligible since they become high-tenure workers in the future. Table IV shows that the costs of business cycles for high-tenure workers are higher than what they are in the baseline model. This result is the net outcome of two opposing forces. On the one hand, earnings losses of displaced workers are not fully permanent, which tends to decrease the cost of business cycles. On the other hand, high-tenure workers face much higher job displacement risk than the workers in the baseline model, which increases the cost of business cycles. Table IV shows that the latter effect dominates. Finally, we note that the social cost of business cycles, calculated using (A21), are very close to the costs of business cycles in the baseline model. More specifically, we have \( \Delta = .49\%, .86\%, 1.5\%, 3.9\% \) for \( \gamma = 1, 2, 3, 4 \), respectively, and these numbers are close to the numbers in the first column in table 1. In this sense, the quantitative results of this paper are robust to introducing earnings recover after job displacement.

VII. Conclusion

This paper analyzed the welfare costs of business cycles when workers face uninsurable job displacement risk that has a cyclical component. Using a simple macroeconomic model with incomplete markets, this paper showed that cyclical variations in the long-term earnings losses of displaced workers can generate arbitrarily large cost of business cycles even if the variance of individual income changes is constant over the cycle. In addition to the theoretical analysis, this paper also conducted a quantitative study of the cost of business cycles using empirical evidence about the long-term earnings losses of displaced U.S. workers. The quantitative analysis suggests that the cost of business cycles due to the cyclical variations in job displacement risk is sizable.

In this paper, the process of long-term earnings losses of displaced workers was taken as given. Clearly, a more detailed analysis of the economic forces behind the cyclical variations in long-term earnings losses would yield important new insights into the cost of business cycles. Such an analysis would require a model that analyzes the search and saving behavior of unemployed, risk averse workers in a setting with idiosyncratic and aggregate shocks.
Moreover, to fully capture the welfare effect discussed here, it seems essential to incorporate skill depreciation during unemployment and/or occupation-specific human capital.\textsuperscript{17} We leave such an analysis for future research.

\textsuperscript{17}See, for example, Pissarides (1992) and Ljungqvist and Sargent (1998) for two macroeconomic contributions that emphasize the skill-depreciation effect of unemployment. Kambourov and Mankovskii (2004) and Rogerson (2005) have recently developed macroeconomic search models with occupation-specific human capital. None of these papers studies models with either risk-averse workers or macroeconomic shocks.
Appendix 1

In this appendix, we construct the equilibrium and derive the welfare expression (7), respectively (8). Notice first that the Euler equations associated with the consumption-saving problem of worker $i$ read

$$c_{it}^{-\gamma} = \beta(1 + r_{t+1})E[c_{i,t+1}^{-\gamma}|F_{it}], \quad (A1)$$

where $F_{it}$ represents the information that is available to household $i$ in period $t$. In the following, we assume that $F_{it}$ contains any variable that has been realized up to time $t$. In particular, it contains $\theta_{it}$, $\eta_{it}$, and $S_t$. In equilibrium, the asset (bond) market must clear. In a closed economy exchange model, this means aggregate saving is zero:

$$\sum_i a_{it} = 0. \quad (A2)$$

Suppose the interest rate is constant and given by:

$$1 + r = \left(\beta E\left[\left(\frac{y_{i,t+1}}{y_{it}}\right)^{-\gamma}\right]\right)^{-1}. \quad (A3)$$

Evaluating the expectations in (A3) using (2) and (3) yields:

$$r = \left(\beta (1 + g)^{-\gamma} e^{\frac{1}{2} g(\gamma + 1)\sigma^2} \sum_s \pi_s \left[ p(1 - d_S)^{-\gamma} + (1 - p) \left(1 + \frac{pd_S}{1 - p}\right)^{-\gamma}\right]\right)^{-1}. \quad (A4)$$

Given this interest rate, the Euler equation (A1) is satisfied if workers consume all their income: $c_{it} = y_{it}$.\(^{18}\) If $c_{it} = y_{it}$, then $a_{it} = 0$ (budget constraint). In Krebs (2004) it is shown that the consumption-saving plan $c_{it} = y_{it}$ and $a_{it} = 0$ also satisfies a corresponding transversality condition if the interest rate is given by (A4) and the following condition is satisfied:

$$\beta E\left[\left((1 + g)^{1-\gamma}(1 + \theta_{i,t+1})(1 + \eta_{i,t+1})\right)^{1-\gamma}\right] \quad (A5)$$

\(^{18}\)Notice that here we use the fact that $\theta_{it}$ and $\eta_{it}$ do not predict future idiosyncratic shocks to income. That is, we have used the fact that $(\theta_{it}, \eta_{it})$ and $(\theta_{i,t+1}, \eta_{i,t+1})$ are uncorrelated. Without this assumption, the Euler equation (A1) would not hold at $a_{it} = 0$ and $c_{it} = y_{it}$.
\[ \beta (1 + g)^{1-\gamma} e^{\frac{1}{2} \gamma (\gamma - 1) \sigma^2} \sum_s \pi_s \left( p(1 - ds)^{1-\gamma} + (1 - p) \left( 1 + \frac{pd_s}{1-p} \right)^{1-\gamma} \right) < 1 \]

In short, the plan \( c_{it} = y_{it} \) and \( a_{it} = 0 \) maximizes expected lifetime utility. Clearly, the choice \( a_{it} = 0 \) also satisfies the market clearing condition (A2), and we have therefore found an equilibrium. Using the preference specification (6) and the definition of the income process (1)-(3), direct calculation yields the formula (7), respectively (8), for equilibrium welfare.

Appendix 2

In this appendix, we prove proposition 2. We have

\[
\text{var} \left[ y_{i,t+1}/y_{it} | S_{t+1} \right] = \text{var} \left[ (1 + g)(1 + \theta_{i,t+1})(1 + \eta_{i,t+1}) | S_{t+1} \right] \quad (A8)
\]

\[ = (1 + g)^2 \text{var} \left[ \theta_{i,t+1} + \eta_{i,t+1} + \theta_{i,t+1} \eta_{i,t+1} | S_{t+1} \right], \]

\[ = (1 + g)^2 \left( \text{var} \left[ \theta_{i,t+1} | S_{t+1} \right] + \text{var} \left[ \eta_{i,t+1} | S_{t+1} \right] + \text{var} \left[ \theta_{i,t+1} \eta_{i,t+1} | S_{t+1} \right] \right) \]

\[ = (1 + g)^2 \left( \text{var} \left[ \theta_{i,t+1} | S_{t+1} \right] + \text{var} \left[ \eta_{i,t+1} | S_{t+1} \right] + \text{var} \left[ \theta_{i,t+1} | S_{t+1} \right] \text{var} \left[ \eta_{i,t+1} | S_{t+1} \right] \right), \]

where the third and fourth lines follow from \( \text{cov} \left[ \theta_{i,t+1}, \eta_{i,t+1} | S_{t+1} \right] = 0 \) and \( E \left[ \theta_{i,t+1} | S_{t+1} \right] = E \left[ \eta_{i,t+1} | S_{t+1} \right] = 0 \).

To simplify the notation, we consider the case of two aggregate states, \( S = L, H \), and also assume that \( d_H = 0 \). Finally, assume constant job displacement rates: \( p_L = p_H = p \). For \( S_{t+1} = H \), we have:

\[
\text{var} \left[ y_{i,t+1}/y_{it} | H \right] = (1 + g)^2 e^{\sigma^2} - 1. \quad (A9)
\]

On the other hand, for \( S_{t+1} = L \) we have:

\[
\text{var} \left[ y_{i,t+1}/y_{it} | L \right] = (1 + g)^2 \left[ e^{\sigma^2} - 1 + \frac{pd^2}{1-p} + \left( e^{\sigma^2} - 1 \right) \frac{pd^2}{1-p} \right]. \quad (A10)
\]

Take any \( \epsilon > 0 \) and \( d \) with \( 0 < d < 1 \), and choose \( p = \frac{\epsilon}{\epsilon + d^2(1+g)^2 e^{\sigma^2}} \). Clearly, by construction we have \( 0 < p < 1 \) and

\[
\text{var} \left[ y_{i,t+1}/y_{it} | L \right] - \text{var} \left[ y_{i,t+1}/y_{it} | H \right] = (1 + g)^2 \frac{pd^2}{1-p} e^{\sigma^2} \quad (A11)
\]
It is left to show that for any number $\bar{\Delta} > 0$ we can find a number $d$ with $0 < d < 1$ (and a corresponding number $p = \frac{\epsilon}{\epsilon + cd^2 (1 + g)^2 e^{\sigma^2}}$) so that the implied welfare cost of business cycles is equal to $\bar{\Delta}$. To simplify notation, introduce $c = (1 + g)^2 e^{\sigma^2} > 0$, so that $p = \frac{\epsilon}{\epsilon + cd^2}$.

Consider the cost of business cycles (15) for $\gamma > 1$ (the argument for the log-utility case is similar). Notice first that the expectations term in (15) can be written as

$$\beta E \left[ (1 + \theta_{i,t+1})^{1-\gamma} \left( 1 + \tilde{\eta}_{i,t+1} \right)^{1-\gamma} \right] = \beta e^{-\frac{1}{2} \sigma^2 (1-\gamma)} f(\epsilon, d)$$

(A12)

and

$$\beta E \left[ (1 + \theta_{i,t+1})^{1-\gamma} \left( 1 + \bar{\eta}_{i,t+1} \right)^{1-\gamma} \right] = \beta e^{-\frac{1}{2} \sigma^2 (1-\gamma)} \bar{f}(\epsilon, d),$$

where we introduced

$$f(\epsilon, d) = \pi_L \left( \frac{\epsilon}{\epsilon + cd^2} (1 - d)^{1-\gamma} + \left( 1 - \frac{\epsilon}{\epsilon + cd^2} \right) \left( 1 + \frac{\epsilon}{\epsilon + cd^2} d \right)^{1-\gamma} \right) + \pi_H$$

(A13)

and

$$\bar{f}(\epsilon, d) = \frac{\epsilon \pi_L}{\epsilon + cd^2} (1 - d \pi_L)^{1-\gamma} + \left( 1 - \frac{\epsilon \pi_L}{\epsilon + cd^2} \right) \left( 1 + \frac{\epsilon \pi_L}{\epsilon + cd^2} d \pi_L \right)^{1-\gamma}.$$

From the fact that $\eta_i$ is a mean-preserving spread of $\bar{\eta}_i$, it follows immediately that

$$\bar{f}(\epsilon, d) < f(\epsilon, d)$$

(A14)

for any $\gamma > 1$. Further, for any $\epsilon > 0$, there is a number $d$ with $0 < d < 1$ so that

$$f(\epsilon, d) = \left( \beta e^{-\frac{1}{2} \sigma^2 (1-\gamma)} \right)^{-1}.$$ 

(A15)

The last equation (A15) follows from the continuity of $f$ in conjunction with $f(\epsilon, 0) = \pi_L + \pi_H = 1$, $\lim_{d \to -1} f(\epsilon, d) = +\infty$, and the fact that the right-hand-side of (A15) is strictly greater than one by assumption (inequality A5). Using (A12)-(A15) in the welfare expression (15) yields the desired result, namely the existence of a $d$ and $p$ so that (A11) is satisfied and the cost of business cycles is equal to $\bar{\Delta}$.
Appendix 3

The income process of the two types of workers is given by (22), respectively (24). As in the basic model, we assume that workers can save at a risk-free rate $r$. However, in contrast to the previous analysis, we assume that workers cannot borrow. Thus, the modified budget constraint reads

$$a_{i,t+1} = (1 + r)a_{it} + y_{it} - c_{it}$$ \hspace{1cm} (A16)

$$a_{i,t+1} \geq 0 \, , \, a_{i0} = 0 .$$

Preference over lifetime consumption are specified as in the basic model.

We define an equilibrium as before. It is again straightforward to show that $c_{it} = y_{it}$ and $a_{it} = 0$ is an equilibrium allocation if condition (A5) is satisfied and the equilibrium interest rate is given by

$$1 + r = \left( \beta E \left[ \frac{y_{i,t+1}}{y_{it}} \right]_{s_{it} = h} \right)^{-1}$$ \hspace{1cm} (A17)

$$= \left( \beta (1 + g)^{-\gamma} e^{\frac{1}{2} \frac{\gamma(\gamma+1)}{2}} \sum_s \pi_s \left[ p_{hs} (1 - d_{hs})^{-\gamma} + (1 - p_{hs}) \left( 1 + \frac{p_{hs} d_{hs}}{1 - p_{hs}} \right)^{-\gamma} \right] \right)^{-1} ,$$

where we used the fact that high-tenure workers are the high-risk workers and $s_{it} = h$ means that worker $i$ is a high-tenure worker in period $t$.

Given the allocation $c_{it} = y_{it}$, we can use the specification of the labor income process and preferences to compute welfare (expected lifetime utility) for each group of workers. Notice first that welfare of low- and high-tenure workers has to satisfy the following recursive equation:

$$V_h(y_i) = \frac{y_i^{1-\gamma}}{1-\gamma} + \beta \sum_s \pi_s p_{hs} E \left[ V_l ((1 + g)(1 + \theta_i)(1 - d_{hs})y_i) \right]$$ \hspace{1cm} (A18)

$$+ \beta \sum_s \pi_s (1 - p_{hs})(1 - q_h) E \left[ V_h \left( (1 + g)(1 + \theta_i)(1 + \frac{p_{hs} d_{hs}}{1 - p_{hs}}) y_i \right) \right]$$

$$+ \beta \sum_s \pi_s (1 - p_{hs}) q_h E \left[ V_l \left( (1 + g)(1 + \theta_i)(1 + \frac{p_{hs} d_{hs}}{1 - p_{hs}}) y_i \right) \right]$$

and

$$V_l(y_i) = \frac{y_i^{1-\gamma}}{1-\gamma} + \beta (1 - q_l) E \left[ V_l \left( (1 + g)(1 + \theta_i)(1 - \frac{q_l E[d_h]}{1 - q_l}) y_i \right) \right]$$
\[ + \beta q_l E \left[ V_h ((1 + g)(1 + \theta_i)(1 + E[d_h]) y_i) \right] \]

Equation (A18) can be directly solved by the methods of undetermined coefficients. That is, it is straightforward that \( V_s(y_i) = a_s \frac{y_i^{1-\gamma}}{1-\gamma} \) solves (A18) if and only of the coefficients \( a_s \) solve the linear equations system:

\[
\begin{pmatrix}
1 - \beta c \sum_S \pi_S (1 - p_{hS})(1 - q_l) \left( 1 + \frac{p_{hS} d_{hS}}{1 - p_{hS}} \right)^{1-\gamma}
\end{pmatrix} a_h
\]

\[= \begin{pmatrix}
\end{pmatrix} a_h \]

\[= \begin{pmatrix}
1 - \beta c \sum_S \pi_S \left( p_{hS}(1 - d_{hS})^{1-\gamma} + (1 - p_{hS}) q_l \left( 1 + \frac{p_{hS} d_{hS}}{1 - p_{hS}} \right)^{1-\gamma} \right) a_l = 1
\]

\[
\begin{pmatrix}
1 - \beta c (1 - q_l) \left( 1 - \frac{q_l E[d_h]}{1 - q_l} \right)^{1-\gamma}
\end{pmatrix} a_l - \left( \beta c q_l (1 + E[d_h])^{1-\gamma} \right) a_h = 1,
\]

where the constant \( c \) is given by:

\[
c = (1 + g)^{1-\gamma} e^{\frac{1}{2} \gamma (\gamma - 1) \sigma^2}.
\]

Repeating the argument made in Section IV, the cost of business cycles for a worker of type \( s \) becomes:

\[
\Delta_s = \left( \frac{\bar{a}_s}{a_s} \right)^{1-\gamma} - 1,
\]

where \((a_l, a_h)\) is the solution to (A19) using state-dependent job displacement parameters \( p_{hS}, d_{hS} \) (economy with business cycles) and \((\bar{a}_l, \bar{a}_h)\) is the solution to (A19) using state-independent job displacement parameters \( \bar{p}_h \) and \( \bar{d}_h \) (economy without business cycles).

Finally, we can define the social cost of business cycles, defined as the number, \( \Delta \), which solves equation (14) when the expectations is also taken over possible worker-types. The social cost of business cycles is given by

\[
\Delta = \left( \frac{\pi_l \bar{a}_l + (1 - \pi_l) \bar{a}_h}{\pi_l a_l + (1 - \pi_l) a_h} \right)^{1-\gamma} - 1,
\]

where \( \pi_l \) stands for the stationary probability that a worker is a low-tenure worker (the fraction of low-tenure workers in the economy).
References


Working Paper, University of Rochester.


Table I. Cost of Business Cycles: Baseline Economy\(^{19}\)

<table>
<thead>
<tr>
<th>Method 1</th>
<th>Method 2</th>
<th>(p_L = p_H)</th>
<th>log-normal</th>
<th>CM</th>
</tr>
</thead>
<tbody>
<tr>
<td>(\gamma = 1)</td>
<td>.527%</td>
<td>.247%</td>
<td>.003%</td>
<td>0%</td>
</tr>
<tr>
<td>(\gamma = 2)</td>
<td>.982%</td>
<td>.479%</td>
<td>.005%</td>
<td>0%</td>
</tr>
<tr>
<td>(\gamma = 3)</td>
<td>1.787%</td>
<td>.908%</td>
<td>.008%</td>
<td>0%</td>
</tr>
<tr>
<td>(\gamma = 4)</td>
<td>4.092%</td>
<td>2.183%</td>
<td>.014%</td>
<td>0%</td>
</tr>
</tbody>
</table>

Table II. Cost of Recessions: Baseline Economy\(^{20}\)

<table>
<thead>
<tr>
<th>(p_L \neq p_H)</th>
<th>(p_L = p_H)</th>
<th>CM</th>
</tr>
</thead>
<tbody>
<tr>
<td>(\gamma = 1)</td>
<td>1.351%</td>
<td>1.069%</td>
</tr>
<tr>
<td>(\gamma = 2)</td>
<td>2.425%</td>
<td>1.914%</td>
</tr>
<tr>
<td>(\gamma = 3)</td>
<td>4.217%</td>
<td>3.304%</td>
</tr>
<tr>
<td>(\gamma = 4)</td>
<td>9.000%</td>
<td>6.880%</td>
</tr>
</tbody>
</table>

\(^{19}\)Costs of business cycles are expressed as percentage of lifetime consumption (equation (16)). The first and second columns assume displacement rates of \(p_L = .05\) and \(p_H = .03\), whereas the third column assumes \(p_L = p_H = .04\). The earnings losses are \(d_L = .21\) and \(d_H = .09\). Method 1 (first column) uses equation (13) and method 2 (second column) uses equation (12) to eliminate business cycles. CM (fifth column) stands for complete markets.

\(^{20}\)Costs of recessions are expressed as percentage of lifetime consumption and are calculated using equation (16) with \(d = d_H\). The first column assumes displacement rates of \(p_L = .05\) and \(p_H = .03\), whereas the second column assumes \(p_L = p_H = .04\). The earnings losses are \(d_L = .21\) and \(d_H = .09\). CM (fifth column) stands for complete markets.
Table III. Cost of Business Cycles: Low-Tenure Worker

<table>
<thead>
<tr>
<th></th>
<th>Method 1</th>
<th>Method 2</th>
<th>( p_L = p_H )</th>
<th>CM</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \gamma = 1 )</td>
<td>.420 %</td>
<td>.203 %</td>
<td>.203 %</td>
<td>0 %</td>
</tr>
<tr>
<td>( \gamma = 2 )</td>
<td>.703 %</td>
<td>.355 %</td>
<td>.357 %</td>
<td>0 %</td>
</tr>
<tr>
<td>( \gamma = 3 )</td>
<td>1.241 %</td>
<td>.666 %</td>
<td>.659 %</td>
<td>0 %</td>
</tr>
<tr>
<td>( \gamma = 4 )</td>
<td>3.365 %</td>
<td>2.069 %</td>
<td>1.835 %</td>
<td>0 %</td>
</tr>
</tbody>
</table>

Table IV. Cost of Business Cycles: High-Tenure Worker

<table>
<thead>
<tr>
<th></th>
<th>Method 1</th>
<th>Method 2</th>
<th>( p_L = p_H )</th>
<th>CM</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \gamma = 1 )</td>
<td>.613 %</td>
<td>.296 %</td>
<td>.296 %</td>
<td>0 %</td>
</tr>
<tr>
<td>( \gamma = 2 )</td>
<td>1.159 %</td>
<td>.587 %</td>
<td>.589 %</td>
<td>0 %</td>
</tr>
<tr>
<td>( \gamma = 3 )</td>
<td>2.085 %</td>
<td>1.112 %</td>
<td>1.109 %</td>
<td>0 %</td>
</tr>
<tr>
<td>( \gamma = 4 )</td>
<td>4.829 %</td>
<td>2.886 %</td>
<td>2.650 %</td>
<td>0 %</td>
</tr>
</tbody>
</table>

Costs of business cycles are expressed as percentage of lifetime consumption (equation (16)). The earnings losses of high-tenure workers are \( d_{hL} = .28 \) and \( d_{hH} = .12 \). Low-tenure workers face no displacement risk. The first and second columns assume displacement rates of \( p_{hL} = .05 \) and \( p_{hH} = .03 \), whereas the third column assumes \( p_{hL} = p_{hH} = .04 \). Method 1 (first column) uses equation (13) and method 2 (second column) uses equation (12) to eliminate business cycles. CM (fourth column) stands for complete markets.