Economics Working Papers

2012-19

Business Cycle Dependent Unemployment Benefits with Wealth Heterogeneity and Precautionary Savings

Mark Strøm Kristoffersen

As of January 2012 ECON-ASB working papers are included in Economics Working Papers

AARHUS UNIVERSITY
BUSINESS AND SOCIAL SCIENCES
DEPARTMENT OF ECONOMICS AND BUSINESS

Business Cycle Dependent Unemployment Benefits with Wealth Heterogeneity and Precautionary Savings *

Mark Strøm Kristoffersen†

August 29, 2012

Abstract

In the wake of the financial and economic crisis the discussion about social insurance and optimal stabilization policies has re-blossomed. This paper adds to the literature by studying the effects of a business cycle dependent level of unemployment benefits in a model with labor market matching, wealth heterogeneity, precautionary savings, and aggregate fluctuations in productivity. The results are ambiguous: both procyclical and countercyclical unemployment benefits can increase welfare relative to business cycle invariant benefits. Procyclical benefits are beneficial due to countercyclicality of the distortionary effect (on job creation) from providing unemployment insurance, whereas countercyclical benefits facilitate consumption smoothing.

JEL classification: E32, H3, J65.
Keywords: Unemployment insurance, business cycles, wealth heterogeneity, precautionary savings.

*Comments from Torben M. Andersen, Mikkel N. Hermansen, Nicolas Petrosky-Nadeau, Rune M. Vejlin as well as participants in seminars at Aarhus University, in the 2012 annual meeting of the Danish Econometric Society, and in the 6th Nordic Summer Symposium in Macroeconomics are gratefully acknowledged. All remaining errors are, of course, my own.

†Aarhus University, Department of Economics and Business, e-mail address: mkristoffersen@econ.au.dk.

1 Introduction

In the wake of the financial and economic crisis the discussion about social insurance and optimal stabilization policies has re-blossomed. To let labor market policies, e.g. the unemployment insurance scheme, depend on the position of the business cycle has been emphasized as a way to strengthen both social insurance and the (automatic) stabilization of economic fluctuations, but the literature (both theoretical and empirical) on these subjects is still of modest size.

The optimal design of unemployment insurance (UI) has been studied for several years, see Fredriksson & Holmlund (2006) for a survey of the literature. However, only recently the literature has started to investigate the effects of UI across the business cycle. The firsts to consider UI in a business cycle context were Kiley (2003), Sánchez (2008), and Andersen & Svarer (2011*b*), who all used static models not allowing for shifts between good and bad times.

Recently, the literature has been fast-growing, and business cycle dependent UI is now being analyzed in dynamic models allowing for shifts between recessions and booms, see[1] Moyen & Stähler (2009), Andersen & Svarer (2010), Kroft & Notowidigdo (2010), Landais, Michaillat & Saez (2010), Mitman & Rabinovich (2011), Jung & Kuester (2011), Ek (2012), and Schuster (2012). However, the conclusions are open as some papers suggest that unemployment benefits (both level and duration) should be countercyclical, i.e., the UI system should be more generous in bad times than in good times, whereas others suggest procyclical UI generosity.

Importantly, all of the above do not allow for savings, and thus, they neither allow for wealth heterogeneity nor partial self-insurance in the form of precautionary savings.[2]

Accounting for precautionary savings is potentially very important when studying the insurance effects of unemployment benefits. The opportunity for individuals to self-insure has important consequences for optimal UI, as shown by Abdulkadiroğlu, Kuruşçu & Şahin (2002). They also show that UI schemes which are designed ignoring the possibility of partial self-insurance via savings can actually be harmful to the economy.

Accounting for the heterogeneity of economic agents, e.g. wealth heterogeneity, has proven to be crucial when answering important economic questions. As an example, the welfare costs of business cycles are orders of magnitude larger in models with heterogeneous agents than originally suggested by Lucas (1987, 2003), see e.g. Storesletten, Telmer & Yaron (2001), and Krusell, Mukoyama, Şahin & Smith (2009). For surveys of the fast growing literature with heterogeneous agents models see Heathcote, Storesletten & Violante (2009), and Guvenen

[1]For considerations about the practical implementation of business cycle contingent unemployment insurance along with more thorough reviews of this literature (both the theoretical and the empirical) see Andersen & Svarer (2009, 2011*a*).

[2]Landais et al. (2010) briefly consider self-insurance in the form of home production in their one-period model.

(2011).

Several papers have studied unemployment insurance in models with savings and heterogeneous agents, see Young (2004), Pollak (2007), Reichling (2007), Lentz (2009), Krusell, Mukoyama & Şahin (2010), Vejlin (2011), and Mukoyama (2011). However, none of these papers study unemployment insurance in a business cycle context.

In this sense, Costain & Reiter (2005) are more related to this paper. They find that procyclical social security contributions are optimal, while unemployment benefits should be almost constant across states. However, their model is different from the model used in this paper in some respects, for example their asset structure is more simplistic, i.e., the interest rate is fixed, there is no physical capital in the production process, and wages are independent of asset holdings.

This paper studies the effects of a business cycle dependent level of unemployment benefits in a model with wealth heterogeneity and precautionary savings. We use the model with aggregate fluctuations in productivity from Krusell et al. (2010), who only explicitly analyze UI in the steady state version of their model. Since labor supply and search effort are both exogenous, UI does not cause moral hazards, and therefore the optimal UI scheme does not trade off insurance and incentives to work/search, but instead it trades off insurance and job creation. The model is basically a merger between two strands of the literature: *i*) the Bewley-Huggett-Aiyagari model,[3] where risk-averse consumers face idiosyncratic earnings risks, against which they can only insure partially (through savings), and *ii*) the Diamond-Mortensen-Pissarides (DMP) search/matching model[4] of the labor market, where equilibrium unemployment and vacancies are determined endogenously.

The model is calibrated to US data, and we find that both procyclical and countercyclical unemployment benefits can increase welfare relative to business cycle invariant benefits. Procyclical UI is beneficial because the distortionary effect of UI (on job creation) is countercyclical, whereas countercyclical UI is beneficial because it facilitates consumption smoothing and raises mean consumption. It turns out that there is a non-monotone relationship between these counteracting effects. The largest welfare gain (in consumption equivalent terms) is obtained by having procyclical unemployment benefits when UI benefits are conditioned on (current) productivity. This finding is robust to changing the calibration strategy, but it turns out that the chosen calibration strategy is crucial for the magnitude of the welfare gain obtained by shifting from constant UI across the business cycle to procyclical UI benefits. However, if UI benefits are conditioned on either the unemployment level or lagged productivity instead and the public

[3] See Bewley (n.d.), Huggett (1993), and Aiyagari (1994).

[4] See Diamond (1981), Pissarides (1985), and Mortensen & Pissarides (1994).

budget is allowed to work as a buffer, the largest welfare gain is achieved from countercyclical UI generosity.

The rest of the paper is structured as follows: The model is presented in Section 2, and Section 3 explains how the model is solved numerically. Section 4 considers the effects of business cycle dependent unemployment benefits, whereas Section 5 contains various robustness checks. Finally, Section 6 concludes.

2 Model

We use the model with aggregate productivity shocks from Krusell et al. (2010) with some minor extensions. Time is discrete. Following Krusell & Smith (1998) it is assumed that aggregate productivity[5] z takes on two values, $z = g$ in good periods, and $z = b$ in bad periods (with $g > b > 0$), and it follows a first-order Markov process, where the probability of moving from state z to state z' is denoted $\pi_{zz'} \in [0, 1]$.

2.1 Matching

The labor market has a Diamond-Mortensen-Pissarides search & matching structure. Thus, unemployed workers and vacant jobs coexist, and existing matches between a worker and a firm are assumed to be separated at the exogenous rate $\sigma \in (0, 1)$.

Unemployed workers and vacant jobs are randomly matched according to the aggregate matching function $M(u, v)$, which exhibits constant returns-to-scale and is increasing in both arguments. u is the number of unemployed workers, and v is the number of vacancies. Thus, the job finding probability λ_w is

$$\lambda_w = \frac{M(u, v)}{u} = M\left(1, \frac{v}{u}\right) = M(1, \theta)$$

where the vacancy-unemployment ratio is defined as $\theta \equiv \frac{v}{u}$. The worker finding probability λ_f is

$$\lambda_f = \frac{M(u, v)}{v} = M\left(\frac{u}{v}, 1\right) = M\left(\theta^{-1}, 1\right).$$

Hence, the law of motion for the unemployment rate u is given by

$$u' = (1 - \lambda_w) u + \sigma (1 - u) \tag{1}$$

[5] For notational convenience time subscripts are left out throughout the model description.

where a prime ($'$) denotes a next period variable.

2.2 Asset structure

It is assumed that no markets exist for insurance against idiosyncratic employment shocks. However, there exist two assets, capital k and equity x, where capital is used in the production process and the equity is a claim for aggregate firm profits.

The joint distribution of assets and employment across consumers is denoted S, and the aggregate state in any given period is governed by (z, S).

Next period's distribution of assets is determined in this period since it depends only on the consumers' asset accumulations and portfolio choice decisions. Likewise, next period's distribution of the employment statuses[6] (the fraction being employed and unemployed, respectively) is also determined in this period since it follows from the law of motion of aggregate unemployment in (1). Therefore, the joint distribution of assets and employment across consumers in the next period is determined in this period, and we can write

$$S' = \Omega(z, S). \tag{2}$$

Hence, the aggregate state in the next period is either (g, S') or (b, S').

Let the consumer's state variable be

$$a \equiv [1 + r(z, S) - \delta]\, k + [p(z, S) + d(z, S)]\, x$$

which is total asset holdings of the individual, and where δ is the depreciation rate of capital; $r(z, S)$ is the interest rate; $p(z, S)$ is the equity price; $d(z, S)$ is the dividend.

Like Krusell et al. (2010) we implement the portfolio choice by considering two Arrow securities, each paying one unit of the consumption good in a given state and nothing in the other state. This implementation is without loss of generality since the two assets, aggregate capital and equity, can be used to create these securities. Investment firms carry out this transformation, see below.

Let $Q_{z'}(z, S)$ denote the price of an Arrow security that provides one unit of the consumption good in the next period if and only if the next period aggregate productivity is z' when the

[6] Note that only the aggregate distribution of employment statuses is determined this period. Next period's employment state is still uncertain at the individual level.

current state is (z, S). Then, the asset prices must satisfy the following no-arbitrage conditions

$$
\begin{aligned}
1 &= Q_g(z, S)\left[1 - \delta + r(g, S')\right] + Q_b(z, S)\left[1 - \delta + r(b, S')\right] &(3)\\
p(z, S) &= Q_g(z, S)\left[p(g, S') + d(g, S')\right] + Q_b(z, S)\left[p(b, S') + d(b, S')\right]. &(4)
\end{aligned}
$$

since we can perfectly track the returns on capital and equity by investing in the two Arrow securities.

2.3 Consumers

There is a continuum of consumers with mass 1, and these are either employed $(1-u)$ or unemployed (u). The consumers face an exogenous borrowing constraint at $\underline{a}$ and are heterogeneous with respect to employment status and asset holdings. Labor supply and search effort are both exogenous.

2.3.1 Unemployed consumers

Let $a'_{z'}$ denote the consumer's demand for an Arrow security that pays out one unit of the consumption good in the next period if and only if the next period's aggregate productivity turns out to be z'. The unemployed worker's optimization problem is

$$
\begin{aligned}
U(a; z, S) = \max_{c, a'_g \geq \underline{a}, a'_b \geq \underline{a}} & \; u(c) + \beta \left\{ \pi_{zg} \left[(1 - \lambda_w(z, S)) U\left(a'_g; g, S'\right) + \lambda_w(z, S) W\left(a'_g; g, S'\right) \right] \right. \\
& \left. + \pi_{zb} \left[(1 - \lambda_w(z, S)) U\left(a'_b; b, S'\right) + \lambda_w(z, S) W\left(a'_b; b, S'\right) \right] \right\}
\end{aligned}
$$

subject to

$$
c + Q_g(z, S) a'_g + Q_b(z, S) a'_b = a + h - T \quad \text{and} \quad S' = \Omega(z, S)
$$

where $u(\cdot)$ is an increasing and strictly concave instantaneous utility function; c is the consumption level; $\beta \in (0, 1)$ is the discount factor; $\lambda_w(z, S)$ is the job finding probability defined above; h is unemployment benefits before tax; T is a lump-sum tax paid by all consumers; $U(a; z, S)$ is the value of being unemployed with asset holding a, and $W(a; z, S)$ is the value of being employed taking the wage determination into account.

Let the decision rule, i.e., the optimal solution to the optimization problem, for $a'_{z'}$ be $\psi^u_{z'}(a; z, S)$.

2.3.2 Employed consumers

The employed worker's optimization problem is

$$\begin{aligned}\widetilde{W}(w,a;z,S) &= \max_{c,a'_g\geq\underline{a},a'_b\geq\underline{a}} u(c)+\beta\left\{\pi_{zg}\left[\sigma U\left(a'_g;g,S'\right)+(1-\sigma)W\left(a'_g;g,S'\right)\right]\right.\\ &\left.+\pi_{zb}\left[\sigma U\left(a'_b;b,S'\right)+(1-\sigma)W\left(a'_b;b,S'\right)\right]\right\}\end{aligned}$$

subject to

$$c+Q_g(z,S)\,a'_g+Q_b(z,S)\,a'_b=a+w-T \quad\text{and}\quad S'=\Omega(z,S)$$

where w is the wage. Hence, $\widetilde{W}(w,a;z,S)$ is the value of being employed given the wage w, and $W(a;z,S)$ is the value of being employed when taking the wage determination into account. Denoting the wage function, i.e., the outcome of the wage determination, as $w=\omega(a;z,S)$ the relationship is

$$W(a;z,S)\equiv\widetilde{W}(\omega(a;z,S),a;z,S).$$

Let the decision rule for $a'_{z'}$ be $\widetilde{\psi}^e_{z'}(w,a;z,S)$ for a given wage, and define

$$\psi^e_{z'}(a;z,S)\equiv\widetilde{\psi}^e_{z'}(\omega(a;z,S),a;z,S).$$

2.4 Firms

Assume a one-firm-one-job structure. To find a vacant worker the firm posts a vacancy. The value of a vacancy, $V(z,S)$, is

$$\begin{aligned}V(z,S) &= -\xi\\ &+Q_g(z,S)\left[(1-\lambda_f(z,S))V(g,S)+\lambda_f(z,S)\int J\left(\psi^u_g(a;z,S);g,S'\right)\frac{f_u(a;S)}{u}da\right]\\ &+Q_b(z,S)\left[(1-\lambda_f(z,S))V(b,S')+\lambda_f(z,S)\int J\left(\psi^u_b(a;z,S);b,S'\right)\frac{f_u(a;S)}{u}da\right]\end{aligned}$$

where ξ is the vacancy cost; $\lambda_f(z,S)$ is the worker finding probability defined above; $f_u(a;S)$ is the population of unemployed workers with asset holdings a, and thus, $f_u(a;S)/u$ is the density function of the unemployed workers over a; $J(a;z,S)$ is the value of a filled job taking the wage determination into account, and hence, the integrals show the expected value of matching with an unemployed worker (given a future state) taking the wage determination and the individual decision rules into account. The firm discounts future values by the Arrow security prices since these are the rates at which the non-constrained consumers discount future states.[7] There is free entry of firms which implies that firms post vacancies $v(z, S)$ until $V(z, S) = 0$.

A matched firm rents capital from the consumers at a rental rate of $r(z, S)$ and pays the worker a wage w. The value of a filled job given the wage w, $\widetilde{J}(w, a; z, S)$, is therefore

$$\begin{aligned}\widetilde{J}(w, a; z, S) &= \widetilde{\pi}(w; z, S) + Q_g(z, S)\left[\sigma V(g, S') + (1-\sigma) J\left(\widetilde{\psi}_g^e(w, a; z, S); g, S'\right)\right] \\ &+ Q_b(z, S)\left[\sigma V(b, S') + (1-\sigma) J\left(\widetilde{\psi}_b^e(w, a; z, S); b, S'\right)\right]\end{aligned}$$

where the instantaneous profit is defined as $\widetilde{\pi}(w; z, S) \equiv \max_k \{zF(k) - r(z, S)k - w\}$, and $zF(k)$ is the production function, which is increasing and strictly concave in the capital input k. Again, we can define

$$J(a; z, S) \equiv \widetilde{J}(\omega(a; z, S), a; z, S).$$

The first-order condition implies $r(z, S) = zF'(k)$. Symmetry implies that in equilibrium each firm has the same capital stock, and the capital stock per job is $\tilde{k} = \hat{k}/(1-u)$, where $\hat{k}$ is the aggregate capital stock. Therefore, the equilibrium profit can be written as

$$\pi(a; z, S) \equiv zF\left(\tilde{k}\right) - r(z, S)\tilde{k} - \omega(a; z, S). \tag{5}$$

The dividend is then calculated as the total profits minus the total vacancy costs, that is

$$d(z, S) = \int \pi(a; z, S) f_e(a; S)\, da - \xi v \tag{6}$$

i.e., aggregated profits over all firms (=all jobs) since $f_e(a; S)$ is the population of employed workers with asset holdings a.

2.5 Wages

When an unemployed worker and a vacant job get matched, the wage is determined through Nash Bargaining. Thus, the wage in a match including a worker with asset holdings a solves

$$\max_w \left(\widetilde{W}(w, a; z, S) - U(a; z, S)\right)^\gamma \left(\widetilde{J}(w, a; z, S) - V(z, S)\right)^{1-\gamma}$$

where $\gamma \in (0, 1)$ is the bargaining power of the worker. The solution is described by $w = \omega(a; z, S)$.

[7] In the numerical solution of the model it turns out that very few (if any) consumers have a binding borrowing constraint.

The bargained wage depends on the asset holdings of the worker, because these affect both the worker's outside option in the current period and the chosen asset holdings next period (contingent on the future aggregate state).[8]

2.6 Investment firms

We envision competitive investment firms who sell contingency claims to consumers by rearranging capital and equity. Asset market clearing requires

$$\int \psi_{z'}^{e}(a; z, S)\, f_e(a; S)\, da + \int \psi_{z'}^{u}(a; z, S)\, f_u(a; S)\, da = \left(1 - \delta + r(z', S')\right) \hat{k}' + p(z', S') + d(z', S') \tag{7}$$

for each z', together with the no-arbitrage conditions (3) and (4).

2.7 Government

The government provides (partial) unemployment insurance as it pays out unemployment benefits to the unemployed workers. This is financed via a lump-sum tax levied on all consumers. Assume (for now) that the public budget has to balance each period, that is

$$T = uh \tag{8}$$

i.e., the tax revenue equals total public expenditures.

3 Solving the model

This section explains how the model is solved numerically. Furthermore, it briefly discusses, how the economy behaves in the benchmark of constant UI benefits across the business cycle.

3.1 Computation

In Appendix A it is shown that the resource balance condition (goods-market equilibrium condition)

$$\hat{c} + \left[\hat{k}' - (1 - \delta)\hat{k}\right] = zF\left(\tilde{k}\right)(1 - u) - \xi v \tag{9}$$

[8] Note that the wage is reset every period, also for pre-existing matches. Thus, it is implicitly assumed that firms cannot commit to future wages.

is fulfilled, where $\hat{c}$ is aggregate private consumption. That is, aggregate private consumption plus investments equal aggregate output (net of aggregate vacancy costs), where we can define $\hat{y} \equiv zF\left(\tilde{k}\right)(1-u) - \xi v$.

Furthermore, for a complete definition of the recursive competitive equilibrium see Krusell et al. (2010). Their appendix also contains a detailed description on how to solve the model numerically, and therefore this section only summarizes the method used.

Using the idea of Krusell & Smith (1998), consumers are assumed to have bounded rational perceptions of the evolutions of key economic variables, i.e., we apply the method of "approximate aggregation".[9] Hence, consumers perceive the next period aggregate capital stock, $\hat{k}'$, as a (log-linear) function of $\left(z, \hat{k}, u\right)$. The same is true for this period's θ, p, d, and Q_g (or Q_b, see below). Krusell et al. (2010) show that these simple prediction rules are highly accurate with R^2s above 0.999, and with very small forecasting and prediction errors.

The numerical solution[10] of the model proceeds as follows (using the $z = g$ case for illustration): **1**) Guess on the law of motion for aggregate capital, i.e., $\hat{k}'$ as a (log-linear) function of $\left(z, \hat{k}, u\right)$. **2**) Guess on coefficients of the prediction rules for θ, p, d and Q_g as (log-linear) functions of $\left(z, \hat{k}, u\right)$. **3**) Calculate u' from the law of motion in (1). **4**) Calculate Q_b using the no-arbitrage condition in (3) and the first three steps. **5**) Perform the individual maximization and determine the wages from the Nash bargaining. **6**) Simulate the economy for many periods[11] using the results from the previous steps, and update the forecasting and prediction rules using the data from the simulation. Iterate until the forecasting and prediction rules converge (gain sufficient accuracy). The resulting forecasting and prediction rules for the standard case are presented in Appendix B.

3.2 Calibration

We apply the calibration of Krusell et al. (2010) who calibrate the model to fit US data. A period is chosen to be six weeks. The production function is $zF(k) = zk^{\alpha}$. The parameters $\alpha = 0.3$, $\delta = 0.01$, and $\beta = 0.995$ are chosen using three calibration targets: a capital share of 0.3, an investment-output ratio of 0.2, and an annual rate of return on capital of 0.04. Also, the borrowing constraint is chosen as $\underline{a} = 0$. The utility function is $u(c) = \log(c)$.

[9] Without this assumption, consumers needed to know the law of motion for the entire distribution of agents, which is an infinite-dimensional object. "Approximate aggregation" assumes that a finite set of moments is sufficient for forecasting future economic variables.

[10] We use 60 grid points in the a direction for the value functions, 15 points in the a direction for the wage function, 4 points in both the $\hat{k}$ and the u direction. We interpolate between grid points using cubic splines in the a direction and linear interpolation in the other directions.

[11] The economy is simulated for 2000 periods, and we disregard the first 500 periods.

Following Cooley & Prescott (1995) the productivity levels are chosen to be $g = 1.02$ and $b = 0.98$ yielding an unconditional mean productivity of 1. Following Krusell & Smith (1999) and Krusell et al. (2009) the average duration of each boom (or recession) is set to two years, i.e., 16 periods in this model, which implies $\pi_{bb} = \pi_{gg} = 0.9375$ with[12] $\pi_{bg} = 1 - \pi_{bb}$ and $\pi_{gb} = 1 - \pi_{gg}$.

In the standard case, the matching parameters are calibrated following Shimer (2005). In the benchmark with constant unemployment benefits across the business cycle we set $h = 0.99$, which turns out to be approximately 40% of the average wage. The separation rate is $\sigma = 0.05$. The matching function is $M(u, v) = \chi u^{\eta} v^{1-\eta}$. Aiming for $\theta = 1$ in equilibrium pins down $\chi = 0.6$. Furthermore, $\xi = 0.5315$ is chosen such that $\theta = 1$ satisfies the free-entry condition. Finally, $\eta = \gamma = 0.72$, again following Shimer (2005).

3.3 Benchmark

This section briefly discusses the benchmark case of invariant UI benefits across the business cycle. Table 1 summarizes the means and fluctuations of the key economic variables across the business cycle.

Table 1: Summary statistics for the benchmark of invariant UI benefits

	z	u	v	θ	$\hat{k}$	$\bar{w}$	h
mean	1.0000	0.0768	0.0771	1.0039	66.955	2.4818	0.9900
Δ_g	+2.00%	−0.63%	+2.36%	+2.99%	+0.43%	+2.01%	0.00%
	T	$\overline{RR}$	p	d	r	$\hat{y}$	$\hat{c}$
mean	0.0761	0.3801	0.9061	0.0042	0.0150	3.2966	2.6321
Δ_g	−0.63%	−2.04%	+2.06%	+56.17%	+1.74%	+2.16%	+0.44%

Note: **mean** denotes the unconditional mean, i.e., $0.5(\bar{x}_g + \bar{x}_b)$, where $\bar{x}_{\tilde{z}}$ is the average of x across periods with $z = \tilde{z}$. Δ_g is the percentage deviation of the average across good states from the unconditional mean. Thus, per definition $\Delta_b = -\Delta_g$, and only Δ_g is shown. $\bar{w}$ is the average wage; $\overline{RR} \equiv \frac{h-T}{\bar{w}-T}$ is the average replacement ratio; $\hat{y}$ is the aggregate output (net of vacancy costs); $\hat{c}$ is the aggregate consumption.

From Table 1 it is seen that the benchmark economy behaves as expected in several aspects. Vacancy creation, and thereby also the v-u ratio, is procyclical. Hence, the job finding rate is procyclical, which leads to a countercyclical unemployment rate. Thus, there is a clear negative relationship between aggregate productivity and unemployment, and the correlation is $corr(z, u) = -0.82$.

[12] The unconditional probability of being in a bad state is thus $\Pr(z = b) = \frac{1-\pi_{gg}}{2-\pi_{bb}-\pi_{gg}} = \frac{\pi_{gb}}{\pi_{gb}+\pi_{bg}} = \frac{1}{2}$, cf. Hamilton (1994, p. 683), and similarly $\Pr(z = g) = \frac{\pi_{bg}}{\pi_{gb}+\pi_{bg}} = \frac{1}{2}$.

Due to the balanced budget requirement, the lump-sum tax is countercyclical as UI expenditures are higher during recessions where more workers are unemployed. The average wage is near-proportional to z, and wages are procyclical. This makes the average replacement ratio countercyclical, i.e., the income of an unemployed worker relative to the (average) income of an employed worker is higher in bad times than in good times.

The dividend is highly procyclical because profits are very volatile. Finally, aggregate output (net of vacancy costs) is procyclical, while aggregate consumption is only slightly procyclical, i.e., consumers are to a large extent able to smooth consumption out over the business cycle.

Table 1 also reveals that the fluctuations in u, v, and θ over the business cycle are very small. This is a well-known result from e.g. Shimer (2005). As a robustness check, in Section 5.2 we use a different calibration strategy inspired by Hagedorn & Manovskii (2008), which delivers much more reasonable fluctuations in these key business cycle variables.

Finally, the Gini coefficient[13] for wealth in the benchmark economy is 0.3153 on average across the business cycle, and it is 0.03% higher in good states.

4 Business cycle dependent unemployment benefits

This section analyzes the effects of allowing unemployment benefits to depend on the position of the business cycle. Similar to Costain & Reiter (2005), we assume that the government is interested in the welfare consequences of a UI scheme where the level of unemployment benefits depends linearly on aggregate productivity, that is[14]

$$h = \overline{h} + \phi_z \frac{z - \overline{z}}{\overline{z}} \tag{10}$$

where $\overline{z}$ is the average aggregate productivity across the business cycle; $\overline{h}$ is the benefit level when aggregate productivity equals its average; ϕ_z is the policy choice variable, and it determines the degree of business cycle dependence. A positive (negative) ϕ_z implies pro(counter)-cyclical benefits, while $\phi_z = 0$ implies a business cycle independent UI level (the benchmark).

[13]Numerically, the Gini coefficient for wealth is calculated as $G = 1 - \frac{\sum_{i=1}^{n} f(a_i)(\Gamma_i + \Gamma_{i-1})}{\Gamma_n}$, where $\Gamma_i \equiv \sum_{j=1}^{i} f(a_j) a_j$, $\Gamma_0 = 0$, $f(a)$ is the discrete probability density function of asset holdings, and n is the number of grid points in the asset distribution, see e.g. Xu (2004).

[14]This UI scheme does not allow unemployment benefits to depend on the whole history of shocks but only on the current period shock, which has a practical implementation appeal more than a purely theoretical appeal. Furthermore, note that choosing $\overline{h}$ as in section 3.2 implies that the average level of unemployment benefits is unaffected compared to Krusell et al. (2010).

4.1 Welfare measure

Consider the welfare consequences of changing ϕ_z from the benchmark of invariant unemployment benefits ($\phi_z = 0$). In order to be able to calculate the expected welfare gain for each individual, we will make the experiment of moving an individual along with its asset level and employment status from the benchmark economy to an economy with a different ϕ_z. As is typical in this literature the welfare consequences of such experiments can be found following Lucas (1987). The welfare gain, μ, can be calculated from[15,16]

$$E_0\left[\sum_{t=0}^{\infty}\beta^t \log\left((1+\mu)\, c_t\right)\right] = E_0\left[\sum_{t=0}^{\infty}\beta^t \log\left(c_t^{EXP}\right)\right]$$

where c_t is the individual's consumption under the benchmark case (business cycle invariant benefits), and c_t^{EXP} is the individual's consumption under the experiment (holding fixed the individual's asset level and employment status in the initial period). Thus, μ measures the consumption equivalent, i.e., by how much should the individual be permanently compensated in terms of consumption if not moving to the "new economy". Hence, $\mu > 0$ ($\mu < 0$) means that the individual gains (loses) from the experiment.

One advantage of the present welfare measure is that one can calculate the expected welfare gain for each individual in the benchmark economy, i.e., it is possible to distinguish between poor and rich workers. A potentially important drawback of this welfare measure is the discrepancy between actual aggregate asset holdings in the economy and the asset holdings aggregated over all the individuals moved to the new economy (one by one). The same applies for actual aggregate employment versus employment aggregated over the moved individuals. Therefore, as a robustness check, one can apply the standard utilitarian welfare measure. Hence, we calculate the mean welfare for different ϕ_z's and compare this to the mean welfare for $\phi_z = 0$, where welfare in a given period is defined as

$$\int W(a; z, S)\, f_e(a; S)\, da + \int U(a; z, S)\, f_u(a; S)\, da$$

i.e., we use the actual distribution of asset holdings and employment statuses, and not the benchmark distribution. When solving the model numerically, it has always been the case that the two approaches provide equivalent conclusion, i.e., all results regarding the optimality of

[15] In practice, μ is found by rearranging to $\mu = \exp\left[\left(V^{EXP} - V\right)(1-\beta)\right] - 1$, where $V^{EXP} \equiv E_0\left[\sum_{t=0}^{\infty}\beta^t \log\left(c_t^{EXP}\right)\right]$ and $V \equiv E_0\left[\sum_{t=0}^{\infty}\beta^t \log\left(c_t\right)\right]$. In the tables we present the welfare gain in percentage, i.e., $100 \cdot \mu$.

[16] This welfare measure is also used by e.g. Krusell et al. (2010) and Mukoyama (2011) in models without aggregate shocks, and by Costain & Reiter (2005) and Krusell et al. (2009) in models with aggregate shocks.

pro- and countercyclical UI benefits, respectively, are sustained when applying this alternative, utilitarian welfare measure, and therefore only the former welfare measure will be presented below.

4.2 Welfare consequences

Table 2 shows the welfare consequences[17] of moving the agents along with their employment statuses and asset holdings from the benchmark economy with constant unemployment benefits to an economy with business cycle dependent unemployment benefits and slope parameter ϕ_z.

The table shows that both procyclical and countercyclical UI benefits can increase welfare relative to constant UI benefits across the business cycle. The mean welfare gain is largest in case of procyclical UI benefits (with $\phi_z = 1.76$). The unemployed and the employed experience almost the same welfare gains on average. Actually, even the poorest unemployed who face a binding borrowing constraint prefer procyclical benefits. Most of the employed gain in both good and bad periods, whereas the unemployed gain more in good periods than they lose in bad periods. On average, every consumer in the economy gain when moving from the benchmark of constant UI benefits to procyclical UI generosity, which is somewhat surprising.

On the other hand, if the cyclicality of benefits is too strong, e.g. $\phi_z = \pm 10$, both pro- and countercyclical UI benefits are harmful to the agents. Consumers facing a binding borrowing constraint will still gain in periods where benefits (and thus consumption) are raised, but they will lose much more in periods where benefits are lowered due to diminishing marginal utility.

The maximum attainable mean welfare gain is 0.002% of consumption, which is small compared to the welfare gains found in other studies. Mitman & Rabinovich (2011) find that the optimal UI scheme, which overall implies procyclicality of both benefit level and duration, yields a mean welfare gain of 0.67% of consumption compared to the current US system. Ek (2012) considers both differentiated taxes and benefit levels, and she finds that taxes should be procyclical whereas benefits should be countercyclical, which yields a mean welfare gain of 0.01% of consumption compared to the optimal uniform system. However, both these studies ignore savings, and therefore they are likely to overrate the welfare gains from business cycle dependent unemployment benefits since self-insurance is not possible.

In a model allowing for savings, Costain & Reiter (2005) calculates the welfare costs of business cycles to be 0.269% of consumption by comparing their static model, i.e., without

[17] We present the average μ across good periods, $\bar{\mu}_g$, and bad periods, $\bar{\mu}_b$, along with the unconditional mean $0.5\left(\bar{\mu}_g + \bar{\mu}_b\right)$. In contrast, Krusell et al. (2009) choose to pick a random good period and a random bad period. However, the welfare gains are almost constant conditional on aggregate productivity, and therefore the two methods are (almost) equivalent.

aggregate fluctuations, to their dynamic benchmark. They find that the optimal policy with strongly procyclical taxes and slightly procyclical benefits eliminates around 70% of the welfare costs of business cycles, i.e., it implies a mean welfare gain of 0.185% of consumption compared to the dynamic benchmark. In contrast to this paper, Costain & Reiter (2005) do not consider aggregate assets, e.g. physical capital and equity, and thus, implicitly they do not allow for insurance against aggregate shocks. However, they are able to calculate the welfare costs of business cycles in the case where "aggregate insurance" is attained. Using this, the welfare gain from the optimal policy described above is 0.049% of consumption relative to the case with "aggregate insurance". This seems to be the relevant number for comparison with this paper, and their number is much larger for two reasons: *i*) the calibration strategy, cf. Section 5.2, and *ii*) Costain & Reiter (2005) consider two policy variables, the cyclicality of benefits and the cyclicality of the public deficit, against only one, the cyclicality of benefits, in this paper where the public budget (for now) is required to balance each period. The welfare gains suggested by both Costain & Reiter (2005) and Ek (2012) primarily stem from allowing taxes to vary over the business cycle, since they find that differentiated taxes over the business cycle result in much larger welfare gains than differentiated UI benefits. As this paper focuses only on the latter policy variable, one would therefore expect much smaller welfare gains from the optimal policy.

Table 2: Welfare consequences of different degrees of cyclicality in UI benefits

ϕ_z	z	Welfare gains (in %)					Fraction gaining (in %)		
		overall	unempl	empl	uC	eC	overall	unempl	empl
-10.00	g	-0.0259	-0.0619	-0.0230	-0.2060	-0.0669	0.00	0.00	0.00
-10.00	b	-0.0037	0.0336	-0.0069	0.1278	0.0174	7.83	100.00	0.10
-10.00	**mean**	**-0.0148**	**-0.0141**	**-0.0149**	**-0.0391**	**-0.0247**	**0.00**	**0.00**	**0.00**
-5.00	g	-0.0088	-0.0268	-0.0073	-0.0924	-0.0270	0.00	0.00	0.00
-5.00	b	0.0026	0.0212	0.0010	0.0734	0.0152	93.77	100.00	93.25
-5.00	**mean**	**-0.0031**	**-0.0028**	**-0.0031**	**-0.0095**	**-0.0059**	**0.00**	**0.00**	**0.00**
-1.00	g	-0.0010	-0.0046	-0.0007	-0.0170	-0.0044	0.45	0.00	0.48
-1.00	b	0.0018	0.0055	0.0015	0.0169	0.0049	100.00	100.00	100.00
-1.00	**mean**	**0.0004**	**0.0004**	**0.0004**	**-0.0000**	**0.0002**	**$^\diamond$100.00**	**99.97**	**100.00**
1.00	g	0.0028	0.0064	0.0025	0.0175	0.0057	100.00	100.00	100.00
1.00	b	0.0002	-0.0035	0.0005	-0.0159	-0.0033	89.66	0.00	97.17
1.00	**mean**	**0.0015**	**0.0014**	**0.0015**	**0.0008**	**0.0012**	**100.00**	**100.00**	**100.00**
1.76	g	0.0041	0.0104	0.0035	0.0299	0.0091	100.00	100.00	100.00
1.76	b	-0.0001	-0.0066	0.0004	-0.0285	-0.0061	82.13	0.00	89.01
1.76	**mean**	**0.0020**	**0.0019**	**0.0020**	**0.0007**	**0.0015**	**100.00**	**100.00**	**100.00**
5.00	g	0.0058	0.0241	0.0043	0.0767	0.0193	99.99	100.00	99.99
5.00	b	-0.0057	-0.0241	-0.0041	-0.0894	-0.0235	0.26	0.00	0.28
5.00	**mean**	**0.0001**	**0.0000**	**0.0001**	**-0.0064**	**-0.0021**	**59.66**	**44.84**	**60.89**
10.00	g	0.0029	0.0395	-0.0002	0.1342	0.0250	40.63	100.00	35.72
10.00	b	-0.0200	-0.0567	-0.0170	-0.2007	-0.0603	0.00	0.00	0.00
10.00	**mean**	**-0.0086**	**-0.0086**	**-0.0086**	**-0.0333**	**-0.0176**	**0.00**	**0.00**	**0.00**

Note: The table shows the welfare gains from moving the agents from an economy with constant UI benefits to an economy with cyclically dependent benefits and slope parameter ϕ_z. uC and eC denote the unemployed and employed, respectively, with a binding borrowing constraint. g is a good state, b is a bad state, **mean** denotes the unconditional mean, i.e., $0.5(\bar{\mu}_g + \bar{\mu}_b)$.

$^\diamond$: Rounded to 100.00%. $\phi_z = 1.76$ is the level that maximizes the mean welfare gain.

4.3 Effects on key economic variables

Table 3 shows how the key economic variables are affected by changing the cyclicality in UI benefits, ϕ_z. The table reveals some of the counteracting effects working in favor of procyclical and countercyclical UI benefits, respectively. From Table 2 we already know that the relative importance of these counteracting effects is non-monotone in ϕ_z.

Table 3: Averages of key economic variables

ϕ_z	z	u (%)	v	θ	$\hat{k}$	$\bar{w}$	h	T	$\overline{RR}$	p	d	$\hat{y}$	$\hat{c}$
−1.00	g	7.6191	0.0796	1.0448	67.240	2.5302	0.9700	0.0739	0.3648	0.9312	0.0074	3.3679	2.64375
−1.00	b	7.7515	0.0746	0.9629	66.671	2.4335	1.0100	0.0783	0.3956	0.8811	0.0009	3.2252	2.62045
−1.00	**mean**	7.6853	0.0771	1.0039	66.955	2.4819	0.9900	0.0761	0.3802	0.9061	0.0042	3.2966	2.63210
0.00	g	7.6364	0.0790	1.0339	67.240	2.5317	0.9900	0.0756	0.3723	0.9247	0.0065	3.3678	2.64376
0.00	b	7.7332	0.0753	0.9738	66.670	2.4320	0.9900	0.0766	0.3878	0.8875	0.0018	3.2253	2.62042
0.00	**mean**	7.6848	0.0771	1.0039	66.955	2.4818	0.9900	0.0761	0.3801	0.9061	0.0042	3.2966	2.63209
1.76	g	7.6673	0.0778	1.0146	67.236	2.5344	1.0252	0.0786	0.3855	0.9132	0.0048	3.3676	2.64373
1.76	b	7.7017	0.0765	0.9931	66.667	2.4292	0.9548	0.0735	0.3741	0.8987	0.0035	3.2254	2.62035
1.76	**mean**	7.6845	0.0771	1.0039	66.952	2.4818	0.9900	0.0761	0.3798	0.9060	0.0041	3.2965	2.63204
5.00	g	7.7266	0.0757	0.9792	67.230	2.5394	1.0900	0.0842	0.4097	0.8921	0.0017	3.3671	2.64366
5.00	b	7.6457	0.0786	1.0286	66.663	2.4242	0.8900	0.0680	0.3489	0.9195	0.0065	3.2256	2.62021
5.00	**mean**	7.6861	0.0771	1.0039	66.946	2.4818	0.9900	0.0761	0.3793	0.9058	0.0041	3.2963	2.63193

Note: The table shows the averages across good and bad periods, respectively. **mean** denotes the unconditional mean, i.e., $0.5(\bar{x}_g+\bar{x}_b)$, where $\bar{x}_{\check{z}}$ is the average of x across periods with $z=\check{z}$. $\bar{w}$ is the average wage; $\overline{RR}\equiv\frac{h-T}{\bar{w}-T}$ is the average replacement ratio. The aggregate output is $\hat{y}\equiv zF\left(\tilde{k}\right)(1-u)-\xi v$. $\phi_z=1.76$ is the level that maximizes the mean welfare gain.

Compared to the benchmark ($\phi_z=0$) procyclical unemployment benefits lead to stabilization of most of the economic variables. Thus, unemployment, vacancies, and the v-u ratio are all stabilized with procyclical UI generosity. When benefits are raised in booms, the wage will increase, and therefore firms will post fewer vacancies. This leads to a decrease in the v-u ratio, which lowers the job finding probability, and therefore the unemployment level will increase. Similarly, vacancy creation will be higher in recessions where benefits are lowered, which makes job finding easier and unemployment decreases. Furthermore, procyclical benefits stabilize the price of equity, profits, and aggregate output (defined as the right-hand side of (9)), whereas wages are destabilized. The aggregate output is stabilized because the number of producers (= the employment level) is stabilized, and because the aggregate vacancy costs are stabilized. In the benchmark, the average replacement ratio is countercyclical due to procyclical wages. However, if the procyclicality of UI benefits is sufficiently strong, the average replacement ratio will be procyclical, which is the case for the optimal degree of procyclicality ($\phi_z=1.76$), in which case UI benefits are 3.56% higher in good times than on average across the business cycle, and the (average) replacement ratio is 1.50% higher.

For countercyclical UI benefits the exact opposite happens. Most variables are destabilized, e.g. unemployment, but wages are stabilized since they increase during recessions due to a better outside option of the worker, and they decrease during booms where the outside option of the worker is worsened. Hence, agents need to save less for bad times and more for good times. For most agents the former dominates, and therefore consumption increases on average. Furthermore, this leads to a stabilization of aggregate consumption.

Table 3 also shows that mean unemployment, which can be thought of as the structural unemployment level, is lowered when moving from the benchmark economy ($\phi_z = 0$) to an economy with (optimal) procyclical benefits ($\phi_z = 1.76$), because unemployment drops more during recessions than it increases during booms. Also, structural unemployment is higher with countercyclical benefits, because unemployment increases more during recessions than it decreases during booms. Hence, the distortionary effects of UI (on job creation) is countercyclical, at least for small absolute values of ϕ_z, and therefore procyclical UI benefits can be welfare improving. This interpretation is in line with Andersen & Svarer (2011*b*) who find that benefits should be lowest in the state with most distortions. On the other hand, if the procyclicality of UI benefits is too strong (e.g. $\phi_z = 5$), structural unemployment increases compared to the benchmark, and in fact, the unemployment rate will be higher during booms than during recessions.

To sum up, procyclical UI generosity can be beneficial due to the countercyclical nature of UI distortions, whereas countercyclical UI generosity can be beneficial as it facilitates consumption smoothing and raises mean consumption. Table 1 showed that most consumers are able to smooth consumption fairly well, even without countercyclical UI, and therefore procyclical UI generosity dominates countercyclical UI.

Finally, Figure 1 shows a sample path for the unemployment rate in the benchmark case of constant UI and in case of (optimal) procyclical UI. It confirms that unemployment is stabilized in case of procyclical UI since unemployment increases (relative to the benchmark) in good times, where unemployment is low, and decreases in bad times, where unemployment is high.

5 Robustness

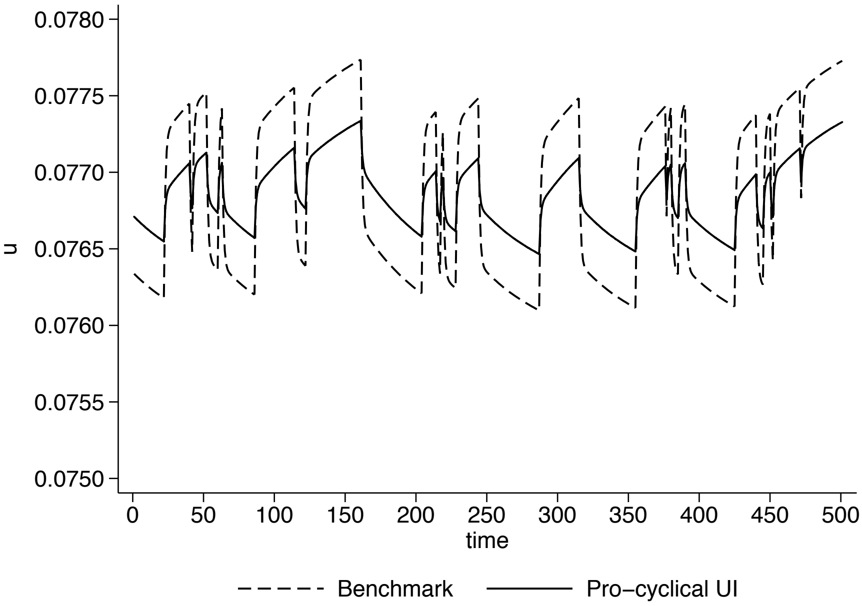
In this section various robustness checks are carried out.

5.1 Alternative public budget requirement

In the analysis above the public budget was not allowed to act as a buffer. However, an important argument in favor of UI is that it works as an automatic stabilizer. Therefore, this section allows the public budget to balance only on average.[18]

[18] To be more precise, the tax now solves $T = 0.5\left[\overline{uh}_g + \overline{uh}_b\right]$, where $\overline{uh}_{\check{z}}$ is the average of $u \cdot h$ in periods with $z = \check{z}$, and 0.5 is the unconditional probability of each state. Thus, the tax is now constant over time.

Figure 1: Sample path for unemployment, constant UI versus procyclical UI



Note: The figure shows sample paths for the unemployment rate, u, in the benchmark case of constant UI across the business cycle (dotted line) and in the case of procyclical UI (full line; $\phi_z = 1.76$).

The results are presented in Tables 4 and 5 in Appendix C.1. They show that allowing the public budget to balance only on average does not change the qualitative results, i.e., both procyclical and countercyclical UI benefits can increase welfare, and procyclical unemployment benefits ($\phi_z = 1.75$) still yield the largest welfare gains. However, the maximum attainable mean welfare gain across individuals is almost 50% lower than when the public budget always balances. The reason is that under a balance budget requirement the tax increase (decrease) counteracts the increase (decrease) in unemployment benefits and, thus, wages. With procyclical UI benefits, consumers no longer gain in bad periods from a low tax or suffer in good periods from a higher tax – the former turns out to be dominant. For the same reasons the welfare gains from countercyclical benefits are larger when the public budget only balances over time. Hence, as is well-known in the literature, requiring the public budget to balance each period works in favor of procyclical UI generosity, see e.g. Andersen & Svarer (2011*b*).

The optimal procyclical UI scheme implies that the public budget deficit is also procyclical (0.0025 on average across good states and −0.0025 across bad states), i.e., UI expenditures are higher in good states than in bad states, since the increase in the benefit level dominates the decrease in the number of unemployed workers when moving from a bad to a good state.

5.1.1 Unemployment dependent UI benefits

In practice, it seems easier to implement a scheme where UI benefits are conditioned on the unemployment level. Thus, the level of unemployment benefits is determined from

$$h = \bar{h} + \phi_u \frac{u - \bar{u}}{\bar{u}}$$

where $\bar{u}$ is the mean unemployment level. Note that the interpretation of ϕ_u is now a bit more complicated[19] since changing ϕ_u will also change $\bar{u}$. As opposed to the interpretation of ϕ_z, a positive (negative) ϕ_u implies counter(pro)-cyclical benefits.

The results are presented in Tables 6 and 7 (budget balance) and Tables 8 and 9 (budget balances only on average) in Appendix C.2. Again, we find that both procyclical and countercyclical benefits can increase welfare.

In the case of budget balance, procyclical benefits are optimal, as the welfare gain is maximized for $\phi_u = -5.00$ with a mean welfare gain of 0.0101% of consumption. However, even though UI benefits are 1.79% *higher* across good times than on average across the business cycle, the (average) replacement ratio is 0.21% *lower.* Hence, the procyclicality of the UI benefits is not strong enough to revert the countercyclicality of the (average) replacement ratio due to procyclical wages.

Furthermore, when the public budget is allowed to work as a buffer, the welfare gain is maximized in case of countercyclical benefits ($\phi_u = 1.20$) with a mean welfare gain of 0.0085% of consumption. This UI scheme implies that the public budget deficit is countercyclical (-0.0013 on average across good states and 0.0013 across bad states), UI benefits are 0.94% lower across good times than on average across the business cycle and the (average) replacement ratio is 3.09% lower. Thus, conditioning UI on unemployment instead of productivity actually alters the choice between pro- and countercyclical UI.

Overall we find that unemployment dependent UI yields much higher welfare gains than UI conditioned on productivity. This is not surprising since the latter (in our model) restricts UI benefits to jump between two levels only, whereas the former allows UI benefits to differ between, say, mild and deep recessions. However, combined with the fact that it is easier, in practice, to condition UI on the unemployment rate, it is somewhat surprising that the approach of conditioning UI directly on unemployment, to the author's knowledge, is new to literature.

[19] To solve this, $\bar{u}$ could be replaced by the unemployment level in steady state. However, this specification would imply that in general the average h is no longer $\bar{h}$, and therefore it would be a different kind of experiment.

5.1.2 UI benefits depending on lagged productivity

In reality, statistics on the position of the business cycle always become available with a certain lag. Therefore, this section studies the consequences of conditioning UI benefits on lagged productivity, instead of current productivity, i.e.,

$$h = \overline{h} + \phi_{z_{-1}} \frac{z_{-1} - \overline{z}_{-1}}{\overline{z}_{-1}}$$

where z_{-1} is previous period's productivity, and $\overline{z}_{-1}$ is mean lagged productivity.[20] To solve the model we need to include z_{-1} as an additional state variable.

The results are presented in Tables 10 and 11 (budget balance) and Tables 12 and 13 (budget balances only on average) in Appendix C.3. Not surprisingly, both procyclical and countercyclical benefits can increase welfare.

With budget balance, procyclical UI benefits are optimal, as the welfare gain is maximized for $\phi_{z_{-1}} = 1.25$ with a mean welfare gain of 0.0012% of consumption. Here, benefits are 2.21% higher across good times than on average across the business cycle, but the (average) replacement ratio is only 0.17% higher. In this case, there is no negative value of $\phi_{z_{-1}}$ delivering a positive welfare gain compared to invariant benefits.

Again we find that when the public budget is allowed to work as a buffer, the welfare gain is maximized in case of countercyclical benefits ($\phi_{z_{-1}} = -4.00$) with a mean welfare gain of 0.0014% of consumption. This UI scheme implies that the public budget deficit is countercyclical (-0.0066 on average across good states and 0.0066 across bad states), UI benefits are 7.06% lower across good times than on average across the business cycle and the (average) replacement ratio is 9.57% lower.

Hence, conditioning UI benefits on lagged productivity results in the same qualitative conclusions as unemployment dependent UI. The reason is that the distribution of asset holdings and employment statuses is determined in the previous period, i.e., it depends on productivity in the previous period, cf. (1) and (2), and therefore lagged productivity matters more for the status of the economic agents than current productivity. Recall that in the benchmark the correlation between current productivity and unemployment is $corr(z, u) = -0.82$, whereas the correlation between lagged productivity and unemployment is $corr(z_{-1}, u) = -0.94$.

[20] The mean lagged productivity is calculated as $\overline{z}_{-1} = 0.5\left(\overline{z}^g_{-1} + \overline{z}^b_{-1}\right)$ where $\overline{z}^g_{-1}$ is the average of lagged productivity across good periods (high current level productivity), and similar for $\overline{z}^b_{-1}$ across bad periods. Again, this ensures that mean unemployment benefits are still $\overline{h}$.

5.2 Alternative calibration

Like Krusell et al. (2010) we also consider a different calibration strategy inspired by Hagedorn & Manovskii (2008), who showed that the Diamond-Mortensen-Pissarides model is consistent with key business cycle facts, in particular it matches the empirically observed volatility of unemployment, vacancies, and the ratio between the two at business cycle frequencies, if using an alternative calibration strategy than Shimer (2005). In particular, the value of being unemployed is now much closer to the value of being employed since h will be much larger. Furthermore, the bargaining power γ will be much smaller, effectively implying that wages are less responsive to productivity shocks.

The vacancy cost is set to $\xi = 2.165$ which is approximately 60% of the average labor productivity in the model. Following Hagedorn & Manovskii (2008) the bargaining power is set to $\gamma = 0.052$. The matching function is $M(u, v) = \frac{uv}{\left(u^l + v^l\right)^{1/l}}$. With $\theta = 0.7$ and a job-finding rate of 0.592 as calibration targets we get $l = 2.2$. Finally, $\bar{h} = 2.29$ implies that $\theta = 0.7$ satisfies the free-entry condition. Therefore, the replacement ratio turns out to be very high, approximately 95%, and the interpretation of the value of non-market activities h must now cover much more than just UI, e.g. home production and self employment.[21]

The summary statistics for the benchmark model is found in Table 14 in Appendix C.4. It shows that unemployment volatility is now much higher, whereas wages are fairly rigid.

The results are presented in Tables 15 and 16 (budget balance) and Tables 17 and 18 (budget balances only on average) in Appendix C.4. They show that using an alternative calibration strategy does not change the overall conclusion: unemployment benefits should be procyclical when conditioning on productivity. But the welfare gains are much larger since unemployment is much more volatile with the Hagedorn-Manovskii calibration, whereas the wages are fairly rigid. In fact, the welfare gains are almost two orders of magnitude larger than with the standard calibration. Again we find that requiring the public budget to balance each period works in favor of procyclical UI since the welfare gains from procyclical UI are higher in Table 15 than in Table 17.

Furthermore, countercyclical UI benefits are no longer welfare improving. The reason is that wages are much less volatile compared to the standard calibration, and therefore there are only small gains from stabilizing wages (and thus consumption). These gains are dominated by the very strong countercyclicality of UI distortions.

[21] In particular, $h = h^{\text{UI}} + h^{\text{non-UI}}$, where only h^{UI} is tax financed via (8). We let $h^{\text{non-UI}} = 1.30\ (= 2.29 - 0.99)$, and h^{UI} is determined from (10) with $\bar{h}^{\text{UI}} = 0.99$. Alternatively (but less realistic), it could be assumed that all income from non-market must be financed via taxes. It turns out that this experiment delivers exactly the same qualitative results.

Note, however, that the interpretation of changing h over the business cycle is less clear with this calibration since the welfare calculations implicitly assume that changing UI does not affect the other determinants of the value of non-market activities, which is probably not a realistic assumption. Furthermore, unemployment is now too responsive to changes in UI.[22]

6 Concluding remarks

This paper considers the effects and optimality of business cycle dependent unemployment benefits in a dynamic general equilibrium model with labor market matching, wealth heterogeneity, precautionary savings, and aggregate fluctuations in productivity. Our results suggest that welfare gains can be achieved by both procyclical and countercyclical UI benefits. Procyclical UI benefits can increase welfare as UI distortions are countercyclical. On the other hand, countercyclical UI benefits can increase welfare as consumption smoothing is facilitated and mean consumption is increased. The non-linear relationship between these two opposing effects is what causes the ambiguous results.

The generosity of the UI scheme should be procyclical when conditioning benefits on (current) productivity. This result is robust to changing the public budget requirement and the chosen calibration strategy. The chosen calibration strategy is very important when quantifying the welfare gains from procyclical UI benefits compared to invariant benefits. However, UI generosity should be countercyclical when conditioning benefits on the unemployment level or lagged productivity and allowing the public budget to balance only on average.

The moral hazards caused by providing unemployment insurance play no role in this paper since search effort and labor supply are both exogenous. It would be interesting to see how the conclusions are altered when allowing for endogenously determined search effort and/or labor supply. If the distortionary effects of UI on search effort is procyclical as suggested by previous studies, see e.g. Andersen & Svarer (2010), this extension of the model is likely to work in favor of countercyclical UI generosity.

[22] Calculations show that in the model without aggregate shocks (see Krusell et al. (2010) for details) unemployment increases with 0.16% when benefits are increased by 1% for the standard (Shimer) calibration. The number is 14% for the alternative (Hagedorn-Manovskii) calibration. Hence, our model exhibits the puzzle pointed out by Costain & Reiter (2008), i.e., either it underpredicts unemployment volatility over the business cycle (for parameter values resulting in a large match surplus), or it overpredicts the response of unemployment to changes in UI benefits (for parameter values resulting in a low match surplus). Solving this puzzle, e.g. by introducing sticky wages or match-specific productivity shocks, is beyond the scope of this paper.

References

Abdulkadiroğlu, A., Kuruşçu, B. & Şahin, A. (2002), 'Unemployment insurance and the role of Self-Insurance', *Review of Economic Dynamics* **5**(3), 681–703.

Aiyagari, S. R. (1994), 'Uninsured idiosyncratic risk and aggregate saving', *The Quarterly Journal of Economics* **109**(3), 659 –684.

Andersen, T. M. & Svarer, M. (2009), 'Konjunkturafhængig arbejdsmarkedspolitik'. Report prepared for the Danish Labour Market Commission. In Danish.

Andersen, T. M. & Svarer, M. (2010), 'Business cycle dependent unemployment insurance'. Economics Working Paper 2010-16, Aarhus University.

Andersen, T. M. & Svarer, M. (2011*a*), 'Business cycle contingent unemployment insurance', *Nordic Economic Policy Review* **1**(2), 91–127.

Andersen, T. M. & Svarer, M. (2011*b*), 'State dependent unemployment benefits', *Journal of Risk and Insurance* **78**(2), 325–344.

Bewley, T. F. (n.d.), 'Interest bearing money and the equilibrium stock of capital'. Mimeo.

Cooley, T. F. & Prescott, E. C. (1995), Economic growth and business cycles, *in* T. F. Cooley, ed., 'Frontiers of Business Cycle Research', Princeton University Press, Princeton.

Costain, J. S. & Reiter, M. (2005), 'Stabilization versus insurance: Welfare effects of procyclical taxation under incomplete markets'. Universitat Pompeu Fabra Economics Working Paper No. 890.

Costain, J. S. & Reiter, M. (2008), 'Business cycles, unemployment insurance, and the calibration of matching models', *Journal of Economic Dynamics and Control* **32**(4), 1120–1155.

Diamond, P. A. (1981), 'Mobility costs, frictional unemployment, and efficiency', *Journal of Political Economy* **89**(4), 798–812.

Ek, S. (2012), 'How should policy makers redistribute income over the business cycle?'. IZA Discussion Paper No. 6308.

Fredriksson, P. & Holmlund, B. (2006), 'Improving incentives in unemployment insurance: A review of recent research', *Journal of Economic Surveys* **20**(3), 357–386.

Guvenen, F. (2011), 'Macroeconomics with heterogeneity: A practical guide', *National Bureau of Economic Research Working Paper Series* **No. 17622**.

Hagedorn, M. & Manovskii, I. (2008), 'The cyclical behavior of equilibrium unemployment and vacancies revisited', *American Economic Review* **98**, 1692–1706.

Hamilton, J. D. (1994), *Time Series Analysis*, Princeton University Press, Princeton.

Heathcote, J., Storesletten, K. & Violante, G. L. (2009), 'Quantitative macroeconomics with heterogeneous households', *National Bureau of Economic Research Working Paper Series* **No. 14768**.

Huggett, M. (1993), 'The risk-free rate in heterogeneous-agent incomplete-insurance economies', *Journal of Economic Dynamics and Control* **17**(5-6), 953–969.

Jung, P. & Kuester, K. (2011), 'Optimal Labor-Market policy in recessions', *Federal Reserve Bank of Philadelphia Working Paper* **No. 11-48**.

Kiley, M. T. (2003), 'How should unemployment benefits respond to the business cycle?', *Topics in Economic Analysis & Policy* **3**(1).

Kroft, K. & Notowidigdo, M. (2010), 'Does the moral hazard cost of unemployment insurance vary with the local unemployment rate? theory and evidence'. Working paper.

Krusell, P., Mukoyama, T., Şahin, A. & Smith, A. A. (2009), 'Revisiting the welfare effects of eliminating business cycles', *Review of Economic Dynamics* **12**(3), 393–402.

Krusell, P., Mukoyama, T. & Şahin, A. (2010), 'Labour-Market matching with precautionary savings and aggregate fluctuations', *Review of Economic Studies* **77**(4), 1477–1507.

Krusell, P. & Smith, A. A. (1998), 'Income and wealth heterogeneity in the macroeconomy', *Journal of Political Economy* **106**(5), 867–896.

Krusell, P. & Smith, A. A. (1999), 'On the welfare effects of eliminating business cycles', *Review of Economic Dynamics* **2**(1), 245–272.

Landais, C., Michaillat, P. & Saez, E. (2010), 'Optimal unemployment insurance over the business cycle', *NBER Working Paper* .

Lentz, R. (2009), 'Optimal unemployment insurance in an estimated job search model with savings', *Review of Economic Dynamics* **12**(1), 37–57.

Lucas, R.E., J. (1987), *Models of Business Cycles*, Basil Blackwell, New York.

Lucas, R.E., J. (2003), 'Macroeconomic priorities', *American Economic Review* **93**, 1–14.

Mitman, K. & Rabinovich, S. (2011), 'Pro-cyclical unemployment benefits? optimal policy in an equilibrium business cycle model'. Working paper.

Mortensen, D. T. & Pissarides, C. A. (1994), 'Job creation and job destruction in the theory of unemployment', *The Review of Economic Studies* **61**(3), 397–415.

Moyen, S. & Stähler, N. (2009), 'Unemployment insurance and the business cycle: Prolong benefits in bad times?'. Deutsche Bundesbank Discussion Paper 30.

Mukoyama, T. (2011), 'Understanding the welfare effects of unemployment insurance policy in general equilibrium'. Working paper.

Pissarides, C. A. (1985), 'Short-Run equilibrium dynamics of unemployment, vacancies, and real wages', *The American Economic Review* **75**(4), 676–690.

Pollak, A. (2007), 'Optimal unemployment insurance with heterogeneous agents', *European Economic Review* **51**(8), 2029–2053.

Reichling, F. (2007), 'Optimal unemployment insurance in labor market equilibrium when workers can Self-Insure'. Mimeo, Stanford University.

Schuster, P. (2012), 'Cyclical unemployment benefits and non-constant returns to matching'. Mimeo, University of St. Gallen.

Shimer, R. (2005), 'The cyclical behavior of equilibrium unemployment and vacancies', *The American Economic Review* **95**(1), 25–49.

Storesletten, K., Telmer, C. I. & Yaron, A. (2001), 'The welfare cost of business cycles revisited: Finite lives and cyclical variation in idiosyncratic risk', *European Economic Review* **45**(7), 1311–1339.

Sánchez, J. M. (2008), 'Optimal state-contingent unemployment insurance', *Economics Letters* **98**(3), 348–357.

Vejlin, R. (2011), 'Optimal unemployment insurance: How important is the demand side?'. Economics Working Paper 2011-3, Aarhus University.

Xu, K. (2004), 'How has the literature on gini's index evolved in the past 80 years?'. Mimeo, Department of Economics, Dalhousie University.

Young, E. R. (2004), 'Unemployment insurance and capital accumulation', *Journal of Monetary Economics* **51**(8), 1683–1710.

APPENDICES

A Resource balance condition

This appendix shows that the resource balance condition (goods-market clearing condition)

$$\hat{c} + \left[\hat{k}' - (1-\delta)\,\hat{k}\right] = zF\left(\tilde{k}\right)(1-u) - \xi v \tag{11}$$

is fulfilled, i.e., private consumption plus investments equal aggregate output (net of aggregated vacancy costs), where $\hat{c}$ is aggregate private consumption

$$\hat{c} \equiv \int c_e(a;z,S)\, f_e(a;S)\, da + \int c_u(a;z,S)\, f_u(a;S)\, da$$

and

$$\begin{aligned} c_e(a;z,S) &\equiv a + \omega(a;z,S) - T - Q_g(z,S)\,\psi_g^e(a;z,S) - Q_b(z,S)\,\psi_b^e(a;z,S) && (12)\\ c_u(a;z,S) &\equiv a + h - T - Q_g(z,S)\,\psi_g^u(a;z,S) - Q_b(z,S)\,\psi_b^u(a;z,S)\,. && (13)\end{aligned}$$

The proof follows the idea of Krusell et al. (2010) but allows unemployment benefits to be financed internally (via taxes). Integrating (12) and (13) over all asset holdings and summing up yields

$$\begin{aligned} \hat{c} &= \int a f_e(a;S)\, da + \int a f_u(a;S)\, da + \int \omega(a;z,S)\, f_e(a;S)\, da + hu - T(1-u) - Tu \\ &\quad - Q_g(z,S)\left[\int \psi_g^e(a;z,S)\, f_e(a;S)\, da + \int \psi_g^u(a;z,S)\, f_u(a;S)\, da\right] \\ &\quad - Q_b(z,S)\left[\int \psi_b^e(a;z,S)\, f_e(a;S)\, da + \int \psi_b^u(a;z,S)\, f_u(a;S)\, da\right] \end{aligned} \tag{14}$$

since $\int f_e(a;S)\, da = (1-u)$ and $\int f_u(a;S)\, da = u$.

Firstly, consider the terms $\int a f_e(a;S)\, da + \int a f_u(a;S)\, da$. Assuming that the decision rules for a' are increasing in a, the law of motion for the asset distribution can be calculated as

$$\begin{aligned} \int_{\underline{a}}^{a'} f_e(\widetilde{a};S')\, d\widetilde{a} &= \lambda_w \int_{\underline{a}}^{\left(\psi_{z'}^u\right)^{-1}(a';z,S)} f_u(a;S)\, da + (1-\sigma) \int_{\underline{a}}^{\left(\psi_{z'}^e\right)^{-1}(a';z,S)} f_e(a;S)\, da \\ \int_{\underline{a}}^{a'} f_u(\widetilde{a};S')\, d\widetilde{a} &= (1-\lambda_w) \int_{\underline{a}}^{\left(\psi_{z'}^u\right)^{-1}(a';z,S)} f_u(a;S)\, da + \sigma \int_{\underline{a}}^{\left(\psi_{z'}^e\right)^{-1}(a';z,S)} f_e(a;S)\, da \end{aligned}$$

where $\left(\psi_{z'}^{u}\right)^{-1}(a';z,S)$ denotes the inverse of the decision rule, i.e., the value of a that satisfies $a'=\psi_{z'}^{u}(a;z,S)$, and similarly for $\left(\psi_{z'}^{e}\right)^{-1}(a';z,S)$. Differentiating the upper equation with respect to a' gives

$$f_e(a';S')=\lambda_w\rho_u(a';z,S)\,f_u\left(\left(\psi_{z'}^{u}\right)^{-1}(a';z,S);S\right)+(1-\sigma)\,\rho_e(a';z,S)\,f_e\left(\left(\psi_{z'}^{e}\right)^{-1}(a';z,S);S\right)$$

applying Leibniz's rule, where

$$\begin{aligned}\rho_u(a';z,S) &\equiv \frac{d\left(\psi_{z'}^{u}\right)^{-1}(a';z,S)}{da'}\\ \rho_e(a';z,S) &\equiv \frac{d\left(\psi_{z'}^{e}\right)^{-1}(a';z,S)}{da'}.\end{aligned}$$

Multiplying this expression by a' and integrating yields

$$\begin{aligned}\int a'f_e(a';S')\,da' &= \lambda_w\int a'\rho_u(a';z,S)\,f_u\left(\left(\psi_{z'}^{u}\right)^{-1}(a';z,S);S\right)da'\\ &\quad+(1-\sigma)\int a'\rho_e(a';z,S)\,f_e\left(\left(\psi_{z'}^{e}\right)^{-1}(a';z,S);S\right)da'.\end{aligned}$$

Changing variables on the right-hand side using $a'=\psi_{z'}^{u}(a;z,S)$ implying $a=\left(\psi_{z'}^{u}\right)^{-1}(a';z,S)$ in the first term, and $a'=\psi_{z'}^{e}(a;z,S)$ implying $a=\left(\psi_{z'}^{e}\right)^{-1}(a';z,S)$ in the second term, yields

$$\begin{aligned}\int a'f_e(a';S')\,da' &= \lambda_w\int \psi_{z'}^{u}(a;z,S)\,\rho_u\left(\psi_{z'}^{u}(a;z,S);z,S\right)f_u(a;S)\,\frac{d\psi_{z'}^{u}(a;z,S)}{da}da\\ &\quad+(1-\sigma)\int \psi_{z'}^{e}(a;z,S)\,\rho_e\left(\psi_{z'}^{e}(a;z,S)\,z,S\right)f_e(a;S)\,\frac{d\psi_{z'}^{e}(a;z,S)}{da}da\\ &= \lambda_w\int \psi_{z'}^{u}(a;z,S)\,f_u(a;S)\,da+(1-\sigma)\int \psi_{z'}^{e}(a;z,S)\,f_e(a;S)\,da\end{aligned}$$

where the last step uses the definitions of $\rho_u(\cdot)$ and $\rho_e(\cdot)$.

Similarly, using the law of motion for the asset distribution of the unemployed workers, it can be shown that

$$\int a'f_u(a';S')\,da'=(1-\lambda_w)\int \psi_{z'}^{u}(a;z,S)\,f_u(a;S)\,da+\sigma\int \psi_{z'}^{e}(a;z,S)\,f_e(a;S)\,da.$$

Summing up yields

$$\begin{aligned}\int a'f_e(a';S')\,da'+\int a'f_u(a';S')\,da' &= \int \psi_{z'}^{u}(a;z,S)\,f_u(a;S)\,da+\int \psi_{z'}^{e}(a;z,S)\,f_e(a;S)\,da\\ &= \left(1-\delta+r(z',S')\right)\hat{k}'+p(z',S')+d(z',S')\end{aligned}$$

using the asset market clearing condition (7), and lagging this expression one period gives

$$\int af_e(a;S)\,da + \int af_u(a;S)\,da = (1-\delta+r(z,S))\,\hat{k} + p(z,S) + d(z,S)\,. \qquad (15)$$

Secondly, using the equilibrium profit (5) in the dividend expression (6) yields

$$\begin{aligned} d(z,S) &= \int \left[zF\left(\tilde{k}\right) - r(z,S)\,\tilde{k} - \omega(a;z,S)\right] f_e(a;S)\,da - \xi v \\ &= zF\left(\tilde{k}\right)(1-u) - r(z,S)\,\hat{k} - \int \omega(a;z,S)\,f_e(a;S)\,da - \xi v \qquad (16) \end{aligned}$$

using $\int f_e(a;S)\,da = (1-u)$ and $\tilde{k} = \hat{k}/(1-u)$.

Thirdly, using the public budget requirement (8) we have

$$hu - T = 0. \qquad (17)$$

Fourthly, using the asset market clearing condition (7) we have

$$\begin{aligned} & Q_g(z,S)\left[\int \psi_g^e(a;z,S)\,f_e(a;S)\,da + \int \psi_g^u(a;z,S)\,f_u(a;S)\,da\right] + \\ & Q_b(z,S)\left[\int \psi_b^e(a;z,S)\,f_e(a;S)\,da + \int \psi_b^u(a;z,S)\,f_u(a;S)\,da\right] \\ = \; & Q_g(z,S)\left[(1-\delta+r(g,S'))\,\hat{k}' + p(g,S') + d(g,S')\right] + \\ & Q_b(z,S)\left[(1-\delta+r(b,S'))\,\hat{k}' + p(b,S') + d(b,S')\right] \\ = \; & \hat{k}' + p(z,S) \qquad (18) \end{aligned}$$

where the last step uses the no-arbitrage conditions (3) and (4).

Finally, we obtain (11) by inserting (15), (16), (17), and (18) in (14).

B Law of motion and prediction rules

This appendix shows the forecasting and prediction rules used by the bounded rational agents (with the standard Shimer calibration). The law of motion for the aggregate capital stock is

$$\log\hat{k}' = 0.0645 + 0.9827\log\hat{k} - 0.0033\log u + 0.0451\log z \qquad \left(R^2 = 0.9999995\right)$$

and the prediction rules for the other aggregate variables are

$$\begin{aligned}
\log\theta &= -2.1097 + 0.5070\log\hat{k} + 0.0071\log u + 1.3913\log z & \left(R^2 = 0.9999834\right) \\
\log(p+d) &= -1.8831 + 0.3923\log\hat{k} - 0.0545\log u + 1.0510\log z & \left(R^2 = 0.9999993\right) \\
\log Q_g &= -0.6803 - 5.0218\log\widetilde{Q}_g + 0.0628\log\hat{k} + 0.0016\log u & \left(R^2 = 0.9999260\right) \\
\log Q_b &= 0.6134 + 6.5404\log\widetilde{Q}_b - 0.0555\log\hat{k} - 0.0014\log u & \left(R^2 = 0.9999217\right)
\end{aligned}$$

where $\widetilde{Q}_z \equiv \pi_{zz}/\left(1-\delta+r\left(z,\hat{k}',u'\right)\right)$ for $z=\{g,b\}$. $\hat{k}'$ is calculated from the law of motion above, whereas u' is calculated from (1).

C Robustness

C.1 Alternative public budget requirement

Table 4: Welfare consequences of different degrees of cyclicality in UI benefits – public budget balances on average

ϕ_z	z	Welfare gains (in %)					Fraction gaining (in %)		
		overall	unempl	empl	uC	eC	overall	unempl	empl
−10.00	g	-0.0499	-0.0864	-0.0469	-0.2710	-0.1209	0.50	0.00	0.55
−10.00	b	0.0261	0.0641	0.0230	0.1788	0.0629	96.71	99.99	96.44
−10.00	**mean**	**-0.0119**	**-0.0111**	**-0.0120**	**-0.0461**	**-0.0290**	**0.00**	**0.00**	**0.00**
−5.00	g	-0.0204	-0.0387	-0.0189	-0.1227	-0.0526	1.08	0.01	1.17
−5.00	b	0.0176	0.0365	0.0160	0.0986	0.0376	99.16	$^\diamond$100.00	99.09
−5.00	**mean**	**-0.0014**	**-0.0011**	**-0.0015**	**-0.0121**	**-0.0075**	**17.41**	**22.71**	**16.97**
−1.00	g	-0.0033	-0.0070	-0.0030	-0.0228	-0.0095	2.58	0.03	2.79
−1.00	b	0.0047	0.0085	0.0044	0.0220	0.0092	99.94	100.00	99.94
−1.00	**mean**	**0.0007**	**0.0007**	**0.0007**	**-0.0004**	**-0.0001**	**99.93**	**99.88**	**99.94**
1.00	g	0.0050	0.0086	0.0047	0.0230	0.0104	99.85	$^\diamond$100.00	99.84
1.00	b	-0.0030	-0.0068	-0.0027	-0.0214	-0.0079	1.13	0.00	1.22
1.00	**mean**	**0.0010**	**0.0009**	**0.0010**	**0.0008**	**0.0012**	**100.00**	**100.00**	**100.00**
1.75	g	0.0078	0.0142	0.0073	0.0391	0.0172	99.62	$^\diamond$100.00	99.59
1.75	b	-0.0057	-0.0122	-0.0051	-0.0377	-0.0140	0.81	0.00	0.87
1.75	**mean**	**0.0011**	**0.0010**	**0.0011**	**0.0007**	**0.0016**	**99.90**	**99.80**	**99.91**
5.00	g	0.0193	0.0378	0.0178	0.1077	0.0473	97.75	99.96	97.57
5.00	b	-0.0190	-0.0378	-0.0175	-0.1175	-0.0469	1.06	0.00	1.15
5.00	**mean**	**0.0001**	**0.0000**	**0.0002**	**-0.0049**	**0.0002**	**62.04**	**58.21**	**62.36**
10.00	g	0.0358	0.0732	0.0327	0.2024	0.0882	95.80	99.82	95.46
10.00	b	-0.0418	-0.0792	-0.0387	-0.2597	-0.1071	1.06	0.01	1.15
10.00	**mean**	**-0.0030**	**-0.0030**	**-0.0030**	**-0.0286**	**-0.0094**	**0.00**	**0.00**	**0.00**

Note: The table shows the welfare gains from moving the agents from an economy with constant UI benefits to an economy with cyclically dependent benefits and slope parameter ϕ_z. uC and eC denote the unemployed and employed, respectively, with a binding borrowing constraint. g is a good state, b is a bad state, **mean** denotes the unconditional mean, i.e., $0.5(\bar{\mu}_g + \bar{\mu}_b)$.
$^\diamond$: Rounded to 100.00%. $\phi_z = 1.75$ is the level that maximizes the mean welfare gain.

Table 5: Averages of key economic variables – public budget balances on average

ϕ_z	z	u (%)	v	θ	$\bar{k}$	$\bar{w}$	h	T	$\overline{RR}$	p	d	r	$\hat{y}$
−1.00	g	7.6195	0.0796	1.0446	67.213	2.5299	0.9700	0.0761	0.3643	0.9310	0.0074	0.0152	3.3675
−1.00	b	7.7517	0.0746	0.9628	66.657	2.4334	1.0100	0.0761	0.3962	0.8810	0.0009	0.0147	3.2250
−1.00	**mean**	7.6856	0.0771	1.0037	66.935	2.4816	0.9900	0.0761	0.3802	0.9060	0.0042	0.0150	3.2963
0.00	g	7.6364	0.0789	1.0338	67.233	2.5317	0.9900	0.0761	0.3722	0.9247	0.0065	0.0152	3.3677
0.00	b	7.7333	0.0753	0.9738	66.665	2.4319	0.9900	0.0761	0.3880	0.8874	0.0018	0.0147	3.2252
0.00	**mean**	7.6849	0.0771	1.0038	66.949	2.4818	0.9900	0.0761	0.3801	0.9061	0.0042	0.0150	3.2965
1.75	g	7.6667	0.0778	1.0150	67.265	2.5347	1.0250	0.0761	0.3860	0.9135	0.0048	0.0152	3.3680
1.75	b	7.7017	0.0765	0.9930	66.676	2.4293	0.9550	0.0761	0.3735	0.8987	0.0035	0.0147	3.2255
1.75	**mean**	7.6842	0.0771	1.0040	66.971	2.4820	0.9900	0.0761	0.3797	0.9061	0.0041	0.0150	3.2968
5.00	g	7.7253	0.0757	0.9799	67.317	2.5404	1.0900	0.0761	0.4114	0.8929	0.0017	0.0152	3.3684
5.00	b	7.6454	0.0786	1.0287	66.686	2.4244	0.8900	0.0761	0.3466	0.9198	0.0066	0.0147	3.2259
5.00	**mean**	7.6853	0.0772	1.0043	67.002	2.4824	0.9900	0.0761	0.3790	0.9063	0.0041	0.0149	3.2972

Note: The table shows the averages across good and bad periods, respectively. **mean** denotes the unconditional mean, i.e., $0.5(\bar{x}_g + \bar{x}_b)$, where $\bar{x}_{\check{z}}$ is the average of x across periods with $z = \check{z}$. $\bar{w}$ is the average wage; $\overline{RR} \equiv \frac{h-T}{\bar{w}-T}$ is the average replacement ratio. The aggregate output is $\hat{y} \equiv zF\left(\tilde{k}\right)(1-u) - \xi v$. $\phi_z = 1.75$ is the level that maximizes the mean welfare gain.

C.2 Unemployment dependent UI benefits

Table 6: Welfare consequences of different degrees of cyclicality in UI benefits – unemployment dependent UI, budget balance

ϕ_u	z	Welfare gains (in %)					Fraction gaining (in %)		
		overall	unempl	empl	uC	eC	overall	unempl	empl
−5.00	g	0.0111	0.0146	0.0108	0.0252	0.0139	◇100.00	◇100.00	100.00
−5.00	b	0.0090	0.0054	0.0094	-0.0095	0.0041	99.98	99.75	100.00
−5.00	**mean**	**0.0101**	**0.0100**	**0.0101**	**0.0079**	**0.0090**	**100.00**	**100.00**	**100.00**
−1.00	g	0.0041	0.0052	0.0040	0.0087	0.0052	◇100.00	◇100.00	100.00
−1.00	b	0.0043	0.0032	0.0044	-0.0010	0.0031	◇100.00	99.97	100.00
−1.00	**mean**	**0.0042**	**0.0042**	**0.0042**	**0.0039**	**0.0042**	**100.00**	**100.00**	**100.00**
1.00	g	0.0025	0.0010	0.0027	-0.0051	0.0005	98.53	80.73	◇100.00
1.00	b	0.0044	0.0059	0.0042	0.0111	0.0061	◇100.00	◇100.00	100.00
1.00	**mean**	**0.0035**	**0.0035**	**0.0034**	**0.0030**	**0.0033**	**100.00**	**100.00**	**100.00**

Note: The table shows the welfare gains from moving the agents from an economy with constant UI benefits to an economy with cyclically dependent benefits and slope parameter ϕ_u. uC and eC denote the unemployed and employed, respectively, with a binding borrowing constraint. g is a good state, b is a bad state, **mean** denotes the unconditional mean, i.e., $0.5(\bar{\mu}_g + \bar{\mu}_b)$.
◇ Rounded to 100.00%. $\phi_u = -5.00$ is the level that maximizes the mean welfare gain.

Table 7: Averages of key economic variables – unemployment dependent UI, budget balance

ϕ_u	z	u (%)	v	θ	$\hat{k}$	$\bar{w}$	h	T	$\overline{RR}$	p	d	r	$\hat{y}$
−5.00	g	7.6569	0.0782	1.0209	67.236	2.5318	1.0077	0.0772	0.3791	0.9172	0.0069	0.0152	3.3677
−5.00	b	7.7113	0.0761	0.9871	66.666	2.4319	0.9723	0.0750	0.3807	0.8935	0.0013	0.0147	3.2253
−5.00	**mean**	7.6841	0.0771	1.0040	66.951	2.4819	0.9900	0.0761	0.3799	0.9054	0.0041	0.0150	3.2965
−1.00	g	7.6427	0.0787	1.0299	67.239	2.5318	0.9954	0.0761	0.3744	0.9226	0.0066	0.0152	3.3678
−1.00	b	7.7264	0.0756	0.9779	66.669	2.4319	0.9846	0.0761	0.3856	0.8895	0.0016	0.0147	3.2253
−1.00	**mean**	7.6845	0.0771	1.0039	66.954	2.4819	0.9900	0.0761	0.3800	0.9060	0.0041	0.0150	3.2966
0.00	g	7.6364	0.0790	1.0339	67.240	2.5317	0.9900	0.0756	0.3723	0.9248	0.0065	0.0152	3.3678
0.00	b	7.7333	0.0753	0.9738	66.671	2.4320	0.9900	0.0766	0.3878	0.8875	0.0018	0.0147	3.2253
0.00	**mean**	7.6848	0.0771	1.0038	66.956	2.4819	0.9900	0.0761	0.3801	0.9061	0.0042	0.0150	3.2966
1.00	g	7.6278	0.0793	1.0394	67.238	2.5317	0.9825	0.0749	0.3694	0.9278	0.0063	0.0152	3.3679
1.00	b	7.7427	0.0750	0.9682	66.669	2.4319	0.9975	0.0772	0.3908	0.8849	0.0021	0.0147	3.2252
1.00	**mean**	7.6853	0.0771	1.0038	66.954	2.4818	0.9900	0.0761	0.3801	0.9063	0.0042	0.0150	3.2965

Note: The table shows the averages across good and bad periods, respectively. **mean** denotes the unconditional mean, i.e., $0.5(\bar{x}_g+\bar{x}_b)$, where $\bar{x}_{\tilde{z}}$ is the average of x across periods with $z=\tilde{z}$. $\bar{w}$ is the average wage; $\overline{RR} \equiv \frac{h-T}{\bar{w}-T}$ is the average replacement ratio. The aggregate output is $\hat{y} \equiv zF\left(\tilde{k}\right)(1-u)-\xi v$. $\phi_u=-5.00$ is the level that maximizes the mean welfare gain.

Table 8: Welfare consequences of different degrees of cyclicality in UI benefits – unemployment dependent UI, public budget balances on average

ϕ_u	z	Welfare gains (in %)					Fraction gaining (in %)		
		overall	unempl	empl	uC	eC	overall	unempl	empl
−5.00	g	0.0042	0.0078	0.0039	0.0213	0.0094	81.13	88.71	80.51
−5.00	b	-0.0091	-0.0129	-0.0088	-0.0317	-0.0170	3.57	3.97	3.54
−5.00	**mean**	**-0.0024**	**-0.0025**	**-0.0024**	**-0.0052**	**-0.0038**	**0.00**	**0.00**	**0.00**
−1.00	g	0.0025	0.0037	0.0025	0.0082	0.0045	98.29	97.30	98.38
−1.00	b	-0.0009	-0.0021	-0.0008	-0.0074	-0.0030	21.64	11.21	22.52
−1.00	**mean**	**0.0008**	**0.0008**	**0.0008**	**0.0004**	**0.0008**	**100.00**	**100.00**	**100.00**
1.00	g	0.0042	0.0027	0.0043	-0.0052	0.0008	95.49	81.36	96.65
1.00	b	0.0109	0.0125	0.0107	0.0189	0.0135	$^{\diamond}$100.00	99.99	100.00
1.00	**mean**	**0.0075**	**0.0076**	**0.0075**	**0.0069**	**0.0072**	**100.00**	**100.00**	**100.00**
1.20	g	0.0052	0.0033	0.0054	-0.0062	0.0013	97.94	85.67	98.95
1.20	b	0.0118	0.0138	0.0116	0.0218	0.0150	$^{\diamond}$100.00	99.99	100.00
1.20	**mean**	**0.0085**	**0.0085**	**0.0085**	**0.0078**	**0.0081**	**100.00**	**100.00**	**100.00**

Note: The table shows the welfare gains from moving the agents from an economy with constant UI benefits to an economy with cyclically dependent benefits and slope parameter ϕ_u. uC and eC denotes the unemployed and employed, respectively, with a binding borrowing constraint. g is a good state, b is a bad state, **mean** denotes the unconditional mean, i.e., $0.5(\bar{\mu}_g+\bar{\mu}_b)$.
$^{\diamond}$: Rounded to 100.00%. $\phi_u=1.20$ is the level that maximizes the mean welfare gain.

Table 9: Averages of key economic variables – unemployment dependent UI, public budget balances on average

ϕ_u	z	u (%)	v	θ	$\hat{k}$	$\bar{w}$	h	T	$\overline{RR}$	p	d	r	$\hat{y}$
−1.00	g	7.6427	0.0787	1.0299	67.239	2.5318	0.9954	0.0761	0.3744	0.9226	0.0066	0.0152	3.3678
−1.00	b	7.7264	0.0756	0.9780	66.669	2.4319	0.9846	0.0761	0.3856	0.8895	0.0016	0.0147	3.2253
−1.00	**mean**	7.6845	0.0771	1.0039	66.954	2.4819	0.9900	0.0761	0.3800	0.9061	0.0041	0.0150	3.2965
0.00	g	7.6364	0.0789	1.0338	67.233	2.5317	0.9900	0.0761	0.3722	0.9247	0.0065	0.0152	3.3677
0.00	b	7.7333	0.0753	0.9738	66.665	2.4319	0.9900	0.0761	0.3880	0.8874	0.0018	0.0147	3.2252
0.00	**mean**	7.6849	0.0771	1.0038	66.949	2.4818	0.9900	0.0761	0.3801	0.9061	0.0042	0.0150	3.2965
1.00	g	7.6280	0.0793	1.0393	67.222	2.5315	0.9825	0.0761	0.3692	0.9277	0.0063	0.0152	3.3676
1.00	b	7.7429	0.0750	0.9681	66.656	2.4318	0.9975	0.0761	0.3911	0.8848	0.0021	0.0147	3.2250
1.00	**mean**	7.6854	0.0771	1.0037	66.939	2.4816	0.9900	0.0761	0.3802	0.9062	0.0042	0.0150	3.2963
1.20	g	7.6259	0.0794	1.0406	67.219	2.5315	0.9807	0.0761	0.3684	0.9287	0.0062	0.0152	3.3676
1.20	b	7.7455	0.0749	0.9665	66.653	2.4318	0.9993	0.0761	0.3919	0.8843	0.0021	0.0147	3.2250
1.20	**mean**	7.6857	0.0771	1.0036	66.936	2.4816	0.9900	0.0761	0.3802	0.9065	0.0042	0.0150	3.2963

Note: The table shows the averages across good and bad periods, respectively. **mean** denotes the unconditional mean, i.e., $0.5(\bar{x}_g+\bar{x}_b)$, where $\bar{x}_{\tilde{z}}$ is the average of x across periods with $z=\tilde{z}$. $\bar{w}$ is the average wage; $\overline{RR} \equiv \frac{h-T}{\bar{w}-T}$ is the average replacement ratio. The aggregate output is $\hat{y} \equiv zF\left(\tilde{k}\right)(1-u)-\xi v$. $\phi_u=1.20$ is the level that maximizes the mean welfare gain.

C.3 UI benefits depending on lagged productivity

Table 10: Welfare consequences of different degrees of cyclicality in UI benefits – UI depending on lagged productivity, budget balance

$\phi_{z_{-1}}$	z	Welfare gains (in %)					Fraction gaining (in %)		
		overall	unempl	empl	uC	eC	overall	unempl	empl
−1.00	g	-0.0015	-0.0049	-0.0012	-0.0167	-0.0048	0.55	5.75	0.11
−1.00	b	0.0008	0.0043	0.0005	0.0159	0.0039	92.68	93.12	92.65
−1.00	**mean**	**-0.0004**	**-0.0003**	**-0.0004**	**-0.0004**	**-0.0004**	**0.00**	**0.00**	**0.00**
1.00	g	0.0021	0.0055	0.0019	0.0168	0.0052	99.56	94.26	$^{\diamond}$100.00
1.00	b	-0.0000	-0.0035	0.0003	-0.0155	-0.0033	82.05	6.88	88.36
1.00	**mean**	**0.0011**	**0.0010**	**0.0011**	**0.0007**	**0.0010**	**100.00**	**100.00**	**100.00**
1.25	g	0.0026	0.0068	0.0022	0.0209	0.0063	99.55	94.26	$^{\diamond}$100.00
1.25	b	-0.0001	-0.0045	0.0002	-0.0195	-0.0042	74.89	6.88	80.60
1.25	**mean**	**0.0012**	**0.0012**	**0.0012**	**0.0007**	**0.0011**	**100.00**	**100.00**	**100.00**

Note: The table shows the welfare gains from moving the agents from an economy with constant UI benefits to an economy with cyclically dependent benefits and slope parameter $\phi_{z_{-1}}$. uC and eC denote the unemployed and employed, respectively, with a binding borrowing constraint. g is a good state, b is a bad state, **mean** denotes the unconditional mean, i.e., $0.5(\bar{\mu}_g + \bar{\mu}_b)$.
$^{\diamond}$: Rounded to 100.00%. $\phi_{z_{-1}} = 1.25$ is the level that maximizes the mean welfare gain.

Table 11: Averages of key economic variables – UI depending on lagged productivity, budget balance

$\phi_{z_{-1}}$	z	u (%)	v	θ	$\hat{k}$	$\bar{w}$	h	T	$\overline{RR}$	p	d	r	$\hat{y}$
−1.00	g	7.6171	0.0797	1.0461	67.240	2.5311	0.9725	0.0741	0.3657	0.9321	0.0066	0.0152	3.3679
−1.00	b	7.7536	0.0746	0.9616	66.671	2.4325	1.0075	0.0781	0.3947	0.8805	0.0019	0.0147	3.2252
−1.00	**mean**	7.6854	0.0771	1.0039	66.956	2.4818	0.9900	0.0761	0.3802	0.9063	0.0042	0.0150	3.2966
0.00	g	7.6358	0.0790	1.0342	67.239	2.5319	0.9900	0.0756	0.3723	0.9250	0.0063	0.0152	3.3678
0.00	b	7.7331	0.0753	0.9738	66.670	2.4317	0.9900	0.0766	0.3879	0.8876	0.0020	0.0147	3.2253
0.00	**mean**	7.6845	0.0771	1.0040	66.955	2.4818	0.9900	0.0761	0.3801	0.9063	0.0042	0.0150	3.2966
1.00	g	7.6549	0.0783	1.0222	67.236	2.5327	1.0075	0.0771	0.3789	0.9178	0.0061	0.0152	3.3677
1.00	b	7.7129	0.0761	0.9861	66.668	2.4309	0.9725	0.0750	0.3810	0.8947	0.0022	0.0147	3.2254
1.00	**mean**	7.6839	0.0772	1.0042	66.952	2.4818	0.9900	0.0761	0.3799	0.9063	0.0041	0.0150	3.2965
1.25	g	7.6598	0.0781	1.0192	67.233	2.5329	1.0118	0.0775	0.3805	0.9160	0.0060	0.0152	3.3676
1.25	b	7.7080	0.0762	0.9891	66.665	2.4307	0.9682	0.0746	0.3793	0.8965	0.0022	0.0147	3.2254
1.25	**mean**	7.6839	0.0772	1.0042	66.949	2.4818	0.9900	0.0761	0.3799	0.9062	0.0041	0.0150	3.2965

Note: The table shows the averages across good and bad periods, respectively. **mean** denotes the unconditional mean, i.e., $0.5(\bar{x}_g+\bar{x}_b)$, where $\bar{x}_{\tilde{z}}$ is the average of x across periods with $z = \tilde{z}$. $\bar{w}$ is the average wage; $\overline{RR} \equiv \frac{h-T}{\bar{w}-T}$ is the average replacement ratio. The aggregate output is $\hat{y} \equiv zF\left(\tilde{k}\right)(1-u) - \xi v$. $\phi_{z_{-1}} = 1.25$ is the level that maximizes the mean welfare gain. For numerical reasons only, the benchmark is slightly different from comparable tables, since lagged productivity is included as an additional state variable, which changes the interpolation outcomes as well as the prediction rules.

Table 12: Welfare consequences of different degrees of cyclicality in UI benefits – UI depending on lagged productivity, public budget balances on average

$\phi_{z_{-1}}$	z	Welfare gains (in %)					Fraction gaining (in %)		
		overall	unempl	empl	uC	eC	overall	unempl	empl
−4.00	g	-0.0148	-0.0285	-0.0137	-0.0927	-0.0398	1.86	3.47	1.72
−4.00	b	0.0176	0.0319	0.0164	0.0842	0.0353	99.69	98.65	99.78
−4.00	**mean**	**0.0014**	**0.0017**	**0.0013**	**-0.0042**	**-0.0023**	**87.87**	**94.11**	**87.36**
−1.00	g	-0.0034	-0.0068	-0.0031	-0.0220	-0.0093	2.27	4.20	2.10
−1.00	b	0.0048	0.0084	0.0045	0.0222	0.0096	99.87	99.14	99.93
−1.00	**mean**	**0.0007**	**0.0008**	**0.0007**	**0.0001**	**0.0001**	**100.00**	**100.00**	**100.00**
0.25	g	0.0011	0.0020	0.0010	0.0057	0.0026	99.24	98.96	99.26
0.25	b	0.0048	-0.0018	-0.0008	-0.0054	-0.0021	0.88	3.07	0.70
0.25	**mean**	**0.0001**	**0.0001**	**0.0001**	**0.0002**	**0.0002**	**92.29**	**87.80**	**92.66**
1.00	g	0.0039	0.0074	0.0037	0.0220	0.0096	98.95	97.78	99.05
1.00	b	-0.0041	-0.0077	-0.0038	-0.0220	-0.0090	0.33	1.68	0.22
1.00	**mean**	**-0.0001**	**-0.0001**	**-0.0001**	**-0.0000**	**0.0003**	**42.09**	**34.20**	**42.74**

Note: The table shows the welfare gains from moving the agents from an economy with constant UI benefits to an economy with cyclically dependent benefits and slope parameter $\phi_{z_{-1}}$. uC and eC denote the unemployed and employed, respectively, with a binding borrowing constraint. g is a good state, b is a bad state, **mean** denotes the unconditional mean, i.e., $0.5(\bar{\mu}_g + \bar{\mu}_b)$.
$^\diamond$: Rounded to 100.00%. $\phi_{z_{-1}} = -4.00$ is the level that maximizes the mean welfare gain.

Table 13: Averages of key economic variables – UI depending on lagged productivity, public budget balances on average

$\phi_{z_{-1}}$	z	u (%)	v	θ	$\hat{k}$	$\bar{w}$	h	T	$\overline{RR}$	p	d	r	$\hat{y}$
−4.00	g	7.5638	0.0818	1.0812	67.157	2.5277	0.9201	0.0763	0.3442	0.9527	0.0074	0.0152	3.3670
−4.00	b	7.8181	0.0723	0.9247	66.628	2.4345	1.0599	0.0763	0.4171	0.8589	0.0013	0.0147	3.2242
−4.00	**mean**	7.6909	0.0770	1.0030	66.893	2.4811	0.9900	0.0763	0.3806	0.9058	0.0043	0.0150	3.2956
−1.00	g	7.6175	0.0797	1.0459	67.215	2.5308	0.9725	0.0761	0.3652	0.9319	0.0066	0.0152	3.3676
−1.00	b	7.7538	0.0746	0.9615	66.657	2.4324	1.0075	0.0761	0.3953	0.8805	0.0018	0.0147	3.2250
−1.00	**mean**	7.6856	0.0771	1.0037	66.936	2.4816	0.9900	0.0761	0.3802	0.9062	0.0042	0.0150	3.2963
0.00	g	7.6359	0.0790	1.0341	67.233	2.5318	0.9900	0.0761	0.3722	0.9249	0.0063	0.0152	3.3677
0.00	b	7.7332	0.0753	0.9738	66.665	2.4317	0.9900	0.0761	0.3880	0.8876	0.0020	0.0147	3.2252
0.00	**mean**	7.6846	0.0771	1.0040	66.949	2.4818	0.9900	0.0761	0.3801	0.9063	0.0042	0.0150	3.2965
1.00	g	7.6547	0.0783	1.0224	67.249	2.5328	1.0075	0.0761	0.3791	0.9179	0.0061	0.0152	3.3679
1.00	b	7.7129	0.0761	0.9861	66.673	2.4310	0.9725	0.0761	0.3807	0.8947	0.0022	0.0147	3.2254
1.00	**mean**	7.6838	0.0772	1.0042	66.961	2.4819	0.9900	0.0761	0.3799	0.9063	0.0041	0.0150	3.2967

Note: The table shows the averages across good and bad periods, respectively. **mean** denotes the unconditional mean, i.e., $0.5(\bar{x}_g+\bar{x}_b)$, where $\bar{x}_{\check{z}}$ is the average of x across periods with $z = \check{z}$. $\bar{w}$ is the average wage; $\overline{RR} \equiv \frac{h-T}{\bar{w}-T}$ is the average replacement ratio. The aggregate output is $\hat{y} \equiv zF\left(\tilde{k}\right)(1-u) - \xi v$. $\phi_{z_{-1}} = -4.00$ is the level that maximizes the mean welfare gain. For numerical reasons only, the benchmark is slightly different from comparable tables, since lagged productivity is included as an additional state variable, which changes the interpolation outcomes as well as the prediction rules.

C.4 Alternative calibration

For the alternative (Hagedorn-Manovskii) calibration we include the second moments in some of the prediction rules. In the benchmark, the law of motion for the aggregate capital stock is

$$\log \hat{k}' = 0.0904 + 0.9765 \log \hat{k} - 0.0032 \log u + 0.0310 \log z \qquad \left(R^2 = 0.9999993\right)$$

and the prediction rules for the other aggregate variables are

$$\begin{aligned} \log \theta \;=\; & -154.7377 + 70.7565 \log \hat{k} + 2.4886 \log u + 192.3435 \log z - 8.0931 \left(\log \hat{k}\right)^2 \\ & -0.0063 \left(\log u\right)^2 - 44.3079 \log \hat{k} \log z - 1.0605 \log u \log z - 0.5941 \log \hat{k} \log u \\ & \left(R^2 = 0.9999736\right) \end{aligned}$$

$$\log \left(p + d\right) = -5.0678 + 1.3788 \log \hat{k} - 0.0572 \log u + 3.3249 \log z \qquad \left(R^2 = 0.9999860\right)$$

$$\begin{aligned} \log Q_g \;=\; & 0.1165 + 1.7180 \log \widetilde{Q}_g - 0.0271 \log \hat{k} - 0.0032 \log u + 0.0026 \left(\log \hat{k}\right)^2 \\ & -0.0001 \left(\log u\right)^2 + 0.0006 \log \hat{k} \log u \\ & \left(R^2 = 0.9999953\right) \end{aligned}$$

$$\begin{aligned} \log Q_b \;=\; & -0.1201 - 0.0529 \log \widetilde{Q}_b + 0.0196 \log \hat{k} + 0.0089 \log u - 0.0019 \left(\log \hat{k}\right)^2 \\ & +0.0002 \left(\log u\right)^2 - 0.0018 \log \hat{k} \log u \\ & \left(R^2 = 0.9999585\right) \end{aligned}$$

where $\widetilde{Q}_z \equiv \pi_{zz} / \left(1 - \delta + r\left(z, \hat{k}', u'\right)\right)$ for $z = \{g, b\}$. $\hat{k}'$ is calculated from the law of motion above, whereas u' is calculated from (1).

Table 14: Summary statistics for the benchmark of invariant UI benefits – alternative calibration, budget balance

	z	u	v	θ	$\hat{k}$	$\bar{w}$	h
mean	1.0000	0.0792	0.0552	0.7138	66.5861	2.3859	2.2934
Δ_g	+2.00%	−9.89%	+9.52%	+19.10%	+0.38%	+0.75%	0.00%
	T	$\overline{RR}$	p	d	r	$\hat{y}$	$\hat{c}$
mean	0.0784	0.9600	2.3735	0.0119	0.0150	3.2069	2.6491
Δ_g	−9.89%	−0.76%	+7.07%	+140.05%	+2.33%	+2.46%	+0.36%

Note: **mean** denotes the unconditional mean, i.e., $0.5(\bar{x}_g+\bar{x}_b)$, where $\bar{x}_{\tilde{z}}$ is the average of x across periods with $z = \tilde{z}$. Δ_g is the percentage deviation of the average across good states from the unconditional mean. Thus, per definition $\Delta_b = -\Delta_g$, and only Δ_g is shown. $\bar{w}$ is the average wage; $\overline{RR} \equiv \frac{h-T}{\bar{w}-T}$ is the average replacement ratio; $\hat{y}$ is the aggregate output (net of vacancy costs); $\hat{c}$ is the aggregate consumption. Note that d can become negative.

Table 15: Welfare consequences of different degrees of cyclicality in UI benefits – alternative calibration, budget balance

ϕ_z	z	Welfare gains (in %)					Fraction gaining (in %)		
		overall	unempl	empl	uC	eC	overall	unempl	empl
−1.00	g	-0.1023	-0.1030	-0.1023	-0.1197	-0.1189	0.00	0.00	0.00
−1.00	b	-0.0909	-0.0904	-0.0909	-0.0971	-0.0978	0.00	0.00	0.00
−1.00	**mean**	**-0.0966**	**-0.0967**	**-0.0966**	**-0.1084**	**-0.1083**	**0.00**	**0.00**	**0.00**
1.00	g	0.0768	0.0775	0.0768	0.0897	0.0888	100.00	100.00	100.00
1.00	b	0.0636	0.0630	0.0636	0.0662	0.0669	100.00	100.00	100.00
1.00	**mean**	**0.0702**	**0.0703**	**0.0702**	**0.0779**	**0.0779**	**100.00**	**100.00**	**100.00**
2.00	g	0.1321	0.1334	0.1320	0.1538	0.1521	100.00	100.00	100.00
2.00	b	0.1029	0.1018	0.1030	0.1037	0.1053	100.00	100.00	100.00
2.00	**mean**	**0.1175**	**0.1176**	**0.1175**	**0.1288**	**0.1287**	**100.00**	**100.00**	**100.00**

Note: The table shows the welfare gains from moving the agents from an economy with constant UI benefits to an economy with cyclically dependent benefits and slope parameter ϕ_z. uC and eC denote the unemployed and employed, respectively, with a binding borrowing constraint. g is a good state, b is a bad state, **mean** denotes the unconditional mean, i.e., $0.5(\bar{\mu}_g + \bar{\mu}_b)$. Convergence is not achieved for values of ϕ_z higher than 2.1.

Table 16: Averages of key economic variables – alternative calibration, budget balance

ϕ_z	z	u (%)	v	θ	$\hat{k}$	$\bar{w}$	h	T	$\overline{RR}$	p	d	r	$\hat{y}$
−1.00	g	7.0150	0.0623	0.8911	66.689	2.3894	2.2734	0.0680	0.9500	2.5786	0.0354	0.0154	3.2825
−1.00	b	9.1879	0.0482	0.5290	66.195	2.3815	2.3134	0.0928	0.9702	2.1325	-0.0116	0.0146	3.1179
−1.00	**mean**	8.1015	0.0553	0.7101	66.442	2.3855	2.2934	0.0804	0.9601	2.3555	0.0119	0.0150	3.2002
0.00	g	7.1373	0.0605	0.8501	66.841	2.4037	2.2934	0.0707	0.9527	2.5412	0.0285	0.0153	3.2856
0.00	b	8.7046	0.0500	0.5775	66.331	2.3681	2.2934	0.0862	0.9673	2.2058	-0.0048	0.0146	3.1281
0.00	**mean**	7.9210	0.0552	0.7138	66.586	2.3859	2.2934	0.0784	0.9600	2.3735	0.0119	0.0150	3.2069
1.00	g	7.2996	0.0587	0.8063	66.930	2.4177	2.3134	0.0737	0.9555	2.4901	0.0213	0.0153	3.2867
1.00	b	8.3105	0.0517	0.6248	66.405	2.3544	2.2734	0.0806	0.9644	2.2663	0.0024	0.0147	3.1353
1.00	**mean**	7.8050	0.0552	0.7155	66.668	2.3861	2.2934	0.0772	0.9599	2.3782	0.0119	0.0150	3.2110
2.00	g	7.5041	0.0569	0.7601	66.986	2.4318	2.3334	0.0773	0.9582	2.4230	0.0141	0.0153	3.2863
2.00	b	7.9825	0.0534	0.6715	66.450	2.3406	2.2534	0.0758	0.9615	2.3139	0.0097	0.0147	3.1403
2.00	**mean**	7.7433	0.0551	0.7158	66.718	2.3862	2.2934	0.0766	0.9599	2.3684	0.0119	0.0150	3.2133

Note: The table shows the averages across good and bad periods, respectively. **mean** denotes the unconditional mean, i.e., $0.5(\bar{x}_g+\bar{x}_b)$, where $\bar{x}_{\tilde{z}}$ is the average of x across periods with $z = \tilde{z}$. $\bar{w}$ is the average wage; $\overline{RR} \equiv \frac{h-T}{\bar{w}-T}$ is the average replacement ratio. The aggregate output is $\hat{y} \equiv zF\left(\tilde{k}\right)(1-u) - \xi v$.

Table 17: Welfare consequences of different degrees of cyclicality in UI benefits – alternative calibration, public budget balances on average

ϕ_z	z	Welfare gains (in percentage)					Fraction gaining (in %)		
		overall	unempl	empl	uC	eC	overall	unempl	empl
−1.00	g	-0.1031	-0.1037	-0.1030	-0.1275	-0.1266	0.00	0.00	0.00
−1.00	b	-0.0713	-0.0708	-0.0714	-0.0725	-0.0732	0.00	0.00	0.00
−1.00	**mean**	**-0.0872**	**-0.0873**	**-0.0872**	**-0.1000**	**-0.0999**	**0.00**	**0.00**	**0.00**
1.00	g	0.0704	0.0711	0.0704	0.0901	0.0892	100.00	100.00	100.00
1.00	b	0.0380	0.0375	0.0380	0.0356	0.0364	100.00	100.00	100.00
1.00	**mean**	**0.0542**	**0.0543**	**0.0542**	**0.0628**	**0.0628**	**100.00**	**100.00**	**100.00**
2.00	g	0.1110	0.1123	0.1109	0.1460	0.1443	100.00	100.00	100.00
2.00	b	0.0461	0.0450	0.0462	0.0376	0.0394	100.00	100.00	100.00
2.00	**mean**	**0.0786**	**0.0787**	**0.0786**	**0.0919**	**0.0919**	**100.00**	**100.00**	**100.00**

Note: The table shows the welfare gains from moving the agents from an economy with constant UI benefits to an economy with cyclically dependent benefits and slope parameter ϕ_z. uC and eC denote the unemployed and employed, respectively, with a binding borrowing constraint. g is a good state, b is a bad state, **mean** denotes the unconditional mean, i.e., $0.5(\bar{\mu}_g + \bar{\mu}_b)$. Convergence is not achieved for values of ϕ_z higher than 2.1.

Table 18: Averages of key economic variables – alternative calibration, public budget balances on average

ϕ_z	z	u (%)	v	θ	$\hat{k}$	$\bar{w}$	h	T	$\overline{RR}$	p	d	r	$\hat{y}$
−1.00	g	7.0355	0.0620	0.8839	66.578	2.3884	2.2734	0.0806	0.9502	2.5839	0.0359	0.0154	3.2809
−1.00	b	9.2071	0.0482	0.5262	66.125	2.3814	2.3134	0.0806	0.9705	2.1460	-0.0119	0.0146	3.1165
−1.00	**mean**	8.1213	0.0551	0.7050	66.352	2.3849	2.2934	0.0806	0.9603	2.3649	0.0120	0.0150	3.1987
0.00	g	7.1590	0.0603	0.8441	66.749	2.4029	2.2934	0.0786	0.9529	2.5377	0.0288	0.0153	3.2841
0.00	b	8.7298	0.0499	0.5743	66.253	2.3677	2.2934	0.0786	0.9675	2.2059	-0.0049	0.0146	3.1265
0.00	**mean**	7.9444	0.0551	0.7092	66.501	2.3853	2.2934	0.0786	0.9602	2.3718	0.0120	0.0150	3.2053
1.00	g	7.3163	0.0586	0.8024	66.870	2.4173	2.3134	0.0774	0.9556	2.4884	0.0215	0.0153	3.2857
1.00	b	8.3357	0.0516	0.6216	66.333	2.3540	2.2734	0.0774	0.9646	2.2650	0.0023	0.0147	3.1338
1.00	**mean**	7.8260	0.0551	0.7120	66.601	2.3856	2.2934	0.0774	0.9601	2.3767	0.0119	0.0150	3.2097
2.00	g	7.5134	0.0568	0.7586	66.961	2.4317	2.3334	0.0767	0.9583	2.4228	0.0141	0.0153	3.2857
2.00	b	8.0072	0.0533	0.6682	66.387	2.3402	2.2534	0.0767	0.9617	2.3106	0.0098	0.0147	3.1390
2.00	**mean**	7.7603	0.0551	0.7134	66.674	2.3859	2.2934	0.0767	0.9600	2.3667	0.0120	0.0150	3.2123

Note: The table shows the averages across good and bad periods, respectively. **mean** denotes the unconditional mean, i.e., $0.5(\bar{x}_g+\bar{x}_b)$, where $\bar{x}_{\tilde{z}}$ is the average of x across periods with $z = \tilde{z}$. $\bar{w}$ is the average wage; $\overline{RR} \equiv \frac{h-T}{\bar{w}-T}$ is the average replacement ratio. The aggregate output is $\hat{y} \equiv zF\left(\tilde{k}\right)(1-u) - \xi v$.

Economics Working Papers

2012-06:	Gustaf Bruze, Michael Svarer and Yoram Weiss: The Dynamics of Marriage and Divorce
2012-07:	Allan Sørensen: Additive versus multiplicative trade costs and the gains from trade
2012-08:	Niclas Berggren and Christian Bjørnskov: Does Religiosity Promote Property Rights and the Rule of Law?
2012-09:	Daniel Monte and Norovsambuu Tumennasan: Centralized Allocation in Multiple Markets
2012-10:	Daniel Monte and Norovsambuu Tumennasan: Matching with Quorums
2012-11:	Ioana Neamtu and Niels Westergård-Nielsen: How are firms affected by the crisis and how do they react?
2012-12:	Lasse Frisgaard Gunnersen and Bo Sandemann Rasmussen: Optimal Tax-Transfer Policies, Life-Cycle Labour Supply and Present-Biased Preferences
2012-13:	Barbara Pertold-Gebicka: Job Market Polarization and Employment Protection in Europe
2012-14:	Alexander K. Koch, Julia Nafziger, Anton Suvorov and Jeroen van de Ven: Self-Rewards and Personal Motivation
2012-15:	Torben M. Andersen: Fiscal sustainability and fiscal policy targets
2012-16:	Tine Louise Mundbjerg Eriksen, Helena Skyt Nielsen and Marianne Simonsen: The Effects of Bullying in Elementary School
2012-17:	Jesper Bagger, Rune Vejlin and Kenneth L. Sørensen: Wage Sorting Trends
2012-18:	Anna Piil Damm: Neighborhood Quality and Labor Market Outcomes: Evidence from Quasi-Random Neighborhood Assignment of Immigrants
2012-19:	Mark Strøm Kristoffersen: Business Cycle Dependent Unemployment Benefits with Wealth Heterogeneity and Precautionary Savings