Unemployment Insurance and Unsecured Credit☆

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Abstract

In many countries, an unemployed has access to both public (unemployment insurance, UI) and private (credit card borrowing) form of insurance, and recent research suggests interactions between the two. I analyze such interactions in a calibrated heterogeneous-agent model with labor market search, unsecured consumer credit, and equilibrium default. Complementary interactions, meaning more generous UI lowers the probability of defaults and thus induces expansion of credit, are consistent with recent research, and imply welfare gains from countercyclical UI policy. On the other hand, unsecured credit substitutes for reduced UI benefits when the costs of defaulting while unemployed with lower UI benefits are sufficiently high. In that case, the unemployed can smooth consumption using unsecured credit and the option to default, which does not cause the moral hazard problem associated with UI.

Keywords: unemployment insurance, labor market, search and matching, unsecured consumer credit, default, public insurance, private insurance, heterogeneous agents
JEL Classification: E21, J64, J65, K35

1. Introduction

In many countries, the government provides public insurance in the form of unemployment insurance (UI) against risk of unemployment. It is known that UI facilitates consumption smoothing for unemployed workers (Gruber (1997)). Private insurance is important since there is no private market specifically to insure against unemployment risk, and many workers do not have enough wealth to make up the loss of income upon unemployment (Gruber (2001)). UI is typically analyzed by comparing the trade off between the benefits of better consumption smoothing and the incentive costs, as provision of public insurance against unemployment is known to distort incentive

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for job search, especially when workers are liquidity constrained and have limited ability to smooth consumption (Chetty (2008)). On the other hand, recent research finds that credit card loans, and the option to default on credit card loans, are used by the unemployed to smooth consumption (Braxton et al. (2018)). Moreover, Hsu et al. (2014) find that, during the Great Recession, credit supply responds to the amount of UI benefits available to the unemployed. These pieces of evidence suggest that there are interactions between UI policy and unsecured credit market. This is what I study in the current paper. Specifically, I build and calibrate heterogeneous-agent model with labor market search, unsecured consumer credit, equilibrium default, and aggregate fluctuations, and investigate the interactions between UI policy and unsecured credit in the model.

The interaction between UI and unsecured credit can be substituting or complementary. It can be substituting because when UI benefits are reduced, workers can instead rely on unsecured credit to smooth consumption during an unemployment spell. Or, when credit supply is limited, it might be desirable to implement more generous UI benefits to unemployed workers. However, the interaction could be complementary, as workers are more likely to replay their debt when UI benefits are more generous. If credit card companies know that workers are more likely to replay their debt, they could offer better terms of unsecured credit. Hsu et al. (2014) offer evidence of complementary interactions between UI and unsecured credit in the manner most relevant to this paper. They compare states in the U.S. in which the maximum amount of UI benefits were raised during the Great Recession, and states in which the maximum UI benefits were not raised, and find that credit card companies offered higher credit limit and a lower interest rate to both employed and unemployed households in the former group of states. This indicates that credit card companies adjust credit supply knowing the likelihood of repayment of their credit extended to workers.

There are three main results. First, in the steady-state environment, there could be both complementary and substituting interactions between UI benefits and unsecured credit. In particular, when the UI replacement rate is very low or eliminated, unsecured credit substitutes for UI benefits. Since non-financial income of unemployed becomes very low, the unemployed have a strong incentive to repay, and thus in turns relaxes the borrowing constraint. On the other hand, when the UI replacement rate is raised, the unemployed have more non-financial income that can be used to repay debt, which also relaxes borrowing constraint of the unemployed. At the end, the optimal level of UI benefit can be either very high or very low, but in my calibrated model, it turns out to be optimal to eliminate UI benefits, but still provides constant non-UI benefits. The size of the welfare gains from the substituting interaction between UI benefits and unsecured credit is equivalent to 0.5% of flow consumption. Second, the model with countercyclical UI policy generates complementary interactions between UI and unsecured credit, which is generally consistent with what Hsu et al. (2014) find using cross-state data. The model implies that countercyclical UI policy lowers defaults and expands credit supply in deep recessions. Third, the model implies welfare gains from countercyclical UI replacement rate. The complementary interactions increase welfare gains from countercyclical UI policy, but the additional gains from such interactions seems relatively minor. Even in the model without credit, countercyclical UI policy turns out to be welfare improving.

There is a long literature on the optimal design of UI program. Hopenhayn and Nicolini (1997) find that the optimal UI policy is characterized by declining UI replacement ratio throughout an unemployment spell, to alleviate the moral hazard problem while providing consumption insurance. Hansen and Imrohoroglu (1992) study the optimal provision of UI in a general equilibrium model. Shimer and Werning (2008) study the role of liquidity and show that, when workers have access to risk-free assets, the optimal UI prescribes constant UI benefits. Lentz (2009) study the optimal design of UI policy using an estimated model of labor market frictions and savings, and find that the optimal UI replacement rate is sensitive to the interest rate that workers are facing. What this paper adds to the literature is studying how the existence of and interaction with unsecured credit affect the optimal design of UI policy.

In terms of cyclicality of UI policy, in the U.S., the UI policy is generally countercyclical, but the duration of UI benefits is typically extended during recessions. However, there seems no agreement about its desirability in the literature. Landais et al. (2018) argue that countercyclical UI replacement rate is desirable since labor market tightness is inefficiently low (high) in recessions (expansions) and a higher UI replacement rate raises labor market tightness. On the other hand, Mitman and Rabinovich (2015) argue that the optimal UI replacement rate should go up right when the recession hits an economy but should remain low afterwards, and is generally characterized as procyclical. This combines concerns for consumption smoothing and dynamic incentive effect. What the paper offers is again how the discussion of desirable cyclicality of UI policy should affected by the existence and interaction with unsecured credit.

In a broader perspective, the paper is investigating the interaction between public and private insurance. In this sense, the paper is closely related to Krueger and Perri (2011) and Park (2014). Krueger and Perri (2011) study the interaction between private and public consumption insurance in an environment with endogenous borrowing constraint through limited enforcement, as in Kehoe and Levine (1993), and find that more public provision of consumption insurance (in the form of higher tax progressivity) could improve or hurt total consumption insurance, depending on how private consumption insurance responds to changes in public insurance. Park (2014) studies the optimal capital labor taxation in a similar environment, in which endogenous borrowing constraint is differently affected for heterogeneous households by the composition of the two types of taxes. The important channel of this paper is also endogenous borrowing constraint implied by the role of unsecured credit sector, but I study the issue of public vs. private insurance provision in the content of UI policy and unsecured credit. And equilibrium default is also an important part of the channel. Finally, I also study an environment with aggregate fluctuations.

The model developed in this paper is based on the standard incomplete-market heterogeneous-agent model, pioneered by Bewley (1986), Aiyagari (1994), and Huggett (1993), but extended by introducing both unsecured, defaultable, credit, labor market frictions, and aggregate uncertainty. As for unsecured credit, the model is based on Livshits et al. (2007) and Chatterjee et al. (2007). They introduce unsecured credit and equilibrium default into an incomplete-market model with uninsured shocks, but do not have labor market frictions. Nakajima and Ríos-Rull (2014) introduce aggregate uncertainty into the model with unsecured credit and equilibrium default, and investigate cyclical properties of credit and default. In terms of labor market frictions, literature recently introduced Mortensen-Pissarides (MP, Mortensen and Pissarides (1994)) style labor market search and matching into incomplete-market models with consumption and saving decision. Reichling (2007) studies the optimal level of UI replacement rate in an incomplete-market model with MP labor market frictions. Krusell et al. (2010) and Nakajima (2012a) study business cycle implications of such model with aggregate uncertainty.

The novel paper that combines all three features (unsecured credit, labor market frictions, and aggregate uncertainty) is Herkenhoff (forthcoming). He investigates the hypothesis that higher availability of unsecured credit allows unemployed workers to search longer and thus makes a recovery from a recession sluggish. Furthermore, in a paper closest to this paper, Braxton et al. (2018) study the optimal level of UI benefits in an incomplete-market model with unsecured credit and labor market frictions, and find substituting effects between UI and unsecured credit — the optimal generosity of UI benefits is lower with higher credit access. The model unsecured credit as a credit line, as in Mateos-Plannas and Ríos-Rull (2010), but is restricted to the steady-state environment. In the current paper, the substitution channel between UI and unsecured credit is present. However, in their model, credit supply is exogenous, while in my model, credit supply itself responds to the UI policy, and more generous UI replacement rate itself could and does expand credit supply, when credit card companies see expanded UI benefits as lowering risk of default. For a similar reason, UI and unsecured credit can be complementary in my model, which is not present in their framework. Finally, they do not study the implications of cyclicality of UI policy as they study a steady-state environment.

The rest of the paper is organized as follows. Section 2 presents the model and Section 3 described how the model is calibrated to capture the salient features of the U,.S. economy. Section 4 and 5 present the results in the steady-state environment and in the environment with aggregate shocks, respectively. Section 6 concludes.

2. Model

I describe below the steady-state model. Time is discrete and continues until $t = \infty$. The model is inhibited by workers, firms, credit card companies, and the government. Sections below provide details of each type of agents, followed by an equilibrium definition. Finally, in Section 2.9, I discuss how the model is extended by introducing aggregate uncertainty.

2.1. Worker: Labor Market Transition

There is a unit mass of workers. Each worker dies with probability γ each period. A worker is characterized by (h, u, d, a), h is skill (productivity) level, u is duration of unemployment ($u = 0$ means employed), d is a binary variable capturing credit history ($d = 0$ means history with no default (good) while $d = 1$ means history with default (bad)), and a represents holding of savings ($a \geq 0$) or debt ($a < 0$).[2]

A deceased worker is replaced by a newborn, thus the total population size remains constant. A newborn worker draws h from an exogenously-given distribution Γ_h^0, is born unemployed ($u = 1$) with probability $\overline{u}^0$, and employed ($u = 0$) with probability $1-\overline{u}^0$, has a clean credit history ($d = 0$), and has zero savings ($a = 0$). I use $m(h, u, d, a)$ to represent a type distribution of households at the beginning of a period, and $\widetilde{m}(h', u', d, a)$ to represent a type distribution after the labor market transition.

A period consists of two stages. In the first stage, labor market transition occurs. In the second stage, which is described in the next section, consumption, saving, and default decisions are made. Two-stage structure allows bond price function $q(.)$ not to depend on the current amount of debt. See discussion in Section 2.6. Labor market transition for employed workers is simple. An employed worker loses his jobs with probability λ and keeps it with probability $1 - \lambda$. At the same time, if the worker remains unemployed, there is a shock to individual labor productivity, characterized by $\Gamma^h_{h'|h,0}$. If the worker loses its job, the labor productivity is kept. This is important because the amount of unemployment insurance benefits depends on the productivity before losing the job. An

[2] Since debt carries a higher interest rate than savings, no worker holds savings and debt simultaneously. Therefore, I only keep track of the consolidated asset position a.

unemployed worker chooses the level of search effort s, and finds a job with probability $f_h s$, where f_h is job-finding rate per search effort, for a worker of skill level h. f_h is determined endogenously (see Section 2.5). If the worker fails to find a job, the worker's labor productivity remains the same. If the worker finds a job, labor productivity changes, following $\Gamma^h_{h'|h,u}$. The transition probabilities depend on the duration of unemployment u, since this transition is used to capture skill depreciation during an unemployment spell. In other words, in general, I will calibrate such that h goes down more on average if the worker was unemployed for a longer period.

The value of an employed ($u = 0$) worker can be characterized by the following Bellman equation:

$$V(h, u = 0, d, a) = (1 - \lambda) \sum_{h'} \Gamma^h_{h'|h,0} \widetilde{V}(h', 0, d, a) + \lambda \widetilde{V}(h, u = 1, d, a) \tag{1}$$

where $V(.)$ and $\widetilde{V}(.)$ are values before and after the labor market transition, respectively. Notice labor productivity changes according to $\Gamma^h_{h'|h,0}$ if the worker remains employed, and remains the same if the worker loses its job. Value for an unemployed ($u > 0$) worker can be characterized as follows:

$$V(h, u > 0, d, a) = \max_{s \in [0, 1/f^s_h]} \left\{ -x(s) + f_h s \sum_{h'} \Gamma^h_{h'|h,u} \widetilde{V}(h', 0, d, a) + (1 - f_h s) \widetilde{V}(h, u + 1, d, a) \right\} \tag{2}$$

where $-x(s)$ denotes disutility from search. $\Gamma^h_{h'|h,u}$ represents the transition probability of labor productivity conditional on finding a job. $g_s(h, u, d, a)$ is the optimal search effort function. For employed workers, $g_s(h, 0, d, a) = 0$ by construction.

2.2. Worker: Consumption, Saving, and Default

At the beginning of a second stage, a worker is characterized by (h', u', d, a). Labor productivity is h' and (un)employment status is u', since labor market transition already occurred in the first stage. A worker with clean credit history ($d = 0$) decides whether to default, if he has debt, or not. Formally:

$$\widetilde{V}(h', u', d = 0, a) = \max\{\widetilde{V}_n(h', u', d = 0, a), (1 + \epsilon_d)\widetilde{V}_d(h', u', d = 0, a)\} \tag{3}$$

where $\widetilde{V}_n(h', u', d = 0, a)$ and $\widetilde{V}_d(h', u', d = 0, a)$ are values conditional on not defaulting and defaulting, respectively. ϵ_d is an i.i.d. preference shock to the value of defaulting. This helps smooths out default decision, and thus the default premium function $q(.)$. I assume that $\epsilon_d \sim N(0, \sigma^2_{h',u'})$ with $\sigma_{h',u'} = \bar{\epsilon}_d(\widetilde{V}_n(h', u', 0.0) - \widetilde{V}_d(h', u', 0, 0))$. In words, the standard deviation of the preference shock is proportional (proportion $\bar{\epsilon}_d$) to the difference between values of non-defaulting and defaulting. With this assumption, I make sure that the contribution of preference shocks to default decision is similar across different types of debtors. Finally, notice that, if ϵ_d is set to zero, the problem becomes the standard binary choice between defaulting and not defaulting.

Value conditional on not defaulting can be characterized by the following Bellman equation:

$$\widetilde{V}_n(h', u', d = 0, a) = \max_{c, a'} \{u(c) + \beta(1 - \gamma)V(h', u', 0, a')\} \tag{4}$$

subject to

$$c + (1-\gamma)q(h', u', d, a')a' = a + \xi(h', u') \tag{5}$$

$$\xi(h', u') = \begin{cases} h'w(1-\tau) & \text{if } u' = 0 \text{ (employed)} \\ \max\{\widetilde{\phi}, \min\{\overline{\phi}, \phi_{u'}h'w\}\} & \text{if } u' = 1, \ldots, \overline{u} \text{ (UI benefits)} \\ \widetilde{\phi} & \text{if } u' > \overline{u} \text{ (non-UI benefits)} \end{cases} \tag{6}$$

In the Bellman equation (4), $u(c)$ is utility from consumption. β is time discount factor. On the left hand side of the budget constraint (5) includes consumption c and discounted value of asset or debt holding carried over to the next period a'. $q(h', u', d, a')$ is the discount price of one-period bond. Workers buy or sell those bonds to carry over savings or debt to the next period. This set-up is common in models with endogenous default. See Chatterjee et al. (2007), for example. Determination of $q(h', u', d, a')$ is discussed in Section 2.6. The term $(1-\gamma)$ comes from an assumption that workers has access to complete annuity market, and insures away survival/mortality risk. On the right hand side are assets or debt carried over from the previous period a, and non-financial income $\xi(h', u')$. Equation (6) specifies the non-financial income. Non-financial income is labor income in case of an employed worker ($u' = 0$), unemployment insurance (UI) benefits in case of an unemployed worker eligible for UI benefits ($u' = 1, 2, ..., \overline{u}$), and non-UI benefits in case an unemployed worker exhausted UI benefits ($u' > \overline{u}$). The implicit assumptions here are all workers are eligible for UI benefits until $\overline{u}$ periods of unemployment. Earnings of an employed workers is the product of individual labor productivity h', market wage per efficiency unit w, which determination will be further discussed in Section 2.3, and $(1-\tau)$ with τ being payroll tax rate. The proceeds of the payroll tax is used to finance UI and non-UI benefits. For an unemployed with UI eligibility, non-financial income is UI-benefits, whose amount is replacement rate $\phi_{u'}$ times the would-be earnings. The replacement rate can depend on the unemployment duration u', although in the baseline case, I do not use this feature, since the amount of UI benefits does not change in the U.S. UI program. The amount of UI benefits is capped by $\overline{\phi}$. Moreover, in case the replacement rate $\phi_{u'}$ is too low, the unemployed worker can receive non-UI benefits $\widetilde{\phi}$ instead, although this feature does not bind in the baseline calibration. Finally, for an unemployed worker ineligible for UI benefits, non-financial income is the non-UI benefits $\widetilde{\phi}$.

Conditional on defaulting, value function is characterized as follows:

$$\widetilde{V}_d(h', u', d, a) = \max_{c} \{u(c) + \beta(1-\gamma)V(h', u', 1, 0)\} \tag{7}$$

subject to

$$c = \xi(h', u') \tag{8}$$

Notice that, upon default, the existing debt is wiped out (there is no a in the left-hand side of the budget constraint), but the worker cannot save in the current period ($a' = 0$) either. This is meant to capture that fact that, when a debtor is filing for a bankruptcy, whatever savings are confiscated and used for (partial) repayment of the defaulted loan. Therefore, it is optimal for the debtor filing for a bankruptcy not to save anything.

Value of of a worker with a bad credit history can be characterized as follows:

$$\widetilde{V}(h', u', d = 1, a) = \max_{c, a' \geq 0} \{u(c) + \beta(1-\gamma)\left(\omega V(h', u', 0, a') + (1-\omega)V(h', u', 1, a')\right)\} \tag{9}$$

subject to

$$c + (1-\gamma)q(h', u', d, a')a' = a + \xi(h', u')(1-\delta_d) \tag{10}$$

Notice three differences from the problem of non-defaulting worker. First, a worker with bad credit history cannot borrow ($a' \geq 0$). Second, with probability γ, the credit history recovers, i.e. the history of defaulting is wiped out. The stochastic recovery of the credit history helps reducing the size of the individual state space, compared with the standard case of keeping track of the number of periods after defaulting. Third, the worker loses a fraction δ_d of non-financial income while having a bad credit history. This is meant to capture the costs of not being able to have a credit card, for example. The optimal decision rules for savings and default are denoted by $g_a(h', u', d, a)$ and $g_d(h', u', d, a)$, respectively. Notice that the optimal decision rule for defaulting, $g_d(h', u', d, a) \in [0, 1]$, due to the preference shock that smooths the default decision.

2.3. Wage Function

Generally, in a model with labor market search and matching, the bargaining outcome between a worker and a firm in a match depends on all the characteristics of the worker and the firm. Since the set of efficient bargaining outcome is large (Hall (2005)), some bargaining protocol needs to be chosen to pick a surplus sharing rule from set of efficient bargaining outcome. Nash bargaining is commonly used to characterize the bargaining outcome. However, for simplicity, I assume the following ad-hoc wage function:[3]

$$w = \overline{w} \exp(\epsilon_z \Delta_z + \epsilon_\phi \Delta_\phi) \tag{11}$$

where $\overline{w}$ is the baseline wage level. Δ_z is the deviation of aggregate productivity shock from the steady-state level, although this is not used in the steady-state model. ϵ_z is the elasticity of wage to a change in aggregate labor productivity. Δ_ϕ is the deviation of UI replacement rate from the baseline level, and ϵ_ϕ is the elasticity of wage to a change in UI replacement rate. In the baseline model in the steady state, $w - \overline{w}$. But w will be different from $\overline{w}$ when the UI replacement rate is raised (and thus worker's reservation value increases) or the economy is hit by aggregate productivity shock (and the total surplus within a match increases). Later in the calibration section, I pin down ϵ_z and ϵ_ϕ using empirical estimates.

2.4. Firm

A firm is characterized by the labor productivity of the worker h that the firm is matched to. With the wage function described in the previous section, firm's value can be recursively characterized as follows:

$$F(h) = \left\{ h(1-w) + \frac{1-\lambda}{1+r} \sum_{h'} \Gamma^h_{h'|h,0} F(h') \right\} \tag{12}$$

where r is the discount rate. Notice that the value of a firm only depends on h since the current profit of a firm only depends on h. In particular, the assumption that wage does not depend on the type of the worker that the firm is matched to is crucial. Also notice the transition probability of h is $\Gamma^h_{h'|h,0}$ because the worker is currently employed ($u' = 0$).

[3] Krusell et al. (2010) and Nakajima (2012a) solve the Nash bargaining problem when workers are risk averse and can save, and consequently the bargaining solution depends on the asset position of the worker.

2.5. Matching

An unmatched firm can enter the market by paying a fixed cost κ_h to post a vacancy in the market to hire workers of productivity h. Since only h affects the value of the firm, markets are segmented only by h. Denote $M(S,V)$ is the constant-returns-to-scale matching function, where S is search effort and V is the number of vacancies posted. Vacancies for h-market, V_h, are determined by the following zero profit condition:

$$\kappa_h = \frac{M(S_h, V_h)}{V_h} F(h) \tag{13}$$

Total search effort by type-h unemployed workers, S_h is characterized as follows:

$$S_h = \int \mathbb{1}_{\overline{h}=h} g_s(\overline{h}, u, d, a) dm(\overline{h}, u, d, a) \tag{14}$$

where $m(h,u,d,a)$ is the type distribution of heterogeneous workers. The probability of finding a job per search effort for a worker with productivity h, f_h, is characterized as follows:

$$f_h = \frac{M(S_h, V_h)}{S_h} \tag{15}$$

2.6. Consumer Credit

There is a competitive consumer credit industry. A credit card company buys one-period discount bond from a borrower of type-$(h', u', 0, a')$ at the price $q(h', u', 0, a')$.[4] As in the standard model with equilibrium defaults (Chatterjee et al. (2007) and Livshits et al. (2007)), a credit card company can target a specific type of borrowers $(h', u', 0)$ with a specific level of debt a'. This implies that there is no cross-subsidization across different types of borrowers in equilibrium. For an employed $(u = 0)$ borrower, the bond price satisfies the following zero profit condition:

$$\begin{aligned} &q(h', u' = 0, d = 0, a')(-a')(1 + r + \iota) = \\ &\qquad \lambda(1 - g_d(1))(-a') + (1 - \lambda) \sum_{h''} \Gamma^h_{h''|h',0} (1 - g_d(0))(-a') \end{aligned} \tag{16}$$

To ease notation, I use a short-handed notation of $g_d(u') = g_d(h', u', 0, a')$. Notice that a consumer credit company can borrow at interest rate r, but has to pay for additional cost ι. Solving for $q(h, u' = 0, d = 0, a')$ yields the following:

$$q(h', u' = 0, d = 0, a') = \frac{\lambda(1 - g_d(1)) + (1 - \lambda) \sum_{h''} \Gamma^h_{h''|h',0}(1 - g_d(0))}{1 + r + \iota} \tag{17}$$

Similarly, for an unemployed $(u' > 0)$ borrower, the bond price satisfies the following zero profit condition:

$$\begin{aligned} &q(h', u' > 0, d = 0, a')(-a')(1 + r + \iota) = \\ &\qquad f_{h'} g_s(u') \sum_{h''} \Gamma^h_{h''|h',u'} (1 - g_d(0))(-a') + (1 - f_{h'} g_s(u'))(1 - g_d(u' + 1))(-a') \end{aligned} \tag{18}$$

[4] Notice that only workers with good credit history $(d = 0)$ can borrow.

where I also use a short-hand notation $g_s(u') = g_s(h', u', 0, a')$. Solving for $q(h', u' > 0, d, a')$ yields the following:

$$q(h', u' > 0, d = 0, a') = \frac{f_{h'} g_s(u') \sum_{h''} \Gamma^h_{h''|h',u'}(1 - g_d(0)) + (1 - f_{h'} g_s(u'))(1 - g_d(u' + 1))}{1 + r + \iota} \tag{19}$$

Notice that the optimal search effort $g_s(u')$ is needed to compute the equilibrium $q(.)$ for unemployed workers. If search effort decision is made simultaneously as saving and borrowing decision, $q(.)$ must depend not only on the amount newly borrowed (a') but also current asset level (a), which the optimal search effort decision depends on. Therefore, dividing one period into two stages allows $q(.)$ not to depend on a and thus to be simpler.

Notice that, when it is optimal never to default in the next period ($g_d(.) = 0$), the bond function becomes simple, as follows.

$$q(h', u', d, a') = \frac{1}{1 + r + \iota} \tag{20}$$

In the opposite extreme, if it is always optimal to default in the next period ($g_d(.) = 1$), the bond price function becomes the following:

$$q(h', u', d, a') = 0 \tag{21}$$

Since no worker chooses a debt level a' with $q(h', u', d, a') = 0$, the smallest debt level a' that yields zero price of bond effectively becomes the endogenous borrowing limit. Finally, in case $a' \geq 0$, there is additional cost of extending loan ($\iota = 0$). Therefore:

$$q(h', u', d, a' \geq 0) = \frac{1}{1 + r} \tag{22}$$

Moreover, a worker with bad credit history cannot borrow, the following holds:

$$q(h', u', d = 1, a' < 0) = 0 \tag{23}$$

2.7. Government

The government runs a UI and and non-UI public insurance programs, subject to period-by-period budget balance. On the income side, the government taxes all employed workers at a constant payroll tax rate τ. On the expenditure side, the government provides UI benefits to all unemployed workers eligible for UI and non-UI benefits to all the other unemployed. The amount of benefits is characterized by the replacement rate $\phi_{u'}$ and the non-UI level $\widetilde{\phi}$. Notice $\phi_{u'}$ depends on the duration of unemployment u'. This formulation allows the government to change the replacement rate depending on the duration of unemployment, which is one of the counterfactual experiments implemented later. The government has to satisfy the following budget constraint each period:

$$\int \min\{\widetilde{\phi}, \max\{\overline{\phi}, \phi_u h' w\}\} \mathbb{1}_{u'=1,\ldots,\overline{u}} \; d\widetilde{m} + \int \widetilde{\phi} \mathbb{1}_{u > \overline{u}} \; d\widetilde{m} = \int h' w \tau \mathbb{1}_{u'=0} \; d\widetilde{m} \tag{24}$$

2.8. Equilibrium

I focus on steady-state equilibrium where prices, distribution, values, and optimal decision rules are time-invariant.

Definition 1 (Steady-state equilibrium). *A steady-state equilibrium consists of value functions for workers, $V(h,u,d,a)$ $\widetilde{V}(h',u',d,a)$, for firms, $F(h)$, decision rules of workers, $g_s(h,u,d,a)$, $g_a(h',u',d,a)$, $g_d(h',u',d,a)$, bond prices $q(h',u',d,a')$, type distribution $m(h,u,d,a)$ and $\widetilde{m}(h',u',d,a)$, number of vacancies posted for h-market, V_h, total search effort by type-h unemployed, S_h, fob-finding rate for type-h unemployed, f_h, wage, w, and payroll tax rate τ, that satisfy the followings:*

1. *Given w, $q(h',u',d,a')$, f_h, and τ, value functions $V(h,u,d,a)$ $\widetilde{V}(h',u',d,a)$ solve the worker's decision problem. $g_s(h,u,d,a)$, $g_a(h',u',d,a)$, and $g_d(h',u',d,a)$ are the associated optimal decision rules.*
2. *Firm's value function $F(h)$ solves the firm's optimal decision problem, specified by (12).*
3. *The number of vacancies posted for h-market, V_h, solves the zero profit condition for new entry, specified by (13). S_h is characterized by (14) and f_h is characterized by (15).*
4. *Wage is determined by the wage function (11).*
5. *Type distribution of workers $m(h,u,d,a)$ and $\widetilde{m}(h',u',d,a)$ are time-invariant and consistent with the optimal decision rules and transition probabilities of exogenous shocks.*
6. *Bond price function $q(h',u',d,a')$ is consistent with the zero-profit condition for each type of borrower, and specifically characterized by equations (17) and (19).*
7. *Payroll tax rate τ satisfies the government budget balance constraint (24).*

2.9. Introducing Aggregate Uncertainty

So far I described a steady-state of the model, but I will implement experiments with aggregate uncertainty. In particular, I consider an economy with aggregate labor productivity shock z. z follows a Markov transition matrix $\Gamma^z_{z'|z}$. With the aggregate labor productivity, there are four changes to the model: (1) earnings of an employed worker become $zh'w(1-\tau)$. (2) firm's current profit becomes $zh(1-w)$, and the firm's value function becomes $F(z,h)$ as it depends on z as well. (3) market tightness for h-market becomes $\theta_{z,h}$. (4) wage w changes with z, as in equation (11).

Notice that the only equilibrium condition which requires aggregation across different types of workers is the government budget constraint. In an economy with aggregate uncertainty, I assume that the payroll tax rate τ is fixed at the steady-state value, which allows the government to keep the constant tax rate and achieve tax smoothing. Moreover, because of the market segmentation in the labor market, and the assumption that wage does not depend on worker's type, the economy exhibits block recursive structure. Since there is no aggregate production function, solving the model with aggregate uncertainty becomes manageable. Finally, an economy with aggregate uncertainty is assumed to start from the steady-state type distribution at time 0.

3. Calibration

I calibrate the baseline model assuming that the unemployment insurance program in the model mimics that of the current U.S. economy in normal times. Parameter values are summarized in Table 1. One period is one month.

3.1. Parameterization

I assume standard functional forms in the literature. Utility from consumption is of constant-relative-risk-aversion type, with the risk aversion parameter σ.

$$u(c) = \frac{c^{1-\sigma}}{1-\sigma} \tag{25}$$

Table 1: Calibrated Parameters

Parameter	Value	Description
β	0.9796	Time-discount factor.
σ	2.0000	Relative risk aversion.
γ	0.0021	Mortality rate. Average life of 40 years.
χ	379.85	Level of disutility from search.
ψ	0.2000	Elasticity of search effort.
$\overline{h}$	1.0000	Average labor productivity.
ρ_h	0.9040	Persistence of individual skill shock.
σ_h	0.1530	Standard deviation of individual skill shock.
δ_h	0.0545	Size of skill depreciation per month.
μ_0	1.0560	Mean of h for a newborn.
σ_0	0.3000	Standard deviation of h for a newborn.
λ	0.0333	Job separation rate.
$\overline{w}$	0.9500	Average surplus share for workers.
α	0.5000	Elasticity of matching function.
μ	2.0705	Level of matching function.
$\{\kappa_h\}$	—	Fixed cost of posting a vacancy in h-market.
$\overline{u}_0$	0.0694	Unemployment rate of newborns.
r	0.0030	Risk-free real interest rate.
ι	0.0040	Consumer credit cost.
δ_d	0.0733	Income loss due to bad credit history.
ω	0.0083	Probability of credit history recovery.
σ_d	0.2841	Standard deviation of preference shock.
$\phi_{u=1}$	0.4610	Replacement rate of UI benefits.
$\overline{\phi}$	0.5120	Upperbound of UI benefits.
$\widetilde{\phi}$	0.1590	Non-UI benefits.
z_1	1.0200	Labor productivity in expansions.
$\Gamma^z_{1\|1}$	0.9829	Persistence of an expansion.
$\Gamma^z_{1\|2}$	0.0140	Probability of a normal recession.
$\Gamma^z_{1\|3}$	0.0031	Probability of a deep recession.
$\Gamma^z_{2\|2}$	0.9099	Persistence of a recession.
ϵ_z	0.4490	Elasticity of wage to labor productivity.
ϵ_ϕ	0.0100	Elasticity of wage to UI replacement rate.

Notes: The table shows the calibrated parameters at monthly frequency. See the main text for explanations and details regarding calibration targets.

Disutility from search takes the following functional form:

$$v(c) = \chi \frac{s^{1+\psi}}{1+\psi} \tag{26}$$

where χ represents the level of disutility from search, and ψ represents the elasticity of search effort. The separable functional form between consumption and search effort is also used by Chetty (2008).

Matching function is also Cobb-Douglas type:

$$M(S,V) = \mu S^{\alpha} V^{1-\alpha} \tag{27}$$

with μ represents the match efficiency and α is the elasticity of matching function.

3.2. Preferences

β is calibrated such that about 48.3% of households have unsecured credit (average of 1998-2007 Survey of Consumer Finances). σ is set at 2.0, which is the value commonly assumed in the literature. γ is set at 0.0021, which implies that the average length of life is 40 years. χ is calibrated such that an unemployed on average spend 32 minutes per day (3.74 percent of disposable time) for job search. This is number reported in Krueger and Mueller (2010). ψ is calibrated such that, the response of the average duration of unemployment to a 10-percentage-point increase in the replacement rate of unemployment insurance benefits is consistent with available empirical estimates (0.5-1.5 weeks). Nakajima (2012b) uses the same calibration strategy.

3.3. Endowment

In calibrating the transition probabilities of the skill level h, I already assume distinct transitions for employed ($u' = 0$) and unemployed ($u' > 0$) workers to accommodate skill depreciation during unemployment spell. Moreover, I use recent findings about nature of shock to earnings (Guvenen et al. (2015) and Grigsby et al. (2018)).

As for the unemployed ($u > 0$), I assume unemployed workers suffer skill depreciation. Skill depreciation is consistent with Farber (2011), who reports that job losers experience on average about 15 percent decline in real weekly earnings. In terms of parameterization, I first discretize the space of log of h into H log-equally-spaced grids $h_1 < h_2 < \ldots < h_H$ and assume that an unemployed worker with the skill level h_i loses its skill and the skill level becomes h_{i-1} in the next period with probability δ_h.[5] Since the median duration of unemployment is 12.4 weeks (2.86 months), δ_h is calibrated to satisfy $0.15 = \frac{h_i - h_{i-1}}{h_i}\delta_h 2.86$.[6]

For the employed ($u = 0$), Guvenen et al. (2015) and Grigsby et al. (2018) find that the distribution of wage growth exhibit high kurtosis, which is inconsistent with the log-normal distribution that has been commonly assumed in the literature. In order to capture the kurtosis, I assume that skill does not change with probability ρ_h, and with probability $1 - \rho_h$, skill changes according to $LN(0, \sigma_h^2)$. In calibrating ρ_h, I follow Grigsby et al. (2018), who find that the quarterly probability of nominal wage change is 74.0%, and set $\rho_h = 0.704^{\frac{1}{3}} = 0.904$. Grigsby et al. (2018) also report that, conditional on any wage change, the standard deviation of nominal wage change is 15.3%. Base on this, I set $\sigma_h = 0.153$. Notice that, although the numbers reported by Grigsby et al. (2018) are nominal, inflation rate is very low during their sample period of 2008-2016, I use the probability of no nominal wage change as the no real wage change as an approximation. Otherwise, no nominal wage change does not mean no real wage change.

As for the distribution of labor productivity of newborns, I assume that the initial h is distributed according to $LN(\mu_h, \sigma_0^2)$. I pin down μ_0 such that h grows by 40% in 40 years on average. σ_h is set at 0.30 based on Storesletten et al. (2004).

[5] For an unemployed with skill level h_1, there is no more skill depreciation.

[6] 12.4 weeks is computed as the average of the median unemployment duration, during 2000-2014.

Table 2: **Calibration by Matching Moments**

	Value	Moment	Data	Model
β	0.9796	Fraction with credit card debt (%)	48.3	48.5
δ_d	0.0733	Total credit card debt relative to income (%)	7.94	7.97
σ_d	0.2841	Bankruptcies per year (%)	0.943	0.955
μ	2.0705	Unemployment rate (%)	5.67	5.67
χ	379.85	Time for job search per day (%)	3.74	3.75
ψ	0.2000	Elasticity of U duration to +10pp UI (week)	0.5-1.5	0.633

Notes: The table shows the calibrated parameters at monthly frequency.

3.4. Labor Market

Job separation rate λ is calibrated to achieve the average job duration of 2.5 years. $\overline{w}$ is set at 0.95, which is consistent with the proportion of firm's surplus in aggregate. α is set at 0.5, which is in the middle of available empirical estimates.[7] κ_h is fixed for each h such that the monthly job-finding rate is 25% for all h. μ is calibrated such that the unemployment rate is 5.67% in the steady state, the average unemployment rate in the U.S. The unemployment rate of newborns, $\overline{u}_0$, is set at 0.0694, using the unemployment rate of individuals in 20s according to CPS.

3.5. Unsecured Credit and Default

Interest rate r is set at $r = 0.003$ at monthly frequency, which implies 3.6% annual risk-free interest rate. ι is set at 0.004 at monthly frequency, or 4.8% at annual frequency. Agarwal et al. (2018) report that reward, fraud expenses and other operational costs total 4.9% per year. Income loss while having a bad credit history, δ_d is set at 0.0733 and the standard deviation of preference shock σ_d is pinned down to 0.2841. These two parameters generate the default rate of 0.943% per year and debt-to-income ratio of 7.94. The bankruptcy rate is the average in the U.S. in the early 2000s. ω is set to 1/120, which is consistent with the fact that history of defaulting can be kept up to 10 years.

3.6. Government Policy

Replicating the current U.S. unemployment insurance program, the UI replacement rate ϕ_u is set at 0.461. This is the average UI replacement rate in normal times (i.e., not during the Great Recession) across U.S. states. The upperbound of UI benefits, $\overline{\phi}$ is set at 0.512 of average earnings, also based on the average across states. The amount of non-UI benefits, $\widetilde{\phi}$ is set at 0.159, based on the average value of food stamps and welfare payments.

3.7. Calibration by Matching Moments

There are six parameters which are calibrated to match jointly six closely-related targets. These are β, χ, ψ, μ, δ_d, and σ_d. Table 2 summarizes the parameters and corresponding moments in the model and in the data. The table confirms that the calibration procedure is successful, in the sense that the six parameters are pinned down simultaneously to replicate closely-related six targets.

[7] See Petrongolo and Pissarides (2001) for summary of empirical estimates.

3.8. Aggregate Shock

For a model with aggregate uncertainty, I assume three aggregate levels of aggregate productivity, corresponding (1) expansion, (2) normal recession, and (3) deep recession. Generally, Markov transition matrix across these three states is characterized by 6 numbers, but I impose that (i) there is no transition between normal and deep recession, (ii) the persistence of two types of recession is the same. Specifically, the Markov transition matrix looks like below:

$$\Gamma^z_{z'|z} = \begin{bmatrix} \Gamma^z_{1|1} & \Gamma^z_{1|2} & 1-\Gamma^z_{1|1}-\Gamma^z_{1|2} \\ 1-\Gamma^z_{2|2} & \Gamma^z_{2|2} & 0 \\ 1-\Gamma^z_{3|3} & 0 & \Gamma^z_{3|3} \end{bmatrix}$$

With those restrictions, the Markov transition matrix is characterized by $\Gamma^z_{1|1}$, $\Gamma^z_{2|2} = \Gamma^z_{3|3}$ and $\Gamma^z_{1|2}$. $\Gamma^z_{1|1}$ and $\Gamma^z_{2|2} = \Gamma^z_{3|3}$ are set at 0.9829 and 0.9099, based on the average duration of expansions (58.4 months) and recessions (11.1 months). $\Gamma^z_{1|2}$ is pinned down such that the relative frequency of a regular recession conditional on a recession is 0.182 (= twice out of 11 recessions in the post war period). In particular, I can pin down $\Gamma^z_{1|2} = (1-0.9829)0.82 = 0.014$, and $\Gamma^z_{1|3} = (1-0.9829)0.18 = 0.0031$. I set that labor productivity is 2% higher than the time series average. I also impose that unconditional mean of labor productivity is 1.0, and labor productivity in a deep recession is twice as large negative as a normal recession. These together imply that $z_1 = 1.0200$, $z_2 = 0.8948$, and $z_3 = 0.7895$.

In terms of elasticity of wage to labor productivity (ϵ_z) and to the UI replacement rate (ϵ_ϕ), I set $\epsilon_z = 0.449$ based on the estimate by Hagedorn and Manovskii (2008), and $\epsilon_\phi = 0.010$ based on Jäger et al. (2018), who find that wage response is at most \$0.01 per \$1.00 increase in UI benefits.

4. Result: Unemployment Insurance and Unsecured Credit

4.1. Design of Experiments

In this section, I use the calibrated steady-state model as a laboratory and use the model to study macroeconomic and welfare implications of changing the characteristics of UI benefits. For the main experiment, I keep the current structure of UI benefits, in the sense that UI benefits last for 6 months, and the amount of benefits does not change during an unemployment spell. I also keep the non-UI benefits $\widetilde{\phi}$ at the baseline level of 0.159. What I change is the replacement rate ϕ_1, whose baseline value is 0.461. At the same time, the upperbound of UI benefits, $\overline{\phi}$ is moved by the same percentage points as ϕ_1 is moved around. The idea behind this is trying not to change the redistribution effects of changing the amount of UI benefits.

When I change $(\phi_1, \overline{\phi})$ to various values, I solve a new steady-state equilibrium under the new policy variables. Notice that the bond price function $q(.)$ changes in response to changes in the policy variables as well, whose response captures the interaction between UI and supply of unsecured credit. In order to learn the role of the interaction between UI and unsecured credit, I implement alternative experiments in which the bond price function $q(.)$ is fixed at the baseline values, and is not allowed to change in response to a policy change. This counterfactual experiment allows us to disentangle out the role of the interaction between UI and unsecured credit. I also implement experiments in an alternative model without unsecured credit.

For welfare analysis, I use three definitions of social welfare. First is the ex-ante expected life-time utility of a newborn, as in Conesa et al. (2009). Specifically, the social welfare in an economy-0,

SW_0 is defined as follows:

$$SW_0 = \sum_h \Gamma_h^0 \left\{ V(h, u=0,0,0)(1-\overline{u}^0) + V(h, u=1,0,0)\overline{u}^0 \right\} \tag{28}$$

where $\overline{u}^0$ is the unemployment rate of a newborn, and Γ_h^0 is the initial draw of h for a newborn. I can construct a social welfare in an alternative economy 1, SW_1 similarly. Moreover, we can convert a different in welfare from economy-0 to economy-1 into a change in flow consumption (consumption equivalence variation, CEV), as follows:

$$CEV_1 = \left(\frac{SW_1 - SW_0^x}{SW_0^u} \right)^{\frac{1}{1-\sigma}} \tag{29}$$

where SW_0^x and SW_0^u are life-time disutility from search and life-time utility from consumption, respectively. By definition, $SW_0 = SW_0^x + SW_0^u$ holds.

The second definition of welfare is the average welfare across all workers at the time of a policy change. Specifically, this measure of welfare can be computed as follows:

$$\overline{SW}_0 = \int V_0(h,u,d,a)\ dm_0(h,u,d,a) \tag{30}$$

where $V_0(.)$ and $m_0(.)$ are the value function and the steady-state type distribution in the baseline equilibrium, respectively. The welfare in the initial steady state under a new policy, $\overline{SW}_{0,1}$ can be defined as follows:

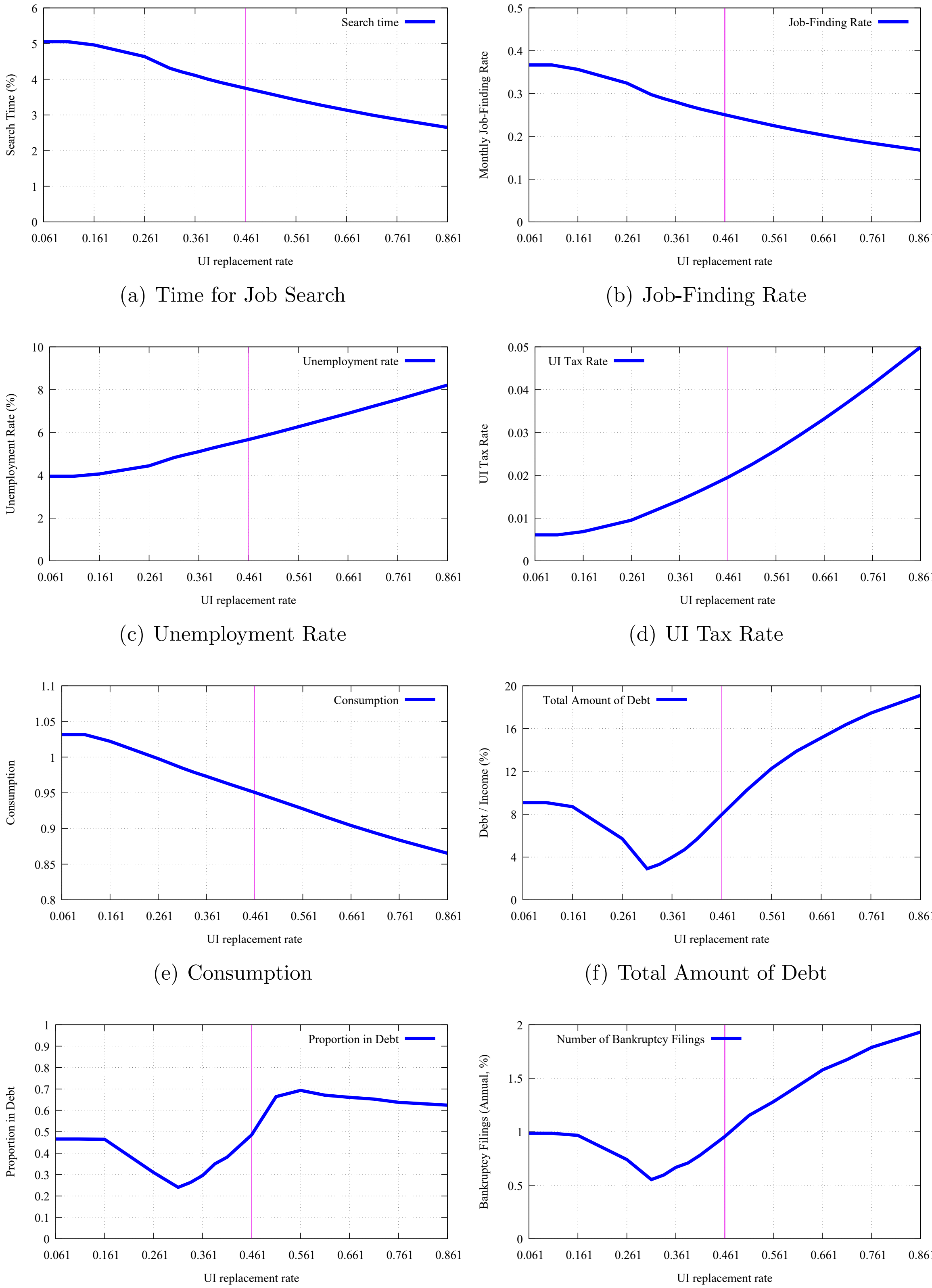
$$\overline{SW}_{0,1} = \int V_1(h,u,d,a)\ dm_0(h,u,d,a) \tag{31}$$

Notice that the first subscript ($= 0$) denotes that the initial steady-state distribution is used to aggregate individual welfare, and the second subscript ($= 1$) denotes that value function under the new policy is used. This is the precise definition of welfare in the initial steady state under the new policy, if there is no equilibrium object changing along the transition path. However, as I discussed in Section 2.9, payroll tax rate τ changes along the transition path between the initial baseline steady state to the new steady state under a new policy, as the unemployment rate changes to the new steady-state level. This definition of social welfare above assumes that τ immediately adjusts to the new steady-state level when there is a policy change. Therefore, if a policy change from the baseline economy (economy-0) to an alternative economy-1 induces a lower (higher) unemployment rate, τ should decline (increase) gradually along the transition path, and thus welfare defined above, which ignores such gradual changes in τ, overestimates (understates) the welfare gain achieved through the policy change. Similarly to the first definition of social welfare, differences in welfare between the baseline economy $\overline{SW}_0$ and an alternative economy with a policy change in the initial steady state, $\overline{SW}_{0,1}$, can be converted into a change in flow consumption $\overline{CEV}_{0,1}$.

Finally, the third definition of social welfare is the average welfare of heterogeneous workers under a new policy in the new steady state, defined as follows:

$$\overline{SW}_{1,1} = \int V_1(h,u,d,a)\ dm_1(h,u,d,a) \tag{32}$$

It is also possible to convert the change in welfare into a change in flow consumption, $\overline{CEV}_{1,1}$ similarly.



(a) Time for Job Search

(b) Job-Finding Rate

(c) Unemployment Rate

(d) UI Tax Rate

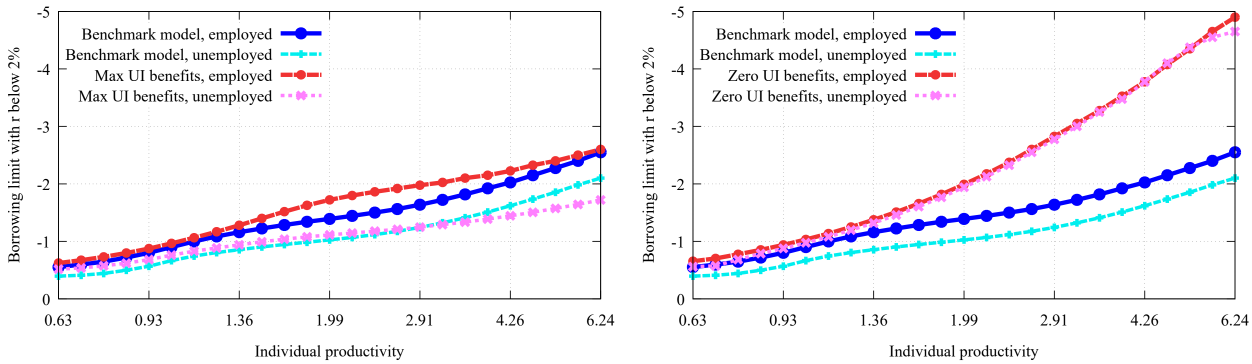
(e) Consumption

(f) Total Amount of Debt

(g) Proportion in Debt

(h) Bankruptcy Filings

Figure 1: Macroeconomic Implications of Changing UI Benefits



(a) High (0.861) UI Replacement Rate

(b) Zero UI Replacement Rate

Figure 2: Borrowing Constraint with Different UI Replacement Rates

4.2. Macroeconomic Implications of Changing UI benefits

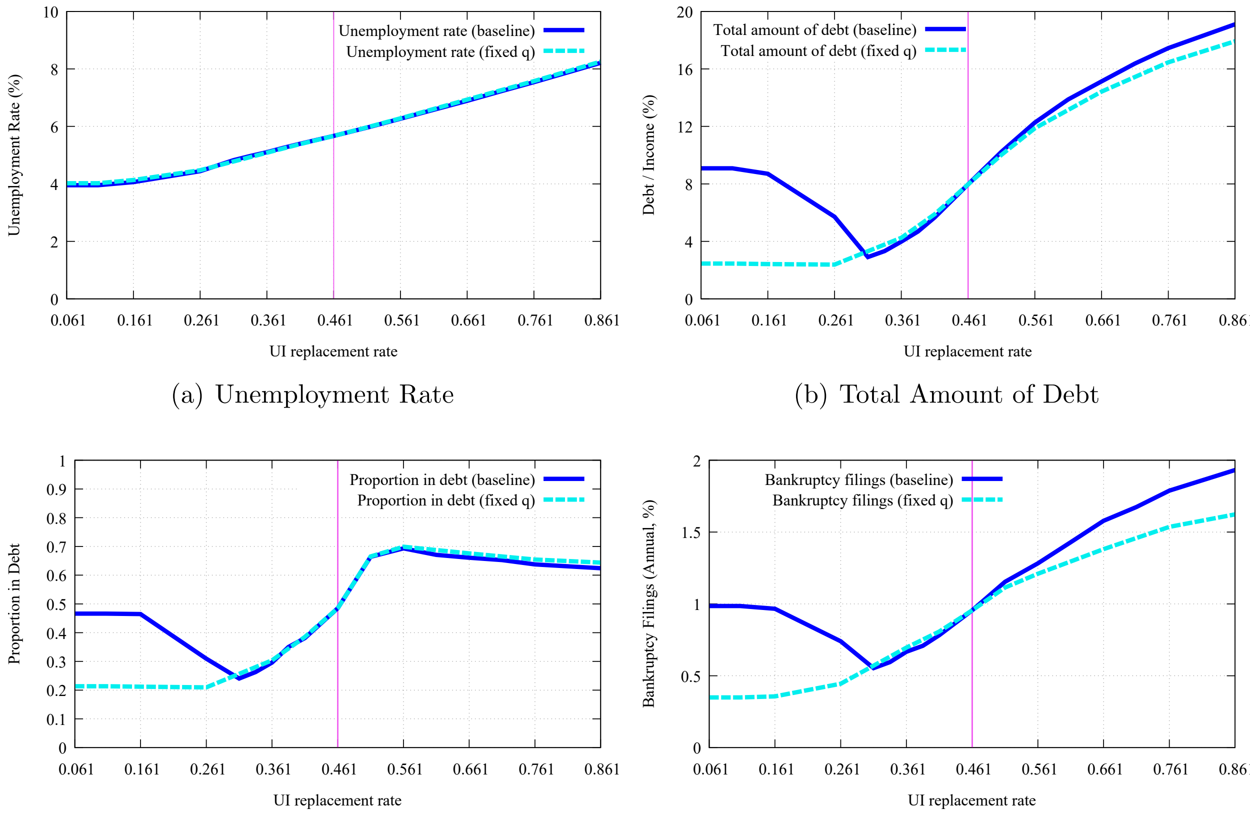
Figure 1 shows how macroeconomic variables change in response to changes in the UI benefit replacement rate ϕ_1. For all figures, x-axis represents the UI replacement rate, from 0.061 to 0.861, with the baseline UI replacement rate of 0.461 marked with a solid (pink) line. Let's look at what happens to the economy when the UI benefit replacement rate is raised (to the right of the pink line) first. Figure 1(a) shows the average time spent for searching for a job among the unemployed. This is the standard moral hazard effect. As the UI replacement rate is raised (right of the baseline value), it becomes less painful to be unemployed, which induces the unemployed to spend less time searching for a job and get out of unemployment. As the unemployed spend less time searching for a job, job-finding rate goes down (Figure 1(b)). As a result, the unemployment rate goes up with a more generous UI benefits. When the UI benefit replacement rate is raised to 0.861 (86.1% of earnings before job loss), the unemployment rate exceed 8%, from the baseline level of 5.67% (Figure 1(c)). Since the UI benefits are more generous, and there are more unemployed, UI tax rate has to increase in a convex manner (Figure 1(d)). When the UI benefit replacement rate is raised to 0.861, UI tax rate has to be raised from 1.95% to 5.00%.

Moving on to implications on consumption and debt, since less workers work when the UI benefits become more generous, average consumption declines (Figure 1(e)). In terms of unsecured credit, there are three forces. First, more generous UI benefits imply that less demand for unsecured credit for smoothing consumption. Second, since consumption smoothing is easier without using savings or credit, workers save less, which increases borrowing. This counteracts the first effect. Finally, there is a channel associated with the interaction between UI and unsecured credit. More generous UI benefits imply that, conditional on a worker's type, the default probability is lower since they receive more UI benefits, and thus borrowing becomes cheaper. This relaxed borrowing constraint allows more workers to borrow or the same worker to borrow more compared with the baseline economy. Figure 2(a) compares the borrowing constraints implied by the bond price function ($q(.)$) in the baseline economy ($\phi_1 = 0.461$) and the economy with a generous UI replacement rate ($\phi_1 = 0.861$). Specifically, the figure shows how much a worker with a particular level of human capital (shown in x-axis) and employment status (employed and unemployed, shown in separate lines) can borrow with the monthly (annual) borrowing interest rate of 2% (24%). It is easy to see that the employed can borrow more than the unemployed, conditional on human capital level, since the employed have higher non-financial income. Conditional on employment status, workers with a higher level of human capital (to the right of the figure) can borrow more with the monthly interest rate below 2%. What is interesting is that, for most workers, the borrowing constraint is relaxed with the generous UI benefit replacement rate, precisely because they are less likely to default with the higher UI benefits. The borrowing constraint of the employed is also relaxed because they could lose their job in the next period and default, so the amount of UI benefits matters even for the employed. This is true even though the UI tax rate is higher, making disposable income lower (and making them more likely to default) for the employed. In the end, even though higher amount of UI benefits lowers demand for credit, total amount of unsecured credit increase monotonically with the UI replacement rate (Figure 1(f)), while the proportion of workers in debt stops increasing after the replacement rate is raised 10 percentage points from the baseline (Figure 1(g)). Finally, although the number of debtors stop rising with the replacement rate, it seems that borrowers are more likely to default, causing the total number of bankruptcies to go up monotonically with the UI benefit replacement rate (Figure 1(h)).

What happens when the UI benefit replacement rate is lowered? Implications to labor market are basically the opposite of what happens when the replacement rate is raised. As UI benefits become less generous, workers search more (Figure 1(a)), which raises the job-finding rate (Figure 1(b)) and lowers the unemployment rate (Figure 1(c)). Since the amount of UI benefits per unemployed is lower and there are less unemployed, UI benefit tax rate needed to balance the government budget becomes lower (Figure 1(d)). As more workers remain employed, average consumption rises with a lowered replacement rate (Figure 1(e)). What is interesting is the dynamics of debt and default. When the UI replacement rate is lowered from the baseline rate of 0.461 to around 0.3, the changes in borrowing and defaulting are the opposite of those associated with a higher replacement rate. Total amount of debt (Figure 1(f)) and proportion in debt (Figure 1(g)) decline as the replacement rate is lowered, as workers save more or borrow less in response to a lower UI replacement rate. Bankruptcy filings becomes less frequent as well, reflecting the lower proportion in debt (Figure 1(h)).

However, when the replacement rate is lowered under around 0.3, effects of lowering the UI replacement rate to credit and default reverse. In particular, both the amount of debt and proportion in debt start rising when the UI replacement rate is lowered. The number of bankruptcy filings also rises. Why? This is because of the interaction between UI benefits and unsecured credit. When the replacement rate is lowered significantly, defaulting becomes significantly painful, and borrowers are less likely to default and suffer exclusion from credit market as well as lower non-financial income. Since credit card companies know it, they start offering better terms for their unsecured credit. As workers face a lower cost of credit, and in the case of unemployed workers, they receive significantly lower amount of UI benefits, unsecured credit become a substitute for UI benefits. Figure 2(b) shows how the amount of debt that workers can borrow by paying the monthly interest rate up to 2% changes when the UI replacement rate is lowered from the baseline level of 0.461 to the zero. Remember that even the UI replacement rate is down to zero, the unemployed can receive non-UI benefits. Basically, at zero replacement rate, the max operator in equation (6) becomes binding for everybody.

In order to see this interaction between UI and unsecured credit clearly, Figure 3 compares the baseline experiments (same as shown in Figure 1) and the alternative experiments in which the bond price function ($q(.)$) is held at the baseline value. In other words, credit card companies cannot adjust prices of loans when the UI replacement rate is changed from the baseline value of 0.461, even in the case they know borrowers are less likely to default. In this alternative environment, amount



(a) Unemployment Rate

(b) Total Amount of Debt

(c) Proportion in Debt

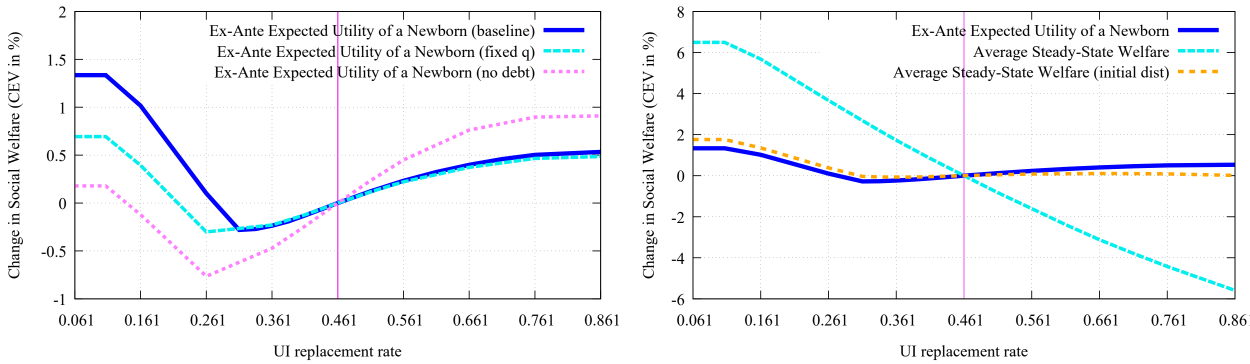
(d) Bankruptcy Filings

Figure 3: Interaction between UI and Unsecured Credit

of debt, proportion in debt, and the number of bankruptcy filings stop changing significantly below around the UI replacement rate of 0.30. Therefore, it is the interaction between UI and unsecured credit, which makes indebtedness to rise when the UI replacement rate is significantly lowered, and allows unsecured credit to substitute for UI benefits.

4.3. Welfare Implications of Changing UI benefits

This section investigates welfare implications of changing the UI replacement rate in the steady state. There are three main channels, which create non-monotonicity of welfare effects from changing the UI replacement rate. First, a higher UI replacement rate facilitate consumption smoothing. This implies that a higher UI replacement rate is associated with higher welfare. Second one is due to the assumption that every unemployed worker is eligible for fixed amount of non-UI benefits. When the UI replacement rate is lowered and more and more unemployed workers opt to receive non-UI benefits, this implies stronger redistribution among the unemployed, since all unemployed receive the same amount, by assumption. This implies that a lower UI replacement rate is associated with higher welfare. Finally, if a lower UI replacement rate makes unemployment significantly painful, both unemployed and employed workers are less likely to default on their debt. The employed can be affected because they could become unemployed in the next period. Since credit card companies know that their debt is going to be more likely to be repaid, they offer higher discount price for



(a) Social Welfare: Ex-ante Measure

(b) Social Welfare: Average Steady-State

Figure 4: Welfare Implications of Changing UI Benefits

debt (lower interest rate of debt), which benefits workers. This channel implies that a lower UI replacement rate is associated with higher welfare.

Figure 4(a) shows how social welfare defined as ex-ante expected life-time utility of a newborn worker, measured as changes in flow consumption from the calibrated baseline model (y-axis), changes with the UI replacement rate (x-axis), in three set-ups. First is the baseline model with unsecured credit (solid blue line). Second is the model in which bond price function ($q(.)$) is fixed at the baseline level associated with the baseline UI replacement rate rate of 0.461 (dashed light blue line). Third is the model without credit (dotted pink line). Interestingly, all three exhibit non-monotonic changes of welfare. But let's start with the model without credit, in which only the first two channels are present. When the UI replacement rate is above 0.26, social welfare increases with the UI replacement rate, suggesting that the first channel (better consumption smoothing) dominates. However, when the UI replacement rate is between 0.11 and 0.26, welfare goes up with lower UI replacement rate, suggesting that the second (redistribution) channel dominates. When the UI replacement rate is below 0.11, since all unemployed workers receive the same amount of non-UI benefits, welfare remains unchanged. Even though the welfare exhibits U-shape, the social welfare is maximized at the most generous level of UI replacement rate (0.861). The model with fixed $q(.)$ also exhibits only the first two channels, since $q(.)$ is unchanged. Welfare increases with the UI replacement rate when the UI replacement rate is above 0.26, while welfare increases with a lower UI replacement rate when the UI replacement rate is between 0.11 and 0.26. There is no welfare effect of changing the UI replacement rate when the rate is below 0.11, since at that level, all unemployed workers receive the same amount of non-UI benefits instead of UI benefits. The welfare function exhibits U-shape again, but the highest welfare is associated with zero UI replacement rate in the model with fixed $q(.)$. This is because the welfare gain from consumption smoothing is weaker in the presence of unsecured credit and the option of defaulting.

Finally, in the benchmark model, the third channel makes the welfare function different from the second case with the fixed $q(.)$. The welfare function is again U-shaped and the highest social welfare is achieved at zero UI replacement rate, implying that the first two channels are similarly operative in the baseline model. However, there are two changes. First, social welfare starts increasing with a higher level of the UI replacement rate, at around 0.31, instead of 0.26. Second, the welfare gain of implementing zero UI replacement rate is 2/3 percentage point higher in the baseline model. If

Table 3: Decomposition of Welfare Effects of Zero UI

	Base	ϕ	$+ w$	$+ v$	$+ q$	$+\tau$
ϕ_1	0.461	0.000	0.000	0.000	0.000	0.000
$\overline{\phi}$	0.512	0.112	0.112	0.112	0.112	0.112
$\widetilde{\phi}$	0.159	0.159	0.159	0.159	0.159	0.159
τ	1.95	1.95	1.95	1.95	1.95	0.61
CEV in % (ex-ante)	0.000	–2.921	–3.227	–0.580	+0.041	+1.335
CEV in % (avg)	0.000	+1.320	+0.984	+5.551	+5.166	+6.492
Unemployment rate (%)	5.670	4.628	4.605	3.967	3.904	3.954
Proportion in debt	48.51	17.94	18.09	22.76	50.29	46.62
Total unsecured credit	7.969	2.049	2.075	2.679	9.617	9.081
Bankruptcy filings (%)	0.955	0.385	0.388	0.359	1.023	0.986
C_{emp}	0.9598	0.9919	0.9887	1.0237	1.0022	1.0325
C_{une}/C_{emp}	64.09	67.89	67.90	70.42	74.06	72.44

Figure 4(a) is compared with Figure 3(b), it is easy to see that the additional welfare gain in the baseline model economy is closely related to relaxed borrowing constraint and resulting increase in indebtedness. In the baseline model, the highest social welfare is again associated with zero UI replacement rate, and the welfare gain of implementing zero UI replacement rate is 1.34% of flow consumption. Meanwhile, the welfare gain of implementing zero UI replacement rate in the alternative model economy with fixed $q(.)$ is 0.69% of flow consumption.

How about social welfare measured by average welfare in the steady state? Figure 4(b) compares the welfare function of the ex-ante welfare measure (CEV_1), and two types of average welfare measures ($\overline{CEV}_{0,1}$ and $\overline{CEV}_{1,1}$) whose only difference is whether to use the initial steady-state distribution or to use the new steady-state distribution. The solid blue line represents the ex-ante social welfare, which is the same as in Figure 4(a). They might look different because the scale of the y-axis is very different. When the average welfare is computed using the initial steady-state distribution ($\overline{CEV}_{0,1}$), the changes in average welfare are similar to those of the ex-ante welfare. However, when the new-steady-state distribution is used to compute the average welfare measure ($\overline{CEV}_{1,1}$), the welfare changes are significantly larger, and welfare monotonically declines with the UI replacement rate. This is because the changes in the steady-state unemployment rate dominate the changes in average welfare. As the UI replacement rate is lowered, the unemployment rate in the steady-state declines (Figure 1(c)), which generates a significant welfare gain in the average welfare, if the new steady-state is used to weight individual welfare.

4.4. Decomposition of Welfare Effects

In this section, I decompose the welfare gain of virtually eliminating the UI benefits and leaving all unemployed with non-UI benefits into five components. Table 3 shows the decomposition of welfare gain. The first column represents the calibrated baseline economy. The first panel shows the policy parameters. In the calibrated baseline model, the UI replacement rate is 0.461, the upperbound of UI benefits is 0.512 of average earnings, and the amount of non-UI benefits is 0.159 of average earnings. In order to finance the UI and non-UI benefits, the government has to impose payroll tax rate at 1.95%. The second panel shows the change in welfare from the baseline, measured in

Table 4: Comparison of Welfare Effects of Zero UI

	Base	ϕ	$+\ w$	$+\ v$	$+\ q$	$+\tau$
CEV in % (ex-ante)						
Baseline model	0.000	–2.921	–3.227	–0.580	+0.041	+1.335
Model with fixed $q(.)$	0.000	–2.921	–3.227	–0.580	–0.580	+0.694
Model without credit	0.000	–3.454	–3.760	–1.092	–1.092	+0.179

two types of CEV. The third panel show some macroeconomic variables. In the calibrated baseline, the unemployment rate is 5.67%. 48.5% of workers have credit card debt, and the total amount of unsecured credit is 7.97% of average income. Every year, 0.955% of workers file for bankruptcy. Average consumption of employed workers is 0.960, while the unemployed with UI benefits consume about 64.1% of employed workers. The last statistics is meant to capture the degree of consumption insurance against the unemployment risk.

The last column shows the results from zero-UI economy, which I discussed in the previous sections, and the columns in-between show decomposition. In particular, starting from the calibrated baseline model, I added five elements one at a time. First (second column), I change the UI policy, but without adjusting anything else, including the tax rate to satisfy the government budget constraint. Second (third column), I allow wage to adjust. Third (fourth column), I allow the number of vacancies and thus the job-finding rate to adjust. Fourth (fifth column), I allow the bond price $q(.)$ to adjust. Finally, I allow the payroll tax rate τ to adjust to satisfy the government budget balance.

When the UI benefits are eliminated (second column), but only the worker's decision adjusts, there is a large social welfare loss equivalent to 2.92% of flow consumption. This is because the unemployed receive less UI benefits (indeed zero), while tax is not adjusted yet. The unemployment increases as workers try harder to avoid unemployment spells. Savings increase and the proportion in debt declines, as workers increase savings to counteract the lack of UI benefits. When wage is allowed to adjust (third column), wage goes down because the reservation value of the worker when negotiating with the firm weakens. Thew welfare loss from the combination of zero UI benefits and lower bargaining position due to weaker bargaining position is equivalent to 3.23% of flow consumption. When the firms are allowed to adjust the number of vacancies (fourth column), they increase vacancies, as workers search longer time. This lowers the unemployment rate even further, from the baseline level of 5.67% to 3.97%. This creates an incremental welfare gain of 2.65%. With all three elements combined, the welfare loss compared with the baseline model is now 0.58%. Next I allow credit card companies to change the price of debt, based on the changing probabilities of default (fifth column). One can see that the borrowing constraint is relaxed significantly. The proportion in debt rises from 22.8% of all workers to 50.3%, and the total amount of unsecured credit increases from 2.7% of total income to 9.6%. The consumption of the unemployed workers is about 74.1%, suggesting that the relaxed borrowing constraint allows the unemployed to smooth consumption better. The welfare effect compared with the baseline model is now a small positive, equivalent to 0.04% of flow consumption. Finally, when the payroll tax rate is allowed to adjust (last column), since there are less unemployed, and the UI benefits are eliminated (all the unemployed receive non-UI benefits), payroll tax rate goes down from 1.95% to 0.61%. Naturally, there is welfare gain from the lower tax rate. This brings the size of the welfare gain from 0.04% of flow consumption to 1.34%.

Table 5: Modeling of Cyclical UI Policy

State	UI Replacement Rate	Max UI Amount	Non-UI Amount	Payroll Tax Rate
Steady state	ϕ_1	$\overline{\phi}$	$\widetilde{\phi}$	τ^{ss}
(E)xpansion	$\phi_1 + \epsilon_E$	$\overline{\phi} + \epsilon_E$	$\widetilde{\phi}$	τ
(R)ecession	$\phi_1 - \epsilon_R$	$\overline{\phi} - \epsilon_R$	$\widetilde{\phi}$	τ
(D)eep recession	$\phi_1 - 2\epsilon_R$	$\overline{\phi} - 2\epsilon_R$	$\widetilde{\phi}$	τ

Table 4 compares how the ex-ante welfare gain of implementing zero UI benefits is decomposed into various factors, in three different models. By comparing the baseline model (which is already explained above) and the model with fixed $q(.)$, it is easy to see that the 0.64 percentage point difference in welfare gain between the two models is due to the response of $q(.)$. When UI benefits are eliminated, borrowing constraint relaxes and unsecured credit substitute for UI benefits, which is worth about 0.6 percentage point of welfare gain. When the model with fixed $q(.)$ is compared with the model without credit, the welfare gain of eliminating the UI benefits is smaller in the latter because workers suffer more from eliminating the UI benefits in the model without credit, as they cannot borrow to mitigate the negative effect to consumption smoothing.

5. Result: Cyclicality of UI benefits and Unsecured Credit

5.1. Design of Experiments

This section studies the macroeconomic and welfare implications of cyclical UI policy in the model with aggregate uncertainty. The modeling and calibration of aggregate labor productivity shock is discussed in Section 2.9 and 3.8, respectively. Table 5 describes how cyclical UI policy is introduced. For now, I make four simplifying assumptions: First, I keep the duration of UI benefits for now, to 6 months. UI benefit extensions will be introduced later. Second, I assume that the replacement rate does not change over depending on the unemployment duration. The actual UI replacement rate changes depending on the economic condition, but all unemployed regardless of how long they are unemployed are affected in the same way. Third, I keep the amount of non-UI benefits acyclical, at the baseline value of $\widetilde{\phi}$ (third column). Finally, I assume that the payroll tax rate is fixed over the business cycles but is determined to satisfy the government budget constraint on average τ (last column). Notice that such τ is potentially (and actually) different from the steady-state τ (τ^{ss}). This assumption is roughly interpreted as the government smooths tax rate over the cycle, but at the same time the level of τ takes into account that the average unemployment rate is different when the UI policy is changed. Technically, this simplifies the computation significantly, as it is not necessary to compute the payroll tax rate that balances government budget every period, and more importantly, the workers do not need to know the dynamics of the tax rate over business cycles.

Cyclicality of UI benefits is introduced by choosing a parameter ϵ_E, which represents how much the UI replacement rate is raised in an expansion (E, first row). In a regular recession (R, second row), the UI replacement rate is lowered by ϵ_R, and considering that a deep recession is modeled as twice as deep as a regular recession, I assume that the UI replacement rate is lowered by $2\epsilon_R$ in a deep recession (D, third row). I also impose that the unconditional average of the replacement rate is the same as in the steady state, which immediately implies that, by choosing ϵ_E, ϵ_R is automatically determined. In this sense, the cyclicality of the UI policy is solely characterized by ϵ_E. Also notice that ϵ_E can be positive (which makes the UI policy procyclical) or negative (countercyclical UI policy). I also assume that the maximum amount of UI benefits, $\overline{\phi}$, is adjusted over the cycles by the same percentage points, in order to minimize the changes in redistribution effects of UI policy over the business cycles.

I set the unconditional policy parameter values as the calibrated values: $\phi_1 = 0.461$ and $\overline{\phi} = 0.512$ and $\widetilde{\phi} = 0.159$. Even if no-UI benefits policy is found to be optimal in the previous section, I study the role of cyclical UI policy around the values calibrated to the normal times of the U.S. economy. One important benefit of this assumption is that it is straightforward to compare the model's implications with the data.

As for the social welfare, I use the ex-ante expected life-time utility of a newborn, in period 0. In period 0, the type distribution of workers is the same as in the steady state, and the aggregate labor productivity shock is drawn from its unconditional distribution. Welfare is converted into the difference in flow consumption growth rate (CEV) from the steady-state social welfare.

5.2. Result: Macroeconomic Implications of Cyclical UI Policy

Table 6 summarizes macroeconomic implications of different cyclicality of UI policy. In order to construct the table, I simulate the models for 6,120 periods (510 years) drop the first 120 periods, and compute the average values of macro variables in three different aggregate states (Expansion, Recession, and Deep recession). I do this for four different model economies with four different cyclicalities of UI policy. The first (second column) is the model with acyclical UI policy. In this model, ϵ_E is set to zero, meaning that both UI replacement rate and the maximum UI amount are fixed at the respective steady-state values over the business cycles. In the second experiment (first column), ϵ_E is set at 0.02, meaning that UI benefits are procyclical. In particular, the UI replacement rate is raised by 2 percentage points in expansions, and lowered in recessions. The third experiment implements a countercyclical UI policy, in which the UI replacement rate inn expansions is lowered by 2 percentage points. Finally, in the last experiment (last column), I implement a stronger countercyclical UI policy. Under the policy, the UI replacement rate is lowered by 4 percentage points in expansions.

Let's start with the model with acyclical UI policy. The unemployment rate is countercyclical, whose average reaching close to 9% in deep recessions. Interestingly, total amount of credit and the proportion in debt are not monotonic, increasing between expansions and regular recessions, but shrink in deep recessions. This suggests a role by credit card companies, squeezing supply when borrowers are riskier. Nakajima and Ríos-Rull (2014) argue that credit card balance is procyclical in the U.S. data, and countercyclicality of individual income risk is important in generating such cyclicality. The number of bankruptcy filings is countercyclical, as reported by Nakajima and Ríos-Rull (2014). Average consumption declines in recessions for both employed and unemployed workers.

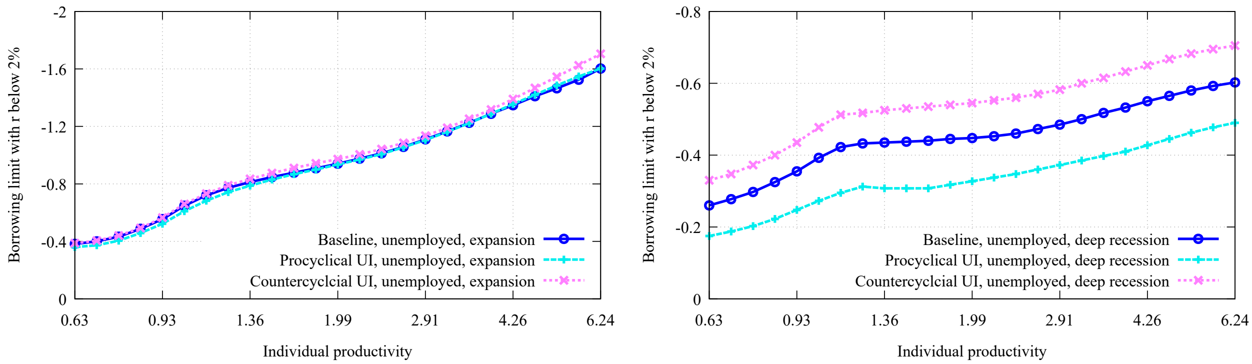
Now, comparing the procyclical UI policy (first column) and countercyclical UI policy (third column), the unemployment rate becomes more volatile with the countercyclical UI policy. This is the standard moral hazard effect, inducing unemployed to spend less time for search in recessions. In terms of credit balance and the proportion of workers with credit, procyclical UI policy induces procyclical credit. Under procyclical UI policy, total amount of credit in deep recessions becomes less than one-third compared with the model with acyclical UI policy. On the other hand, the countercyclical UI policy implies countercyclical amount of unsecured credit. Total unsecured credit in deep recessions increases about 50 percent compared with acyclical UI policy. Since workers are

Table 6: Macroeconomic Implications of Cyclical UI Policy

	Procyclical	Acyclical	Countercyclical	
ϵ_E	$+0.02$	0.00	-0.02	-0.04
$\phi_{z=E}$	0.481	0.461	0.441	0.421
$\phi_{z=R}$	0.372	0.461	0.550	0.639
$\phi_{z=D}$	0.283	0.461	0.639	0.817
τ	2.080	2.078	2.093	2.117
(E)xpansion				
Unemployment rate (%)	5.86	5.75	5.66	5.58
Total unsecured credit	4.92	6.03	6.34	6.16
Proportion in debt (%)	35.5	38.8	39.6	39.2
Bankruptcy filings (annual %)	0.62	0.74	0.79	0.80
Consumption (employed)	0.953	0.952	0.952	0.952
Consumption (unemployed)	0.633	0.628	0.624	0.622
(R)ecession				
Unemployment rate (%)	6.70	7.13	7.55	7.96
Total unsecured credit	4.58	7.00	8.32	8.75
Proportion in debt (%)	37.4	47.8	50.4	50.0
Bankruptcy filings (annual %)	1.31	1.29	1.18	1.05
Consumption (employed)	0.906	0.911	0.916	0.921
Consumption (unemployed)	0.516	0.531	0.551	0.571
(D)eep recession				
Unemployment rate (%)	7.85	8.97	9.80	10.42
Total unsecured credit	1.94	6.59	9.35	10.47
Proportion in debt (%)	25.7	44.7	49.1	50.1
Bankruptcy filings (annual %)	2.17	1.72	1.37	1.19
Consumption (employed)	0.846	0.865	0.878	0.887
Consumption (unemployed)	0.412	0.456	0.500	0.538

likely in need of more credit in recessions, this countercyclicality of credit could imply positive welfare effects. Also interestingly, total unsecured credit in higher with countercyclical UI policy in all three aggregate states. In expansions, with a lower UI replacement rate under countercyclical UI policy, more workers need to use unsecured credit. On the other hand, in recessions, more generous UI replacement rate could imply less borrowing, but it seems that a higher UI replacement rate induces a lower default premium (higher price of debt) as credit card companies know that unemployed workers receive more UI benefits and thus are less likely to default, and workers respond by borrowing more in recessions. Under the procyclical UI policy, the opposite happens. Total unsecured credit is lower than under acyclical UI policy in expansions because a higher UI benefits lower demand for unsecured credit, while total unsecured credit is lower in recessions since the lower UI replacement rate induces tighter borrowing constraint, and workers can borrow less than under acyclical UI policy.

Turning to the number of bankruptcy filings, interestingly, there are less bankruptcy filings in recessions under countercyclical UI policy compared with acyclical UI policy, even though the total



(a) Borrowing Constraint: Expansions

(b) Borrowing Constraint: Deep Recsion

Figure 5: Comparison of Borrowing Constraints under Various UI Policy

amount of unsecured debt and the proportion in debt are both higher under the countercyclical UI policy. And there are more bankruptcy filings in expansions under the countercyclical UI policy. Opposite are true under procyclical procyclical UI policy. This suggests that the workers are less likely to default, thanks to the generous UI benefits under the countercyclical UI policy. The average number of bankruptcy filings in deep recessions under the countercyclical UI policy (1.37% per year) is about 20% lower than the number of filings under the acyclical UI policy, and 1/3 lower than under the procyclical UI policy. Consumption of both employed and unemployed workers is higher in recessions under the countercyclical UI policy, and only slightly lower in expansions.

Looking at the implications of stronger countercyclical UI policy (last column), all the features described for the countercyclical UI policy are strengthened. In particular, the unemployment rate becomes even more countercyclical and volatile. Total unsecured credit increases even more in recessions, although unsecured credit balance is smaller in expansions compared with milder countercyclical UI policy, suggesting that the negative effect from tighter borrowing constraint dominates the positive effect from higher demand for credit with a lower UI replacement rate. The number of bankruptcy filings becomes even lower in recessions.

5.3. Interaction between UI and Unsecured Credit

Figure 5 compares the amount of unsecured credit (y-axis) that an unemployed worker with various labor productivity levels (x-axis) can borrow by paying up to monthly 2% (annual 24%) interest rate, in expansions (Figure 5(a)) and in deep recessions (Figure 5(b)), under three different models with three different cyclicalities of UI policy. In Figure 5(b), the borrowing constraint in the acyclical UI policy is in the middle, and the borrowing constraint under the countercyclical UI policy is above it, meaning that unemployed workers can borrow more in a deep recession by paying up to 2% interest rate under the countercyclical UI policy. The opposite happens under the procyclical UI policy. Under the countercyclical UI policy, unemployed workers receive more UI benefits in a recession and are less likely to default on their debt. Credit card companies recognize it and offer lower default premium to unemployed workers. What is surprising is Figure 5(a). In expansions, under three different cyclicalities of UI policy, the borrowing constraints are similar. There are possibly three reasons. First, job-finding rate is higher in expansions, which makes the UI replacement rate in expansions less important. Moreover, since workers are more likely to default in recessions, and

Table 7: Interaction between Cyclical UI policy and Unsecured Credit

	Acyclical	Countercyclical		Acyclical-UI $q(.)$	
ϵ_E	0.00	-0.02	-0.04	-0.02	-0.04
$\phi_{z=E}$	0.461	0.441	0.421	0.441	0.421
$\phi_{z=R}$	0.461	0.550	0.639	0.550	0.639
$\phi_{z=D}$	0.461	0.639	0.817	0.639	0.817
τ	2.078	2.093	2.117	2.094	2.118
(E)xpansion					
Unemployment rate (%)	5.75	5.66	5.58	5.66	5.58
Total unsecured credit	6.03	6.34	6.16	6.07	5.82
Proportion in debt (%)	38.8	39.6	39.2	39.1	38.6
Bankruptcy filings (annual %)	0.74	0.79	0.80	0.76	0.76
Consumption (employed)	0.952	0.952	0.952	0.952	0.953
Consumption (unemployed)	0.628	0.624	0.622	0.624	0.622
(R)ecession					
Unemployment rate (%)	7.13	7.55	7.96	7.56	7.96
Total unsecured credit	7.00	8.32	8.75	7.85	8.16
Proportion in debt (%)	47.8	50.4	50.0	49.9	49.4
Bankruptcy filings (annual %)	1.29	1.18	1.05	1.12	0.97
Consumption (employed)	0.911	0.916	0.921	0.916	0.921
Consumption (unemployed)	0.531	0.551	0.571	0.551	0.570
(D)eep recession					
Unemployment rate (%)	8.97	9.80	10.42	9.81	10.43
Total unsecured credit	6.59	9.35	10.47	8.69	9.61
Proportion in debt (%)	44.7	49.1	50.1	48.7	49.6
Bankruptcy filings (annual %)	1.72	1.37	1.19	1.28	1.06
Consumption (employed)	0.865	0.878	0.887	0.878	0.887
Consumption (unemployed)	0.456	0.500	0.538	0.500	0.538

the increase in default probability in recessions is mitigated (amplified) under the countercyclical (procyclical) UI policy, which mitigates the differences across borrowing constraints under the three different cyclicalities of UI policy in expansions. Finally, expansions are milder and the changes in UI replacement rate in expansions are smaller in calibration. Because the borrowing constraints are similar across three regimes, total unsecured credit is larger under the countercyclical UI policy, as more workers want to borrow to smooth consumption with a lower UI replacement rate, and can do so without paying a significantly higher interest rate.

In order to investigate the role of the interaction between UI and unsecured credit in shaping the cyclical behavior of macroeconomic variables, in Table 7, the models in which credit card companies can adjust bond prices knowing the cyclicality of UI policies (first three columns) are compared with models in which credit card companies adjust price of debt $q(.)$ to aggregate shocks but do not adjust $q(.)$ to the cyclicality of the UI policy (last two columns). Technically, The first three columns, which show the models with acyclical UI policy ($\epsilon_E = 0$), and models with countercyclical UI policy ($\epsilon_E = -0.02$ or -0.04) are the same as in Table 6. As for the model shown in the fourth column with $\epsilon_E = -0.02$, $q(.)$ of the acyclical model (first column) is used, but workers know the countercyclicality of UI and reoptimize their behavior. As for model shown in the last column ($\epsilon_E = -0.04$), $q(.)$ is taken from the model with acyclical UI policy (first column) but workers reoptimize knowing the strong countercyclicality of UI policy. Intuitively, those are the models in which credit card companies can and do adjust $q(.)$ to aggregate shocks, but cannot adjust to the cyclicality of UI policy, and the consequent adjustment of workers' behavior.

Models with (second and third columns) and without (last two columns) adjustments of bond price function to cyclicality of UI policy, interaction of cyclical UI policy and unsecured credit sector does not change the dynamics of the unemployment rate and consumption in a visible manner. However, when $q(.)$ is adjusted to take into account cyclicality of UI policy, the amount of debt, the proportion of workers in debt, and the number of bankruptcy filings are all higher, somewhat surprisingly in both expansions and recessions. In case of expansions, the UI replacement rate is lower under the countercyclical UI policy, which makes demand for credit higher. On the other hand, as we saw in Figure 5(a), bond price function seems slightly relaxed when credit card companies can adjust to countercyclical UI policy, possibly because credit is less risky in case the economy heads into a recession in the next period. Therefore, workers can borrow more with relaxed borrowing constraint when there is an interaction between cyclical UI policy and unsecured credit. In the case of recessions, again, as we saw in Figure 5(b), borrowing constraint is significantly more relaxed, taking into account the lower risk of unemployed borrowers with a higher UI replacement rate in recessions. This allows workers to borrow more in recessions. As workers borrow more, even if the default probability might be lower conditional on a worker's type and the amount of debt, the number of bankruptcy filings increases.

5.4. Model Implications and Data

Hsu et al. (2014) implement cross-state comparison, in particular, compare states which raised the maximum UI benefit amount (corresponding to $\overline{\phi}$ in the model) during the Great Recession and states which did not. They find that the states which increased the maximum UI benefits saw alleviated mortgage delinquency, especially among the unemployed. Moreover, households living in those states enjoyed better credit access. In particular, controlling for household characteristics, both unemployed and employed households were offered a higher credit card limit, and lower credit card and mortgage interest rates. In order to compare their findings with the corresponding implications of the model, I introduce cyclicality to only the maximum UI amount ($\overline{\phi}$) into the baseline model without acyclical UI. Table 8 summarizes the results of the models in which the maximum amount of UI is procyclical (first column), acyclical (second column), moderately countercyclical (third column) and strongly countercyclical (last column). There are properties consistent with the empirical findings — countercyclicality of the maximum amount of UI induces expanded credit supply — but not strong, especially compared with the experiments shown in the previous sections. This is not surprising since those with a lower productivity and thus lower income, who are the ones who borrow and default more, are not affected by cyclicality of the maximum UI amount. The response of the model to cyclicality of the maximum amount of UI benefits would be stronger if workers with more assets are liquidity constrained, such as due to the existence of illiquid assets (Kaplan et al. (2014)).

Table 8: Macroeconomic Implications of Cyclical UI Maximum

	Procyclical	Acyclical	Countercyclical	
ϵ_E	+0.02	0.00	−0.02	−0.04
$\overline{\phi}_{z=E}$	0.532	0.512	0.492	0.472
$\overline{\phi}_{z=R}$	0.423	0.512	0.601	0.690
$\overline{\phi}_{z=D}$	0.334	0.512	0.690	0.868
τ	2.066	2.078	2.071	2.054
(E)xpansion				
Unemployment rate (%)	5.77	5.75	5.72	5.70
Total unsecured credit	5.95	6.03	6.05	6.05
Proportion in debt (%)	38.3	38.8	38.8	38.7
Bankruptcy filings (annual %)	0.73	0.74	0.74	0.74
Consumption (employed)	0.952	0.952	0.953	0.955
Consumption (unemployed)	0.630	0.628	0.627	0.626
(D)eep recession				
Unemployment rate (%)	8.61	8.97	9.03	9.01
Total unsecured credit	6.47	6.59	6.60	6.59
Proportion in debt (%)	42.6	44.7	44.7	44.6
Bankruptcy filings (annual %)	1.82	1.72	1.70	1.70
Consumption (employed)	0.860	0.865	0.868	0.870
Consumption (unemployed)	0.440	0.456	0.462	0.465

Table 9: Welfare Effects of Cyclical UI Policy

	Procyclical	Acyclical	Countercyclical	
ϵ_E	+0.02	0.00	−0.02	−0.04
Policy Parameters				
$\phi_{z=E}$	0.481	0.461	0.441	0.421
$\phi_{z=R}$	0.372	0.461	0.550	0.639
$\phi_{z=D}$	0.283	0.461	0.639	0.817
τ (Baseline)	2.080	2.078	2.093	2.117
Welfare (Ex-ante, average, in %)				
CEV (Baseline)	–0.268	0.000	+0.177	+0.295
CEV (Acyclical-UI $q(.)$)	–0.223	0.000	+0.155	+0.264
CEV (No credit)	–0.196	0.000	+0.107	+0.166
Welfare (Ex-ante, deep recession, in %)				
CEV (Baseline)	–1.466	0.000	+1.067	+1.920
CEV (Acyclical-UI $q(.)$)	–1.403	0.000	+1.044	+1.889
CEV (No credit)	–1.562	0.000	+1.045	+1.885

5.5. Welfare Implications of Cyclical UI Policy

What are the welfare implications of cyclical UI policy? Table 9 compares changes in welfare from acyclical UI policy, in the baseline model with unsecured credit and credit card companies fully adjust the price of bond to cyclicality of UI policy, the model in which bond price function is fixed at the one associated with acyclical UI policy, and the model without credit. The first column is associated with procyclical UI policy ($\epsilon_E = +0.02$), the second column concerns the model with acyclical UI policy ($\epsilon_E = 0$), and the last two columns are associated with countercyclical UI policy ($\epsilon_E = -0.02$ and -0.04). The first panel shows the UI policy variables, the second and the third panels summarize the changes in welfare, measured as changes in ex-ante expected life-time utility converted into changes in flow consumption. The second panel shows the average across all aggregate states, and the third panel shows the welfare gains in a deep recession.

Let's look at the average welfare across aggregate states (second panel). Starting from the model without credit (the bottom row), welfare increases with countercyclical UI policy. Even without the interaction with credit, countercyclical UI policy generates welfare gain by offering better consumption smoothing in recessions. The welfare gain of implementing a moderate countercyclical UI policy ($\epsilon_E = -0.02$) is 0.107% in CEV. On the other hand, the welfare gain of implementing moderate countercyclical UI policy in the baseline model is slightly larger at 0.177%. What part of it is due to the interaction between cyclicality of UI policy and unsecured credit? If the bond price function (default premium) is now allowed to the cyclicality of UI benefits, the welfare gain of introducing moderate cyclical UI policy becomes slightly smaller at 0.155%. Therefore, the extra gain from the response of equilibrium default premium to cyclicality of UI benefits is positive but small, at 0.02%. It is larger if the UI policy is more strongly cyclical, but still it is about 0.03% ($= 0.295 - 0.264$).

The third panel shows if the welfare gains from implementing cyclical UI policy are different in a deep recession. The levels of welfare changes are significantly larger than the average across aggregate states. For example, welfare gain from implementing moderately (strongly) countercyclical UI policy in the baseline model with unsecured credit is 0.177% (0.295%) on average across all aggregate states, but 1.067% (1.920%) in a deep recession. However, comparing the first and the second row, the additional gains from the interaction with unsecured credit sector are not very different, at 0.023% ($= 1.067 - 0.044$) with the moderately countercyclical UI policy and 0.031% ($= 1.920 - 1.889$) in the case of strongly countercyclical UI policy.

6. Conclusion

I investigate the interaction between unemployment benefits (UI) and unsecured credit in a calibrated heterogeneous-agent model with labor market search, unsecured consumer credit, and equilibrium default. The general message of the paper is that the design of UI program should be made considering how unsecured credit sector responds to different UI policies, since unsecured credit can either complement or substitute UI benefits. In particular, complementary interactions between UI and unsecured credit, meaning more generous UI lowers the probability of defaults and thus induces expansion of credit, are consistent with recent empirical evidence, and further increase welfare gains from countercyclical UI policy. On the other hand, unsecured credit substitutes for reduced UI benefits when the costs of defaulting while unemployed with lower UI benefits are sufficiently high. In that case, the unemployed can smooth consumption using unsecured credit and the option to default, which does not cause the moral hazard problem associated with UI.

The natural next step is to build the model developed in the current paper into a New-Keynesian DSGE model, so that aggregate demand effects through unsecured credit and default can be studied. As explored in McKay and Reis (2019), the UI policy is an important part of economic stabilization policy in the U.S. and many other countries. The interaction between the UI program and unsecured credit sector explored in the current paper implies that the optimal design of the UI policy could depend on how developed unsecured credit sector is and how the sector works. Auclert et al. (2019) find that states with more generous bankruptcy exemptions had significantly smaller declines in non-tradable employment and larger increases in unsecured debt write-downs compared to states with less generous exemptions. This result implies a potential aggregate demand effect from bankruptcy provisions, which could be studied by the extended model within a New-Keynesian DSGE model. This is going to be my next project.

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