The Impact of Unemployment Insurance and Unsecured Credit on Business Cycles[†]

Michael Irwin[‡]

Bank of Canada

August 31, 2023

Abstract

How does unsecured consumer credit impact the effectiveness of unemployment insurance (UI) in insuring households against aggregate risk? The answer depends on whether credit acts as a complementary or substitutable form of consumption insurance for households. Using a real business cycle model with frictional labor markets and defaultable debt, I find that unsecured credit amplifies the consumption-equivalent welfare gains of a policy which extends the duration of UI during recessions. This occurs because UI extensions mitigate the rise in the default-risk premium during recessions, which allows households to better smooth consumption over the business cycle.

†. I have a great appreciation for the help given to me by my advisors Kyle Dempsey and Aubhik Khan. Without their guidance, the work in this paper would not have been possible. I also thank Julia Thomas, Yasou Terajima, James MacGee, José-Victor Ríos-Rull, Kyle Herkenhoff, Makoto Nakajima, and J. Carter Braxton for discussions which greatly improved the work in this paper. I am grateful for the detailed comments of Shu Lin Wee. I also thank Ruben Hipp, Heejeong Kim, Nuno Paixão, Kerem Tuzcuoglu, Matías Vieyra, and many other colleagues for generous help and suggestions. The views expressed in this paper are my own and do not reflect the views of the Bank of Canada.

‡. Bank of Canada, Financial Stabilility Department, Economic and Financial Research Department. 234 Wellington Street W, Ottawa, ON K1A 0G9. irwinmj011@gmail.com

1 Introduction

Unemployment insurance (UI) is a well-established automatic stabilizer of the economy. In 1970, the US government enhanced the UI program by instituting automatic triggers to extend the duration of benefits by 13 weeks during recessions.[1] This policy was enacted with the goal of mitigating the welfare costs of business cycles by providing additional consumption insurance to households when income risk is high. Since this time, the unsecured consumer credit market has grown at an unprecedented rate in the US. The total balance of revolving consumer credit now exceeds $1.2 trillion, and nearly 45% of households report having positive balances of credit card debt. Despite the growing significance for the balance sheets of US households, it is unclear how unsecured credit impacts the effectiveness of UI in insuring households against aggregate risk. The answer depends on whether credit acts as a complementary or substitutable form of consumption insurance for households over the business cycle.

There are two main channels that determine whether unsecured credit complements or substitutes for UI: a substitution effect and a risk premium effect. When households become unemployed, many borrow to replace a fraction of their lost income. An increase in the transfer of resources via UI allows households to borrow less to finance the same level of consumption. I refer to this as the substitution effect. In isolation, this channel could dampen the impact of UI on consumption because households are substituting one form of insurance for the other. The risk premium effect moves in the opposite direction. When the government increases the transfer of resources to households, financial intermediaries reduce the default-risk premium for a given level of debt because the probability of a bankruptcy falls. The risk premium effect could amplify the impact of UI on consumption because the two forms of insurance are complementing each other: enhancements to UI make it cheaper to use unsecured credit.

The main quantitative result of this paper is that unsecured credit amplifies the consumption-equivalent (CE) welfare gains of a policy which extends the duration of UI during recessions. The result is driven by the risk premium effect. When the government extends the duration

1. The Federal-State Extended Benefits (EB) Program provides 13 additional weeks of UI benefits when unemployment is persistently high in a state.

of UI, it mitigates the rise in consumer bankruptcies and the default-risk premium during recessions. UI extensions also reduce the incentive for indebted households to delever for precautionary reasons. These forces cause the risk premium effect to dominate, and households are better able to smooth consumption over the business cycle.

The results of this paper come from an incomplete markets general equilibrium real business cycle model that incorporates frictional labor markets into a model with unsecured credit and consumer bankruptcy. In the style of Krusell et al. (2017), the labor market features standard labor supply forces and frictions. Flows between employment and unemployment are determined by endogenous labor supply decisions by households and by exogenous labor market frictions. The credit market is modeled in the style of Chatterjee et al. (2007) and Livshits, MacGee, and Tertilt (2007), where financial intermediaries offer a menu of loan prices to households dependent on default probabilities. Business cycles are driven by cyclical changes to TFP and labor market frictions. In this setting, changes in bankruptcy behavior over the business cycle result in fluctuations in the menu of loan prices offered by financial intermediaries. UI policies have the potential to mitigate cyclical fluctuations in unsecured credit markets by insuring against bankruptcy risk. The theory that the price of unsecured credit depends on default behavior is supported by empirical work from Gross et al. (2021), which finds that a 1 percent increase in bankruptcy risk results in a 70-90 basis points increase in the interest rate of credit cards.

Unsecured consumer credit is highly volatile and pro-cyclical in the data.[2] In order to quantitatively assess the importance of liquidity constraints and borrowing behavior for consumption smoothing over the business cycle, we need a model that can explain these facts: a task that has not yet been completed by pre-existing literature. Herkenhoff (2019) generates pro-cyclical credit by assuming that credit supply exogenously expands following a recession via the efficiency of matching lenders to households. Nakajima and Ríos-Rull (2019) provides a theory to explain why credit is pro-cyclical, but their model with cyclical earnings skewness shocks can only generate about one-quarter of the volatility of unsecured credit. By comparison, my model generates pro-cyclical credit and over 84% of the standard deviation of unsecured credit balances despite being untargeted in the calibration procedure.

2. Revolving credit balances are about 3 times as volatile as GDP.

To better understand why my model with unemployment risk improves in matching the data, I run a decomposition exercise where I remove cyclical changes to TFP, job separation rates, and job finding rates for unemployed workers one at a time. I find that over 92% of the volatility in unsecured credit is driven by the cyclical dynamics of job finding rates. Job finding rates drive aggregate fluctuations because UI is designed to insure households against relatively short unemployment spells. When job finding rates fall during recessions, intermediaries raise the default-risk premium on credit, and households delever (or save) to insure themselves against the possibility of a prolonged unemployment spell. My model improves on the literature's ability to match the cyclical properties of unsecured credit in the data because I specifically model the underlying unemployment dynamics that generate changes in the skewness of earnings over the business cycle.

The main experiment of this paper is to quantify the implications of counter-cyclical UI policies in the benchmark economy with unsecured credit and in a counter-factual economy without credit. I find that a policy which extends the duration of UI by 13 weeks during recessions has larger CE welfare gains for households in the economy with credit. Specifically, households would trade 0.054% of lifetime consumption on average to obtain the policy in the economy with credit, and they would only trade 0.043% to obtain the same policy in the economy without credit.[3] I also find that UI is more effective at stabilizing aggregate fluctuations when households have unsecured credit. The policy which extends the duration of UI by 13 weeks during recessions reduces the average peak-to-trough fall in aggregate consumption during recessions by 0.42pp in the economy with credit. The same policy only reduces the average peak-to-trough fall in aggregate consumption by 0.24pp in the economy without credit. This result adds to the literature which studies the usefulness of credit as consumption insurance. Athreya, Tam, and Young (2009) finds that unsecured credit does not smooth consumption over the life cycle, and Nakajima and Ríos-Rull (2019) finds that it does not smooth aggregate consumption over the business cycle. Although unsecured credit does not smooth cyclical consumption fluctuations by itself, I show that it does amplify the extent to which UI stabilizes aggregate consumption: the largest component of aggregate

3. CE welfare is the share of lifetime consumption a household born during an expansion in the economy with an acyclical UI policy would trade to be in the economy where the government extends the duration of UI during recessions.

demand.

I conclude the analysis of this paper by comparing the aggregate implications of the UI policy which extends the duration of benefits during recessions to a counterfactual policy which increases the level of benefits. It is essential to understand how these policies impact aggregate fluctuations because both have been implemented in recent recessions.[4] I find that a policy which increases the replacement rate (RR) of benefits during recessions has a smaller impact on aggregate fluctuations. Even though the policy costs the same for the government, increasing the RR of benefits only reduces the average peak-to-trough fall in aggregate consumption during recessions by 0.13pp: compared to 0.42pp for UI extensions. Increasing the level of benefits has smaller aggregate implications because households have an incentive to use the transfers to delever (or save) for precautionary reasons to insure themselves against the possibility of a prolonged unemployment spell. In terms of welfare, households on average prefer the policy which extends the duration of UI, but low-income households prefer the policy which increases the level of benefits. This means the relative success of the policy may depend on the goal of the policymaker. If the goal is to stabilize the aggregate economy, extending the duration of UI is a more effective policy. If the goal is to help low-income households, increasing the RR of benefits is the superior policy.

1.a Related Literature

Since Zeldes (1989) showed empirical evidence that liquidity constraints have a significant impact on consumption for a sizeable portion of the population, the quantitative importance of borrowing constraints for consumption smoothing behavior has become well-established in the macroeconomics literature. Papers such as Kaplan and Violante (2010, 2014) show that the consumption response to income shocks and fiscal policy is significantly affected by the tightness of borrowing constraints. Imrohoroglu (1989) found that borrowing can reduce the welfare costs of business cycles by as much as a factor of six depending on the borrowing limit in the economy. My work contributes to this literature by developing a

4. The Emergency Unemployment Compensation Act extended the duration of UI up to 99 weeks during the Global Financial Crisis. The Federal Pandemic Unemployment Compensation Program provided up to $600 of additional benefits per week to UI recipients during Covid-19.

model which can explain the business cycle properties of unsecured credit. Previously, the model with cyclical earnings skewness shocks in Nakajima and Ríos-Rull (2019) was able to explain about one-quarter of the volatility in unsecured credit over the business cycle. They calibrate their model to match moments from Guvenen, Ozkan, and Song (2014), which uses annual tax return data to find that earnings risk becomes significantly more left-skewed during recessions. The difficulty with calibrating a model to match moments from annual tax return data is that it is impossible to tell if the change in earnings risk is coming from changes in wages or unemployment. A change in wages, job separation rates, or job finding rates could all create earnings risk that is more left-skewed during recessions, but I show that the latter is what drives the high volatility of unsecured credit balances. Therefore, it is necessary to account for the underlying unemployment dynamics that generates changes in the skewness of earnings risk to explain the business cycle properties of unsecured credit.

This paper also contributes to the literature which studies the relationship between forms of public and private insurance. The most related empirical work is by Hsu, Matsa, and Melzer (2014, 2018) which shows evidence that more generous UI policies result in lower interest rates and higher borrowing limits on credit cards.[5] Their paper also finds that extensions in UI significantly reduced mortgage defaults during the Global Financial Crisis (GFC). Bornstein and Indarte (2023) finds evidence that higher levels of Medicaid lead to more credit card borrowing. Braxton, Herkenhoff, and Phillips (2022) studies how consumer credit impacts the optimal replacement rate of UI. The most similar theoretical work is by Athreya and Simpson (2006) which studies the relationship between UI, unsecured credit, and consumer bankruptcies in an economy without aggregate fluctuations.[6] Their paper finds that increasing the generosity of UI leads to a steady-state equilibrium with higher unsecured credit balances. The intuition behind the results is similar across all of the papers in this literature: public insurance complements private insurance by reducing default incentives. My paper is the only one to show that the relationship between UI and credit plays a key role in driving cyclical fluctuations. Focusing on business cycle dynamics provides an important

5. The results pertaining to the interest rate and borrowing limit on credit cards are in the 2014 working paper version of the paper.

6. Preliminary work by Makoto Nakajima also studies the relationship between UI, unsecured credit, and consumer bankruptcies using a model economy.

contribution to the literature because most changes to UI are temporary and occur during recessions.

Most of the literature which has studied the aggregate implications of UI policies has focused on employment outcomes. Recent papers which measure the impact of UI on employment outcomes during the GFC have mixed findings. Johnston and Mas (2018) uses administrative data from Missouri to show that a cut in the maximum duration of UI after the GFC led to a reduction in unemployment. In contrast, Chodorow-Reich, Coglianese, and Karabarbounis (2019) finds that the extension in the duration of benefits during the GFC had minimal effects on unemployment. The most related work in the literature is Kekre (2023) which studies how UI policies impact aggregate demand. His paper finds that extending the duration of UI during the GFC actually prevented a further rise in unemployment because the policy stabilized aggregate demand. Although I do not focus on employment outcomes, my paper adds to Kekre's result by showing that unsecured credit amplifies the extent to which UI stabilizes aggregate consumption: the largest component of aggregate demand.

There are many papers in the macroeconomics literature which study the optimal construction of UI. Papers such as Hansen and Imrohoroglu (1992) and Chetty (2008) solve for the replacement rate of UI that maximizes household welfare. Acemoglu and Shimer (1999) solves for the level of benefits that maximizes output in an economy with directed search. Recently, the literature started to consider the optimal construction of UI over the business cycle (Mitman and Rabinovich (2015)). Although I do not solve for the optimal construction of UI, I do compare the CE welfare gains of different counter-cyclical UI policies. The results from my paper suggest that the welfare gains for households may differ significantly based on whether the government optimally sets the level or the duration of benefits. This result hinges on incomplete consumption insurance and precautionary savings because in a representative-agent model with complete insurance against idiosyncratic risk, all that matters for consumption is the unemployment rate and the aggregate transfer of resources to households.

The rest of the paper is organized as follows. Section 2 describes the model economy. Section 3 maps the model to the data. Section 4 runs a decomposition exercise to better understand the sources of aggregate fluctuations. Section 5 provides results to the main research question. Section 6 provides concluding remarks.

2 Model

This section defines a general equilibrium real business cycle model with four types of economic agents. A representative firm rents capital and labor to produce a single output good. Overlapping generations of households choose whether or not to supply labor to the firm in a frictional labor market. They also borrow and save by purchasing securities from financial intermediaries. Idiosyncratic risk and incomplete asset markets give rise to an endogenous distribution of households in the spirit of Huggett (1993) and Aiyagari (1994). Financial intermediaries sell securities to households at a discount price that reflects the probability of a bankruptcy occurring. Intermediaries also own capital and rent it to the firm in a competitive market. The government uses income taxes to fund transfers to households. The model is defined recursively in discrete time.

2.a The Firm's Problem

A representative firm produces output from aggregate capital K and aggregate labor L. Let $\Omega = \{x, \mu\}$ be the aggregate state space of the model economy, where μ is the endogenous distribution of households over individual state variables, and x is the exogenous state of the economy. The exogenous state fluctuates between expansions x_g and recessions x_b, and $\pi_x(x, x')$ is the probability matrix governing the transitions. I assume that aggregate productivity $z(x)$ is a function of exogenous state such that TFP falls during recessions.

$$\max_{K,L} \; z(x)F(K, L) - \delta K - r(\Omega)K - w(\Omega)L \tag{1}$$

The firm rents capital and labor to solve the problem described by equation (1). Let $r(\Omega)$ be the price of purchasing a unit of capital from financial intermediaries in a competitive market. Similarly, $w(\Omega)$ is the price of purchasing a unit of labor from households. Equilibrium prices solve the firm's problem, where r depends on the marginal product of capital, and w is the marginal product of labor.

2.b Households

There are J overlapping generations of households in the model economy. Every period, a cohort of size ϕ_J dies and is replaced by a new cohort of the same size. I assume there is a measure one continuum of households such that $\sum_{j=1}^{J} \phi_j = 1$. Age 1 households are born into the economy with good credit, zero assets, and a fraction Φ_E are employed. They retire at age J_r and die at age J. They derive utility $u(c_j, n_j)$ by consuming the single output good minus utility costs of work. Households discount future utility at rate β. Let $\Psi_j = (\epsilon_j, a_j, n_j, s_j)$ be a point in the individual state space of the household problem.

Households differ with respect to their labor productivity. Productivity has two components: an age component and a persistent component. The age component of productivity γ_j exhibits a hump-shaped life cycle profile which gives young households an incentive to borrow against future earnings. I assume that the persistent component of productivity ϵ_j evolves according to the stochastic AR(1) process detailed below. Let η be the innovations to the persistent process where σ_η^2 is the variance of innovations. The persistence of individual productivity is ρ.

$$\log(\epsilon_{j+1}) = \rho \log(\epsilon_j) + \eta, \quad \textit{where} \quad \eta \in N\big(0, \sigma_\eta^2\big)$$

The labor market is modeled in the style of Krusell et al. (2017) where households have the option to supply labor to the firm in a frictional market. The environment simultaneously accounts for labor market frictions and standard labor supply forces that are present in the stochastic growth model. A household can be employed E, nonemployed N, or nonemployed with no UI $\tilde{N}$. Let n_j be the employment state of an age j household. An employed household chooses whether or not to quit a job, and a nonemployed household chooses whether or not to search for work. Equation (2) describes the extensive-margin labor supply decision where $h \in \{e, u\}$ is the corresponding decision rule.[7] I assume that households pay a utility cost of χ_s to search for work when in nonemployment. Therefore, households must weigh the expected future earnings of work against the costs of participating in the labor market.

7. Let e be the decision to keep a job while employed or search for a job when not employed. Similarly, u is the decision to quit a job or refrain from search.

$$V(\Psi_j,\Omega) = \max\left[V^e(\Psi_j,\Omega) - \chi(n_j), V^u(\Psi_j,\Omega)\right] \tag{2}$$

$$h(\Psi_j,\Omega) = \begin{cases} e \quad if \quad V^e(\Psi_j,\Omega) - \chi(n_j) \geq V^u(\Psi_j,\Omega) \\ u \quad otherwise \end{cases}$$

$$\chi(n_j) = \begin{cases} \chi_s \quad if \quad n_j \in \{N, \tilde{N}\} \\ 0 \quad otherwise \end{cases}$$

Employment flows are also affected by labor market frictions. Let $\xi(x)$ be the involuntary separation rate: the fraction of households who transition to unemployment despite choosing to work. Let $\lambda(x)$ be the job finding rate: the probability of finding a job when searching for work. These frictions vary with the exogenous state of the economy such that the labor market becomes more frictional during recessions. I assume that all employment transitions take place after production, meaning aggregate labor is known at the start of a model period.

The UI regime is modeled to depict the key features of the US system. A worker who is involuntarily separated transitions to N and is eligible for UI. However, workers who quit a job are not eligible for benefits and transition to $\tilde{N}$. The level of benefits is determined by the replacement rate υ_r which is the fraction of lost labor earnings. Let $\overline{\upsilon}$ be the maximum level of benefits that an individual can receive. Households must be searching for work to receive UI. While receiving benefits, $\upsilon_d(x)$ is the probability of losing access to UI and transitioning to $\tilde{N}$. This allows the model to replicate the average duration of benefits during an unemployment spell without adding a variable to the state space. The duration of UI depends on the aggregate exogenous state so the benchmark economy can be calibrated to replicate the Federal-State Extended Benefits Program (EB) which provides 13 additional weeks of benefits during recessions.

Equation (3) describes the default decision where $d \in \{p, b\}$ is the subsequent decision rule.[8] Let $a_j \in A$ be the current asset level where I make the standard assumption that $a_j < 0$ is debt and $a_j > 0$ is savings. In the spirit of Chatterjee et al. (2007) and Livshits, MacGee, and Tertilt (2007), the default decision is modeled to depict a chapter 7 bankruptcy filing

8. I define p as the decision to repay debts and b as the decision to declare bankruptcy.

in the US. I make the following assumptions about bankruptcy: all assets are immediately discharged, the household pays a utility cost χ_b, and there is no saving allowed in the period of a bankruptcy. Furthermore, access to credit is determined by credit status s_j. Bankruptcy causes a household to move to bad credit s_b where there is no borrowing. Let $V^{h,b}$ be the value of declaring bankruptcy and moving to bad credit.

$$V^h(\Psi_j, \Omega) = \max \left[V^{h,p}(\Psi_j, \Omega), V^{h,b}(\Psi_j, \Omega) - \chi_b \right] \tag{3}$$

$$d(\Psi_j, \Omega) = \begin{cases} p & if \quad V^{h,p}(\Psi_j, \Omega) \geq V^{h,b}(\Psi_j, \Omega) - \chi_b \\ b & otherwise \end{cases}$$

Let $q(a_{j+1}; \Psi_j, \Omega)$ be the menu of discount prices over all of the possible choices of securities. The price for a specific security a_{j+1} reflects the probability of a bankruptcy occurring next period. In this setting, the discount price decreases with the amount borrowed, and a household's borrowing limit is an endogenous outcome of the loan price schedule. The intuition for the endogenous borrowing limit is similar to a Laffer Curve: if a household tried to borrow an infinite amount of debt, intermediaries would offer a discount price of zero and households couldn't borrow any resources. Similarly, households do not borrow if they choose $a_{j+1} = 0$. Therefore, along the menu of loan prices there is a maximum amount of debt that can be borrowed. The equilibrium menu of loan prices provides an essential feedback mechanism for my analysis. UI affects bankruptcy behavior which feeds back through the menu of prices for credit to impact the consumption decisions of households.

Households choose consumption and net savings as described by equation (4). Let $W(\Psi_j, \Omega)$ be a function that determines the pre-tax labor earnings of a household with characteristics Ψ_j. Labor earnings are individual productivity times the equilibrium wage rate when employed. Similarly, $T^U(\Psi_j, \Omega)$ is the transfer of UI benefits dependent on the eligibility of the household. I assume that benefits are calculated using the persistent productivity ϵ_j from the most recent period of employment.[9] This reflects the fact that UI benefits are based on an individual's labor earnings from before the unemployment spell began. Households also receive transfers during retirement T^R, and they receive a lump-sum transfer of T

9. This is accomplished by assuming $\epsilon_{j+1} = \epsilon_j$ when a household is not employed.

from the government during working years. Households who begin the period in bad credit still solve Bellman equations (2)-(4) except that the borrowing limit is set to 0, and they transition to good credit next period with probability θ. This assumption allows the model to replicate the average duration that a bankruptcy stays on the credit score of an individual without increasing the size of the state space.

$$V^{h,p}(\Psi_j,\Omega) = \max_{c_j,\,a_{j+1}} u(c_j,n_j) + \beta \sum_{x'} \pi_x(x,x')\, E\Big[V(\Psi_{j+1},\Omega')|\Psi_j\Big] \tag{4}$$

$$\text{s.t.} \qquad c_j + q(a_{j+1};\Psi_j,\Omega)\,a_{j+1} = a_j + (1-\tau)W(\Psi_j,\Omega) + T^U(\Psi_j,\Omega) + T_j$$

$$\text{and} \qquad \mu' = \Gamma(\Omega), \qquad c_j > 0, \qquad a_{j+1} \geq 0 \quad if \quad s_j = s_b$$

$$W(\Psi_j,\Omega) = \begin{cases} w(\Omega)\gamma_j\epsilon_j \quad if \quad n_j = E \\ 0 \quad otherwise \end{cases}$$

$$T^U(\Psi_j,\Omega) = \begin{cases} \min\{\upsilon_r w(\Omega)\gamma_j\epsilon_j, \overline{\upsilon}\} \quad if \quad n_j = N \quad and \quad h(\Psi_j,\Omega) = e \\ 0 \quad otherwise \end{cases}$$

$$T_j = \begin{cases} T^R \quad if \quad j \geq J^R \\ T \quad otherwise \end{cases}$$

Retired households are permanently out of the labor force. I choose to model retirement to create a realistic life cycle savings motive for working households. Retirement is not of primary interest to the paper because retired households are not affected by unemployment risk or UI policies. I assume that retired households do not have access to unsecured credit. This assumption should not have a significant effect on the results of the paper because unsecured credit and default are concentrated in young households in the model and in the data.

All of the decision problems outlined in equations (2) through (4) assume households have rational expectations. Uninsurable idiosyncratic risk coupled with incomplete asset markets creates an endogenous distribution of households over state variables. In the spirit of Krusell and Smith (1998), the distribution of households follows the law of motion $\mu' = \Gamma(\Omega)$.

Agents in the model economy know the law of motion which allows them to form rational expectations over future prices.

2.c Financial Intermediaries

A continuum of risk-neutral financial intermediaries serve two main purposes in the model economy: they sell securities to households, and they rent capital to the firm. I assume that the market for intermediation is competitive such that zero profits are earned in expectation on each security. Equation (5) describes the menu of equilibrium prices offered to an age j household for all possible choices of a_{j+1}. I assume that the intermediary knows the productivity and employment status of a household, and the intermediary has rational expectations with respect to the future return on capital. The prices offered to an age j household depend on the probability of a bankruptcy next period at age $j+1$. All else equal, an increase in the probability of a bankruptcy reduces the expected return of the loan, and the discount price falls to ensure zero profits in expectation. I assume that ι is a proportional cost paid by the intermediary to monitor debt contracts. For savings, the discount price is always equal to the inverse of the expected return on capital because there is no default on positive assets.

$$q(a_{j+1}; \Psi_j, \Omega) = \sum_{x'} \pi_x(x, x')\, E\left[\frac{1 - d(\Psi_{j+1}, \Omega') - \iota(a_{j+1})}{1 + r(\Omega')}\right] \tag{5}$$

$$\text{where} \quad \mu' = \Gamma(\Omega), \quad \text{and} \quad \iota(a_{j+1}) = \iota \quad if \quad a_{j+1} < 0$$

Financial intermediaries own all of the capital in the model economy. They rent net household savings in the form of capital to the firm. Because intermediaries have both loans and capital on the balance sheet, these assets must have the same expected return in equilibrium. This has important general equilibrium implications for credit. All else equal, a fall in the return to capital increases the discount price of credit making it cheaper to borrow.

$$
\begin{aligned}
\Pi(\Omega) = (1 + r(\Omega))\, K - K' + \sum_{j=1}^{J} \int_{\Psi} q(a_{j+1}; \Psi_j, \Omega)\, a_{j+1}\, \mu(d\Psi_j) \\
- \sum_{j=1}^{J} \int_{\Psi} \left(1 - d(\Psi_j, \Omega) - \iota(a_j)\right)\, a_j\, \mu(d\Psi_j)
\end{aligned}
\tag{6}
$$

Intermediaries earn zero profits in expectation on each security, but aggregate uncertainty makes it such that they can have realized profits or losses. Equation (6) details the profits of intermediaries $\Pi(\Omega)$ in a model period. Intermediaries receive the returns to capital net of depreciation, and they invest capital with the firm for next period's production. They also sell new securities a_{j+1} at the discount price q. Intermediaries pay out the net balance of securities that were sold last period. No revenue is received from debt that is in a bankruptcy claim. They also pay monitoring costs for pre-existing debt contracts. The total return on past securities and the total liabilities from newly issued securities are aggregated over the distribution of households.[10] I assume that net profits are taxed fully each period by the government. Realized net profits in the calibrated model economy are quite small such that distributing them in a different way should have a small effect on the results of the paper.

2.d The Government

The government collects income taxes from all households where τ is the tax rate. The government also facilitates transfers to households through three different programs: UI benefits, social security benefits, and lump-sum transfers. Equation (7) describes the government budget constraint where $G(\Omega)$ is net government expenditures. I assume that the government consumes the remaining goods after collecting taxes and distributing transfers. Government consumption is always positive in equilibrium.

10. I integrate over the entire individual state space for households. I represent this with an integral over Ψ_j. A more detailed description of the aggregation process would be to sum over discrete states ϵ, n, and s and integrate over the continuous state a. I suppress the full notation to improve the readability of the model equations.

$$
\begin{aligned}
G(\Omega) = &\sum_{j=1}^{J_R} \int_{\Psi} \tau\, W(\Psi_j, \Omega)\mu(d\Psi_j) - \sum_{j=1}^{J_R} \int_{\Psi} T^U(\Psi_j, \Omega)\, \mu(d\Psi_j) \\
&- \sum_{j=1}^{J} \int_{\Psi} T_j\, \mu(d\Psi_j) + \Pi(\Omega)
\end{aligned} \tag{7}
$$

2.e Equilibrium Definition

An equilibrium in the model economy occurs when economic agents behave optimally and all markets clear. Before defining the equilibrium concept, I define aggregate variables needed to solve for an equilibrium in the model economy. Aggregate labor supply is the total productivity of households who are currently employed at the market wage. Similarly, aggregate consumption is the total consumption summed over the distribution of households. Aggregate investment I is derived from the intermediaries problem as invested capital less non-depreciated capital.

$$L = \sum_{j=1}^{J_r} \int_{\Psi\{n_j = E\}} \gamma_j \epsilon_j\, \mu(d\Psi_j) \tag{8}$$

$$C = \sum_{j=1}^{J} \int_{\Psi} c(\Psi_j, \Omega)\, \mu_j(d\Psi_j) \tag{9}$$

$$K' = \sum_{j=1}^{J} \int_{\Psi} q(a_{j+1}; \Psi_j, \Omega)\, a_{j+1}\, \mu(d\Psi_j) \tag{10}$$

$$I = K' - (1-\delta)K \tag{11}$$

$$\iota A^- = \sum_{j=1}^{J} \int_{\Psi\{a<0\}} \iota\, a_j\, \mu(d\Psi_j) \tag{12}$$

Definition 1 A recursive equilibrium is the household value function V, decision rules (a_{j+1}, c_j, h_j, d_j), prices (r, w), the menu of discount prices q, and the distribution of households μ such that

1. Factor prices (r, w) solve the firm problem described by equation (1).

2. The decision rules (a_{j+1}, c_j, h_j, d_j) solve the household problems described by equations (2)-(4) where V is the resulting value function.

3. Financial intermediaries offer a menu of prices q to earn zero profits in expectation described by equation (5).

4. Net government expenditures are described by the government budget constraint in equation (7).

5. The distribution of households is consistent with individual decisions and the transition probabilities for individual state variables.

6. The market for securities clears at the menu of loan prices. The markets for capital and labor clear at the factor prices. The market for goods clear in equation (13) below where ιA^- are the resources spent to monitor debt contracts.

$$C + I + G(\Omega) + \iota A^- = zF(K, L) \tag{13}$$

3 Model to Data

The model is mapped to the data to depict the US economy from 1980Q1 to 2019Q4. The specified period covers five recessions in which the Federal Government extended the duration of UI benefits. The US economy also experienced significant cyclical fluctuations in unsecured credit and consumer bankruptcies making it an excellent basis to study how credit affects the implications of UI policies. Mapping the model to the data proceeds in three stages. First, a group of parameters are chosen outside the model solution. A separate group of parameters are then calibrated so the model replicates a set of key moments from the data. Finally, I compare simulated results to a set of untargeted moments from the data to test the validity of the model.

3.a Parameters Set Outside the Model Solution

The values of the aggregate exogenous transition matrix π_x are set using the average duration of expansions and recessions in the US. To this end, let the length of a model period be 1 quarter. The persistence of expansions is set such that the average expansion lasts just under 7 years, and the persistence of recessions is set such that the average recession lasts 4.6 quarters. The transition values reported below make the model consistent with business cycle data on peak and trough quarters reported by the NBER from 1980Q1 to 2019Q4.

$$\pi_x = \begin{vmatrix} 0.964 & 0.036 \\ 0.217 & 0.783 \end{vmatrix}$$

The parameters governing the UI regime in the model economy are chosen to be consistent with the Regular Benefits and the Federal-State Extended Benefits (EB) Program in the US. There are four parameters that determine the level and duration of benefits: $\{\upsilon_r, \overline{\upsilon}, \upsilon_d(x_g), \upsilon_d(x_b)\}$. I set $\upsilon_d(x_g)$ so the average duration of UI benefits is 2 quarters during expansions. Similarly, I set $\upsilon_d(x_b)$ so the average duration of benefits is 3 quarters during recessions. This policy is consistent with the EB Program which provieds 13 additional weeks of benefits when unemployment is high. The remaining parameters are chosen such that UI replaces 50% of lost earnings, and the maximum level of benefits is 42% of average earnings in the economy. The parameters governing the UI regime are consistent with the summary statistics on benefits reported in Hsu, Matsa, and Melzer (2018).[11]

The parameters governing the life cycle of the household are set such that the model exhibits an empirically consistent hump-shaped earnings profile. Households are born into the economy at age 25, they retire at age 65, and they die at age 75. Due to the quarterly frequency of the model, the total number of periods in the life cycle of a household is 200. The retirement age J_r is set to 160. The age-component of productivity is parameterized such that $\gamma_j = \nu_1 j + \nu_2 j^2$. Using data on earnings from the SCF, I estimate ν_1 and ν_2 to be $4.58e^{-2}$ and $-9.36e^{-4}$ respectively.[12] Because age is only reported in one-year intervals in the SCF, I assume that γ_j changes deterministically every 4 model periods. The estimated

11. They look at data on UI in the United States from 1991-2010. They report the median duration of benefits across states to be 26 weeks. Also, the ratio of max weekly benefits to average weekly wages is 0.42.

12. I estimate the age-component of earnings in every survey from 1989 through 2019 and take the average.

age-component of productivity generates a hump-shaped earnings profile over the life cycle which has been shown by Livshits, MacGee, and Tertilt (2007) and Athreya, Tam, and Young (2009) to be a significant component of the demand for borrowing by young households who have higher default rates.

The remaining parameters chosen outside the model solution are set to be consistent with commonly used values from the literature.[13] The process governing the persistent-component of productivity is consistent with Krusell et al. (2017): the persistence of the productivity process is 0.989 and the standard deviation is 0.103. Households value consumption with constant relative risk aversion (CRRA) preferences $u(c,n) = \frac{c^{1-\sigma}}{1-\sigma} - \chi_w \mathbb{1}_{\{n=E\}}$. The coefficient of relative risk aversion σ is set to 2.0. Let χ_w be the utility cost of work. Aggregate production follows a Cobb-Douglass function $F(K,L) = zK^{\alpha}L^{1-\alpha}$ where the capital share of production is 35%. The tax rate τ is set to 30%, and the pre-tax transfer to retired households is 50% of average earnings in the model economy. The probability of leaving bad credit θ is 2.5% so the average duration of bad credit lasts 10 years, which is the amount of time a bankruptcy remains on an individual's credit score in the US.

3.b Model Calibration

The remaining parameters are calibrated so the model reproduces a set of key moments from the data over the time period of interest. To this end, I simulate the benchmark economy and update parameters until the model generated moments match the data. Table 1 details all of the moments targeted in the calibration procedure.

To simultaneously match aggregate capital holdings and revolving credit balances, I assume heterogeneity in household discount factors. Specifically, there are two types of households: patient who discount the future at rate β_h, and impatient who discount at rate β_ℓ. The discount factors are calibrated to match the ratios of capital and revolving credit balances to GDP. The share of impatient households π_ℓ is then set to match the fraction of households in the labor force with positive balances of credit card debt. The assumption of preference heterogeneity is supported by empirical work from Fulford and Schuh (2017) who estimate a life cycle model of consumption, unsecured credit, and default with patient

13. A table with the full set of model parameters is included in appendix A.

Table 1: Calibration Targets

	Data	Model
	First Moments	
Capital / GDP	224.07	224.04
Investment / Capital	7.89	7.88
Government exp / GDP	5.38	5.27
Credit balance / GDP	4.83	4.86
Debt share	41.37	41.69
Credit spread	11.73	11.69
Bankruptcy rate	0.88	0.86
Participation rate	73.73	73.63
Unemploy. rate	6.32	6.33
Unemploy. duration (weeks)	20.93	20.92
	Second Moments	
σ(GDP)	1.23	1.23
σ(Unemp. Rate)	11.12	11.02
σ(Job Find)/ σ(Job Sep)	1.62	1.58

Note.— Data from 1980Q1-2019Q4 except for debt share which begins in 1983 and credit spreads which begin in 1994Q4. First moments are annualized and in percentages except for unemployment duration which is in weeks. Government exp is national defense spending in the data. Debt share is the fraction of households in the labor force with credit card debt. Second moments are log and HP filtered with a smoothing parameter of 1600. σ(Job Find) is standard deviation of job finding rates, and σ(Job Sep) is standard deviation of job separation rates.

and impatient individuals. The calibrated share of impatient households in my benchmark economy is within their range of estimates.

The model is also calibrated to match various moments for output and unemployment. I normalize the expansion value of TFP to 1, and I set the recession value in order to match the standard deviation of real GDP in the data. The expansion value of involuntary job separation rates ξ is chosen to match the average unemployment rate in the data. Similarly, the expansion value of job finding rates λ is chosen to match the average duration of unemployment. The recession values for job separation rates and finding rates are chosen to match second moments for unemployment. Specifically, the model matches the standard deviation of unemployment rates in the data. The model also matches the ratio of the standard deviation of job finding rates to the standard deviation of job separation rates. This is done to ensure that the share of fluctuations in unemployment coming from each labor market friction is consistent with the data. To calculate these moments in the data, I use the methodology described in Shimer (2012). This methodology calculates job separation rates and finding rates using readily available aggregate time series data.

Furthermore, the model is calibrated to match various aggregate and financial variables in the data. The disutility of bankruptcy χ_b and the cost of monitoring ι are set to match the bankruptcy rate and the credit spread respectively.[14] Capital depreciation δ is set to match the average aggregate investment to capital ratio. The lump-sum transfer to working households T is chosen to match the ratio of government expenditures to real GDP. I choose to target national defense spending as the measure of government expenditures in the data for two main reasons. First, it is intuitively the closest measure to government consumption in the model, which is expenditures that do not flow back to households. Second, it ensures that government consumption is always positive in equilibrium. With regards to labor markets, I make the simplifying assumption that the utility cost of work is equal to the utility cost of search, and χ_w is calibrated to match the labor force participation rate. I also assume that the share of new households who are employed is equal to the average share of employed households in the model economy.

3.c Model Validation

I test the validity of the model by comparing simulated results to empirical moments that were not targeted in the calibration procedure. Specifically, the model-generated results are compared to standard moments used for business cycle analysis: second moments of aggregate and financial time series. Table 2 details the standard deviation and cross-correlation with real GDP for key times series in the benchmark model economy and in the data. The empirical moments are generated using quarterly data that is seasonally adjusted, in logs, and HP filtered with a smoothing parameter of 1600.[15] All data is available from 1980Q1 except for unsecured credit spreads which are available from 1994Q4.

The most important result from this section of the paper is the model generates the cyclical properties of unsecured revolving credit balances in the data. This is a significant

14. The unsecured credit spread in the data is the spread of the average interest rate on credit card accounts that are assessed interest over the interest rate on 1-year treasury bills.

15. Revolving credit balances, unemployment rates, and participation rates are quarterly averages of monthly data. Bankruptcy data is non-business filings.

Table 2: Untargeted Business Cycle Properties

		C	I	D	B	Q	U	P
$\sigma(X)/\sigma(GDP)$	Data	0.77	4.89	2.97	13.62	5.17	9.05	0.20
	Model	0.50	2.49	2.51	13.38	1.76	8.96	0.02
Corr(X,GDP)	Data	0.86	0.90	0.32	-0.35	-0.71	-0.86	0.42
	Model	0.88	0.68	0.58	-0.59	-0.85	-0.83	0.91

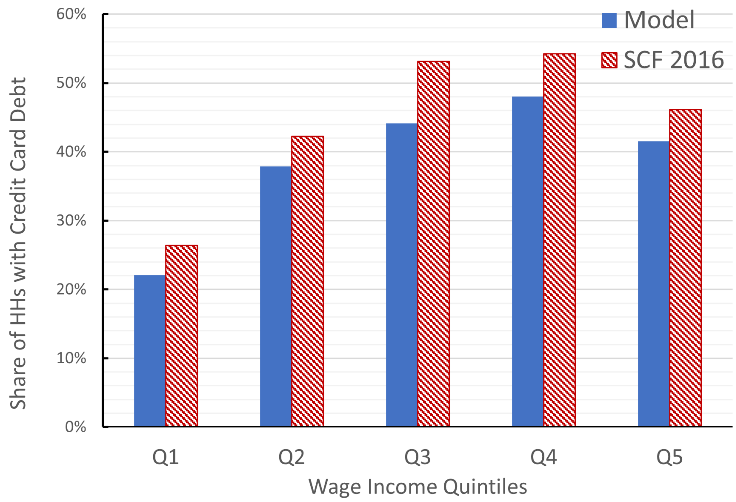
Note.— Data is from 1980Q1-2019Q4 except for credit spreads which begin in 1994Q4. Data is in logs, seasonally adjusted and HP filtered with a smoothing parameter of 1600. C is aggregate consumption; I is investment; D is unsecured credit balances; B is consumer bankruptcies; Q is unsecured credit spreads; U is unemployment; P is labor force participation. $\sigma(X)/\sigma(GDP)$ is relative standard deviation of variable X to GDP. $Corr(X, GDP)$ is correlation coefficient of variable X with GDP.

contribution to the consumer credit and default literature because the leading models have not been able to explain why unsecured credit is so volatile over the business cycle. The model with cyclical earnings skewness shocks in Nakajima and Ríos-Rull (2019) can explain about one-quarter of the total standard deviation of unsecured credit. Fieldhouse, Livshits, and MacGee (2016) studies the cyclical moments of unsecured credit and consumer bankruptcy in an endowment economy with aggregate shocks to a persistent income process. They find that the model needs intermediation shocks to generate credit that is procyclical, and their model also under-predicts the volatility of unsecured credit balances. My benchmark model economy generates over 84% of the volatility in unsecured credit balances by using empirically consistent unemployment dynamics over the business cycle. The model also generates consumer bankruptcies and unsecured credit spreads which are highly volatile and counter-cyclical.[16] Reproducing the cyclical properties of unsecured credit and consumer bankruptcies is not just an important contribution to the literature, it is also a necessary step towards quantifying how unsecured credit affects the usefulness of UI in insuring households against aggregate risk.

The model also has success generating the cyclical properties of other aggregate time series in the data. Aggregate consumption is pro-cyclical and less volatile than GDP. Aggregate investment is pro-cyclical and more volatile than GDP. The model under-predicts the volatility of investment which isn't surprising because there are no adjustment costs for capital or financial frictions for firms. With regards to labor markets, the standard deviation

16. Non-business bankruptcies are still highly volatile and counter-cyclical in the data if you use a shorter time period that ignores the effects of the 2005 Bankruptcy Abuse and Consumer Protection Act.

Figure 1: Distribution of Households with Credit Card Debt



Note.— Share of households with a positive balance on credit cards over the income distribution. Data from the SCF 2016 for households in the labor force. Income is wage income. Drop self-employed households. Credit card debt is the balance on bank cards after making the most recent payment. Moments from the model are calculated during a prolonged expansion: 50 quarters since the most recent recession.

of unemployment was targeted in the calibration procedure, but the model also generates a counter-cyclical correlation very close to the data. Labor force participation is pro-cyclical and much less volatile than GDP. The model under-predicts the volatility of labor force participation, but this should not be of first-order importance to the results of the paper because UI isn't available to individuals who are out of the labor force.

I conclude this section by comparing the distribution of unsecured credit over income in the model to micro-level data. Figure 1 details the share of households with a positive balance on credit cards in each quintile of the income distribution.[17] This provides a robust test of the model because the distribution of income is simultaneously accounting for persistent productivity, age, and employment status. The model has a lot of success generating the key patterns seen in the data. Credit card debt is the least prevalent among low-income households. This occurs in the model because low-income households are high-risk borrowers, and financial intermediaries charge them a high default-risk premium. Furthermore, the distribution of credit over income is hump-shaped where credit card debt is most prevalent in income quintiles 3 and 4. These results show that the model is able to generate key

17. Figure 1 focuses on the extensive margin of the credit distribution. Appendix B also compares the intensive margin of the credit distribution to the data by looking at the average debt held in each quintile.

Table 3: Decomposition of Aggregate Fluctuations

		C	I	D	B	Q	U
Std Dev (X)	(1) Benchmark	0.62	3.06	3.09	16.46	2.17	11.02
	(2) Acyclical z	0.47	2.46	3.86	14.93	1.46	10.97
	(3) Acyclical ξ	0.50	2.46	2.03	13.67	1.47	6.69
	(4) Acyclical λ	0.26	2.52	0.23	5.12	1.28	4.72
Corr(X,GDP)	(1) Benchmark	0.88	0.68	0.58	-0.59	-0.85	-0.83
	(2) Acyclical z	0.23	0.48	0.85	-0.13	-0.44	-1.00
	(3) Acyclical ξ	0.94	0.70	0.49	-0.57	-0.86	-0.74
	(4) Acyclical λ	0.98	0.94	-0.63	-0.73	-0.87	-0.72

Note.— C is aggregate consumption; I is investment; D is unsecured credit balances; B is average bankruptcy rate; Q is average spread of credit over capital returns; U is unemployment rate. Acyclical z holds TFP constant; Acyclical ξ holds involuntary job separation rates constant; Acyclical λ holds job finding rates constant.

macro-level moments in an environment that is consistent with micro-level data.

4 The Sources of Aggregate Fluctuations

I now conduct a decomposition exercise to quantify the sources of aggregate fluctuations over the business cycle. To this end, I simulate the model economy removing cyclical changes to TFP, involuntary job separation rates, and job finding rates for unemployed workers one at a time.[18] This methodology allows me to isolate the impact of each dynamic variable in driving aggregate fluctuations. The decomposition exercise accomplishes two things: it explains why the model improves on the literature's ability to match the cyclical properties of unsecured consumer credit, and it highlights the importance of studying business cycles in an environment with incomplete asset markets and idiosyncratic risk.

The main result from the decomposition exercise is job finding rates for unemployed workers are the main driver of aggregate fluctuations over the business cycle. As seen in simulation (4) of table 3, the majority of the volatility in consumption, unsecured credit, and consumer bankruptcies is explained by job finding rates: the standard deviation of all three variables falls by more than half when job finding rates are held constant. Addition-

18. Even when involuntary job separation rates are held constant, households are still allowed to endogenously separate from a job by quitting.

ally, unsecured credit balances would be counter-cyclical which is inconsistent with the data. Comparing the results to simulation (3), it is easy to see that involuntary job separation rates have a smaller impact on aggregate fluctuations. Part of this result is simply explained by the fraction of unemployment that is caused by each labor market friction. Consistent with results from Shimer (2012), the majority of the volatility in unemployment is driven by job finding rates. However, this does not fully explain why job finding rates have a stronger impact on aggregate fluctuations. The main mechanism driving these results is the precautionary motives of households. When job finding rates fall, households have a strong incentive to reduce consumption and delever (or save) to insure themselves against the possibility of a prolonged unemployment spell. Credit plays an important role in understanding this mechanism because in an economy with defaultable debt, indebted households want to delever to avoid bankruptcy if they experience a prolonged unemployment spell. When job separation rates increase during a recession, there is a much smaller impact on consumption and credit decisions because UI protects households against relatively short unemployment spells.

The results from the decomposition exercise highlight why the model is able to generate the cyclical properties of aggregate consumption, unsecured credit, and consumer bankruptcies. The most important contribution to the consumer credit literature is that the model explains over 84% of the standard deviation of unsecured revolving credit balances in the data. The model with cyclical earnings skewness shocks in Nakajima and Ríos-Rull (2019) generates about one-quarter of the same volatility. Their earnings process is calibrated to match annual moments from Guvenen, Ozkan, and Song (2014), which shows earnings risk becomes more left-skewed during recessions. Cyclical changes to earnings skewness in the data could be caused by changes to wages, job separation rates, or job finding rates, but I show that the latter is what drives aggregate fluctuations. Calibrating an earnings process to annual tax return data can miss some of the key details that result in large aggregate fluctuations because you cannot determine the underlying cause of a fall in earnings during a recession. An earnings shock caused by a fall in job finding rates has a larger impact on consumption and unsecured credit because it causes a stronger increase in precautionary behavior and default risk.

The insight that job finding rates have a larger impact on aggregate fluctuations highlights the importance of studying business cycles in an environment with incomplete asset markets and idiosyncratic risk. If asset markets were complete, separation rates and finding rates would have the same impact on macroeconomic aggregates if they caused the same change in unemployment because they would cause the same change in income for a representative household. The results from the decomposition exercise clearly show that fluctuations in unemployment can have a vastly different impact on the aggregate economy depending on which labor market friction is driving the change.

The final result from the decomposition exercise is that TFP fluctuations do not explain the cyclical properties of unsecured credit and consumer bankruptcies. Unsecured credit balances are actually more volatile when TFP is held constant, meaning that a model with only TFP shocks would generate counter-cyclical credit. This result is driven by general equilibrium price movements. During a recession, TFP falls which reduces the equilibrium return on capital. Financial intermediaries pass capital returns through to the debt price offered to households. All else equal, it is cheaper to borrow when TFP falls during recessions. This result is consistent with the results from Nakajima and Ríos-Rull (2019) who show that a model with only TFP shocks cannot explain the cyclical properties of unsecured credit and consumer bankruptcies. The impact of TFP on aggregate consumption and investment is standard in the real business cycle literature. When TFP falls, households invest less because the returns to capital fall, and they consume less because real wages fall. I incorporate cyclical changes to TFP in the benchmark economy because they help the model generate realistic consumption and investment dynamics over the business cycle. The results from simulation (2) are not entirely novel, but they do serve as a good validity test of the model mechanics.

5 Quantitative Results

This section quantifies how unsecured credit impacts the effectiveness of counter-cyclical UI policies. I first measure the effects of a policy which extends the duration of UI by 13 weeks during recessions in the benchmark economy with unsecured credit and in a counterfactual economy with no credit. To compare the effectiveness of the policy across the two economies, I use two statistics: a consumption-equivalent (CE) welfare analysis and peak-to-trough changes in aggregate consumption during recessions. Using both statistics allows me to simultaneously quantify how credit impacts the welfare gains of the UI policy and the extent to which UI smooths aggregate fluctuations over the business cycle. I conclude this section by comparing the policy which extends the duration of UI to a budget-neutral policy which increases the level of benefits during recessions.

5.a The Amplifying Effects of Unsecured Credit

I begin by measuring the welfare gains of the policy which extends the duration of UI by 13 weeks during recessions. The welfare calculation used is CE: it is the share of lifetime consumption a household would trade to be indifferent between two policies. In this case, the household is indifferent between the policy which extends the duration of UI and a policy where the terms of UI don't change over the business cycle. I refer to the former as the *extending UI* policy and the latter as the *acyclical UI* policy. Welfare is calculated for age 1 households in order to quantify the full lifetime consumption that makes the household indifferent between the policies.[19]

Equation (14) describes the CE welfare calculation used in this paper. The equation is generalizable to separable household preferences with a CRRA utility function for consumption. Let ω be the share of lifetime consumption that equates value function V from the *extending UI* policy to value function $\tilde{V}$ from the *acyclical UI* policy. In order to calculate CE welfare with separable preferences, it is important to differentiate between the household value function and the value of future consumption streams V_c. For the model used in this paper, households have separable preferences with respect to consumption, utility costs of work, utility costs of search, and the utility costs of filing for bankruptcy. I provide additional details about how to derive equation (14) in appendix D. There are two main benefits of calculating welfare in this way. First, the solution is analytical, meaning there is no additional computational burden to solve for ω. Second, the measurement is CE, making

19. It is easy to calculate the welfare of older households, but the interpretation differs slightly. Then, you are calculating the share of remaining lifetime consumption that makes the household indifferent between the two policies.

it easy to compare welfare gains across different policy counterfactuals and different models in the literature.

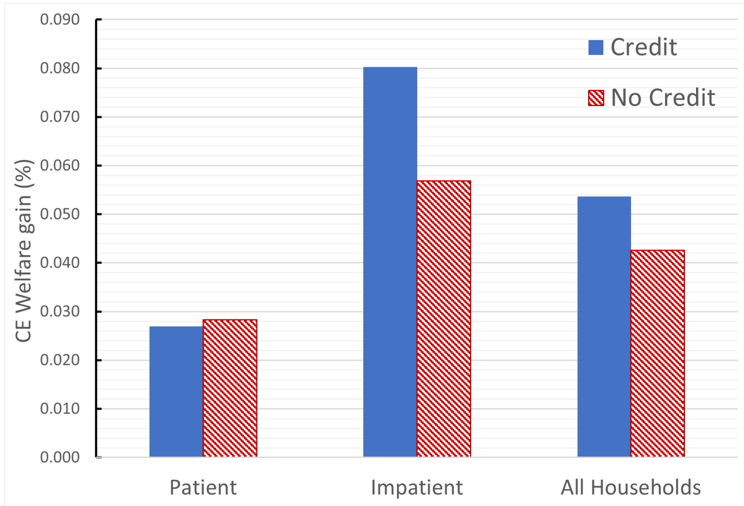
$$\omega(\Psi_j;\Omega) = \left[\frac{V(\Psi_j;\Omega) - \tilde{V}(\Psi_j;\Omega) + \tilde{V}_c(\Psi_j;\Omega)}{\tilde{V}_c(\Psi_j;\Omega)}\right]^{\frac{1}{1-\sigma}} - 1 \tag{14}$$

Figure 2 details the CE welfare gains of the policy which extends the duration of UI during recessions in the benchmark economy with unsecured credit and in the counterfactual economy with no credit. The main result is that unsecured credit amplifies the CE welfare gains of the *Extending UI* policy. The average household born into the economy with credit would trade 0.054% of lifetime consumption to obtain the extending UI policy. Whereas, the average household would only trade 0.043% to obtain the same policy in the model with no credit. The impact of credit is even larger for impatient households. These households would trade 0.080% of lifetime consumption for the extending UI policy in the economy with credit, but only 0.057% in the economy without credit.

Unsecured credit amplifies the welfare gains of the policy because credit and UI work as complimentary forms of insurance. When the government extends the duration of UI, households reduce their default rates. Lower default rates allow financial intermediaries to lower the default risk premium on unsecured credit which allows households to more readily use credit to smooth consumption. This explains why the welfare gains are largely being driven by impatient households. Impatient households are more likely to use unsecured credit during their lifetime, so they benefit more when the terms of credit improve. The mechanism where UI impacts the default risk premium of unsecured credit is supported by empirical evidence from the literature. Hsu, Matsa, and Melzer (2014, 2018) showed evidence that people in states with more generous UI policies receive credit card offers with higher borrowing limits and lower interest rates. Gross et al. (2021) also provided evidence of this mechanism by showing that a 1 percent reduction in bankruptcy probability translates to a 70-90 basis point decrease in the interest rate on credit cards in the US.

I now measure how unsecured credit impacts the extent to which UI stabilizes aggregate consumption fluctuations. UI has long been considered an automatic stabilizer of the economy, so it is important to understand how the emergence of unsecured credit has impacted

Figure 2: The Impact of Credit on Welfare Gains of UI



Note.— Average consumption-equivalent (CE) welfare gains across age 1 households: percent of lifetime consumption traded to obtain the policy which extends the duration of UI during recessions. Patient are high discount factor households; impatient are low discount factor. Credit is benchmark economy with unsecured credit. No credit is counterfactual economy with no credit.

the stabilizing effects of UI. To quantify aggregate fluctuations, I measure the peak-to-trough change in aggregate consumption averaged across all recessions in a 2000 period simulation. Table 4 details how the peak-to-trough change in consumption is affected by the policy which extends the duration of UI by 13 weeks during recessions. In the benchmark economy with unsecured credit, the UI policy reduces the average peak-to-trough fall in consumption by 0.42pp. In the economy with no credit, the policy only reduces the average peak-to-trough fall in consumption by 0.24pp. In appendix E, I show that the same result holds if you use the total deviation in aggregate consumption during a recession as opposed to the peak-to-trough change.

Unsecured credit amplifies the extent to which the *Extending UI* policy stabilizes aggregate consumption because credit acts as a complementary form of consumption insurance. Evidence of this complementary relationship is seen by looking at the peak-to-trough change in aggregate credit balances. Credit is pro-cyclical in the model and in the data. When the government extends the duration of UI during recessions, it reduces the average peak-to-trough fall in credit balances during recessions by 2.01pp. Households use the additional credit to smooth consumption expenditures during recessions. This equilibrium credit chan-

Table 4: Peak-to-Trough Declines: Extending Duration of UI

	Benchmark		No Credit	
	C	D	C	D
Acyclical UI (%)	2.62	10.11	1.89	0.00
Extending UI (%)	2.20	8.10	1.65	0.00
Difference (pp)	0.42	2.01	0.24	0.00

Note.— Peak-to-trough fall in aggregate consumption (C) and credit balances (D) averaged over all recessions in a 2000 period simulation. Peak is the period before a recession starts. Simulation results are in logs and HP filtered with a smoothing parameter of 1600. Benchmark is the economy with unsecured credit and No Credit is the economy with no borrowing.

nel is the result of both supply and demand factors. Extending the duration of UI during recessions mitigates the rise in consumer bankruptcies which allows financial intermediaries to supply credit with a lower default risk premium. On the demand side, the UI extension reduces the incentive for households to delever for precautionary reasons. The culminating effect is a significant increase in the extent to which UI stabilizes aggregate consumption fluctuations.

The results from this section make a significant contribution to the real business cycle literature and to the unsecured credit literature. Athreya, Tam, and Young (2009) shows that unsecured credit does not smooth consumption for households over the life cycle. Nakajima and Ríos-Rull (2019) shows that unsecured credit does not smooth aggregate fluctuations in consumption over the business cycle. Although credit does not smooth aggregate consumption fluctuations by itself, I find that it does amplify the extent to which cyclical UI policies stabilize consumption over the business cycle. The mechanism driving this result is that extensions in the duration of UI promote more unsecured credit during recessions, which allows households to better smooth consumption.

5.b Extending the Duration vs. Increasing the Level

The US government has implemented policies which extend the duration of UI and policies which increase the level of benefits during recent recessions. The Emergency Unemployment Compensation Act of 2008 extended the maximum duration of UI to 99 weeks during the Global Financial Crisis. The Federal Pandemic Unemployment Compensation Act increased the level of weekly benefits by \$600 during the Covid-19 pandemic. However, it is unclear which policy is a more efficient use of government resources. In this section, I use the general equilibrium model of this paper to compare the effectiveness of the *Extending UI* policy to a counter-factual policy which increases the replacement rate (RR) of benefits during recessions.[20] I refer to the latter as the *Increasing RR* policy. The two policies considered are budget-neutral in the sense that they generate the same average level of government expenditures over the business cycle.

The main result from this section is that extending the duration of UI during recessions has a larger impact on aggregate fluctuations than increasing the level of benefits. Table 5 details how the policy which increases the RR of benefits during recessions impacts the average peak-to-trough change in consumption and unsecured credit balances over the business cycle. The *Increasing RR* policy reduces the average fall in aggregate consumption during recessions by 0.13pp. By comparison, the *Extending UI* policy reduced the average fall in aggregate consumption by 0.42pp. You see a similar result when looking at fluctuations in unsecured credit balances. The *Increasing RR* policy reduced the fall in credit balances by 0.38pp, compared to the 2.01pp reduction from the *Extending UI* policy.[21]

If the goal of the policymaker is to stabilize aggregate fluctuations, extending the duration of UI during recessions is the superior policy. This occurs because the *Extending UI* policy is able to provide insurance to many households without even making a transfer of resources. The majority of unemployed workers do not utilize extended benefits, but the extensions increase the likelihood of finding a job before UI expires. This reduces the incentive for households to delever (or save) for precautionary reasons. Comparatively, when the government increases the RR of benefits, a transfer must be made to all unemployed workers, and households have an incentive to delever (or save) to insure themselves against the possibility of not finding a job before benefits expire. Therefore, the government must transfer a larger quantity of resources to generate the same amount of consumption insurance as in the *Extending UI* policy.

Although the *Extending UI* policy is more effective at smoothing aggregate fluctuations,

20. The replacement rate increases from 0.50 to 0.62 during recessions with the counter-factual policy.

21. Appendix E also shows that this results holds when looking at the total deviation in aggregate variables, as opposed to the peak-to-trough change

Table 5: Peak-to-Trough Declines: Increasing Level of UI

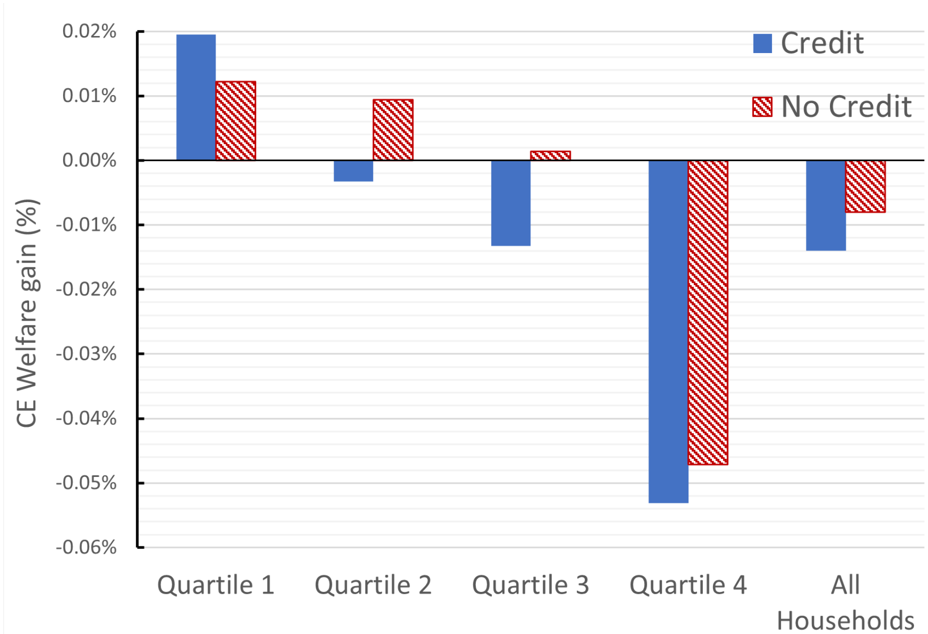
	Benchmark		No Credit	
	C	D	C	D
Acyclical UI (%)	2.62	10.11	1.89	0.00
Increasing RR (%)	2.49	9.73	1.81	0.00
Difference (pp)	0.13	0.38	0.08	0.00

Note.— Peak-to-trough fall in aggregate consumption (C) and credit balances (D) averaged over all recessions in a 2000 period simulation. Peak is the period before a recession starts. Simulation results are in logs and HP filtered with a smoothing parameter of 1600. Benchmark is the economy with unsecured credit and No Credit is the economy with no borrowing.

it isn't clear that it is the policy which is preferred by households. Figure 3 details the CE welfare gains of switching the *Extending UI* policy to the *Increasing RR* policy: it is the share of lifetime consumption households with the former policy would trade to obtain the latter. On average, households prefer the *Extending UI* policy: they would trade 0.014% of lifetime consumption on average to keep the policy. However, low-income households prefer the policy which increases the RR of benefits. Therefore, the relative success of the policy may depend on the goal of the policymaker. If the goal is to smooth aggregate fluctuations, extending the duration of UI is more effective. If the goal is to have a targeted policy which benefits low-income households, increasing the level of benefits is superior.

Unsecured credit plays an important role in understanding the welfare gains of the UI policies. On average, households more strongly prefer the *Extending UI* policy in the economy with credit. This is not surprising because extending the duration of UI was much more effective at minimizing the fall in unsecured credit balances during recessions. Both policies have the potential to increase the supply of credit by reducing the default risk premium. However, extending the duration of UI simultaneously reduces the incentive for households to delever for precautionary reasons, meaning that they use the improved terms of credit to borrow more and smooth consumption. Income quartile 1 is the only group of households which more strongly prefers the *Increasing RR* policy in the model with credit. These households are more likely to be liquidity constrained, which means they wouldn't have room for precautionary behavior. Increasing the level of UI benefits allows them to increase consumption, and it reduces the risk of bankruptcy in the near-term.

Figure 3: CE Welfare: extending the duration vs increasing the RR



Note.— Consumption equivalent (CE) welfare gains from changing UI from a policy which extends the duration during recessions to one which increases the replacement rate (RR). Positive value means household prefers increasing RR. Measured across income quartiles for age 1 households in the model.

6 Conclusion

In this paper, I studied how unsecured consumer credit impacts the effectiveness of UI in insuring households against aggregate risk. To do so, I developed an incomplete markets general equilibrium real business cycle model with frictional labor markets and defaultable debt. The model generates the cyclical properties of unsecured credit and consumer bankruptcies in the data using empirically consistent fluctuations in unemployment risk over the business cycle. This serves as a key preliminary step towards quantifying the importance of liquidity constraints and borrowing behavior for consumption smoothing in the presence of aggregate risk. I found that the majority of the volatilility in aggregate consumption, unsecured credit, and consumer bankruptcies is driven by job finding rates, as opposed to job separation rates or TFP.

The main quantitative result of this paper is that unsecured credit amplifies the welfare gains of a policy which extends the duration of UI by 13 weeks during recessions. This occurs because credit and UI act as complementary forms of consumption insurance for households.

When the government extends the duration of UI, it mitigates the rise in the default-risk premium during recessions, which allows households to better smooth consumption over the business cycle. I also found that the UI policy is significantly more effective at smoothing aggregate consumption fluctuations in the economy with unsecured credit. A counterfactual policy which increases the level of benefits during recessions had a much smaller effect on aggregate consumption fluctuations, but it was preferred by low-income households.

Given the recent surge in Heterogeneous-Agent New Keynesian (HANK) models, future research should analyze how the channels studied in the current paper impact the transmission of monetary policy. Kaplan, Moll, and Violante (2018) showed that most of the transmission of monetary policy occurs through indirect effects on labor demand. A key driving force to generate this result is the presence of high MPC hand-to-mouth households who face high borrowing costs. It is essential to understand how the transmission of monetary policy is affected by the presence of unsecured credit which is highly volatile and pro-cyclical because in this setting the costs of borrowing are increasing during recessions. Also, the results from my paper suggest that a change in labor demand could have significantly different aggregate implications depending on if it is being transmitted through a change in hours worked, layoffs, or vacancy posting by firms. I leave these analyses to future research.

References

Acemoglu, D., and R. Shimer. 1999. “Efficient Unemployment Insurance.” *Journal of Political Economy* 107 (5): 893–928.

Aiyagari, R. 1994. “Uninsured Idiosyncratic Risk and Aggregate Saving.” *The Quarterly Journal of Economics* 109 (3): 659–684.

Athreya, K., and N. Simpson. 2006. “Unsecured Debt with Public Insurance: From Bad to Worse.” *Journal of Monetary Economics* 53:797–825.

Athreya, K., X. Tam, and E. Young. 2009. “Unsecured Credit Markets are not Insurance Markets.” *Journal of Monetary Economics* 56:83–103.

Bornstein, G., and S. Indarte. 2023. “The Impact of Social Insurance on Household Debt.” *Unpublished Manuscript.*

Braxton, J., K. Herkenhoff, and G. Phillips. 2022. “Can the Unemployed Borrower? Implications for Public Insurance.” *Unpublished Manuscript.*

Chatterjee, S., D. Corabe, M. Nakajima, and J. Ríos-Rull. 2007. “A Quantitative Theory of Unsecured Consumer Credit with Risk of Default.” *Econometrica* 76 (6): 1525–1589.

Chetty, R. 2008. “Moral Hazard versus Liqudity and Optimal Unemployment Insurance.” *Journal of Political Economy* 116 (2): 173–234.

Chodorow-Reich, G., J. Coglianese, and L. Karabarbounis. 2019. “The Macro Effects of Unemployment Benefits Extensions: A Measurement Error Approach.” *Quarterly Journal of Economics* 134 (1): 227–279.

Den Haan, W. 2010. “Assessing the accuracy of the aggregate law of motion in models with heterogeneous agents.” *Journal of Economic Dynamics and Control* 34:79–99.

Fieldhouse, D., I. Livshits, and J. MacGee. 2016. “Aggregate Fluctuations, Consumer Credit, and Bankruptcy.” *Unpublished Manuscript.*

Fulford, S., and S. Schuh. 2017. “Credit Card Utilization and Consumption over the Life Cycle and Business Cycle.” *Federal Reserve Bank of Boston Working Paper.*

Gross, T., R. Kluender, F. Liu, M. Notowidigdo, and J. Wage. 2021. “The Economic Consequences of Bankruptcy Reform.” *American Economic Review* 111 (7): 2309–2341.

Guvenen, F., S. Ozkan, and J. Song. 2014. "The Nature of Countercyclical Income Risk." *Journal of Political Economy* 122 (3): 621–660.

Hansen, G., and A. Imrohoroglu. 1992. "The Role of Unemployment Insurance in an Economy with Liquidity Constraints and Moral Hazard." *Journal of Political Economy* 100 (1): 118–142.

Herkenhoff, K. 2019. "The Impact of Consumer Credit Access on Unemployment." *Review of Economic Studies* 86 (6): 2605–2642.

Hsu, J., D. Matsa, and B. Melzer. 2014. "Positive Externalities of Social Insurance: Unemployment Insurance and Consumer Credit." *NBER Working Paper Series,* Paper 20353.

———. 2018. "Unemployment Insurance as a Housing Market Stabilizer." *American Economic Review* 108 (1): 49–81.

Huggett, M. 1993. "The Risk-Free Rate in Heterogeneous-Agent Incomplete-Insurance Economies." *Journal of Economic Dynamics and Control* 17:953–969.

Imrohoroglu, A. 1989. "Cost of Business Cycles with Indivisibilities and Liquidity Constraints." *Journal of Political Economy* 97 (6): 1364–1383.

Johnston, A., and A. Mas. 2018. "Potential Unemployment Insurance Duration and Labor Supply: The Individual and Market-Level Response to a Benefit Cut." *Journal of Political Economy* 126 (6): 2480–2522.

Kaplan, G., B. Moll, and G. Violante. 2018. "Monetary Policy According to HANK." *American Economic Review* 108 (3): 697–743.

Kaplan, G., and J. Violante. 2010. "How Much Consumption Insurance Beyond Self-Insurance?" *American Economic Journal: Macroeconomics* 2 (4): 53–87.

———. 2014. "A Model of the Consumption Response to Fiscal Stimulus Payments." *Econometrica* 82 (4): 1199–1239.

Kekre, R. 2023. "Unemployment Insurance in Macroeconomic Stabilization." *Review of Economic Studies, forthcoming.*

Krusell, P., T. Mukoyama, R. Rogerson, and A. Sahin. 2017. "Gross Worker Flows Over the Business Cycle." *American Economic Review* 107 (11): 3447–3476.

Krusell, P., and A. Smith. 1998. "Income and Wealth Heterogeneity in the Macroeconomy." *Journal of Political Economy* 106 (5): 867–896.

Livshits, I., J. MacGee, and M. Tertilt. 2007. "Consumer Bankruptcy: a Fresh Start." *American Economic Review* 97 (1): 402–418.

Mitman, K., and S. Rabinovich. 2015. "Optimal Unemployment Insurance in an Equilibrium Business-cycle Model." *Journal of Monetary Economics* 71:99–118.

Nakajima, M., and J. Ríos-Rull. 2019. "Credit, Bankruptcy, and Aggregate Fluctuations." *Unpublished Manuscript.*

Shimer, R. 2012. "Reassessing the Ins and Outs of Unemployment." *Review of Economic Dynamics* 15:127–148.

Zeldes, S. 1989. "Consumption and Liquidity Constraints: An Empirical Investigation." *Journal of Political Economy* 97 (2): 305–346.

Appendix

A Model Parameters

Table 6: Model Parameters

	Description	Parameter	Value
	Risk Aversion	σ	2.00
	Capital Share	α	0.35
	Income Tax	τ	0.30
	Duration Bad Credit	θ	0.03
	Earnings Persistence	ρ	0.99
	Earnings SD	σ_η	0.10
	Patient Discount	β_h	0.99
	Impatient Discount	β_ℓ	0.86
	Share of Patient	π_ℓ	0.50
	Bankruptcy Disutility	χ_b	1.20
	Credit Markup	ι	0.02
	Work Disutility	χ_w	0.14
	Search Disutility	χ_s	0.14
	Capital Depreciation	δ	0.02
	Share Age 1 Workers	Φ_E	0.86
	Transfer	T	0.35
	Retirement Transfer	T_R	1.39
	UI Replacement Rate	υ_r	0.50
	UI Max Benefit	$\overline{\upsilon}$	1.67
Expansion Values	TFP	$z(x_g)$	1.00
	Separation Rate	$\xi(x_g)$	0.04
	Finding Rate	$\lambda(x_g)$	0.65
	UI Duration	$\upsilon_d(x_g)$	0.50
Recession Values	TFP	$z(x_b)$	0.97
	Separation Rate	$\xi(x_b)$	0.05
	Finding Rate	$\lambda(x_b)$	0.48
	UI Duration	$\upsilon_d(x_b)$	0.33

B Data

NBER recession dates are used to pin down the aggregate transition matrix of the model economy. There are 5 recessions that occur between 1980Q1 and 2019Q4. The average duration of a recession over this time-period is 4.6 quarters. The average duration of the expansions that lie between these recessions is 27.4 quarters. An alternative way of mapping the model to the data would be to combine the 1980 and 1981 recessions. The justification for doing so is that unemployment rates never fell during the short-lived expansion at the end of 1980. If these recessions were combined, then the persistence of recessions would increase from 0.78 to 0.82. The corresponding persistence of expansions would increase from 0.96 to 0.97. Constructing the aggregate transition matrix using 4 recessions as opposed to five does not have a significant impact on the results of this paper.

Table 7: Peak and Trough Quarters in US

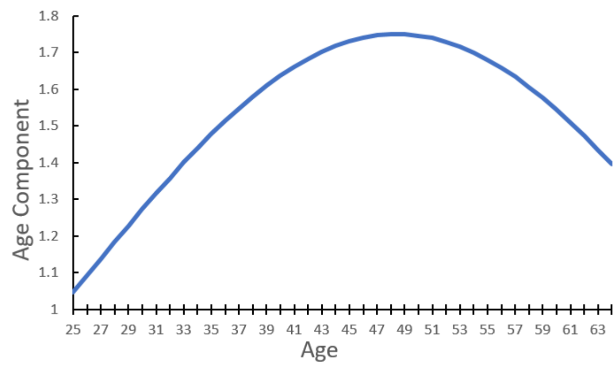
Peak	Trough	Quarters
1980Q1	1980Q3	3
1981Q3	1982Q4	6
1990Q3	1991Q1	3
2001Q1	2001Q4	4
2007Q4	2009Q2	7

The Survey of Consumer Finances (SCF) is used to pin down the hump-shaped life cycle earnings profile in the model economy. The age-component of productivity takes the form $\gamma_j = \nu_1 j + \nu_2 j^2$. To estimate the age-component of earnings in the data, I regress log earnings on age, age-squared and numerous control variables. Earnings in the estimation is income from wages plus two-thirds of business income. The control variables include, sex of the head of household, race, education, education of the spouse and multiple dummy variables for occupation types. Estimating the equation for γ_j in every survey year from 1989 to 2019, the average values for the coefficients are $\nu_1 = 4.6e^{-2}$ and $\nu_2 = -9.4e^{-4}$. This setting causes households to experience hump-shaped earnings where they earn more each year through age 49 (model period 96). After this age, there are decreasing earnings each year until retirement.

The SCF is also used to calculate the share of households with unsecured credit balances. Specifically, I calculate two different statistics: the debt share and the credit share. Debt share is the fraction of households who report having positive balances of credit card debt after making their last payment. Credit share is the fraction of households who have at least one credit card account. To calculate both moments, I focus on bank credit cards (Visa,

Figure 4: Age-Component of Earnings

Survey Year	ν_1	ν_2
1989	$5.72e^{-2}$	$-1.24e^{-3}$
1992	$4.42e^{-2}$	$-8.91e^{-4}$
1995	$4.11e^{-2}$	$-7.55e^{-4}$
1998	$5.07e^{-2}$	$-1.02e^{-3}$
2001	$4.15e^{-2}$	$-9.00e^{-4}$
2004	$4.27e^{-2}$	$-8.18e^{-4}$
2007	$4.11e^{-2}$	$-8.56e^{-4}$
2010	$4.70e^{-2}$	$-9.54e^{-4}$
2013	$4.98e^{-2}$	$-1.07e^{-3}$
2016	$4.86e^{-2}$	$-1.01e^{-3}$
2019	$3.95e^{-2}$	$-7.86e^{-4}$
Average	$4.58e^{-2}$	$-9.36e^{-4}$



Note.— Data from the Survey of Consumer Finances. Age-component of earnings takes the form $\gamma_j = \nu_1 j + \nu_2 j^2$. Earnings in the data is income from wages plus two-thirds of business income. Each coefficient is significant to 1.0%.

Mastercard, etc...) and observations where the head of the household is currently in the labor force. I choose to restrict attention to households in the labor force because workers who are out of the labor force are not eligible for UI. The average share of households with positive balances of credit card debt is 41.4% and the average share of households with at least one credit card is 69.2%.

In section 3, I validated the model by comparing the distribution of credit over income to SCF data. The analysis focused on the extensive margin of credit card debt: the share of households with a positive balance on credit cards. Figure 5 extends the analysis to look at the average credit card debt held by households over the distribution of wage income. Specifically, I look at the ratio of the average credit card debt held by households in an income quintile to the average credit card debt held by households in the entire economy. I divide by the average credit card debt in the economy to make it easy to compare model results to the data. The model has moderate success generating the intensive margin of the distribution of credit card debt over income. Households hold progressively more debt on average in quintiles 1 through 4. The model is furthest from the data in quintile 5. The data suggests that a relatively small number of high-income households hold very high balances of credit card debt. The model does not currently have a mechanism that can replicate this

Table 8: Share of Households with Credit Card Debt

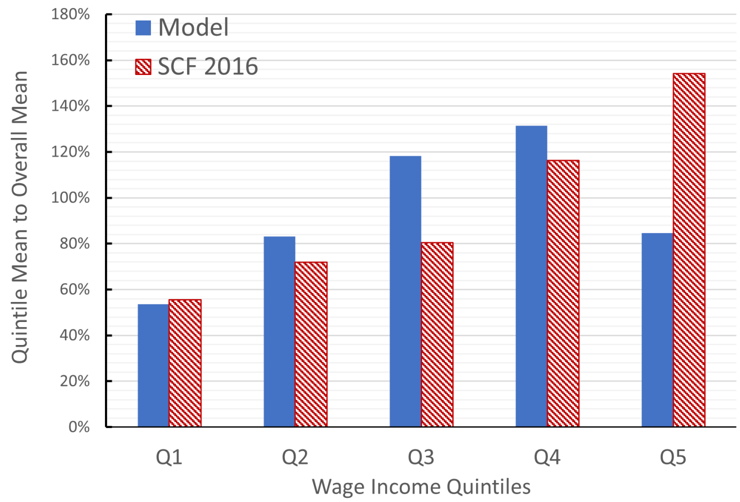
Survey Year	Debt Share	Credit Share
1983	27.44%	47.81%
1989	36.43%	61.15%
1992	40.06%	68.34%
1995	45.19%	71.77%
1998	43.91%	71.90%
2001	45.53%	77.15%
2004	46.74%	75.02%
2007	46.52%	72.27%
2010	39.13%	66.90%
2013	36.85%	66.64%
2016	43.60%	73.54%
2019	44.99%	77.74%
Average	41.37%	69.19%

Note.— Data from the SCF. Debt share is the share of households with debt after making their last payment. Credit share is share of households with at least one credit card. I restrict attention to households where the head is in the labor force.

fact. It is possible that adding expenditure shocks could help bridge the gap because high-income households have the most generous borrowing limits in the model, and expenditure shocks could force them to borrow more to smooth consumption in the short-term. However, this should not have a significant effect on the results of the paper because a small share of high-income households will not drive the consumption response to a change in UI.

Data organized by the Bureau of Labor Statistics (BLS) from the Current Population Survey (CPS) is used to pin down unemployment dynamics in the model economy. Monthly data from the CPS on employment, unemployment, and short-term unemployment (5 weeks or less) is used to calculate job separation rates and job finding rates. Job separation rates are calculated in continuous time using the methodology described in Shimer (2012), who shows that alternative methods that ignore the time aggregation problem overstate the importance of job separation rates in driving unemployment fluctuations over the business cycle. All statistics for job separation rates and job finding rates are quarterly averages of monthly data. To calculate business cycle properties, log data is HP filtered with a smoothing parameter of 1600. Detrended job separation rates have a standard deviation of 4.75 and a correlation coefficient with real GDP of -0.58. Job finding rates have a standard deviation of 7.68 and

Figure 5: Average Credit Card Debt by Income



Note.— Ratio of the average credit card debt in an income quintile to the overall average credit card debt in the economy. Data from the SCF 2016 for households in the labor force. Income is wage income. Drop self-employed households. Credit card debt is the balance on bank cards after making the most recent payment. Moments from the model are calculated during a prolonged expansion: 50 quarters since the most recent recession.

a correlation with real GDP of 0.83.

C Forecasting Rules

To solve for an equilibrium with rational expectations, economic agents know the law of motion that governs the distribution of households. Forecasting an infinite-dimensional endogenous state variable causes a well-established computational problem for the heterogeneous-agent macro literature. This paper uses the state-space approximation method described in Krusell and Smith (1998). Specifically, the first moments for the distribution of capital and labor are used to approximate the distribution of households. These moments are sufficient to know the equilibrium prices in the model economy. Now, forecasting the future aggregate state of the economy is achieved by forecasting the future values capital and labor. Because all employment transitions take place after production, aggregate labor is known at the beginning of the period, and agents must only forecast future labor.

$$K'(x) = \nu_0^k(x) + \nu_1^k(x)\log(K) + \nu_2^k(x)\log(L) \tag{15}$$

$$L'(x) = \nu_0^\ell(x) + \nu_1^\ell(x)\log(L) + \nu_2^\ell(x)\log(K) \tag{16}$$

Equations (15) and (16) describe the forecasting rules for the first moments of capital and labor. The coefficients depend on the aggregate exogenous state of the economy x. Therefore, agents have a set of forecasting rules during expansions and a set of rules during recessions. Solving for an equilibrium in the model economy proceeds as follows. I first guess a set of values for the coefficients in the forecasting rules. I then solve for the optimal decision rules of households at each possible point in the state space. Using the decision rules, I simulate the distribution of households for a sequence of fluctuations in the aggregate exogenous state.[22] I calculate the first moments for the distributions of capital and labor in each period of the simulation. Given the sequences for capital and labor, I regress future capital and labor realizations using the reduced form equations described by (15) and (16). Finally, I update the guesses for the coefficients of the forecasting rules and iterate until convergence.

Table 9 details the coefficients for the forecasting rules in the benchmark model economy.[23] As described in Krusell and Smith (1998), there is no functional form for the forecasting rules that guarantees an equilibrium solution with rational expectations. To check if the forecasting rules approximate the law of motion with sufficient accuracy, I calculate the R^2 values and the residuals. The chosen functional form proves to have high accuracy, accounting for over 99% of the fluctuations in capital and labor, with maximum residuals all less less than $8.0e^{-4}$.

To further check the accuracy of the forecasting rules, I use multi-period ahead forecasting errors. Specifically, I simulate capital and labor for 2300 periods using the initial values for capital and labor, and the forecasting rules described by equations (15) and (16). The error in each period is the difference between these sequences and the values for capital and

22. In practice, I simulate the economy for 2300 periods, and I drop the first 300 periods before proceeding to the next step.

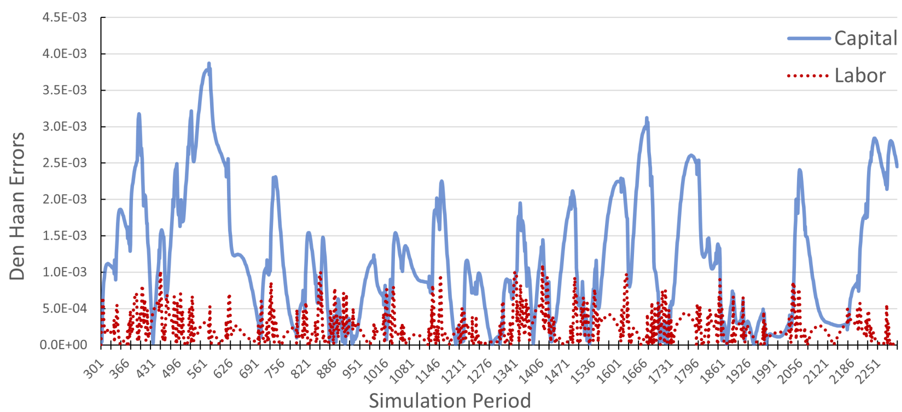
23. Each experiment has its own set of forecasting rules. I only report the coefficients for the benchmark economy to minimize the space used for the table.

Table 9: Coefficients for Forecasting Rules

	ν_0	ν_1	ν_2	R^2	Max Res.	Mean Res.
$K'(x_g)$	0.037	0.985	0.073	0.999	$3.38e^{-4}$	$5.38e^{-5}$
$K'(x_b)$	0.032	0.986	0.077	0.999	$4.32e^{-4}$	$8.30e^{-5}$
$L'(x_g)$	0.388	0.321	-0.055	0.993	$7.49e^{-4}$	$1.42e^{-4}$
$L'(x_b)$	0.251	0.491	-0.036	0.998	$6.97e^{-4}$	$2.39e^{-4}$

Note.— Coefficients for the forecasting rules described by equations (15) and (16). Results obtained using a 2300 period simulation, dropping the first 300 periods.

Figure 6: Multi-period ahead forecasting errors



Note.— Calculated as the difference between simulated model data, and aggregate capital and labor values obtained by simulating the forecasting rules for the same number of periods.

labor from the simulated model economy. Den Haan (2010) suggests evaluating accuracy using the maximum error from the multi-period ahead forecasting test. In this model economy, the maximum error for capital is 0.38% and the maximum error for labor is 0.11%. To assess the accuracy of this model relative to the literature, I compare the errors with the two models used in Krusell and Smith (1998). In their benchmark model, the maximum error is 0.3%. In their stochastic beta model, the maximum errors is 2.0%. By comparison, the model economy in my paper proves to be highly accurate.

D Welfare with Separable Preferences

This section derives the analytical expression for consumption-equivalent (CE) welfare described by equation (14). The welfare expression is generalized to the class of separable preferences with CRRA utility functions for consumption. The main advantage of having an analytical expression for welfare is that it requires no additional computational burden. A numerical calculation of CE welfare could be quite cumbersome in a heterogeneous-agent model with a large state space.

The welfare calculation is the share of lifetime consumption which equates the household value function across two regimes. Let V be the value function for a household in the benchmark model economy. Similarly, $\tilde{V}$ is the value function in the alternative model economy. For the rest of this section, I assume that the benchmark economy has the *Extending UI* policy, and the alternative economy has the *Acyclical UI* policy. Equation (17) describes the household value function in state $(\Psi_j; \Omega)$. For generality, I define $v(x_i)$ to be the utility of all model elements that are not consumption; in the current model, v is the utility costs of work, search, and filing for bankruptcy. In order to calculate CE welfare, we must differentiate between the household's value function and the value of expected future consumption. Let V_c be the value of expected future consumption streams. Similarly, $\tilde{V}_c$ is the value of consumption streams with the *Acyclical UI* policy.

$$V(\Psi_j; \Omega) = E_j \sum_{i=j}^{J} \beta^{i-j} \left[u(c_i) + v(x_i)\right] \tag{17}$$

$$V_c(\Psi_j; \Omega) = E_j \sum_{i=j}^{J} \beta^{i-j} \, u(c_i) \tag{18}$$

Equation (19) describes the share of lifetime consumption $\omega(\Psi_j; \Omega)$ that makes the household indifferent between the two regimes. Let $\tilde{c}$ be consumption in the economy with the *Acyclical UI* policy.[24] Absent an analytical expression for ω, you must solve equation (19) numerically. To begin the derivation, add the expected value of consumption streams in the alternative model economy to each side of equation (19). Then, rearrange terms and substitute $\tilde{V}$ and $\tilde{V}_c$ into the equation. Finally, factor $(1+\omega)^{1-\sigma}$ out of the consumption stream and solve for ω. This final step is standard in analytical calculations of CE welfare with CRRA preferences. What differs from the standard calculation is the separable preferences.

24. Let $v(\tilde{x})$ be the utility costs of work, search, and filing for bankruptcy in the economy with the *Acyclical UI* policy.

With separable preferences, it is necessary to save the value of consumption streams and rearrange terms before solving for ω.

$$E_j \sum_{i=j}^{J} \beta^{i-j} \left[u\Big(\big(1+\omega(\Psi_j;\Omega)\big)\tilde{c}_i \Big) + v(\tilde{x}_i) \right] = V(\Psi_j;\Omega) \tag{19}$$

$$E_j \sum_{i=j}^{J} \beta^{i-j} \left[u\Big(\big(1+\omega(\Psi_j;\Omega)\big)\tilde{c}_i \Big) + v(\tilde{x}_i) \right] + E_j \sum_{i=j}^{J} \beta^{i-j} u(\tilde{c}_i) = V(\Psi_j;\Omega) + E_j \sum_{i=j}^{J} \beta^{i-j} u(\tilde{c}_i)$$

$$E_j \sum_{i=j}^{J} \beta^{i-j} \left[u\Big(\big(1+\omega(\Psi_j;\Omega)\big)\tilde{c}_i \Big) + u(\tilde{c}_i) + v(\tilde{x}_i) \right] = V(\Psi_j;\Omega) + \tilde{V}_c(\Psi_j;\Omega)$$

$$E_j \sum_{i=j}^{J} \beta^{i-j} u\Big(\big(1+\omega(\Psi_j;\Omega)\big)\tilde{c}_i \Big) + \tilde{V}(\Psi_j;\Omega) = V(\Psi_j;\Omega) + \tilde{V}_c(\Psi_j;\Omega)$$

$$\big(1+\omega(\Psi_j;\Omega)\big)^{1-\sigma} \tilde{V}_c(\Psi_j;\Omega) = V(\Psi_j;\Omega) - \tilde{V}(\Psi_j;\Omega) + \tilde{V}_c(\Psi_j;\Omega)$$

$$\therefore \quad \omega(\Psi_j;\Omega) = \left[\frac{V(\Psi_j;\Omega) - \tilde{V}(\Psi_j;\Omega) + \tilde{V}_c(\Psi_j;\Omega)}{\tilde{V}_c(\Psi_j;\Omega)} \right]^{\frac{1}{1-\sigma}} - 1$$

I now compare CE welfare described by equation (14) to two alternative calculations of welfare. The first alternative calculation is what I call the standard method, which is described by the equation for ω_s below. The standard method is consumption-equivalent in a model with only CRRA utility for consumption. When there are separable preferences over leisure, this calculation is no longer consumption-equivalent. The second alternative calculation is what I call *consumption only* welfare, which is described by the equation for ω_c below. This calculation is specifically calculating the share of lifetime consumption that equates the value of future consumption streams between the two regimes. However, the *consumption only* calculation ignores the effects of leisure and the utility costs of default.

$$\omega_s(\Psi_j;\Omega) = \left[\frac{V(\Psi_j;\Omega)}{\tilde{V}(\Psi_j;\Omega)} \right]^{\frac{1}{1-\sigma}} - 1; \qquad \omega_c(\Psi_j;\Omega) = \left[\frac{V_c(\Psi_j;\Omega)}{\tilde{V}_c(\Psi_j;\Omega)} \right]^{\frac{1}{1-\sigma}} - 1$$

In table 10, I replicate the results from figure 2 using the three different calculations of welfare. Regardless of the welfare calculation, the main qualitative result of this paper holds: unsecured consumer credit amplifies the welfare gains of a policy which extends the duration of UI during recessions. Moreover, the *consumption only* welfare calculation gives very similar quantitative results to the CE calculation. However, the quantitative results differ non-trivially when you use the standard method of calculating welfare. The standard method says that households would need 0.041% of lifetime consumption to be indifferent between the who polices; the CE welfare calculation says households would need 0.054%.

Table 10: Comparing Difference Welfare Calculations

	Benchmark			No Credit		
	(A)	(B)	(C)	(A)	(B)	(C)
Patient HHs	0.027	0.027	0.021	0.028	0.028	0.022
Impatient HHs	0.080	0.083	0.061	0.057	0.057	0.044
All HHs	0.054	0.055	0.041	0.043	0.043	0.033

Note.— Welfare effects of the policy which extends the duration of UI by 13 weeks during recessions. All results are percentages. Benchmark is the economy with unsecured credit. No Credit is the economy with no borrowing. (A) is CE Welfare, which is calculated by equation (14); (B) is the consumption only calculation, which is the equation for ω_c; (C) is the standard calculation, which is the equation for ω_s.

E Robustness: Aggregate Fluctuations

This section provides robustness for the results of section 5. I previously used the average peak-to-trough change in consumption and credit during recessions to measure how UI impacts aggregate fluctuations. I now measure the average total deviation in consumption and credit during recessions. Total deviation is the percent change from the pre-recession value summed over each period of a recession. For example, assume there is a two-period recession. If consumption is 1% below its pre-recession level in the first period, and 2% below in the second period, then the total deviation is 3pp. I then average the total deviation over all recessions in a 2000 period simulation. The takeaway from this section is that the main results detailing how UI impacts aggregate fluctuations hold whether you use the peak-to-trough change or the total deviation in aggregate variables during recessions.

The first result is that unsecured credit amplifies the extent to which UI mitigates aggregate fluctuations. Table 11 shows that this result still holds when using the average total deviation in aggregate consumption and unsecured credit during recessions. The policy which extends the duration of UI by 13 weeks during recessions reduces the average total fall in consumption by 1.33pp in the benchmark economy with credit. It only reduces the total fall during recessions by 1.19pp in the economy without credit. This result is driven by a large and persistent impact on unsecured credit. The UI policy reduces the average total fall in unsecured credit balances by 8.55pp.

Table 11: Total Declines: Extending Duration of UI

	Benchmark		No Credit	
	C	D	C	D
Acyclical UI (pp)	11.30	42.62	8.88	0.00
Extending UI (pp)	9.97	34.07	7.69	0.00
Difference (pp)	1.33	8.55	1.19	0.00

Note.— Total decline in aggregate consumption (C) and credit balances (D) during a recession averaged over all recessions in a 2000 period simulation. Total decline is the deviation from the pre-recession value of a variable summed over each period of a recession. Simulation results are in logs and HP filtered with a smoothing parameter of 1600. Benchmark is the economy with unsecured credit and No Credit is the economy with no borrowing.

The second result is that extending the duration of UI is more effective at smoothing aggregate fluctuations than increasing the level of benefits during recessions. Table 12 shows this result still holds when using the average total deviation during recessions. The policy which increases the replacement rate of benefits during recessions only reduces the average total fall in consumption by 0.53pp, compared to 1.33pp for the *Extending UI* policy. There are also substantial differences in the response of unsecured credit. The *Increasing RR* policy only reduces the average total fall in unsecured credit balances by 1.40pp, compared to 8.55pp for the *Extending UI* policy. The mechanism driving this result is the same as what was discussed in section 5: when the government increases the RR of benefits, households still have an incentive to delever to insure themselves against the possibility of not finding a job before UI expires. On the other hand, extending the duration simultaneously transfers resources to households and mitigates the incentive to delever for precautionary reasons.

Table 12: Total Declines: Increasing Level of UI

	Benchmark		No Credit	
	C	D	C	D
Acyclical UI (pp)	11.30	42.62	8.88	0.00
Increasing RR (pp)	10.77	41.22	8.53	0.00
Difference (pp)	0.53	1.40	0.35	0.00

Note.— Total decline in aggregate consumption (C) and credit balances (D) during a recession averaged over all recessions in a 2000 period simulation. Total decline is the deviation from the pre-recession value of a variable summed over each period of a recession. Simulation results are in logs and HP filtered with a smoothing parameter of 1600. Benchmark is the economy with unsecured credit and No Credit is the economy with no borrowing.