Can the Unemployed Borrow? Implications for Public Insurance

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Abstract

We show that unemployed individuals maintain significant access to credit. Following job loss, the unconstrained borrow, while the constrained default and delever. Both defaulters and borrowers are using credit to smooth consumption. We quantitatively show that credit-registries and long-term credit relationships allow the unemployed to partially offset income losses using credit, despite various forms of adverse selection. We estimate the model and find that the optimal provision of public insurance is unambiguously lower as credit access expands. The median individual in our simulated economy would gain both in steady-state as well as during the transition if the income replacement rate from public insurance programs is lowered from the current US policy of 41.2% to 39.8%.

Keywords: default, credit limits, borrowing, unemployment, optimal public insurance

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By the first quarter of 2018, aggregate credit card limits exceeded 17% of GDP. In this paper, we explore how the presence of this well developed credit market affects optimal labor market policy. To what extent can – and do – displaced workers offset income loss and thus self-insure using credit? Given the degree to which displaced workers can privately self-insure, what is the optimal provision of public insurance?

Our empirical contribution is to measure the borrowing behavior and borrowing ability of unemployed individuals. Using newly linked administrative earnings and credit bureau data, we show that borrowers retain significant credit access after job loss. We document that unconstrained workers who lose their jobs borrow, while constrained workers who lose their jobs default and delever. Both borrowing and defaulting allow job losers to transfer resources across time and states of the world, allowing unemployed individuals to partially self-insure their losses.

Our quantitative contribution is to compute optimal unemployment insurance in an environment that features both current levels of U.S. credit access as well as various forms of adverse selection that may limit unemployed individuals' access to capital markets. Our model integrates adverse selection in the credit market (e.g. Guerrieri, Shimer, and Wright [2010], Chang [2010], Corbae and Glover [2017]) into an environment with credit lines (e.g. Mateos-Planas and Ríos-Rull [2010]) and employment risk (e.g. Moen [1997], Burdett et al. [2001], and Menzio and Shi [2011]).

After estimating our framework to match aggregate credit access and credit use moments, we show that by incorporating credit lines, our model successfully replicates the responses of borrowing, credit limits, and defaults to job loss. Given our model’s ability to replicate the micro data, we use our framework to compute optimal transfers to the unemployed (we express the optimal transfers as a replacement rate of lost earnings during unemployment). We find that the median voter in our simulated economy would vote for a 39.8% replacement rate, which is lower than the current U.S. replacement rate of 41.2%. However, a utilitarian government would opt to raise the unemployment insurance replacement rate. What limits the ability of the government to substitute out of public insurance and into private borrowing is that default rates rise and credit becomes more costly if public insurance is cut. In other words, public insurance and private self-insurance are complementary at the aggregate level (aggregate transfers and aggregate borrowing comove positively), even though at the individual level they are substitutes (ceteris paribus, individuals borrow more if the public transfer is reduced). Therefore, moderate levels of public insurance are necessary to sustain access to credit markets among the unemployed.

The empirical section of our paper documents four facts using newly linked administrative earnings and credit bureau data: (1) prior to displacement, workers who lose their jobs can replace a significant fraction of their prior income with unused credit (44% with unused revolving credit, on average), (2) credit limits and credit scores do not immediately respond to job loss and do not decline in an economically significant manner within five years after job loss, (3) unconstrained individuals, those with credit scores in the top two quintiles prior to job loss, borrow and replace
a significant fraction of lost earnings with credit, and (4) constrained individuals, who have credit scores in the bottom two quintiles prior to job loss, default and delever.

These facts suggest that credit markets play an important role in the way workers self-insure. Displaced workers have a large capacity to borrow which is unresponsive to job loss. Those who have significant debts enter default. Ex-post, both groups of individuals, borrowers and defaulters, smooth consumption using credit markets. In particular, when individuals borrow they pay a premium in the form of a spread over the risk free rate, reflecting default risk. In bad states of the world, such as when a borrower loses their job, they may default to smooth consumption. Similar to Zame [1993], default partially completes the market.

Why are the unemployed able to borrow? Our theory relies on two features of the U.S. credit market: (i) the credit registry generates reputation concerns in the form of exclusion from credit markets in the event of default, and (ii) lenders issue long-term contracts in the form of revolving lines of credit, such as credit cards and home equity lines of credit, whose limits and interest rates are not contingent on subsequent income changes. Despite adverse selection, lenders are still willing to offer credit contracts to individuals both before job loss and after job loss because reputation concerns ensure that most individuals will repay their debts.

We quantitatively evaluate our theory using a defaultable debt model with unemployment risk. The innovation relative to existing studies is to integrate a theory of credit lines and unemployment risk into an environment with asymmetric information in the credit market. In a model without credit lines, where debt is individually priced each period, unemployed individuals would face a sudden change in borrowing limits. However, changes in borrow limits upon job loss are inconsistent with the facts we document. By modeling credit lines, we are able to capture the stability of credit limits following job loss, and thus capture the degree of self-insurance provided by credit markets. In addition, we consider different forms of asymmetric information in the credit market, including private information about discount factors and the future probability of job loss.

We calibrate the model to be consistent with current U.S. credit access. We then compute the optimal provision of public insurance to displaced workers using two welfare criteria: utilitarian welfare (equal weights placed on all individuals), and median welfare (the 50th percentile of the welfare distribution). Given current levels of credit access, we find that the median voter in our simulated economy would prefer to have the earnings replacement rate of public insurance lowered from the current US policy of 41.2% to 39.8%. The median individual gains both in steady state and along the transition path from lowering the replacement rate. If credit markets were shut down, the median voter would choose an unambiguously higher replacement rate of 42.5%. A utilitarian government would actually prefer to raise the UI replacement rate to 43.9% under current levels of credit access. However, if credit markets were shut down, the utilitarian government would choose an unambiguously higher replacement rate of 45.3%. The inability of the government to fully substitute out of public insurance and into private borrowing reflects a tradeoff. With a lower replacement rate, fewer taxes need to be raised to fund the unemployment
insurance system. However, if the unemployment insurance replacement rate becomes too low, the default rate of workers who lose their jobs increases and credit finding rates among the unemployed drop sharply. For the median household in our economy, these competing forces are balanced at a replacement rate of 39.8%.

Our paper contributes to recent work which has integrated credit markets into models with labor markets (e.g. Athreya and Simpson [2006], Herkenhoff [2013], Bethune, Rocheteau, and Rupert [2013], Bethune [2017], Athreya, Sánchez, Tam, and Young [2015], Luo and Mongey [2016], and Ji [2018]). The most closely related paper is by Athreya and Simpson [2006] who compute the responsiveness of bankruptcies to public insurance provisions, showing that more generous unemployment insurance may actually raise bankruptcies. We build on Athreya and Simpson [2006] in three key ways. We model long-term credit contracts which allows us to match the degree of self-insurance provided by the credit market, we model the labor market in general equilibrium, and we calculate the optimal provision of public insurance.

Our model adds to a small but growing literature on individual credit lines, credit scoring, and long-term relationships between borrowers and lenders. Of particular note, work by Mateos-Planas and Ríos-Rull [2010] analyzes bankruptcy reform in an economy with credit lines and private information about endowments. In terms of theory, we depart from Mateos-Planas and Ríos-Rull [2010] by modeling the labor market and we obtain tractability, both with and without adverse selection, via competitive search over credit contracts.

Our paper is also related to studies which integrate unemployment insurance into Bewley-Huggett-Aiyagari frameworks (e.g. Lentz and Tranaes [2001], Krusell, Mukoyama, and Şahin [2010], Nakajima [2012a], and Nakajima [2012b]) as well as studies of optimal unemployment insurance with assets ( inter alia Shimer and Werning [2005], Chetty [2008], Lentz [2009], Koehne and Kuhn [2015] and Chaumont and Shi [2017]). Closely related papers by Shimer and Werning [2005] and Lentz [2009] compute optimal UI in models with savings. Relative to these studies we make several contributions: (i) we empirically document the large self-insurance role that credit markets play in the US economy, (ii) we incorporate the institutions that allow this self-insurance to exist in our model (long-term contracts, reputation concerns, and defaultable debt), and (iii) we quantify the substitutability between private borrowing and public forms of insurance.

Empirically, we reconcile two literatures with seemingly conflicting results. Existing studies based on checking-account data and the Survey of Consumer Finances suggest that there is roughly zero net borrowing, on average, by workers who lose their jobs (e.g. Gelman, Kariv, Shapiro, Silverman, and Tadelis [2015], Baker and Yannelis [2015], and Ganong and Noel [2015])

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1See Mateos-Planas and Seccia [2006], Mateos-Planas and Ríos-Rull [2010], and Mateos-Planas [2013] on models of credit lines; Chatterjee, Corbae, and Ríos-Rull [2008a], Chatterjee, Corbae, and Ríos-Rull [2008b], and Chen [2012] on models of credit scoring; and Mitman [2011] and Hedlund [2011] for models of long term relationships between borrowers and lenders.

2Our paper also complements studies on optimal UI over the business cycle ( Mitman and Rabinovich [2011], Birinci and See [2017], and references therein).
with the exception of Bethune [2017] who actually finds delevering), whereas direct questions about borrowing among workers who lose their jobs and other survey data imply that roughly 20% of the unemployed borrow (e.g. Sullivan [2008], Hurd and Rohwedder [2010], Herkenhoff [2013], and Collins, Edwards, and Schmeiser [2015]), and roughly 30% become delinquent on debt obligations (e.g. Hurd and Rohwedder [2010], Gerardi, Herkenhoff, Ohanian, and Willen [2015], and Herkenhoff, Phillips, and Cohen-Cole [2015]).\(^3\) We reconcile these results by showing that some job losers borrow, while other job losers default and delever. While these offsetting forces yield zero net-borrowing by the unemployed, both the borrowers and defaulters are using credit to smooth consumption.

Our article is also related to the literature on private unemployment insurance (Chiu and Karni [1998] and Hendren [2015]). Similar to Zame [1993], borrowing and default partially complete the market, allowing individuals to imperfectly mimic unemployment insurance contracts. However, we find that this form of self-insurance is costly and that credit markets and public insurance are complements at the aggregate level. Our paper is about income replacement through personal borrowing after job loss, whereas Hendren [2015] is about pooled insurance, but we arrive at a similar conclusion: smoothing consumption via private markets is costly for the unemployed. As a result, even with well developed credit markets, there is limited ability to substitute out of public insurance.

The paper proceeds as follows. Section 1 describes both our time-series and cross-sectional unemployed borrowing results, Section 2 describes the model, Section 3 describes the calibration, Section 4 computes optimal transfers to the unemployed, and Section 5 concludes.

1 Empirical Results Using Administrative Data

Do the unemployed have access to credit? Do they borrow or default? We answer these questions by studying time-series and cross-sectional credit market outcomes for workers who lose their jobs. To mitigate endogeneity of job loss, we focus on mass layoffs (e.g. Jacobson, LaLonde, and Sullivan [1993]). We first compare the average response of borrowing, credit limits, and scores between workers who lose their jobs and those that do not. We find that workers who lose their jobs have significant amounts of credit access, and that credit access does not respond in an economically meaningful way to job loss. The mean amount borrowed by workers who lose their jobs is approximately zero.

We show that the zero-net-borrowing result is driven by heterogeneity. Using the cross-section

\[^{3}\text{Herkenhoff [2013] updates Hurd and Rohwedder [2010] through 2015 and shows that 25\% of workers who lose their jobs increase their debt in response to job loss, and a similar fraction report delinquency. Likewise, small-sample surveys of bankrupt individuals cite job loss an important factor in their decision to file (Sullivan et al. [1999]). Aggregate data reveals countercyclical borrowing but also countercyclical default (e.g. Rocheteau et al. [2012] and Nakajima and Rios-Rull [2014]) which is consistent with the mechanism in this paper. An exception is Hundtofte and Pagel [2017] who attribute delevering upon job loss to preferences.}\]
of workers who lose their jobs, we show that roughly 1/3 of workers who lose their jobs borrow, 1/3 default or delever, and roughly 1/3 do not alter their borrowing. We establish that unconstrained individuals, those with credit scores in the top two quintiles prior to job loss, borrow and replace a significant fraction of lost earnings with credit, and constrained individuals, those with credit scores in the bottom two quintiles prior to job loss, default and delever.

1.1 Data

Our main dataset is a randomly drawn panel of 5 million TransUnion credit reports linked through a scrambled social security number to the Longitudinal Employment and Household Dynamics (LEHD) administrative records database. The TransUnion database contains information on the balance, credit score, limit, and status (delinquent, current, etc.) across different types of consumer debt held by individuals at an annual frequency from 2001 through 2008. The LEHD database is a matched employer-employee dataset covering 95% of U.S. private sector jobs. The LEHD includes quarterly data on earnings, worker demographic characteristics, firm size, firm age, and average wages. Our primary sample of employment records includes individuals with credit reports between 2001 and 2008 from the 11 states for which we have LEHD data: California, Illinois, Indiana, Maryland, Nevada, New Jersey, Oregon, Rhode Island, Texas, Virginia, and Washington.

Since job dismissal and reason of dismissal are not recorded in the LEHD, we follow Jacobson et al. [1993] and focus on mass layoffs. Unlike Jacobson et al. [1993] who focus on workers from Pennsylvania with 6 years of tenure prior to job loss, we focus on a representative cross-section of workers with just 3 years of tenure prior to job loss. We show that the bulk of earnings losses in our sample are temporary and that nearly 1/3 of the workers who lose their jobs immediately find a job that pays more than their prior job, and thus their earnings losses are purely transitory. In a companion paper Braxton, Herkenhoff, and Phillips [2019], we use filtering methods to recover permanent and transitory income shocks. We show that individuals borrow in response to negative transitory shocks and default in response to negative permanent shocks.

Our analysis focuses on revolving credit because it can be drawn down immediately after job loss, with no additional application or income verification, and it can be repaid slowly. The main components of revolving credit include bank revolving (bank credit cards), retail revolving (retail credit cards), finance revolving credit (other personal finance loans with a revolving feature), and mortgage related revolving credit (HELOCs). Appendix B includes an analysis of bank cards as well as total credit, each of which exhibit similar patterns to revolving credit. However, it is important to note that not all types of credit balances affect the budget constraint in the same way. A first mortgage lowers liquid resources on hand (buying a house involves handing money to the bank), whereas an increase in revolving debt augments liquid resources on hand. We also study the response of credit scores, delinquencies (30 days late and 60 days late), and chargeoffs
to job loss.

1.2 Sample Descriptions and Summary Statistics

We use two samples in this paper.4

1. Panel Sample: Our first sample includes all 18 to 64 year olds who were at a firm that underwent a mass layoff episode, had at least 3 years of tenure at the time of the mass layoff and made at least $5,000 dollars at the firm in the prior year.5 We split this sample into a treatment group of 31,000 individuals who were displaced as part of the mass layoff, and a randomly selected control group of roughly equal size that includes individuals who worked at a firm with a mass layoff but were not displaced. We require that individuals in the treatment group are never displaced as part of another mass layoff episode, and we require the control group is never displaced as part of a mass layoff episode.

2. Cross Sectional Sample: Our second sample includes 19,000 displaced workers in the treatment group who had a decline in annual earnings comparing the year after displacement relative to the year prior to displacement.

Table 1 includes summary statistics for both samples. The top panel of Table 1 provides summary statistics for the treatment and control groups in the Panel Sample in the year prior to the mass layoff event. Annual earnings, as well as credit limits and balances are deflated by the CPI. Column (1) of Table 1 summarizes the treatment group while column (2) summarizes the control group. The treatment group earned $44k in the year prior to displacement while the control group earned over $49k. In the empirical analysis we include individual fixed effects, controls for age, and proxies for wealth to account for differences across treatment and control groups.

The treatment and control groups are very similar in terms of their credit market variables. Our measure of the credit score is the TransUnion “bankruptcy score,” which is designed to measure the probability of bankruptcy.6 The bankruptcy score lies between 0 and 1000 and higher scores reflect lower odds of bankruptcy. The treatment group has an average credit score in the year before displacement of 427, while the control group’s average score is 437. Revolving credit balances, limits and unused limits to income are also very similar across treatment and control groups.

Individuals have substantial revolving credit limits in the year before job loss, with an average of nearly $27k for the treatment group. Individuals in the treatment group can replace, on average,

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4All sample sizes are rounded to the nearest thousand in compliance with Census Bureau disclosure rules.
5These restrictions on tenure and prior earnings are common in the literature, e.g. Davis and Von Wachter [2011], and are used to mitigate issues associated with seasonal employment or weak labor force attachment.
6Rather than using a traditional credit risk score, we use the TransUnion bankruptcy score in regression analysis. Bankruptcy scores are used only by more sophisticated lenders, and when they are used, they are used in conjunction with a traditional credit risk score.
44 percent of their income with unused revolving debt in the year before job loss. The magnitude of unused credit prior to layoff indicates that these individuals have significant reserves of unused credit which can be drawn down when they enter into unemployment.

The second panel of Table 1 includes summary statistics for the Cross Sectional sample in the year prior to mass layoff. In the analysis that follows, we define credit constraints using the credit score. Table 1 shows that unused credit is monotone increasing by credit score quintile. The table also shows that in the year prior to mass layoff, the majority of individuals have a substantial amount of unused credit. Individuals with the highest credit scores have unused revolving credit that totals more than their annual income, while individuals in the third credit score quintile are able to replace 27 percent of their annual income with revolving credit.

The summary statistics of Table 1 indicate that individuals have, on average, a large stock of credit prior to layoff. We next examine how access to – and use of – credit evolves following job loss.

1.3 Average Response of Earnings and Credit Following Job Loss

Our first approach is to estimate the average response of credit variables following job loss using a distributed lag framework as in Jacobson et al. [1993] around a mass layoff episode. This empirical strategy compares displaced to nondisplaced individuals before and after the mass layoff episode to identify how individuals use credit following job loss.

Let \( i \) index individuals and \( t \) index years. Let \( \alpha_i \) denote a set of individual fixed effects and \( \gamma_t \) denote year dummies. Let \( Y_{i,t} \) denote the outcome of interest (such as real earnings, credit score, real revolving debt balance, etc.). Let \( D_{x,i,t} \) be a dummy variable taking the value 1 when an individual is \( x \) periods before (if \( x \) is negative) or after (if \( x \) is positive) displacement. For example, \( D_{-1,i,t} \) is a dummy variable indicating an individual is 1 period before displacement. The vector \( X_{i,t} \) contains control variables, including a quadratic in age and deciles for lagged cumulative earnings. We include deciles for lagged cumulative earnings to proxy for an individual’s wealth prior to displacement. The specification we use is of the following form:

\[
Y_{i,t} = \alpha_i + \gamma_t + \sum_{j=-4}^{5} \beta_j D_{j,i,t} + \Gamma X_{i,t} + \epsilon_{i,t}
\] (1)

The objects of interest are \( \beta_0, \beta_1, \ldots, \beta_5 \), which summarize the impact of job loss on the outcome variable in the year of displacement and subsequent years. To examine the validity of the point estimates, we show that the treatment and control groups have parallel trends prior to displacement (i.e. \( \beta_{-4}, \beta_{-3}, \ldots, \beta_{-1} \) are not statistically different from zero).

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Note unused revolving credit to income is winsorized at the 1 percent level at the top and bottom of the distribution.

Appendix A includes details on the identification of mass layoffs.
Table 2 documents the average response of earnings and borrowing behavior following job loss. The coefficients in Table 2 correspond to \((\beta_4, \beta_3, ..., \beta_4, \beta_5)\) in equation (1), and are interpreted as the difference in the outcome variable between displaced and nondisplaced individuals. Figure 1 plots the coefficient estimates from Table 2 along with 95 percent confidence intervals.

Panel (a) of Figure 1 plots the differences in real annual earnings between displaced and non-displaced individuals. The figure shows that earnings losses following job loss are large and persistent. In the year of job loss, a displaced individual makes nearly $3k less than a nondisplaced individual, and one year later, this difference in earnings increases to nearly $14k. Five years after job loss, a displaced individual still earns $3k less than a nondisplaced individual. These large and persistent effects of job loss are consistent with prior studies, e.g. Jacobson et al. [1993], Davis and Von Wachter [2011], Jarosch [2014], and Huckfeldt [2014].

Panel (b) of Figure 1 shows the impact of job loss on an individual’s credit score. The graph shows that displaced and nondisplaced workers exhibit parallel pretrends. However, in the year of layoff, a displaced individual’s credit score declines by nearly 6.5 points, on average, relative to a nondisplaced individual. In the following year, the difference in credit scores between displaced and nondisplaced individuals is roughly 16 points. While statistically significant, these changes are economically small. The average credit score for an individual in the treatment group is 427 points in the year prior to displacement, with a standard deviation of 268 points. Relative decreases of 6 and 16 points, then represent less than a 1.5 percent and 4 percent decline in credit scores, respectively. An individual’s credit score represents their marginal cost of borrowing. Therefore our results indicate that the marginal cost of borrowing is unresponsive to job loss.

Panel (c) of Figure 1 demonstrates that the stock of credit, not just the marginal cost of credit, is largely unresponsive to job loss. Panel (c) compares the revolving credit limits of displaced and nondisplaced individuals around a layoff episode. In the year of displacement, a displaced individual’s credit limit decreases relative to a nondisplaced individual by $1k, on average. One year after displacement, the difference in credit limits between displaced and nondisplaced individuals increases to just over $1,700. In the year prior to displacement, individuals in the treatment group had, on average, a revolving credit limit of nearly $27k. Thus, in the year of displacement, the borrowing limit drops from $27k to $26k, on average. These results indicate that in the year of job loss, individuals maintain substantial lines of credit.

Panel (d) of Figure 1 measures the impact of job loss on borrowing. We focus on revolving credit since it can be drawn down immediately, without notice or further income verification, upon job loss. Panel (d) shows that displaced individuals do not borrow more than nondisplaced individuals, on average. This zero response of borrowing following job loss is consistent with the recent work of Gelman et al. [2015], Baker and Yannelis [2015], and Ganong and Noel [2015].

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9 The increase in earnings of the treatment group relative to the control group prior to displacement is also observed in Davis and Von Wachter [2011].

10 The results presented in Table 2 and Figure 1 include all types of revolving credit (HELOCs, etc.) rather than...
However, the cross-sectional analysis in Section 1.4 reveals that nearly two-thirds of workers who lose their jobs alter their balances upon job loss, and a significant fraction use the credit market to smooth consumption.

1.3.1 Default Following Job Loss

We now investigate whether individuals can use credit markets to relax their budget constraint by defaulting and refusing to make scheduled debt repayments. When a lender and borrower enter into a debt contract, both sides know that there is potential for the borrower to not repay the loan. Lenders price contracts accordingly by charging a premium over the risk free rate, and in bad states of the world, an indebted individual may default to smooth consumption. Table 3 and Figure 2 document the propensity of individuals to smooth consumption via default following job loss.

Panel (a) of Figure 2 shows the difference in the probability of having a 60 day delinquency within the past year for displaced and nondisplaced individuals around a mass layoff episode. One year after job loss, displaced individuals are 3.1 percentage points more likely to be 60 days delinquent.\(^{11}\) This result suggests that individuals use the skipping of payments as a means to smooth consumption following job loss.

After a sufficient amount of time (typically 6 months) the creditor ceases to try to collect missing payments and they notify the credit bureau to “chargeoff” the debt. Panel (b) of Figure 2 shows the difference in the probability of having a debt chargeoff within the past year for displaced and nondisplaced individuals. Prior to job loss, displaced and nondisplaced individuals are not significantly different in their probability of having a debt chargeoff. However, in the year of job loss, the probability a displaced individual will have a debt chargeoff is nearly 0.9 percentage points higher than a nondisplaced individual. One year after displacement, the difference is nearly 3 percentage points.

After charging off a debt, the creditor can sell the debt obligation to a collection agency who will attempt to collect on the debt. The collection agency reports to the credit bureau, and the credit bureau flags individuals in collection. Panel (c) of Figure 2 displays the difference in the probability of having a debt enter into collections within the past 12 months for displaced and nondisplaced individuals around a mass layoff. In the year they are laid off, the probability a displaced individual enters collection is 1.1 percentage points higher than a nondisplaced individual. This represents a 10% increase relative to the average collection rate of 11.2 percent between 2001 and 2008.\(^{12}\)

\(^{11}\) These results are robust to using other measures of default or delinquencies. See Appendix B.2 for additional average response results for measures of credit access, usage and default.

The effect of job loss on collections is very persistent. Four years after job loss, displaced individuals remain nearly 2 percentage points more likely to be in collections than nondisplaced individuals. The persistent emergence of collections following job loss indicates that individuals relax their budget constraint by missing debt payments following job loss for a substantial period of time.

Panel (d) of Figure 2 shows the difference in the probability of having a derogatory public flag within the past year for displaced and non-displaced individuals.\textsuperscript{13} One-year after job loss, displaced individuals are 0.7 percentage points more likely to have a derogatory flag on their credit report relative to a non-displaced individual.

The results presented in Table 3 and Figure 2 indicate that individuals use missed debt repayments and default in response to job loss. A striking feature of these results is their persistence. Two years after job loss, individuals remain significantly more likely to have their outstanding debts charged off. Four years after displacement, individuals are still in collection. The results in this section show that despite not borrowing on average, credit markets play a central role in an individual’s response to unemployment.

1.4 Heterogeneous Responses: Credit Replacement Rates

We now explore the cross-sectional patterns of borrowing by workers who lose their jobs. Despite the fact that there is zero net borrowing following job loss, we show that roughly 1/3 of workers who lose their jobs borrow, 1/3 delever or default, and roughly 1/3 do not alter their borrowing patterns. Both defaulters and borrowers are using credit markets to smooth consumption.

To formalize the analysis of heterogeneous responses of borrowing to job loss, we measure \textit{revolving credit replacement rates} (we will refer to this as the ‘replacement rate’ in this section). Let \( t \) denote year of displacement and \( i \) denote the individual. The replacement rate is the ratio of an individual’s change in their revolving debt balance to the change in their earnings, where we measure the change in revolving debt balance and earnings from the year prior to displacement to the year after displacement (\( RR_{it} = \frac{-(\text{debt}_{i,t+1} - \text{debt}_{i,t-1})}{\text{earnings}_{i,t+1} - \text{earnings}_{i,t-1}} \)).\textsuperscript{14} Since the replacement rate is only defined for those with an earnings loss, we restrict our sample to individuals with an earnings loss between the year prior to displacement and the year after displacement. The numerator in the replacement rate is the negative of the change in revolving debt to ease interpretation. Figure 3 presents a smoothed density of the replacement rates in our cross-sectional sample. The density exhibits significant variance, with some individuals replacing over 70 percent of their earnings loss.

\textsuperscript{13} Individuals obtain a derogatory flag on their credit report for bankruptcy, tax liens, foreclosure, civil judgments, etc.

\textsuperscript{14} We measure the change in earnings and revolving debt balances over a two year window since Panel (a) of Figure 2 shows that the decline in earnings due to job loss is concentrated in the year after displacement. Our previous draft used a one year window (comparing \( t \) to \( t-1 \)) and found similar results – those results are available upon request.
with revolving debt (replacement rate of 0.7) and some individuals who decrease their balances by over 70 percent of their earnings loss (replacement rate of −0.7).\textsuperscript{15}

In Figure 3, 39% of the displaced workers delever. Among those who delever, a large fraction default. Table 4 reveals that roughly 43.6% (=.17/.39) of those who delever enter delinquency in the year after layoff. Moreover, 21% (=.08/.39) of those who delever receive a debt chargeoff. Among those who delever without a delinquency flag, it may be the case that the banks renegotiated the loan without charging it off (Adelino et al. [2013]), however, we cannot identify renegotiations.

Our theory, which we present later in Section 2, as well as existing theories, predict that credit constraints are an important determinant of the borrowing decision. To proxy for credit constraints, we separate individuals into credit score quintiles based on their credit score in the year prior to displacement.\textsuperscript{16} Let $C_{y,i,t-1}$ be a dummy variable taking the value 1 when individual $i$ is in credit score group $y$ in year $t − 1$ and will be displaced in year $t$. For example, $C_{3,i,t-1}$ is a dummy variable indicating an individual is in credit score quintile 3 one year before being displaced in year $t$. The vector $X_{i,t}$ contains control variables, including a quadratic in age and deciles for lagged cumulative earnings. Using our cross sectional sample of displaced workers who had an earnings loss, we estimate regressions of the replacement rate ($RR_{it}$) on credit score quintiles:

$$RR_{it} = \lambda_1 + \lambda_2 C_{2,i,t-1} + \lambda_3 C_{3,i,t-1} + \lambda_4 C_{4,i,t-1} + \lambda_5 C_{5,i,t-1} + \gamma_t + \Phi X_{it} + \epsilon_{it} \quad (2)$$

The objects of interest are ($\lambda_1, \lambda_2, \lambda_3, \lambda_4, \lambda_5$). The coefficient $\lambda_k$ for $k \geq 2$, gives the difference in replacement rates for individuals in the $k^{th}$ credit score quintile relative to individuals in the first credit score quintile, holding all else constant.

To estimate the average replacement rate for an individual in the $k^{th}$ credit score quintile we take the average values of the control variables for individuals in the sample denoted by $\bar{X}_i$ and use the OLS coefficients in the following expression:

$$\hat{RR}_k = \hat{\lambda}_k + \hat{\lambda}_1 + \hat{\Phi} \bar{X}_i \quad (3)$$

The statistic $\hat{RR}_k$ can be interpreted as the average replacement rate for the $k^{th}$ group conditional on the controls. Additionally, taking the difference between $\hat{RR}_k$ and $\hat{RR}_1$ returns the marginal effect at the mean of moving from credit score group 1 to credit score group $k$.

Table 5 documents the role that credit scores prior to displacement play in determining an individual’s replacement rate. The coefficients in column (1) of Table 5 correspond to ($\lambda_1, \lambda_2, \lambda_3, \lambda_4, \lambda_5$) in equation (2). The first column of Table 5 documents significant differences in replacement rates

\textsuperscript{15}In Appendix B.4, we show that the credit replacement rate for the unemployed measured in the 2007-09 SCF panel reveals a similar pattern of credit usage around job loss.

\textsuperscript{16}Note the credit score quintiles are defined among all displaced individuals in our Cross Sectional sample. These individuals experienced an earnings loss in the 2-year window around displacement, which compares real annual earnings in the year after displacement relative to the year before displacement.
across credit score quintiles. \(^{17}\) Holding all else constant, an individual in the fifth credit score quintile has a replacement rate that is 18.4 percentage points higher than an individual in the first credit score quintile.

Figure 4 displays the estimated replacement rate \(\hat{RR}_k\) by credit score quintile. The figure shows that average replacement rates are an increasing function of credit score quintile. Individuals in the bottom two credit score quintiles reduce their revolving debt balances while individuals in the top three credit score quintiles replace earnings losses with revolving debt. Individuals in the fourth credit score quintile replace 9 percent of their lost earnings by borrowing, while individuals in the highest credit score quintile replace 15 percent of their lost earnings by borrowing. For comparison, in Section 3, we estimate that job losers replace 41.2% of lost earnings with public transfers. Hence the amount of self-insurance that individuals with the highest credit scores obtain through increasing their revolving credit balances is equivalent to over a third of the amount of public insurance currently offered in the U.S.

While replacement rates are easy to interpret and capture overall credit market use during job loss, replacement rates may be driven by factors other than earnings losses (e.g. high score individuals may simply borrow more, on average). In the next section, we isolate the portion of the replacement rate attributable to earnings losses.

### 1.5 Heterogeneous Response: Role of Earnings Losses

Our final approach is to estimate the heterogeneous responses of credit outcomes to earnings losses associated with job loss across individuals with different credit scores. Let \(\Delta e_{i,t+1,t-1} = e_{i,t+1} - e_{i,t-1}\) be the change in earnings between year \(t + 1\) and year \(t - 1\) for an individual \(i\) who was displaced in year \(t\) and had an earnings loss. As above, let \(C_{y,i,t-1}\) be a dummy variable taking the value 1 when individual \(i\) is in credit score group \(y\) in year \(t - 1\) and will be displaced in year \(t\). Let \(Y_{i,t+1}\) be the outcome variable of interest (such as the change in real revolving debt balances, or an indicator variable for having a 60-day delinquency). We estimate the following specification:

\[
Y_{i,t+1} = \gamma_t + \eta + \mu \Delta e_{i,t+1,t-1} + \sum_{j=2}^{5} (\eta_j C_{j,i,t-1} + \mu_j C_{j,i,t-1} \times \Delta e_{i,t+1,t-1}) + \Psi X_{i,t} + \epsilon_{i,t} \tag{4}
\]

The objects of interest are \((\mu, \mu_2, \mu_3, \mu_4, \mu_5)\). The coefficient \(\mu\) summarizes the marginal change in the outcome variable for each dollar lost among individuals in the lowest credit score group, and the sum of the coefficients \(\mu + \mu_j\) return the marginal effect for individuals in the \(j\)th credit score group. We relegate the corresponding tables to Appendix B.3.

We first consider the heterogeneous responses of borrowing to changes in earnings. Panel (a) of Figure 5 plots the marginal effect of a $10k earnings loss on revolving credit balances by credit score quintiles.

\(^{17}\)Note the replacement rate used in the estimation of equation (2) is winsorized at the top and bottom of the distribution by 10 percent.
quintile. Individuals with the highest credit scores replace 5.39% of lost earnings by borrowing. So for every $10k of lost earnings, they borrow $539 ($ = \(-10,000 \times [0.021 - 0.0749]\)). Individuals in the lowest credit score quintile reduce their credit balances by 2.1% of lost earnings (the p-value of this point estimate is just slightly larger than .1). For every $10k of lost earnings, they reduce borrowing by $210 ($ = -10,000 \times 0.021$). These results highlight that there is heterogeneity in the role that earnings losses play in an individual’s borrowing behavior following displacement. Hence part of the heterogeneity in replacement rates observed in Figure 4 is attributable to differences across credit score groups in the response of revolving debt balances to earnings losses.

We next consider the heterogeneous responses of default to changes in earnings. Panel (b) of Figure 5 plots the marginal effect of a $10k earnings loss on the probability of a 60-day delinquency in the year after displacement. For individuals in the lowest two credit score quintiles, a $10k decline in earnings increases the probability of a 60-day delinquency by 1.23 percentage points. For individuals in the three highest credit score groups, a decline in earnings is not associated with higher delinquency rates. Panels (c) and (d) of Figure 5 plot the marginal effect of a $10k earnings loss on the probability of a debt chargeoff and a derogatory public flag, respectively. For those in the lowest credit score quintiles, a $10k decline in earnings increases the probability of a chargeoff by .74 percentage points and increases the probability of a derogatory public flag by .61 percentage points. For those in the highest credit score quintiles, the chargeoff and derogatory flag response is roughly two to four times weaker.

1.6 Taking Stock: Heterogeneous Responses

Across credit score quintiles, individuals use credit markets to smooth consumption in very different ways. Unconstrained individuals in the highest credit score quintile increase their revolving credit balances in response to income losses. Conversely, constrained individuals in the middle and bottom of the credit score distribution default and chargeoff loans in response to income losses. Both groups of individuals are using credit markets to self-insure. In the subsequent sections, we develop a quantitative model to replicate these observations from the data. We then quantify the optimal degree of public insurance given the level of credit access observed in the data.

2 Model

In this section, we compute optimal unemployment insurance in an environment that features both current levels of U.S. credit access as well as various forms of adverse selection that may limit unemployed individuals’ access to capital markets (we consider both private discount factor and future job loss heterogeneity, e.g. Chiu and Karni [1998] and Hendren [2015]). Our framework is a labor search model with credit lines (e.g. Mateos-Planas and Ríos-Rull [2010]) and adverse selection in the credit market (e.g. Guerrieri, Shimer, and Wright [2010] and Chang [2010]). By
modeling credit lines, we are able to replicate the non-responsiveness of credit access to job loss. We use the calibrated model to show that regardless of the type of adverse selection considered, borrowing is costly and complementary with public insurance. These factors limit the willingness of the government to substitute out of unemployment benefits.

Time is discrete and runs forever. There is a unit measure of individual agents, a continuum of potential risk-neutral lenders, and a continuum of potential entrant firms. There are $T \geq 2$ overlapping generations of risk averse individuals that face idiosyncratic risk, similar to Menzio et al. [2012]. Each individual lives $T$ periods. Individuals have heterogeneous discount factors in the benchmark economy, and in Section 4.3, we consider the case of heterogeneous job layoff rates. Let $\beta_i$ be a type $i$ individual’s discount factor, where $i \in \{H, L\}$ denotes a individual’s type and types are permanent. We set $0 < \beta_H < \beta_L < 1$, i.e. type $L$ individuals are more patient than type $H$ individuals. The share of type $i$ individuals in the economy is $\pi_i$. The information structure is such that firms observe, and may condition on, a individual’s type but lenders do not observe a individual’s type. We elaborate on contracts and market structure in the paragraphs that follow.

At the start of each period, individuals direct their search for jobs (e.g. Moen [1997], Burdett et al. [2001], and Menzio and Shi [2011]). Individuals then participate in an asset market where they make asset accumulation, borrowing, and default decisions. Let $t$ denote age and $t_0$ denote birth cohort. We assume that individuals must apply (i.e. search) for credit contracts at utility cost $\kappa_S$. Let $S_{i,t,t+t_0}$ be a dummy that equals 1 if a type $i$, age $t$ individual searches for credit in period $t + t_0$. Individuals may default on their loans $b_{i,t,t+t_0}$ at utility cost $\psi_D(b_{i,t,t+t_0})D_{i,t,t+t_0}$, where $D_{i,t,t+t_0}$ is a dummy that equals 1 in the event of default. The objective of a individual is to maximize the present discounted value of utility over non-durable consumption $(c_{i,t,t+t_0})$ net of any utility penalties of default and application costs:

$$E_{t_0} \left[ \sum_{t=1}^{T} \beta_i^t (u(c_{i,t,t+t_0}) - \psi_D(b_{i,t,t+t_0})D_{i,t,t+t_0} - \kappa_S S_{i,t,t+t_0}) \right]$$

For the remainder of the paper we focus on a recursive representation of the problem, dropping the time subscript $t + t_0$.

In addition to types, individuals are heterogeneous along multiple dimensions. Individuals are either employed or unemployed, with employed value functions denoted $W$, and unemployed value functions denoted $U$. Let $e \in \{W, U\}$ denote employment status. Let $b \in \mathcal{B} \equiv [\underline{B}, \overline{B}] \subset \mathbb{R}$ denote the net asset position of the individual, where $b > 0$ indicates saving and $b < 0$ indicates borrowing. Let $\tilde{h} \in \mathcal{H} \equiv [\underline{h}, \overline{h}] \times [\underline{e}, \overline{e}] \subset \mathbb{R}^2$ be a tuple representing an individual’s human capital. Human capital is comprised of two components, a persistent component $(\tilde{h})$ and a transitory component $(e)$. Human capital follows a Markov chain which depends on an individual’s employment status, and it is calibrated to match earnings changes of the employed, as well as earnings losses following job loss. Workers differ with respect to their piece-rate $\omega \in [0, 1]$ which denotes the share of their
per-period match output that they receive as a wage. Individuals also differ with respect to their credit access \( a \in \{C, N\} \), where \( a = C \) denotes those with credit access who can borrow, and \( a = N \) denotes those without credit access who are unable to borrow. Individuals that have credit access are heterogeneous with respect to their borrowing limit \( b \in \mathcal{B} \equiv [\mathcal{B}, 0] \) as well as their interest rate \( r \in \mathcal{R} \equiv [\underline{r}, \bar{r}] \subset \mathbb{R}_+ \).

Unemployed individuals direct their search for employment across vacancies which specify a fixed piece rate \( \omega \) for the duration of the employment match. Let \( M(u, v) \) denote the labor market matching function, and define labor market tightness to be the ratio of vacancies \( v \) to unemployment \( u \). Since search is directed, there is a separate labor market tightness for each submarket, defined by an agent’s age \( (t) \), type \( (i) \) which is observed by firms, requested piece-rate \( (\omega) \), and human capital \( (\vec{h}) \). Although individuals differ along other dimensions, an agent’s age, type, human capital, and requested piece-rate are the only characteristics that matter for firm profitability. In each submarket, the job finding rate for individuals, \( p(\cdot) \), is a function of labor market tightness \( \theta_{i,t}(\omega, \vec{h}) \), such that \( p(\theta_{i,t}(\omega, \vec{h})) = \frac{M(u, t, \omega, \vec{h}, \vec{h}, r)}{u, t, \omega, \vec{h}, \vec{h}} \). On the other side of the market, the hiring rate for firms \( p_f(\cdot) \) is also a function of labor market tightness and is given by \( p_f(\theta_{i,t}(\omega, \vec{h})) = \frac{M(u, t, \omega, \vec{h}, \vec{h}, r)}{v, t, \omega, \vec{h}} \). Once matched with a firm, a worker produces \( f(\vec{h}) : \mathcal{H} \rightarrow \mathbb{R}_+ \) and keeps a share \( \omega \) of this production as their wage. Matches end exogenously each period with probability \( \delta \) (in the current formulation, firm profits are not impacted by the worker type, however, in Section 4.3 we allow \( \delta \) to differ by worker type, and in that case firm profits do depend on worker type). It is important to note that because we model piece-rate contracts, workers’ wages grow over time with their human capital. This generates a motive for employed workers to borrow against future income, and we need newly laid off workers to be indebted prior to job loss in order to generate defaults and deleveraging.

Every period individuals without credit access choose whether or not to search for a credit line, which entails a utility cost \( \kappa_S \). After incurring the utility cost, the agent then directs their search over the menu of credit lines, which specify a borrowing limit \( b \), and interest rate \( r \). Let \( M_C(u_C, v_C) \) denote the credit market matching function, and define the credit market tightness to be the ratio of vacant credit contracts \( v_C \) to individuals searching for a credit contract \( u_C \). As in the labor market, since search is directed, credit market tightness is specific to each submarket; however, unlike the labor market, we assume that lenders cannot observe the workers type. Thus a submarket is defined by an agent’s age \( (t) \), employment status \( (e \in \{W, U\}) \), piece-rate wage \( (\omega) \), prior debt \( (b) \), human capital \( (\vec{h}) \), and the requested contract \( (b, r) \). In each submarket, the credit finding rate for individuals, \( p^e(\cdot) \), is a function of the credit market tightness \( \theta_{1,e,t}^{i,c}(\omega, b, \vec{h}; b, r) \), such that \( p^e(\theta_{1,e,t}^{i,c}(\omega, b, \vec{h}; b, r)) = \frac{M_C(u_C, t, \omega, b, \vec{h}, b, r)}{u_C, t, \omega, b, \vec{h}, b, r} \). On the other side of the market, the probability a lender matches with a borrower, denoted \( p_f(\cdot) \), is also a function of credit market tightness and is given by \( p_f(\theta_{1,e,t}^{i,c}(\omega, b, \vec{h}; b, r)) = \frac{M_C(u_C, t, \omega, b, \vec{h}, b, r)}{v_C, t, \omega, b, \vec{h}, b, r} \). A individual remains matched with a lender until the individual defaults, or the match is destroyed exogenously at rate
The timing is such that individuals enter the credit search stage and must decide whether to apply for a credit line. They then make borrowing, saving, and consumption decisions. Idiosyncratic human capital risk is then realized. At the start of the next period individuals enter the labor market and apply for jobs, and they may endogenously separate from lenders by defaulting or they may receive an exogenous credit separation shock.

Let $U_{i,t}^S(b, \vec{h}; 0, 0)$ denote the value of entering the credit search stage for an unemployed, age $t$, type $i$ individual with net worth $b$, and human capital $\vec{h}$. The last two elements of the state space are zero, reflecting the fact that the agent does not have a credit contract, and thus $b = 0$ and $r = 0$. This agent must decide whether to pay the utility cost $\kappa_S$ of searching for a credit contract or remaining without credit,

\[
U_{i,t}^S(b, \vec{h}; 0, 0) = \max \left\{ -\kappa_S + U_{i,t}^A(b, \vec{h}; 0, 0) ; U_{i,t}^N(b, \vec{h}; 0, 0) \right\} \quad \forall t \leq T
\]

\[
U_{i,T+1}^S(b, \vec{h}; 0, 0) = 0
\]

where $U_{i,t}^N(b, \vec{h}; 0, 0)$ is the value of an unemployed individual without credit access, specified below, and $U_{i,t}^A(b, \vec{h}; 0, 0)$ is the value of applying for a credit contract which is given by

\[
U_{i,t}^A(b, \vec{h}; 0, 0) = \max_{(\vec{b}, r) \in \vec{B} \times R} \left[ p^c(\theta_t^cU(b, \vec{h}; \vec{b}, r))U_{i,t}^C(b, \vec{h}; \vec{b}, r) + \left( 1 - p^c(\theta_t^cU(b, \vec{h}; \vec{b}, r)) \right) U_{i,t}^N(b, \vec{h}; 0, 0) \right]
\]

After the asset market closes, the agent makes their consumption and savings decisions with savings accruing interest at the risk free rate $r_f$. For an agent that did not receive a credit contract, their consumption and savings problem is constrained in that the agent is not allowed to borrow. An unemployed individual receives a public transfer $z$.\textsuperscript{18} The transfer to unemployed individuals is funded through a proportional tax $\tau$ on labor income that is levied across all employed individuals. Additionally, unemployed individuals receive the value of home production $g$, which is assumed to be constant across the duration of unemployment as well as homogeneous across unemployed individuals.

After consuming, idiosyncratic human capital risk is realized with the expectations operator. Unemployed individuals, on average, lose human capital, while employed individuals gain human capital. Agents then enter the labor market where they direct their search over piece-rate wage contracts $\omega$. At the end of the period, individuals without credit access enter the credit search

\textsuperscript{18}This transfer incorporates all forms of assistance that unemployed workers receive, which can include unemployment compensation and emergency unemployment assistance as well as general transfer programs such as welfare and food stamps that unemployed individuals may be enrolled in. As discussed in Section 3, we will calibrate $z$ to be consistent with the change in total transfers to the change in income among unemployed individuals.
stage. The continuation value of an unemployed agent without credit access is,

\[ U_{i,t}^N(b, \vec{h}; 0, 0) = \max_{b' \geq 0} u(c) + \beta_i \mathbb{E} \left[ \max_{\tilde{\omega}} p(\theta_{i,t+1}(\tilde{\omega}, \vec{h}')) W_{i,t+1}^S(\tilde{\omega}, b', \vec{h}'; 0, 0) + \left(1 - p(\theta_{i,t+1}(\tilde{\omega}, \vec{h}'))\right) U_{i,t+1}^S(b', \vec{h}; 0, 0) \right] \quad \forall t \leq T \]

\[ U_{i,T+1}^N(b, \vec{h}; 0, 0) = 0 \]

subject to the budget constraint,

\[ c + q(b', 0)b' \leq z + g + b \]

and the law of motion for human capital, which is indexed by employment status \( U \),

\[ \vec{h}' = H(\vec{h}, U) \quad (5) \]

The bond price \( q(b', r) \) includes both the discount on the face-value of loans as well as the savings rate,

\[ q(b', r) = \mathbb{I}\{b' < 0\} \frac{1}{1+r} + \mathbb{I}\{b' \geq 0\} \frac{1}{1+r_f} \]

For an agent that received a credit contract, their consumption and savings problem is constrained by their borrowing limit \( b \). The agent chooses their asset position, searches for jobs, and then decides whether to default on any outstanding debts. The value function of an agent with credit is given by,

\[ U_{i,t}^C(b, \vec{h}; b, r) = \max_{b' \geq b} u(c) + \beta_i \mathbb{E} \left[ \max_{\tilde{\omega}} p(\theta_{i,t+1}(\tilde{\omega}, \vec{h}')) W_{i,t+1}^D(\tilde{\omega}, b', \vec{h}'; b, r) + \left(1 - p(\theta_{i,t+1}(\tilde{\omega}, \vec{h}'))\right) U_{i,t+1}^D(b', \vec{h}; b, r) \right] \quad \forall t \leq T \]

\[ U_{i,T+1}^C(b, \vec{h}; b, 0) = 0 \]

subject to the budget constraint,

\[ c + q(b', r)b' \leq z + g + b \]

and the law of motion for unemployed individuals’ human capital (equation (5)). After directing their search over firms in the labor market, the agent observes if their credit match has been exogenously destroyed. With probability \( \delta_c \), the agent looses their credit market access. After the realization of the credit separation shock, the agent decides whether or not to default. The default
decision and the resulting continuation value for an unemployed worker is given by

\[
U^{D}_{i,t+1}(b', \tilde{h}; b, r) = \delta_c \max \{U^{N}_{i,t+1}(0, \tilde{h}; 0, 0) - \psi_D(b') - U^{N}_{i,t+1}(b', \tilde{h}; 0, 0) \}
\]

\[
+ (1 - \delta_c) \max \{U^{N}_{i,t+1}(0, \tilde{h}; 0, 0) - \psi_D(b') - U^{C}_{i,t+1}(b', \tilde{h}; b, r) \}
\]

(7)

Let \(D^{N,U}_{i,t+1}(b', \tilde{h}; b, r)\) be an indicator function denoting an individual’s default decision when they are unemployed and are hit by the credit separation shock \((D^{N,U}_{i,t+1} = 1 \text{ when the individual defaults and is equal to zero otherwise})\). Let \(D^{C,U}_{i,t+1}(b', \tilde{h}; b, r)\) be an indicator function denoting an individual’s default decision when they are unemployed and are not hit by the credit separation shock.

Employed individuals in the economy face similar credit constraints to unemployed individuals. The primary difference is that with probability \(\delta\), employed individuals are laid off and must search for a new job. Appendix C.1 contains the Bellman equations for employed workers.

### 2.1 Lenders

There is a continuum of potential lenders who are risk neutral and can obtain funds without constraint at the risk free rate \(r_f\). Lenders discount their stream of future profits at rate \(\beta_l f \in (0, 1)\). Lenders offer credit contracts which specify a borrowing limit \(b < 0\) and an interest rate \(r\). Let \(\Pi^{U}_{i,t}(\tilde{x})\) denote the profits to a lender of being matched with a type \(i\), age \(t\), unemployed individual where an individual’s state is given by \(\tilde{x} = (b, \tilde{h}; b, r)\). Let \(b'_{i,t}(\tilde{x})\) and \(\hat{D}^{N,U}_{i,t+1}(\tilde{x})\) denote the asset and default policy functions of the individual. The profits to the lender of offering a contract with borrowing limit \(b\), and interest rate \(r\) is

\[
\Pi^{U}_{i,t}(b, \tilde{h}; b, r) = \beta_l f b'_{i,t}(\tilde{x}) \left( \frac{(r_f - r)}{1 + r} + \mathbb{E} \left[ \delta_c \hat{D}^{N,U}_{i,t+1}(\tilde{x}) + (1 - \delta_c) \hat{D}^{C,U}_{i,t+1}(\tilde{x}) \right] \right) \times I\{b'_{i,t}(\tilde{x}) < 0\}
\]

(8)

At the end of period \(t\), the agent makes their savings decision, \(b'_{i,t}(\tilde{x})\). If the individual is borrowing, \(b'_{i,t}(\tilde{x}) < 0\), then in period \(t + 1\) the lender earns the spread between the interest rate \(r\) and the risk free rate \(r_f\). However, the lender faces default risk on the outstanding loan \(b'_{i,t}(\tilde{x})\). The default risk faced by the lender incorporates the probability of the credit separation shock, as well as shocks to human capital and the individual’s job search decision. The default probability of the agent

\[\text{Let } \tilde{x}' \text{ denote the state space of the individual in the next period.}\]
who receives the credit separation shock is denoted $\hat{D}^{N,U}_{i,t+1}(\vec{x'})$, and is given by:

$$
\hat{D}^{N,U}_{i,t+1}(\vec{x'}) = p\left(\theta_{i,t+1}(\hat{\omega},\vec{h})\right) D^{N,W}_{i,t+1}(\hat{\omega}, b', \vec{h}'; \vec{x}) + \left(1 - p\left(\theta_{i,t+1}(\hat{\omega},\vec{h})\right)\right) D^{N,U}_{i,t+1}(b', \vec{h}'; \vec{x}) \tag{9}
$$

where $\hat{\omega}$ is the unemployed worker’s choice of where to search for a job. If the agent does not default and the credit match is not hit by the credit separation shock, the match between the lender and borrower continues to the next period. The profits to the lender in period $t+1$, are denoted by $\hat{\Pi}^{U}_{i,t+1}(\vec{x'})$, and take into account the agent’s choice of where to search for a job. The continuation profits to the lender are

$$
\hat{\Pi}^{U}_{i,t+1}(\vec{x'}) = p\left(\theta_{i,t+1}(\hat{\omega},\vec{h})\right) \Pi^{W}_{i,t+1}(\hat{\omega}, b', \vec{h}'; \vec{x}) + \left(1 - p\left(\theta_{i,t+1}(\hat{\omega},\vec{h})\right)\right) \Pi^{U}_{i,t+1}(b', \vec{h}'; \vec{x})
$$

Lenders cannot observe the borrower’s type $i$. However, lenders can see if an individual is employed or unemployed when they meet the potential borrower, as well as all additional individual state variables (assets, firm type, and age). Since lenders cannot observe the type $i$ of a potential borrower, they form beliefs about the type of a borrower who is searching for a given contract. Let $\chi^{U}_{i,t}(b, \vec{h}; \vec{x})$ denote lender’s beliefs about the share of individuals who arrive in market $(b, \vec{x})$ with states $(b, \vec{h})$ that are type $i$, unemployed, and age $t$. A free entry condition pins down the number of lenders who enter in the market in equilibrium. The free entry condition is

$$
\kappa_{C} \geq \hat{p}^{f}_{i} \left(\theta^{C,U}_{i,t}(b, \vec{h}; \vec{x})\right) \sum_{i} \chi^{U}_{i,t}(b, \vec{h}; \vec{x}) \Pi^{U}_{i,t}(b, \vec{h}; \vec{x}) \tag{10}
$$

Note that individuals who are searching for credit contracts are not currently able to borrow, hence the free entry condition (equation (10)) holds for $b \geq 0$.

Lenders in a match with an employed individual face a similar problem, but their continuation value must take into account the probability that the individual becomes unemployed. Appendix C.2 contains the Bellman equation for a lender in a match with an employed worker.

### 2.2 Firms

Firms are assumed to have access to a linear production technology, and to have an exogenous job destruction rate $\delta$. Firms have the same discount factor $\beta_{lf}$ as lenders. The continuation value of

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20 The default probability when the agent is not hit by the credit separation shock is denoted $\hat{D}^{C,U}_{i,t+1}(\vec{x})$. It follows the same structure as equation (9), but with the policy functions for default when the agent is not hit by the credit separation shock, $D^{C,W}_{i,t+1}$ and $D^{C,U}_{i,t+1}$.

21 Note the choice of where to search for a job is a function of state variables, which are suppressed for convenience.
a firm that has committed to pay piece rate $\omega$ to their age $t$ employee with human capital $\tilde{h}$ is

$$J_{i,t}(\omega, \tilde{h}) = (1 - \omega)f(\tilde{h}) + \beta_{it}\mathbb{E}\left[(1 - \delta)J_{i,t+1}(\omega, \tilde{h}')\right]$$

$$J_{i,T+1}(\omega, \tilde{h}) = 0$$

subject to the law of motion for human capital for employed individuals,

$$\tilde{h}' = H(\tilde{h}, W)$$

Firms must pay cost $\kappa$ to post a vacancy. A vacancy specifies a wage piece rate $\omega$, worker type $i$, as well as a human capital requirement $\tilde{h}$, and age $t$. Free-entry requires that:

$$\kappa \geq p_f\left(\theta_{i,t}(\omega, \tilde{h})\right) J_{i,t}(\omega, \tilde{h})$$  \hspace{1cm} (11)

The free entry condition binds for all submarkets such that $\theta_{i,t}(\omega, \tilde{h}) > 0$.

### 2.3 Government

The government runs the public unemployment insurance benefit system. We assume the government must maintain budget balance in every period.

All unemployed individuals receive public transfers $z$. Public transfers are paid for by a proportional labor income tax, $\tau$, which is levied on all employed individuals to satisfy

$$z \sum_{(i,t)} \sum_{\bar{x}} \hat{u}_{i,t}(\bar{x}) = \sum_{(i,t)} \sum_{\bar{x}} \tau \left(\omega f(h)\hat{e}_{i,t}(\bar{x})\right)$$  \hspace{1cm} (12)

where $\hat{u}_{i,t}(\bar{x})$ is the share of individuals with state $\bar{x}$ that are type $i$ and age $t$ who are unemployed, and $\hat{e}_{i,t}(\bar{x}) = 1 - \hat{u}_{i,t}(\bar{x})$ is the share who are employed.

### 2.4 Equilibrium

The definition of equilibrium follows from Guerrieri, Shimer, and Wright [2010]. See Appendix D for the formal definition of equilibrium.\textsuperscript{22}

\textsuperscript{22}In Appendix F, we show that the assumptions of Guerrieri et al. [2010] are satisfied in limiting cases of our model where workers are heterogeneous by discount factor. In Appendix E, we present numerical results to access our ability to generate a separating equilibrium.
3 Calibration

Due to the computationally demanding nature of the model, our calibration strategy is to assign values from the literature to standard parameters wherever possible and then estimate the remaining non-standard parameters to match moments.\textsuperscript{23} We estimate our steady state to match moments from 1995 to 2007.

The period is one quarter. We set the annualized risk free rate to 4%, and the corresponding quarterly discount factor for firms and lenders is $\beta_{lf} = 0.99$. The low worker type (who generates low profits to the lender) also discounts the future at the same rate, $\beta_L = 0.99$. We estimate the discount factor of the high type (who generates high profits for the lender), $\beta_H = 0.634$, to match the 95th percentile of the real credit card interest rate distribution. We measure the 95th percentile of real credit card interest rates to be 19.03% in the SCF between 1995 and 2007.\textsuperscript{24}

We calibrate the fraction of individuals that are high types, denoted $\pi_H = 1 - \pi_L = 0.091$, to target the fact that 31.38% of individuals report having a ratio of net liquid assets to annual gross income that is less than 1 percent in the SCF between 1995 and 2007. This measure allows us to capture the large mass of individuals at, or marginally above, zero net liquid assets.\textsuperscript{25}

In terms of labor market variables, we set the job destruction rate to a constant 10% per quarter, $\delta = 0.1$ (Shimer [2005]). For the labor market matching function, we use a constant returns to scale matching function that yields well-defined job finding probabilities:

$$M(u, v) = \frac{u \cdot v}{(u^\zeta + v^\zeta)^{1/\zeta}} \in [0, 1)$$

The matching elasticity parameter is chosen to be $\zeta = 1.6$ as measured in Schaal [2012]. The labor vacancy posting cost $\kappa = 0.728$ is estimated to target an unemployment rate of 5.1%, which is the average reported by the Bureau of Labor Statistics from 1994 to 2007.

Human capital evolves following a Markov chain with a persistent and transitory component. Let $\vec{h} = (\tilde{h}, \epsilon)$, denote the human capital of an agent, where $\tilde{h}$ denotes the individual’s persistent human capital, and $\epsilon$ denotes the transitory component. We assume the production function is linear and additive in the human capital of the worker, $f(\tilde{h}) = \tilde{h} + \epsilon$. The process for the persistent component of human capital is governed by two parameters $p_{\tilde{h}, L}$ and $p_{\tilde{h}, H}$.

$$H_P(\vec{h}, U) = \vec{h}' = \begin{cases} 
\tilde{h} - \Delta & \mathrm{w/\ pr. \ } p_{\tilde{h}, L} \mathrm{ \ if \ unemployed} \\
\tilde{h} & \mathrm{w/\ pr. \ } 1 - p_{\tilde{h}, L} \mathrm{ \ if \ unemployed}
\end{cases}$$

\textsuperscript{23}Appendix G describes our solution algorithm in detail.
\textsuperscript{24}Interest rates are made real by subtracting the CPI inflation rate in a given year.
\textsuperscript{25}As in Herkenhoff et al. [2015], for each household we sum cash, checking, money market funds, CDS, corporate bonds, government savings bonds, stocks, and mutual funds less credit card debt over annual gross income. We measure the net liquid asset to income among households in the 1995-2007 waves of the SCF.
\[ H_P(\vec{h}, W) = \vec{h}' = \begin{cases} 
\vec{h} + \Delta & \text{w/ pr. } p_{\vec{h},H} \text{ if employed} \\
\vec{h} & \text{w/ pr. } 1 - p_{\vec{h},H} \text{ if employed} 
\end{cases} \]

The grid for the persistent component of human capital \( \vec{h} \in [0.6, 0.7, 0.8, 0.9, 1] \) as well as the step size \( \Delta = 0.1 \) between grid points are taken as given. To estimate the probability that the persistent component of a worker’s human capital increases while employed \( p_{\vec{h},H} = 0.093 \), we target the semi-elasticity of earnings with respect to age using the 1996 to 2007 Current Population Surveys.\(^{26}\) To estimate the probability that a worker’s productivity decreases while unemployed \( p_{\vec{h},L} = 0.647 \), we target the 6.9% decline in earnings 5 years following job loss as measured in Section 1.3. The rapid pace at which workers lose the persistent component of their human capital tends to dampen the importance of credit for self-insurance. Smaller values of \( p_{\vec{h},L} \) considered in earlier drafts of this paper resulted in greater substitutability between credit and public insurances.

The process for the transitory component of human capital is governed by the parameters \( p_{\epsilon,L} \) and \( p_{\epsilon,H} \):

\[ H_T(\vec{h}', W) = \epsilon' = \begin{cases} 
\Delta_\epsilon(\vec{h}') & \text{w/ pr. } p_{\epsilon,H} \\
0 & \text{w/ pr. } 1 - p_{\epsilon,L} - p_{\epsilon,H} \\
-\Delta_\epsilon(\vec{h}') & \text{w/ pr. } p_{\epsilon,L} 
\end{cases} \]

The step size \( \Delta_\epsilon(\vec{h}') = 0.095\vec{h}' \) is taken as given, and we estimate the parameters \( p_{\epsilon,H} = 0.252 \) and \( p_{\epsilon,L} = 0.109 \) to target the share of employed workers who experience a 9.5% wage increase and decrease, respectively, as reported in Kurmann and McEntarfer [2017].\(^{27}\) Given the processes for the transitory and persistent components of human capital, the evolution of human capital proceeds as:

\[ H(\vec{h}, W) = (H_P(\vec{h}, W), H_T(H_P(\vec{h}, W), W)) \]

\[ H(\vec{h}, U) = (H_P(\vec{h}, U), 0) \]

The public transfer to unemployed workers \( z = .302 \) is estimated to match the 41.2% public transfer replacement rate (change in public transfers divided by change in annual income) among

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\(^{26}\) We estimate the earnings gain associated with an increase in age using the following regression of age on earnings on a cross-section of individuals in period \( t \): 
\[ \ln(Y_{i,t}) = \alpha + \beta_{\text{age}} \times \text{Age}_{i,t} + \epsilon_{i,t}, \] where \( Y_{i,t} \) denotes the earnings of individual \( i \) in year \( t \), and \( \text{Age}_{i,t} \) denotes the age of individual \( i \) in year \( t \). The coefficient \( \beta_{\text{age}} \) estimates the average increase in log earnings associated with an increase in age. Using data from the CPS for the years 1996-2007, we estimate a relative gain in earnings with a 1-year increase in age of 0.82%. We additionally include educational attainment dummies, as well as industry and year dummies in the estimation.

\(^{27}\) Kurmann and McEntarfer [2017] report that in 2009-2010, 7.65% of job stayers (individuals who report being at the same establishment (SEIN) for 10 consecutive quarters) experienced a wage decline of at least 9.5%. They report 19% of job stayers experienced a wage increase of 9.5% or higher.
laid-off workers observed in the PSID between 2001 and 2013.\footnote{Our measure of income from the PSID is household income less transfers, which is the sum across household members of (1) wage and salary income; (2) business income; and (3) interest dividend income. Transfers are also measured at the household level. We measure the public transfer replacement rate (change in transfers over the change in household income less transfers), for households where either the head of household or spouse has an involuntary unemployment spell with a duration of greater than 1 quarter. We additionally require an income decline of at least $1k, and we winsorize the replacement rate at the 1% level. We focus on involuntary layoffs to avoid unemployment spells due to quits, and as involuntary layoffs are more consistent with the notion of a layoff in the model. We similarly use individuals with an unemployment duration of at least three months given the quarterly timing of the model where unemployed individuals are out of work for at least a full quarter. Using the SIPP, Rothstein and Valletta \cite{Rothstein2017} estimate a replacement rate (changes in transfers over changes in earnings) of 43.6\%.} We focus on the change in transfers around job loss rather than the level of transfers to focus on the transfers that are received upon job loss.

The value of home production $g = 0.137$ is calibrated to target the decline in consumption associated with job loss. Using the PSID, we estimate that, on average, individuals who experience at least 1-quarter of unemployment have annual consumption that is 93.8\% of their consumption level prior to layoff.\footnote{In the PSID, we measure the change in family consumption across survey waves for families where the head of household had an involuntary unemployment spell with a duration of at least one quarter between 2005 and 2013. Additionally, we require that the household have at least $5k of consumption both before and after layoff, and that the head of household was employed in the prior wave of the PSID. We winsorize the change in consumption among this sample at the 5\% level.}

In terms of credit market variables, we set the quarterly exogenous credit separation rate to 2.6\% per quarter, $\delta_c = 0.026$, based on Fulford \cite{Fulford2015}. For the credit market matching function, we again use a constant returns to scale matching function that yields well-defined credit finding probabilities:

$$M_C(u_C, v_C) = \frac{u_C \cdot v_C}{(u_C^{SC} + v_C^{SC})^{1/\zeta_C}} \in [0, 1)$$

The matching elasticity parameter is chosen to be $\zeta_C = 0.37$ as measured in Herkenhoff \cite{Herkenhoff2013}.

There is an exogenously given grid of interest rates for credit contracts over the interval $[r, \bar{r}]$. We set the minimum annual interest rate ($r$) to be 10.5\%, which comes from taking the sum of average interest charges and total fees as reported in Agarwal, Chomsisengphet, Mahoney, and Stroebel \cite{Agarwal2014} for individuals with FICO scores less than 620. We set the maximum interest rate ($\bar{r}$) to be non-binding.

Credit contracts also specify a borrowing limit which must lie in the interval $[B, 0)$, where $B < 0$ is the minimum value of the asset grid. We estimate $B = -1.25$, so that the average unused credit (credit limit less outstanding balance) to income ratio is 23.5\% as measured in the SCF from 1995 to 2007.\footnote{Using the SCF from 1995-2007, we estimate an unused credit ratio to income ratio of 23\%.} The credit posting cost $\kappa_C = 2.075 \times 10^{-5}$ is estimated so that the credit finding rate in the model matches the new-borrower credit approval rate of 65\%, which can only be measured in the 2007 to 2009 SCF panel. The utility cost of searching for a credit
contract $\kappa_S = 2.161 \times 10^{-4}$ is calibrated to match the fact that 69.8% of the population has credit access in the SCF from 1995 to 2007.

A worker’s life span is set to $T = 80$ quarters (20 years). Newly born individuals enter as unemployed workers, with zero assets and without a credit contract. Their human capital is drawn from a uniform distribution over the grid of human capital. Individual preferences over non-durable consumption are given by:

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

We set the risk aversion parameter to a standard value, $\sigma = 2$. The utility penalty of default is assumed to be linear in the amount of assets defaulted upon:

$$\psi_D(b) = -b \cdot \psi$$

We set the default penalty $\psi = 20.703$ to match the bankruptcy rate in the U.S. from 1998-2007 of 0.145% per quarter.\(^{31}\)

Table 6 contains a summary of the model parameters, and Table 7 displays the calibrated parameters and their calibration targets. The estimated model matches the targeted moments very well. We discuss non-targeted moments in the next section.

### 3.1 Model Estimated Borrowing and Default Responses to Job Loss

In this section, we compare the model estimated borrowing and default responses of displaced workers to the data. These moments were not targeted in the calibration.

To estimate the average effect of job loss on credit access and usage, we estimate the distributed lag regression model of equation (1) on model simulated data.\(^{32}\) Figure 6 plots the estimated coefficients. To facilitate the comparison between model estimates and the data, we normalize reported coefficients by pre-displacement earnings. Panel (a) presents the difference in earnings between displaced and non-displaced individuals from the model simulation. Similar to the data, displaced individuals’ earnings drop by 40%, on average. The shorter term recovery of earnings is quicker in the model than in the data; however, the losses 5 years after layoff are closer to the data since they are targeted in our calibration.

Despite the large and persistent decline in earnings, Panel (b) shows that borrowing limits are largely unaffected by job loss. Individuals take out credit lines, as opposed to one period debt as in Herkenhoff \cite{2013}, and thus borrowing limits are unresponsive to job loss, similar to

\(^{31}\)Using the SCF from 1998-2007, we measure that 0.58% of individuals with a credit card report having filed for bankruptcy within the past year.

\(^{32}\)We impose the same sampling requirements in the simulation as in the data. In particular, we require individuals to have 3 years of tenure at a firm to be in either the treatment or control samples.
the data. Borrowing follows a similar pattern. Panel (c) reveals that debt is unresponsive to job loss in both the model and data. We will revisit this result and show that there is a distribution of responses both in the model and data, with some individuals delevering and defaulting, while other individuals borrow. The net effect is zero borrowing after job loss.

Panel (d) examines the propensity of individuals to default in the model following job loss. Between the year before layoff (t=-1) and the year after layoff (t=1), the default rate rises by .291% in the model and by .639% in the data. Thus, while the model appears to produce default rates toward the low-end of the confidence interval, it accounts for 45% (=.291/.639) of the rise in defaults following job loss.

Figure 7 shows the model’s heterogeneous response of borrowing and default to job loss. We plot the model’s distribution of credit replacement rates following job loss versus the distribution of credit replacement rates in the 2007 to 2009 SCF panel (the change in debt can only be measured in the panel years). The model is able to partially replicate the distribution of replacement rates observed in the data. The model produces too little deleveraging, but it successfully captures the large mass at zero and a significant fraction of borrowing. Overall, Figures 6 and 7 highlight the model’s ability to generate similar unemployed borrowing and default patterns as the data.

4 Optimal Unemployment Insurance

In this section, we compute optimal public transfers to the unemployed under various levels of credit access. Our benchmark U.S. economy features a transfer to the unemployed that replaces 41.2% of lost earnings on average. When assessing optimality, we use two different social welfare criteria: (i) utilitarian welfare and (ii) median welfare. Our utilitarian welfare criterion is an equally weighted average of consumption-equivalent gains of moving to the new policy, whereas the median welfare criterion is the median consumption-equivalent gain of moving to the new policy.

In our first experiment, we consider the baseline model where workers have private information about their discount factors. We compute optimal transfers in steady state, and then we compute the full transition path from current U.S. policy to the new optimum. In our second experiment, we consider the case when workers have private information about their odds of being laid off. In both cases we find that access to credit implies a lower optimal UI replacement rate relative to a world without credit access; however, relative to current U.S. policy, the optimal utilitarian policy is to raise public unemployment insurance, whereas the median voter would want to lower public

\[33\text{We consider derogatory public flags, which include bankruptcy, foreclosure, tax liens and other debt discharges. While our model’s concept of default is Chapter 7 bankruptcy, these derogatory public flags (including bankruptcy) are typically correlated and result in the same end-result of debt discharge. These are rare events in the data, and so we use public derogatory flags in the data to maximize power.}\]

\[34\text{See Appendix H for details on the estimation of the share of lifetime consumption an individual would be willing to give up to move across economies.}\]
unemployment insurance. Credit acts as a limited substitute for public insurance because private credit access and public insurance are complements in the aggregate. As public insurance is cut, default rates rise and credit markets become more costly to use.

4.1 Heterogeneous Discount Factors: Steady State Comparison

We first compute optimal policy in our baseline model, which features private information about discount factors. Figure 8 displays our utilitarian welfare criterion and median welfare criterion for various levels of public transfers to the unemployed. Panel (a) shows that under the utilitarian welfare criterion, welfare is maximized with a transfer to the unemployed replacing 43.9% of lost earnings. On average, individuals are willing to give up 0.059% of lifetime consumption to be born in an economy with a 43.9% replacement rate as opposed to our baseline economy with a 41.2% replacement rate. This is a slightly higher replacement rate than what is observed in the U.S. Panel (b) shows that under the median welfare criterion, welfare is maximized at a replacement rate of 39.8%.

While the above policies raise welfare on average, or for the median individual, they are not Pareto-improving. Figure 9 plots the distribution of welfare effects. Panel (a) plots the distribution of consumption equivalent gains and losses from changing the public insurance replacement rate to 43.9%. Panel (b) plots the distribution of consumption equivalent gains and losses from changing the UI replacement rate to 39.8%. In both cases, individuals with low initial human capital levels are most sensitive to the replacement rate. Raising the replacement rate in panel (a) primarily benefits low human capital individuals, leaving high human capital individuals largely unaffected. Lowering the replacement rate in panel (b) primarily benefits high human capital individuals, leaving low human capital individuals substantially worse-off.

Under both the utilitarian and median welfare criteria, the optimal replacement rates differ from the current US policy of a 41.2% replacement rate. Under the utilitarian welfare criterion, benefits should be raised, and under the median welfare criterion, benefits should be lowered. These results obfuscate the fact that relative to optimal public insurance in an economy without credit access (i.e. no borrowing, $b = 0$ for all available contracts), it is always optimal under both welfare criteria to lower public unemployment insurance when credit access expands. Table 8 makes this point by computing the optimal public provision of unemployment insurance under the assumption that individuals cannot borrow. Without credit access, the optimal utilitarian policy is a 45.3% replacement rate. This is higher than both the current U.S. replacement rate of 41.2% and the optimal replacement rate of 43.9% under current levels of U.S. credit access. Using the median welfare criterion, the optimal unemployment insurance rate is 42.5% without credit access, and 39.8% with credit access.

Why is it so difficult to substitute from public forms of insurance into private forms of insurance? Panel (a) of Figure 10 shows that as the level of public insurance declines from its current
value of 41.2%, there are more defaults in the economy, which decreases profits to lenders and
duces entry of lenders into the market. The decline in the entry of lenders into the market
duces the credit finding rate (the probability that individuals without a credit contract are
able to match with a lender in the credit market) from 65% in the baseline economy to 63.7% when
the replacement rate is lowered to 34%. The fraction of the unemployed who borrow drops from
21.3% in the baseline economy to 19.7% when the replacement rate is lowered to 34%. Therefore,
at the aggregate level, credit and public insurance are complements and comove positively.

As credit is an expensive form of self insurance, individuals’ consumption falls as public insur-
ance is cut. Panel (b) of Figure 10 shows that the consumption drop following job loss steadily
increases as the generosity of the public transfer to the unemployed declines. Conversely, when
the public insurance policy becomes too generous, individuals default at a higher rate (since credit
access is less valuable) and the consumption drop follow job loss decreases. However, the increased
tax burden makes the mean and median individual worse off with extremely high levels of public
insurance. The optimal provision of public insurance balances these competing forces.

4.2 Heterogeneous Discount Factors: Transition Path

The above welfare experiment compared steady states with different levels of generosity of public
insurance to the unemployed. In this section, we conduct a welfare experiment where we simulate
the transition path of the economy from the current 41.2% replacement rate to a 39.8% replacement
rate (the optimal policy under the median voter). To conduct the experiment, we start from the
steady state of the baseline economy. We simulate an unexpected decline in the generosity of the
public insurance to the unemployed, where the replacement rate is lowered to 39.8%. After the
initial unexpected decline, individuals in the economy have rational expectations that the decline
in replacement rate is permanent.\textsuperscript{35} We simulate the policy change, and use the policy functions
from the model to simulate the outcomes for a large mass of individuals.

We find that the median individual who is alive at the time that the transition occurs has
a 0.03% consumption equivalent gain due to the policy change. Figure 11 plots the fraction of
individuals, alive at the time of the reform, who have welfare gains along the transition path. We
stratify the welfare gains by the persistent component of human capital. The figure shows that
at higher levels of persistent human capital, a larger share of individuals have a welfare gain from
the policy change. Moreover, at all levels of persistent human capital, the majority of individuals
experience a welfare gain as the economy transitions from the current 41.2% replacement rate to
a 39.8% replacement rate.

\textsuperscript{35} See appendix I for details on the transition path experiment.
4.3 Heterogeneous Job Loss Probabilities

In this subsection, we consider a version of our model that is designed to capture the type of private information discussed in Hendren [2015]. We assume that workers have private information about their probability of future job loss as well as their discount factor. We assume that lenders cannot observe a worker’s job loss probability or discount factor whereas firms can. In this exercise, the ‘high’ worker types have a higher probability of future job loss as well as a lower discount factor. The ‘low’ worker types have a lower probability of future job loss and are more patient (higher discount factor). Hendren [2015] estimates a difference in annual job loss probabilities of 8% across individuals with the highest and lowest perception of future job loss, which corresponds to a 2% difference at a quarterly frequency. Therefore, we set the future job loss probability of ‘low’ types \( \delta_L \) to 9.82% per quarter and the future job loss probability of high types \( \delta_H \) to 11.82%. This parameter choice keeps the aggregate job loss probability consistent with our baseline estimation of the model. With these heterogeneous job loss probabilities and keeping the remaining parameters at their values from the baseline estimation of the model, we perform the welfare experiment of choosing the replacement rate of public insurance to maximize welfare.

Table 9 contains the optimal public UI replacement rate in this environment. Column (2) of Table 9 shows that in this environment the optimal policy under the utilitarian welfare criterion is to set the replacement rate of public insurance to 39.8% of lost earnings, while column (3) shows that the median voter sets the optimal replacement rate at 38.5%. The utilitarian government and the median voter would optimally lower the public insurance rate in an environment where individuals can privately self-insure with credit. In an environment without credit, the utilitarian government would optimally raise the public insurance replacement rate to 42.6%, while the median voter would keep the replacement rate at 41.2%. Despite severe adverse selection over the future probability of job loss, there is roughly similar scope for substitution out of public insurance.

5 Conclusions

In this paper we ask two questions: Can the unemployed borrow? What does the presence of a well-developed credit market imply for optimal unemployment insurance? To answer the first question, we built a new dataset which links employment records to TransUnion credit reports. Our empirical contribution is to show that workers who lose their jobs maintain access to credit and that unconstrained workers who lose their jobs borrow, while constrained workers who lose their jobs default and delever. We reconcile previous studies by showing that displaced workers do not borrow on average, but roughly 1/3 of displaced workers default and delever, and roughly 1/3 of displaced workers borrow more. For both sets of individuals, credit markets play an important consumption smoothing role.
Our quantitative contribution is to measure the optimal degree of public insurance in an economy that features both current levels of U.S. credit access as well as various forms of adverse selection that may limit unemployed individuals' access to capital markets. Our model integrates adverse selection in the credit market (e.g. Guerrieri, Shimer, and Wright [2010], Chang [2010], Corbae and Glover [2017]) into an environment with credit lines (e.g. Mateos-Planas and Ríos-Rull [2010]) and employment risk (e.g. Moen [1997], Burdett et al. [2001], and Menzio and Shi [2011]). We find that the optimal provision of public insurance is unambiguously lower as credit access expands, regardless of the form of adverse selection considered. In our benchmark economy, the median individual would prefer to have the income replacement rate from public unemployment insurance lowered from the current US policy of 41.2% to 39.8%. The median individual would gain both in steady state and along the transition path from this reform.

Our paper complements the growing micro-macro research agenda which estimates models to match micro-behavior in general equilibrium and then aggregates individuals in order to inform macro policy. This paper provides basic facts regarding job loss, default, and borrowing that can also be used to calibrate or test incomplete-market frameworks to better inform aggregate implications for policy.

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### Table 1: Summary Statistics

#### Panel Sample (Year Prior to Mass Layoff)

<table>
<thead>
<tr>
<th></th>
<th>(1)</th>
<th>(2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual Earnings</td>
<td>$44,230</td>
<td>$49,260</td>
</tr>
<tr>
<td>Credit Score</td>
<td>427</td>
<td>437</td>
</tr>
<tr>
<td>Age</td>
<td>40.6</td>
<td>41.3</td>
</tr>
<tr>
<td>Revolving Credit Balance</td>
<td>$10,680</td>
<td>$11,200</td>
</tr>
<tr>
<td>Revolving Credit Limit</td>
<td>$26,910</td>
<td>$28,580</td>
</tr>
<tr>
<td>Unused Revolving Credit to Income</td>
<td>0.44</td>
<td>0.41</td>
</tr>
<tr>
<td>Observations (Rounded to 000s)</td>
<td>31000</td>
<td>30000</td>
</tr>
</tbody>
</table>

#### Cross Sectional Sample (Year Prior to Mass Layoff)

<table>
<thead>
<tr>
<th>Credit Score Quintile</th>
<th>Avg. Unused Revolving Debt to Income</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quintile 1</td>
<td>0.06</td>
</tr>
<tr>
<td>Quintile 2</td>
<td>0.12</td>
</tr>
<tr>
<td>Quintile 3</td>
<td>0.27</td>
</tr>
<tr>
<td>Quintile 4</td>
<td>0.58</td>
</tr>
<tr>
<td>Quintile 5</td>
<td>1.04</td>
</tr>
</tbody>
</table>

**Note:** Sample selection criteria in Section 1.2. Annual earnings, revolving credit balance and revolving credit limit are in 2008 dollars. Credit score refers to the TransUnion bankruptcy score. Unused revolving credit to income is winsorized at the 1-percent level at the top and bottom of the distribution.
Table 2: Average Response of Earnings and Credit Variables to Displacement

<table>
<thead>
<tr>
<th></th>
<th>(1) Earnings</th>
<th>(2) Credit Score</th>
<th>(3) Revolving Credit Limit</th>
<th>(4) Revolving Credit Balance</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 Years Before Displacement</td>
<td>1,169***</td>
<td>0.0699</td>
<td>-217.5</td>
<td>39.66</td>
</tr>
<tr>
<td></td>
<td>(167.2)</td>
<td>(1.664)</td>
<td>(232.3)</td>
<td>(149.9)</td>
</tr>
<tr>
<td>3 Years Before Displacement</td>
<td>2,757***</td>
<td>-0.964</td>
<td>-363.8</td>
<td>-49.26</td>
</tr>
<tr>
<td></td>
<td>(220.1)</td>
<td>(2.013)</td>
<td>(334.7)</td>
<td>(202.9)</td>
</tr>
<tr>
<td>2 Years Before Displacement</td>
<td>5,049***</td>
<td>1.019</td>
<td>-365.1</td>
<td>-36.50</td>
</tr>
<tr>
<td></td>
<td>(262.8)</td>
<td>(2.210)</td>
<td>(403.0)</td>
<td>(240.8)</td>
</tr>
<tr>
<td>1 Year Before Displacement</td>
<td>5,157***</td>
<td>-4.488*</td>
<td>-347.4</td>
<td>47.28</td>
</tr>
<tr>
<td></td>
<td>(296.8)</td>
<td>(2.427)</td>
<td>(473.4)</td>
<td>(281.0)</td>
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<tr>
<td>Year of Displacement</td>
<td>-2,850***</td>
<td>-6.352**</td>
<td>-996.4*</td>
<td>-473.2</td>
</tr>
<tr>
<td></td>
<td>(353.5)</td>
<td>(2.595)</td>
<td>(533.7)</td>
<td>(315.8)</td>
</tr>
<tr>
<td>1 Year After Displacement</td>
<td>-13,830***</td>
<td>-15.79***</td>
<td>-1,738***</td>
<td>-583.7*</td>
</tr>
<tr>
<td></td>
<td>(410.6)</td>
<td>(2.714)</td>
<td>(572.3)</td>
<td>(336.9)</td>
</tr>
<tr>
<td>2 Years After Displacement</td>
<td>-9,735***</td>
<td>-15.40***</td>
<td>-1,503**</td>
<td>-455.1</td>
</tr>
<tr>
<td></td>
<td>(429.0)</td>
<td>(2.966)</td>
<td>(624.8)</td>
<td>(368.3)</td>
</tr>
<tr>
<td>3 Years After Displacement</td>
<td>-7,246***</td>
<td>-12.52***</td>
<td>-1,223*</td>
<td>-211.5</td>
</tr>
<tr>
<td></td>
<td>(446.3)</td>
<td>(3.216)</td>
<td>(693.2)</td>
<td>(414.8)</td>
</tr>
<tr>
<td>4 Years After Displacement</td>
<td>-5,293***</td>
<td>-11.99***</td>
<td>-1,423*</td>
<td>-186.9</td>
</tr>
<tr>
<td></td>
<td>(491.2)</td>
<td>(3.554)</td>
<td>(783.8)</td>
<td>(474.0)</td>
</tr>
<tr>
<td>5 Years After Displacement</td>
<td>-3,081***</td>
<td>-9.055**</td>
<td>-1,667*</td>
<td>-653.4</td>
</tr>
<tr>
<td></td>
<td>(556.1)</td>
<td>(4.146)</td>
<td>(889.9)</td>
<td>(552.1)</td>
</tr>
</tbody>
</table>

Individual Fixed Effects: Y, Year Fixed Effects: Y, Age and Wealth Controls: Y
R-squared: 0.153, Indiv-Yr Obs: 472000, No. of Indiv: 61000

Notes: Clustered SE in parenthesis, where the clustering is performed at the level of the firm where the worker was displaced. ***p < 0.01, **p < 0.05, *p < 0.1. Age and wealth controls include a quadratic in age, and deciles for lagged cumulative earnings. The set of variables “K Years Before (After) Displacement” are dummy variables equal to one when an individual is K years before (after) displacement, and equal to zero otherwise. Annual earnings, revolving credit balance and revolving credit limit are in 2008 dollars. Credit score refers to the TransUnion bankruptcy score.
<table>
<thead>
<tr>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a)</td>
<td>(b)</td>
<td>(c)</td>
<td>(d)</td>
</tr>
<tr>
<td>60 Day Delinquency (d)</td>
<td>Chargeoff (d)</td>
<td>Collections (d)</td>
<td>Derogatory Public Flag (d)</td>
</tr>
<tr>
<td>4 Years Before Displacement</td>
<td>0.000733</td>
<td>0.00274</td>
<td>0.00353</td>
</tr>
<tr>
<td>0.00428</td>
<td>0.00350</td>
<td>0.00388</td>
<td>(0.00230)</td>
</tr>
<tr>
<td>3 Years Before Displacement</td>
<td>-0.000547</td>
<td>0.00445</td>
<td>-0.000502</td>
</tr>
<tr>
<td>0.00473</td>
<td>0.00357</td>
<td>0.00408</td>
<td>(0.00237)</td>
</tr>
<tr>
<td>2 Years Before Displacement</td>
<td>-0.0118**</td>
<td>-0.00644*</td>
<td>0.00228</td>
</tr>
<tr>
<td>0.00490</td>
<td>0.00354</td>
<td>0.00424</td>
<td>(0.00245)</td>
</tr>
<tr>
<td>1 Year Before Displacement</td>
<td>-0.00520</td>
<td>-0.00171</td>
<td>0.00351</td>
</tr>
<tr>
<td>0.00516</td>
<td>0.00374</td>
<td>0.00452</td>
<td>(0.00253)</td>
</tr>
<tr>
<td>Year of Displacement</td>
<td>0.00688</td>
<td>0.00872**</td>
<td>0.0109**</td>
</tr>
<tr>
<td>0.00544</td>
<td>0.00391</td>
<td>0.00480</td>
<td>(0.00262)</td>
</tr>
<tr>
<td>1 Year After Displacement</td>
<td>0.0308***</td>
<td>0.0287***</td>
<td>0.0278***</td>
</tr>
<tr>
<td>0.00563</td>
<td>0.00406</td>
<td>0.00495</td>
<td>(0.00270)</td>
</tr>
<tr>
<td>2 Years After Displacement</td>
<td>0.0186***</td>
<td>0.0151***</td>
<td>0.0298***</td>
</tr>
<tr>
<td>0.00618</td>
<td>0.00438</td>
<td>0.00538</td>
<td>(0.00297)</td>
</tr>
<tr>
<td>3 Years After Displacement</td>
<td>0.00993</td>
<td>0.00666</td>
<td>0.0251***</td>
</tr>
<tr>
<td>0.00685</td>
<td>0.00483</td>
<td>0.00585</td>
<td>(0.00322)</td>
</tr>
<tr>
<td>4 Years After Displacement</td>
<td>-0.00834</td>
<td>0.00111</td>
<td>0.0187***</td>
</tr>
<tr>
<td>0.00771</td>
<td>0.00535</td>
<td>0.00649</td>
<td>(0.00354)</td>
</tr>
<tr>
<td>5 Years After Displacement</td>
<td>-0.0190**</td>
<td>-0.00704</td>
<td>0.0123</td>
</tr>
<tr>
<td>0.00947</td>
<td>(0.00648)</td>
<td>(0.00776)</td>
<td>(0.00423)</td>
</tr>
</tbody>
</table>

Individual Fixed Effects: Y Y Y Y
Year Fixed Effects: Y Y Y Y
Age and Wealth Controls: Y Y Y Y
R-squared: 0.007 0.003 0.010 0.001
Indiv-Yr Obs.: 472000 472000 472000 472000
No. of Indiv: 61000 61000 61000 61000

Notes: Clustered SE in parenthesis, where the clustering is performed at the level of the firm where the worker was displaced. ***p < 0.01, **p < 0.05, *p < 0.1. Age and wealth controls include a quadratic in age, and deciles for lagged cumulative earnings. The symbol (d) indicates a dummy variable. The set of variables “K Years Before (After) Displacement” are dummy variables equal to one when an individual is K years before (after) displacement, and equal to zero otherwise. All outcome variables are indicators for having the outcome occur within the past 12 months.
Table 4: Delevering Statistics: Year of Mass Layoff

<table>
<thead>
<tr>
<th>Fraction of Treatment Group with:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Decline in Revolving Credit Balances</td>
<td>0.39</td>
</tr>
<tr>
<td>Decline in Revolving Credit Balances and 60-day Delinquency</td>
<td>0.17</td>
</tr>
<tr>
<td>Decline in Revolving Credit Balances and Debt Chargeoff</td>
<td>0.08</td>
</tr>
</tbody>
</table>

Note: Summary statistics for cross-sectional sample in Figure 3.

Table 5: Replacement Rates of Revolving Credit by Credit Score Quintile

<table>
<thead>
<tr>
<th>Credit Score Quintile</th>
<th>(1) OLS</th>
<th></th>
<th>(2) Predicted Value</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Replacement Rate (2-Year)</td>
<td></td>
<td>Replacement Rate (2-Year)</td>
<td></td>
</tr>
<tr>
<td>Credit Score Quintile 1</td>
<td>-0.0359***</td>
<td>(0.00435)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Credit Score Quintile 2</td>
<td>-0.00804</td>
<td>(0.00651)</td>
<td>-0.0439***</td>
<td>(0.00502)</td>
</tr>
<tr>
<td>Credit Score Quintile 3</td>
<td>0.0319***</td>
<td>(0.00790)</td>
<td>-0.00395</td>
<td>(0.00660)</td>
</tr>
<tr>
<td>Credit Score Quintile 4</td>
<td>0.124***</td>
<td>(0.00823)</td>
<td>0.0883***</td>
<td>(0.00696)</td>
</tr>
<tr>
<td>Credit Score Quintile 5</td>
<td>0.184***</td>
<td>(0.00822)</td>
<td>0.148***</td>
<td>(0.00685)</td>
</tr>
<tr>
<td>Constant</td>
<td>-0.0742*</td>
<td>(0.0390)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Year FE: Y, Age and Wealth Controls: Y

R squared: 0.040, NA

No Obs.: 19000

Notes: Clustered SE in parenthesis, where the clustering is performed at the level of the firm where the worker was displaced. ***p < 0.01, **p < 0.05, *p < 0.1. Replacement rate is the negative of the change in revolving credit balance over the change in earnings, where the change in earnings and the change in borrowing is measured from the year after displacement relative to the year before displacement. The replacement rate is only defined for individuals who had a decline in earnings around displacement. A replacement rate of 0.2 indicates that an individual replaced 20 percent of their lost earnings with revolving credit. Credit score quintiles are based upon an individual's TransUnion bankruptcy score in the year prior to displacement. Age and wealth controls include a quadratic in age, and deciles for lagged cumulative earnings. Column (1) reports OLS estimates of equation (2) which estimates the replacement rate as a function of credit score quintile. The replacement rate used in the estimation is winsorized at the top and bottom at the 10 percent level. Column (2) reports predicted values of the replacement rate by credit score quintile implied by the results of Column (1), where the control variables are evaluated at their sample means, as in equation (3).
Table 6: Model Parameters

<table>
<thead>
<tr>
<th>Variable</th>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>$r_f$</td>
<td>0.04</td>
<td>Risk free rate</td>
</tr>
<tr>
<td>$\beta_{lf}$</td>
<td>0.99</td>
<td>Discount factor: lenders and firm</td>
</tr>
<tr>
<td>$\beta_L$</td>
<td>0.99</td>
<td>Discount factor low worker type</td>
</tr>
<tr>
<td>$\delta$</td>
<td>0.1</td>
<td>Exogenous job destruction rate</td>
</tr>
<tr>
<td>$\zeta$</td>
<td>1.6</td>
<td>Labor match elasticity</td>
</tr>
<tr>
<td>$\delta_C$</td>
<td>0.026</td>
<td>Exogenous credit destruction rate</td>
</tr>
<tr>
<td>$\zeta_C$</td>
<td>0.37</td>
<td>Credit match elasticity</td>
</tr>
<tr>
<td>$\tau$</td>
<td>10.5%</td>
<td>Minimum (annualized) interest rate</td>
</tr>
<tr>
<td>$\sigma$</td>
<td>2</td>
<td>Risk aversion</td>
</tr>
<tr>
<td>$T$</td>
<td>80</td>
<td>Lifespan in quarters</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Variable</th>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>$z$</td>
<td>0.302</td>
<td>Public insurance transfer to unemployed</td>
</tr>
<tr>
<td>$\kappa$</td>
<td>0.728</td>
<td>Firm entry cost</td>
</tr>
<tr>
<td>$\kappa_C$</td>
<td>$2.075 \times 10^{-5}$</td>
<td>Lender entry cost</td>
</tr>
<tr>
<td>$\kappa_S$</td>
<td>$2.161 \times 10^{-4}$</td>
<td>Utility penalty of searching for credit</td>
</tr>
<tr>
<td>$\psi_D$</td>
<td>20.703</td>
<td>Utility penalty of default</td>
</tr>
<tr>
<td>$p_{h,L}$</td>
<td>0.647</td>
<td>Prob. persistent human capital decrease</td>
</tr>
<tr>
<td>$p_{h,H}$</td>
<td>0.093</td>
<td>Prob. persistent human capital increase</td>
</tr>
<tr>
<td>$p_{\epsilon,L}$</td>
<td>0.109</td>
<td>Prob. transitory human capital low</td>
</tr>
<tr>
<td>$p_{\epsilon,H}$</td>
<td>0.252</td>
<td>Prob. transitory human capital high</td>
</tr>
<tr>
<td>$g$</td>
<td>0.137</td>
<td>Home production</td>
</tr>
<tr>
<td>$B$</td>
<td>-1.25</td>
<td>Lower bound for borrowing limit</td>
</tr>
<tr>
<td>$\beta_H$</td>
<td>0.634</td>
<td>Discount factor: high worker type</td>
</tr>
<tr>
<td>$\pi_L$</td>
<td>0.909</td>
<td>Share of low type individuals</td>
</tr>
</tbody>
</table>
Table 7: Model Calibration

<table>
<thead>
<tr>
<th>Variable</th>
<th>Value</th>
<th>Target</th>
<th>Model</th>
<th>Data</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>$z$</td>
<td>0.302</td>
<td>Transfer to Income Loss</td>
<td>41.1%</td>
<td>41.2%</td>
<td>PSID 2001-2013</td>
</tr>
<tr>
<td>$\kappa$</td>
<td>0.728</td>
<td>Unemployment Rate</td>
<td>5.1%</td>
<td>5.1%</td>
<td>BLS 1994-2007</td>
</tr>
<tr>
<td>$\kappa_C$</td>
<td>$2.075 \times 10^{-5}$</td>
<td>Credit Finding Rate</td>
<td>65.2%</td>
<td>65.0%</td>
<td>SCF 2007-2009</td>
</tr>
<tr>
<td>$\kappa_S$</td>
<td>$2.161 \times 10^{-4}$</td>
<td>Share of Agents w/ Credit Access</td>
<td>68.5%</td>
<td>69.8%</td>
<td>SCF 1995-2007</td>
</tr>
<tr>
<td>$\psi$</td>
<td>20.703</td>
<td>Bankruptcy Rate</td>
<td>0.148%</td>
<td>0.145%</td>
<td>SCF 1998-2007</td>
</tr>
<tr>
<td>$p_{h,L}$</td>
<td>0.647</td>
<td>Earnings Loss 5 Yr. After Layoff</td>
<td>4.9%</td>
<td>6.9%</td>
<td>LEHD/TU 2003-2008</td>
</tr>
<tr>
<td>$p_{h,H}$</td>
<td>0.093</td>
<td>Earnings Gain With Age</td>
<td>0.81%</td>
<td>0.82%</td>
<td>CPS 1996-2007</td>
</tr>
<tr>
<td>$p_{e,L}$</td>
<td>0.109</td>
<td>Share of Indiv. w/ 9.5% Wage Decline</td>
<td>8.2%</td>
<td>7.65%</td>
<td>KM (2017)</td>
</tr>
<tr>
<td>$p_{e,H}$</td>
<td>0.252</td>
<td>Share of Indiv. w/ 9.5% Wage Increase</td>
<td>19.4%</td>
<td>19.0%</td>
<td>KM (2017)</td>
</tr>
<tr>
<td>$g$</td>
<td>0.137</td>
<td>Consumption After Layoff</td>
<td>93.8%</td>
<td>93.8%</td>
<td>PSID 2005-2013</td>
</tr>
<tr>
<td>$B$</td>
<td>$-1.25$</td>
<td>Unused Credit Limit to Income</td>
<td>23.5%</td>
<td>23.0%</td>
<td>SCF 1995-2007</td>
</tr>
<tr>
<td>$\beta^H$</td>
<td>0.634</td>
<td>P95 Real Credit Card Interest Rate</td>
<td>17.4%</td>
<td>19.0%</td>
<td>SCF 1995-2007</td>
</tr>
<tr>
<td>$\pi_L$</td>
<td>0.909</td>
<td>Share of Agents w/ Net Liquid Assets to Income &lt; 1%</td>
<td>32.7%</td>
<td>31.4%</td>
<td>SCF 1995-2007</td>
</tr>
</tbody>
</table>

Notes: KM (2017) refers to Kurmann and McEntarfer [2017].
### Table 8: Optimal Unemployment Insurance

<table>
<thead>
<tr>
<th></th>
<th>(1) US Policy w/ Credit</th>
<th>(2) Optimal Policy w/ Credit (Utilitarian)</th>
<th>(3) Optimal Policy w/ Credit (Median)</th>
<th>(4) Optimal Policy w/o Credit (Utilitarian)</th>
<th>(5) Optimal Policy w/o Credit (Median)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transfer/Income Loss</td>
<td>41.1%</td>
<td>43.9%</td>
<td>39.8%</td>
<td>45.3%</td>
<td>42.5%</td>
</tr>
<tr>
<td>Mean Welfare Chg.</td>
<td>-</td>
<td>0.059%</td>
<td>-0.035%</td>
<td>0.137%</td>
<td>0.067%</td>
</tr>
<tr>
<td>Median Welfare Chg.</td>
<td>-</td>
<td>-0.035%</td>
<td>0.016%</td>
<td>-0.045%</td>
<td>0.008%</td>
</tr>
<tr>
<td>Unemployment Rate</td>
<td>5.1%</td>
<td>5.2%</td>
<td>5.0%</td>
<td>5.4%</td>
<td>5.1%</td>
</tr>
<tr>
<td>Fraction of Agents w/ NLATI &lt; 1%</td>
<td>32.7%</td>
<td>33.4%</td>
<td>30.8%</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Default Rate</td>
<td>0.148%</td>
<td>0.147%</td>
<td>0.149%</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Consumption Loss</td>
<td>93.8%</td>
<td>94.2%</td>
<td>93.6%</td>
<td>93.9%</td>
<td>93.6%</td>
</tr>
<tr>
<td>Marginal Tax rate</td>
<td>2.11%</td>
<td>2.31%</td>
<td>2.01%</td>
<td>2.19%</td>
<td>2.46%</td>
</tr>
</tbody>
</table>

Notes: ‘Welfare’ is the consumption equivalent of leaving an economy with the US policy of a 41.2% replacement rate to an economy with an alternate replacement rate. For example, in column (2), the utilitarian welfare change of 0.059% indicates that an individual, on average, would give up 0.059% of lifetime consumption to have a 43.9% replacement rate as opposed to a 41.2% replacement rate. The median welfare change of −0.035% means that the median individual would be willing to give up 0.035% of lifetime consumption to have a 41.2% replacement rate as opposed to a 43.9% replacement rate. See Appendix H for details on the estimation of the welfare effect.
Table 9: Optimal UI Replacement Rate with Private Information on Future Job Loss

<table>
<thead>
<tr>
<th></th>
<th>(1) Baseline</th>
<th>(2) Optimal Policy w/ Credit (Utilitarian)</th>
<th>(3) Optimal Policy w/ Credit (Median)</th>
<th>(4) Optimal Policy w/o Credit (Utilitarian)</th>
<th>(5) Optimal Policy w/o Credit (Median)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transfer/Income Loss</td>
<td>41.2%</td>
<td>39.8%</td>
<td>38.5%</td>
<td>42.6%</td>
<td>41.2%</td>
</tr>
<tr>
<td>Mean Welfare Chg.</td>
<td>-</td>
<td>0.055%</td>
<td>0.054%</td>
<td>0.025%</td>
<td>0%</td>
</tr>
<tr>
<td>Median Welfare Chg.</td>
<td>-</td>
<td>0.011%</td>
<td>0.018%</td>
<td>-0.041%</td>
<td>0%</td>
</tr>
<tr>
<td>Unemployment Rate</td>
<td>5.0%</td>
<td>5.0%</td>
<td>4.9%</td>
<td>5.1%</td>
<td>5.0%</td>
</tr>
<tr>
<td>Fraction of Agents w/ NLATI &lt; 1%</td>
<td>32.8%</td>
<td>32.4%</td>
<td>31.5%</td>
<td>18.3%</td>
<td>17.9%</td>
</tr>
<tr>
<td>Default Rate</td>
<td>0.170%</td>
<td>0.170%</td>
<td>0.172%</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Consumption Loss</td>
<td>93.6%</td>
<td>93.4%</td>
<td>93.2%</td>
<td>93.3%</td>
<td>93.1%</td>
</tr>
<tr>
<td>1Q After Job Loss</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Marginal Tax rate</td>
<td>2.08%</td>
<td>1.99%</td>
<td>1.90%</td>
<td>2.20%</td>
<td>2.07%</td>
</tr>
<tr>
<td>Job Loss Prob. Low Type (δ_L)</td>
<td>9.82%</td>
<td>9.82%</td>
<td>9.82%</td>
<td>9.82%</td>
<td>9.82%</td>
</tr>
<tr>
<td>Job Loss Prob. High Type (δ_H)</td>
<td>11.82%</td>
<td>11.82%</td>
<td>11.82%</td>
<td>11.82%</td>
<td>11.82%</td>
</tr>
</tbody>
</table>

Notes: Agents have heterogeneous layoff probabilities that are private information. See Table 8 for interpretation of welfare results.
Figure 1: Average Response of Earnings and Credit Variables to Displacement

Notes: Figure presents estimates of the effect of job loss on earnings and credit variables. Solid line is the difference in the outcome variable between displaced and nondisplaced individuals. Dashed line represents a 95 percent confidence interval. Figures present coefficient estimates from Table 2.
Figure 2: Average Response of Default Measures to Displacement

Notes: Figure presents estimates of the effect of job loss on measures of default and delinquency. Solid line is the difference in the outcome variable between displaced and nondisplaced individuals. Dashed line represents a 95 percent confidence interval. Figures present coefficient estimates from Table 3.
Figure 3: Replacement Rate of Lost Earnings with Revolving Credit

Notes: Figure shows the distribution of replacement rates using a kernel density. Replacement rate is the negative of the change in revolving credit balance over the change in earnings, where the change in earnings and the change in borrowing are measured from the year after displacement relative to the year before displacement. The replacement rate is defined for individuals who had a decline in earnings around displacement. A replacement rate of 0.2 indicates that an individual replaced 20 percent of their lost earnings with revolving credit.

Figure 4: Replacement Rate of Lost Earnings with Revolving Credit by Credit Score Quintile

Notes: Replacement rate estimates are from Column (2) of Table 5. See notes to Figure 3 for definition of replacement rate. Credit score quintiles are based upon an individual’s TransUnion bankruptcy score in the year prior to displacement.
Notes: Squares in the figures present the marginal effect of earnings loss on the variable of interest. Earnings loss is measured as the difference in real annual earnings in the year after displacement relative to the year before displacement. The estimates are taken from Column (3) of Tables 13-16. The coefficient for Credit Score Quintile 1 corresponds to the coefficient Chg. Earnings from the table, while the coefficient for Credit Score Quintile k corresponds to the sum of the coefficients Chg. Earnings and Chg. Earnings Credit Quin k. The dots represent a 95 percent confidence interval.
Notes: Figure presents estimates of the effect of job loss on earnings and credit variables comparing estimates from the data (red solid line) to estimates from the data (red dashed line). The black finely dashed lines represent 95 percent confidence intervals of data estimates.
Figure 7: Kernel Density of Replacement Rates, Model versus Data

Notes: Figure presents the models estimate of the replacement rate of credit (red dashed line) following job loss compared to the data estimate of the replacement rate of credit around job loss as measured in the 2007-2009 SCF panel (black solid line).
Figure 8: Welfare Effect of Change in Public Transfer to Unemployed

(a) Utilitarian Welfare Effect

(b) Median Welfare Effect

Notes: ‘Welfare’ is the consumption equivalent of leaving an economy with the US policy of a 41.2% replacement rate to an economy with an alternate replacement rate. Panel (a) plots an equal weighted average of welfare. Panel (b) plots the median welfare. For example, in panel (a), the utilitarian welfare change of 0.059% indicates that an individual, on average, would give up 0.059% of lifetime consumption to have a 43.9% replacement rate as opposed to a 41.2% replacement rate. In panel (b), the median welfare change of −0.035% means that the median individual would be willing to give up 0.035% of lifetime consumption to have a 41.2% replacement rate as opposed to a 43.9% replacement rate. See Appendix H for details on the estimation of the welfare effect.
Figure 9: Distribution of Welfare Changes from Changing Public Transfer to Unemployed

(a) Moving to 43.9% Replacement Rate  
(b) Moving to 39.8% Replacement Rate

Notes: ‘Welfare’ is the consumption equivalent of leaving an economy with the US policy of a 41.2% replacement rate to an economy with an alternate replacement rate. For this graph only, the tails of the distribution have been winsorized at the 1% level. See Appendix H for details on the estimation of the welfare effect.
Figure 10: Steady State Welfare Experiment

(a) Default Rate

(b) Consumption ratio (year after job loss to year before)

Notes: Figure shows output from the steady state welfare experiment where the replacement rate of public insurance to the unemployed is adjusted.
Notes: The figure shows the share of the population alive at the time of the transition that has a welfare gain when the replacement rate is lowered from 41.2% to 39.8%, where welfare is measured using consumption equivalents. The population is stratified by the persistent level of human capital.
A Data Appendix

A.1 Identifying Mass Layoffs

To identify mass layoffs, we combine data from the Longitudinal Business Dynamics (LBD) database on establishment exits with the LEHD. In each state, employers are assigned a State Employment Identification Number (SEIN) in the LEHD database. This is our unit of analysis for mass layoffs. We define a mass layoff to occur when an SEIN with at least 25 employees reduces its employment by 30% or more within a quarter and continues operations, or exits in the LEHD with a contemporaneous plant exit in the LBD. In California, we do not have LBD establishment exit information, however. To ensure that there was actually a mass layoff, we then verify that fewer than 80% of laid-off workers move to any other single SEIN using the Successor Predecessor File (SPF). This allows us to remove mergers, firm name-changes, and spin-offs from our sample.

B Robustness

In this appendix, we provide various robustness checks on our primary results. We include summary statistics for additional measures of consumer credit. We also present additional results for the average response of credit variables following job loss, and estimates of the response of borrowing to unemployment as measured in the SCF.

B.1 Summary Statistics: Additional Credit Measures

Table 10 provides summary statistics on the panel sample for additional measures of credit access and usage. The table shows that the treatment and control groups are very similar in their use of bank cards as well as their limits and unused limits to income in the year prior to mass layoff. The table also shows that individuals in the treatment and control groups are similar in their amount of total outstanding credit as well as credit limit in the year prior to layoff.

B.2 Additional Average Response Results

In this section, we estimate the average response of additional credit variables to job loss. First, we examine estimates of credit access as well as usage (Table 11), and then examine the impact on measures of default (Table 12). The coefficients in Tables 11 and 12 correspond to \((\beta_{-4}, \beta_{-3}, ..., \beta_4, \beta_5)\) in equation (1), and are interpreted as the difference in the outcome variable between displaced and nondisplaced individuals. Figure 12 plots the coefficient estimates from Tables 11 and 12 along with 95 percent confidence intervals for bank card limits and balances, as well as 60 day delinquencies and bankruptcy flags.
Table 10: Summary Statistics: Bank Cards and Total Credit

<table>
<thead>
<tr>
<th></th>
<th>Panel Sample (Year Prior to Mass Layoff)</th>
<th>(1) Treatment</th>
<th>(2) Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bank Card Balance</td>
<td>$5,641</td>
<td>$6,103</td>
<td></td>
</tr>
<tr>
<td>Bank Card Limit</td>
<td>$16,660</td>
<td>$18,020</td>
<td></td>
</tr>
<tr>
<td>Unused Bank Card Limit to Income</td>
<td>0.30</td>
<td>0.28</td>
<td></td>
</tr>
<tr>
<td>Total Balance</td>
<td>$116,900</td>
<td>$125,500</td>
<td></td>
</tr>
<tr>
<td>Total Limit</td>
<td>$143,300</td>
<td>$154,200</td>
<td></td>
</tr>
<tr>
<td>Observations (Rounded to 000s)</td>
<td>31000</td>
<td>30000</td>
<td></td>
</tr>
</tbody>
</table>

*Note: Sample selection criteria in Section 1.2. Credit balances and limits are in 2008 dollars. Unused bank card credit limit to income is winsorized at the 1-percent level at the top and bottom of the distribution.*

**B.2.1 Credit Access and Usage**

Table 11 documents the average response of additional measures of credit access and usage following job loss. Column (1) of Table 11 and Panel (a) of Figure 12 shows the difference in bank card limits for displaced and nondisplaced individuals around a mass layoff event. The figure shows that displaced and nondisplaced individuals do not have significantly different bank card limits prior to job loss; however in the years following displacement, displaced individuals have bank card limits which are significantly lower than nondisplaced individuals. While statistically significant, the size of the difference in bank card limits between displaced and nondisplaced individuals never exceeds $1200 and is economically small relative to the size of limits that individuals have prior to job loss (over $16.5k for individuals in the treatment group).

Column (2) of Table 11 and Panel (b) of Figure 12 displays the difference in bank card balances for displaced and nondisplaced individuals around a mass layoff event. The figure shows that displaced and nondisplaced individuals do not have significantly different bank card balances in the years prior to job loss and for the first several years following job loss. Two years after job loss, the difference in bank card balances between displaced and nondisplaced individuals is only $282, which, while statistically significant, is not economically significant, especially relative to the size of earnings losses, which two years after layoff remain over $9k.

Columns (3) and (4) show that there are similar results for total credit limits and balances around job loss. The magnitude of the decline in total credit balances is larger and statistically significant, however, column (5) shows the decline in total credit balances following job loss is driven almost entirely by declining mortgage balances.

Column (6) of Table 11 shows the difference in the probability to take out a new home equity line of credit for displaced and nondisplaced individuals around a mass layoff event. One year after job loss, the probability a displaced individuals takes out a new home equity line is 0.379 percentage points less than a nondisplaced individual. In all other years, there is no significant difference.
between the probability of taking out a new home equity line for displaced and nondisplaced individuals.

**B.2.2 Measures of Default**

Table 12 documents the average response of additional measures of default activity following job loss.

Column (1) of Table 12 and Panel (c) of Figure 12 shows the difference in the probability of having a 30 day delinquency within the past year between displaced and nondisplaced individuals. The figure shows that individuals begin to default on their outstanding debt balances following job loss. One year after displacement, the probability that a displaced individual has a 30 day delinquency is nearly 3 percentage points higher than a nondisplaced individual.

Column (2) of Table 12 and Panel (d) of Figure 12 shows the difference in the probability of having a bankruptcy flag between displaced and nondisplaced individuals. The figure shows that following job loss there is a steady increase in the probability that an individual has a bankruptcy flag on their credit report.

Column (3) of Table 12 shows the difference in the probability of having a foreclosure within the past year between displaced and nondisplaced individuals. The coefficient estimates show that in the year following displacement, the probability an individual has a foreclosure increases by nearly 0.5 percentage points.

Column (4) of Table 12 shows the difference in the probability of having a 60-day mortgage delinquency within the past year between displaced and nondisplaced individuals. The coefficient estimates show that in the year following displacement, the probability an individual has a sixty day mortgage delinquency increases by nearly 0.8 percentage points.
Table 11: Average Response of Additional Credit Variables to Displacement: Credit Access and Usage

<table>
<thead>
<tr>
<th></th>
<th>(1) Bank Card Limit</th>
<th>(2) Bank Card Balance</th>
<th>(3) Total Credit Limit</th>
<th>(4) Total Credit Balance</th>
<th>(5) Mortgage Balance</th>
<th>(6) New Home Equity Line (d)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 Years Before Displacement (d)</td>
<td>-85.24</td>
<td>41.51</td>
<td>440.2</td>
<td>629.2</td>
<td>756.4</td>
<td>-0.000220</td>
</tr>
<tr>
<td></td>
<td>(123.6)</td>
<td>(70.73)</td>
<td>(1,040)</td>
<td>(982.4)</td>
<td>(914.7)</td>
<td>(0.00155)</td>
</tr>
<tr>
<td>3 Years Before Displacement (d)</td>
<td>-202.1</td>
<td>-4.864</td>
<td>-891.8</td>
<td>-622.0</td>
<td>-747.1</td>
<td>-1.20e-05</td>
</tr>
<tr>
<td></td>
<td>(161.7)</td>
<td>(87.64)</td>
<td>(1,412)</td>
<td>(1,319)</td>
<td>(1,214)</td>
<td>(0.00164)</td>
</tr>
<tr>
<td>2 Years Before Displacement (d)</td>
<td>-301.0</td>
<td>-33.00</td>
<td>-2,015</td>
<td>-1,624</td>
<td>-1,968</td>
<td>0.000381</td>
</tr>
<tr>
<td></td>
<td>(186.6)</td>
<td>(94.32)</td>
<td>(1,746)</td>
<td>(1,622)</td>
<td>(1,483)</td>
<td>(0.00169)</td>
</tr>
<tr>
<td>1 Year Before Displacement (d)</td>
<td>-244.7</td>
<td>4.168</td>
<td>-2,909</td>
<td>-2,211</td>
<td>-2,854</td>
<td>-8.66e-05</td>
</tr>
<tr>
<td></td>
<td>(209.2)</td>
<td>(102.3)</td>
<td>(2,081)</td>
<td>(1,929)</td>
<td>(1,750)</td>
<td>(0.00182)</td>
</tr>
<tr>
<td>Year of Displacement (d)</td>
<td>-486.1**</td>
<td>-139.1</td>
<td>-7,670***</td>
<td>-6,488***</td>
<td>-6,111***</td>
<td>-0.000649</td>
</tr>
<tr>
<td></td>
<td>(227.8)</td>
<td>(108.5)</td>
<td>(2,343)</td>
<td>(2,171)</td>
<td>(1,981)</td>
<td>(0.00190)</td>
</tr>
<tr>
<td>1 Year After Displacement (d)</td>
<td>-837.3***</td>
<td>-149.9</td>
<td>-14,710***</td>
<td>-12,590***</td>
<td>-11,280***</td>
<td>-0.00379**</td>
</tr>
<tr>
<td></td>
<td>(242.0)</td>
<td>(114.6)</td>
<td>(2,576)</td>
<td>(2,385)</td>
<td>(2,178)</td>
<td>(0.00179)</td>
</tr>
<tr>
<td>2 Years After Displacement (d)</td>
<td>-966.1***</td>
<td>-282.6**</td>
<td>-13,440***</td>
<td>-11,230***</td>
<td>-10,100***</td>
<td>-6.11e-05</td>
</tr>
<tr>
<td></td>
<td>(262.7)</td>
<td>(124.0)</td>
<td>(2,841)</td>
<td>(2,632)</td>
<td>(2,404)</td>
<td>(0.00199)</td>
</tr>
<tr>
<td>3 Years After Displacement (d)</td>
<td>-1,059***</td>
<td>-385.9***</td>
<td>-11,540***</td>
<td>-9,111***</td>
<td>-8,310***</td>
<td>0.00260</td>
</tr>
<tr>
<td></td>
<td>(288.3)</td>
<td>(136.2)</td>
<td>(3,185)</td>
<td>(2,958)</td>
<td>(2,704)</td>
<td>(0.00225)</td>
</tr>
<tr>
<td>4 Years After Displacement (d)</td>
<td>-1,148***</td>
<td>-307.3**</td>
<td>-12,860***</td>
<td>-10,180***</td>
<td>-9,742***</td>
<td>0.000949</td>
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<tr>
<td></td>
<td>(328.4)</td>
<td>(156.3)</td>
<td>(3,567)</td>
<td>(3,313)</td>
<td>(3,026)</td>
<td>(0.00241)</td>
</tr>
<tr>
<td>5 Years After Displacement (d)</td>
<td>-1,133***</td>
<td>-427.7***</td>
<td>-13,000***</td>
<td>-10,490***</td>
<td>-9,551***</td>
<td>0.00299</td>
</tr>
<tr>
<td></td>
<td>(390.4)</td>
<td>(184.7)</td>
<td>(3,972)</td>
<td>(3,696)</td>
<td>(3,366)</td>
<td>(0.00268)</td>
</tr>
</tbody>
</table>

| Individual Fixed Effects       | Y                   | Y                     | Y                      | Y                        | Y                    | Y                           |
| Year Fixed Effects             | Y                   | Y                     | Y                      | Y                        | Y                    | Y                           |
| Age and Wealth Controls        | Y                   | Y                     | Y                      | Y                        | Y                    | Y                           |
| R-squared                      | 0.012               | 0.006                 | 0.081                  | 0.074                    | 0.072                | 0.007                       |
| Indiv-Yr Obs.                  | 472000              | 472000                | 472000                 | 472000                   | 472000              | 472000                      |
| No. of Indiv                   | 61000               | 61000                 | 61000                  | 61000                    | 61000               | 61000                       |

Notes: Clustered SE in parenthesis, where the clustering is performed at the level of the firm where the worker was displaced. ***p < 0.01, **p < 0.05, *p < 0.1. Age and wealth controls include a quadratic in age, and deciles for lagged cumulative earnings. The symbol (d) indicates a dummy variable. Bank card limit and balance are in 2008 dollars.
Table 12: Average Response of Additional Credit Variables to Displacement: Measures of Default

<table>
<thead>
<tr>
<th></th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>30 Day</td>
<td>Bankruptcy</td>
<td>60 Day</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Delinq. (d)</td>
<td>Flag (d)</td>
<td>Mort. Delinq. (d)</td>
<td></td>
</tr>
<tr>
<td>4 Years Before Displacement</td>
<td>0.00430 (0.00467)</td>
<td>0.00539** (0.00212)</td>
<td>0.00114 (-0.000562)</td>
<td></td>
</tr>
<tr>
<td>3 Years Before Displacement</td>
<td>-0.00153 (0.00510)</td>
<td>0.00978*** (0.00276)</td>
<td>0.00104 (0.000782)</td>
<td></td>
</tr>
<tr>
<td>2 Years Before Displacement</td>
<td>-0.00938* (0.00527)</td>
<td>0.00862*** (0.00320)</td>
<td>0.00110 (-0.000114)</td>
<td></td>
</tr>
<tr>
<td>1 Year Before Displacement</td>
<td>-0.00308 (0.00556)</td>
<td>0.0119*** (0.00363)</td>
<td>0.00154* (0.000822)</td>
<td></td>
</tr>
<tr>
<td>Year of Displacement</td>
<td>0.0120** (0.00577)</td>
<td>0.0160*** (0.00339)</td>
<td>0.00247** (0.000966)</td>
<td></td>
</tr>
<tr>
<td>1 Year After Displacement</td>
<td>0.0295*** (0.00600)</td>
<td>0.0206*** (0.00426)</td>
<td>0.00468** (0.00103)</td>
<td></td>
</tr>
<tr>
<td>2 Years After Displacement</td>
<td>0.0185*** (0.00651)</td>
<td>0.0232*** (0.00463)</td>
<td>0.00347*** (0.00106)</td>
<td></td>
</tr>
<tr>
<td>3 Years After Displacement</td>
<td>0.00455 (0.00725)</td>
<td>0.0235*** (0.00498)</td>
<td>0.00287** (0.00121)</td>
<td></td>
</tr>
<tr>
<td>4 Years After Displacement</td>
<td>-0.0181** (0.00811)</td>
<td>0.0255*** (0.00561)</td>
<td>0.00172 (0.00136)</td>
<td></td>
</tr>
<tr>
<td>5 Years After Displacement</td>
<td>-0.0246** (0.00979)</td>
<td>0.0318*** (0.00676)</td>
<td>0.000127 (-0.00396)</td>
<td></td>
</tr>
</tbody>
</table>

| Individual Fixed Effects      | Y        | Y        | Y        | Y        |
| Year Fixed Effects            | Y        | Y        | Y        | Y        |
| Age and Wealth Controls       | Y        | Y        | Y        | Y        |
| R-squared                     | 0.008    | 0.020    | 0.003    | 0.006    |
| Indiv-Yr Obs.                 | 472000   | 472000   | 472000   | 472000   |
| No. of Indiv                  | 61000    | 61000    | 61000    | 61000    |

Notes: Clustered SE in parenthesis, where the clustering is performed at the level of the firm where the worker was displaced. ***p < 0.01, **p < 0.05, *p < 0.1. Age and wealth controls include a quadratic in age, and deciles for lagged cumulative earnings. The symbol (d) indicates a dummy variable. Bank card limit and balance are in 2008 dollars.
Figure 12: Additional Average Response Results

Notes: Figure presents estimates of the effect of job loss on credit market variables and measures of default and delinquency. Solid line is the difference in the outcome variable between displaced and nondisplaced individuals. Dashed line represents a 95 percent confidence interval. Figures present coefficient estimates from Tables 11 and 12.
B.3 Heterogeneous Response to Earnings Changes

In this Appendix we present the estimation results of equation (4) for: (1) changes in revolving credit balances (Table 13); (2) 60 day delinquencies (Table 14); (3) debt chargeoffs (Table 15); and (4) derogatory public flags (Table 16). These results underlie the graphs presented in Figure 5.

B.4 SCF Evidence

In this section we present results from the publicly available SCF and show that they are consistent with the results from our LEHD/TransUnion sample.

In Figure 13, we present the credit replacement rate of the unemployed as measured in the SCF. To estimate the credit replacement rate in the SCF, we exploit the panel nature of the SCF between 2007 and 2009. In particular, we estimate the change in non-mortgage debt and income for individuals who experienced at least one month of unemployment in the past year when interviewed as part of the 2009 SCF. Figure 13 reveals a similar pattern on the borrowing activity of the unemployed as our LEHD/TransUnion sample (Figure 3).

Figure 13: Credit Replacement Rate of Unemployed from SCF

Notes: Figure presents the credit replacement rate using the 2007-2009 waves of the SCF.
Table 13: Earnings Losses and Change in Revolving Credit Balances by Credit Score

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>2 Yr. Chg. Earnings</td>
<td>-0.0304*** (0.00853)</td>
<td>0.0330** (0.0135)</td>
<td>0.0210 (0.0145)</td>
</tr>
<tr>
<td>2 Yr. Chg. Earnings x Credit Score Quin 2</td>
<td>0.00454 (0.0209)</td>
<td>0.00595 (0.0209)</td>
<td></td>
</tr>
<tr>
<td>2 Yr. Chg. Earnings x Credit Score Quin 3</td>
<td>-0.0299 (0.0234)</td>
<td>-0.0303 (0.0235)</td>
<td></td>
</tr>
<tr>
<td>2 Yr. Chg. Earnings x Credit Score Quin 4</td>
<td>-0.0515** (0.0241)</td>
<td>-0.0517** (0.0241)</td>
<td></td>
</tr>
<tr>
<td>2 Yr. Chg. Earnings x Credit Score Quin 5</td>
<td>-0.0737*** (0.0222)</td>
<td>-0.0749*** (0.0223)</td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>324.6 (246.3)</td>
<td>-627.7** (305.0)</td>
<td>-4,587** (1,991)</td>
</tr>
<tr>
<td>Credit Score Quin 2 (d)</td>
<td>-359.7 (504.3)</td>
<td>-321.1 (507.9)</td>
<td></td>
</tr>
<tr>
<td>Credit Score Quin 3 (d)</td>
<td>-335.3 (595.6)</td>
<td>-220.1 (596.9)</td>
<td></td>
</tr>
<tr>
<td>Credit Score Quin 4 (d)</td>
<td>3,220*** (704.6)</td>
<td>3,369*** (699.9)</td>
<td></td>
</tr>
<tr>
<td>Credit Score Quin 5 (d)</td>
<td>6,365*** (754.6)</td>
<td>6,618*** (749.5)</td>
<td></td>
</tr>
</tbody>
</table>

Year Fixed Effects: N; Age and Wealth Controls: N, Y
R-Square: 0.001, 0.031, 0.034; No of Indiv.: 19000, 19000, 19000
P-Value Chg Earn Quin 2: 0.0197, 0.113; P-Value Chg Earn Quin 3: 0.870, 0.632; P-Value Chg Earn Quin 4: 0.347, 0.139; P-Value Chg Earn Quin 5: 0.0209, 0.00403

Notes: Clustered SE in parenthesis, where the clustering is performed at the level of the firm where the worker was displaced. ***p < 0.01, **p < 0.05,*p < 0.1. The 2-year change in real annual earnings, and 2-year change in real revolving balances are measured comparing the year after displacement relative to the year prior to displacement, are both winsorized at the top and bottom at the 1 percent level, and are measured in 2008 dollars. Credit Score Quin k refers to credit score quintile k, where credit score quintiles are based upon an individuals TransUnion bankruptcy score in the year prior to displacement. The symbol (d) indicates a dummy variable. Age and wealth controls include a quadratic in age, and deciles for lagged cumulative earnings. P-Value Chg Earn Quin k refers to the p-value for the sum of the coefficients Chg. Earn and Chg. Earn x Credit Score Quin k.
### Table 14: Earnings Losses and 60 Day Delinquency by Credit Score In Year After Mass Layoff

<table>
<thead>
<tr>
<th></th>
<th>(1) 60 Day Delinq (d)</th>
<th>(2) 60 Day Delinq (d)</th>
<th>(3) 60 Day Delinq (d)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(Year After Mass Layoff)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 Yr. Chg. Earnings</td>
<td>8.57e-07***</td>
<td>-6.54e-07*</td>
<td>-1.23e-06***</td>
</tr>
<tr>
<td></td>
<td>(1.33e-07)</td>
<td>(3.78e-07)</td>
<td>(3.90e-07)</td>
</tr>
<tr>
<td>2 Yr. Chg. Earnings x Credit Score Quin 2 (d)</td>
<td>-2.21e-08</td>
<td>-2.22e-08</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(5.45e-07)</td>
<td>(5.45e-07)</td>
<td></td>
</tr>
<tr>
<td>2 Yr. Chg. Earnings x Credit Score Quin 3 (d)</td>
<td>9.57e-07*</td>
<td>9.67e-07*</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(4.96e-07)</td>
<td>(4.96e-07)</td>
<td></td>
</tr>
<tr>
<td>2 Yr. Chg. Earnings x Credit Score Quin 4 (d)</td>
<td>7.70e-07*</td>
<td>8.11e-07*</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(4.53e-07)</td>
<td>(4.53e-07)</td>
<td></td>
</tr>
<tr>
<td>2 Yr. Chg. Earnings x Credit Score Quin 5 (d)</td>
<td>9.88e-07**</td>
<td>1.03e-06**</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(4.24e-07)</td>
<td>(4.25e-07)</td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>0.419***</td>
<td>0.526***</td>
<td>0.486***</td>
</tr>
<tr>
<td></td>
<td>(0.00557)</td>
<td>(0.0129)</td>
<td>(0.0540)</td>
</tr>
<tr>
<td>Credit Score Quin 2 (d)</td>
<td>-0.0302</td>
<td>-0.0320*</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.0185)</td>
<td>(0.0185)</td>
<td></td>
</tr>
<tr>
<td>Credit Score Quin 3 (d)</td>
<td>-0.0835***</td>
<td>-0.0822***</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.0179)</td>
<td>(0.0179)</td>
<td></td>
</tr>
<tr>
<td>Credit Score Quin 4 (d)</td>
<td>-0.241***</td>
<td>-0.236***</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.0170)</td>
<td>(0.0170)</td>
<td></td>
</tr>
<tr>
<td>Credit Score Quin 5 (d)</td>
<td>-0.309***</td>
<td>-0.301***</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.0163)</td>
<td>(0.0164)</td>
<td></td>
</tr>
<tr>
<td>Year FE</td>
<td>N</td>
<td>N</td>
<td>Y</td>
</tr>
<tr>
<td>Age and Wealth Controls</td>
<td>N</td>
<td>N</td>
<td>Y</td>
</tr>
<tr>
<td>R-Square</td>
<td>0.002</td>
<td>0.074</td>
<td>0.078</td>
</tr>
<tr>
<td>No of Indiv.</td>
<td>19000</td>
<td>19000</td>
<td>19000</td>
</tr>
<tr>
<td>P-Value 2-Year Chg Earn Quin 2</td>
<td>0.0862</td>
<td>0.00190</td>
<td></td>
</tr>
<tr>
<td>P-Value 2-Year Chg Earn Quin 3</td>
<td>0.354</td>
<td>0.432</td>
<td></td>
</tr>
<tr>
<td>P-Value 2-Year Chg Earn Quin 4</td>
<td>0.646</td>
<td>0.116</td>
<td></td>
</tr>
<tr>
<td>P-Value 2-Year Chg Earn Quin 5</td>
<td>0.0851</td>
<td>0.325</td>
<td></td>
</tr>
</tbody>
</table>

**Notes:** Clustered SE in parenthesis, where the clustering is performed at the level of the firm where the worker was displaced. ** ***p < 0.01, ** p < 0.05, *p < 0.1. The 2-year change in real annual earnings measures the change in earnings from the year after mass layoff relative to the year before mass layoff and is winsorized at the top and bottom at the 1 percent level. Earnings are measured in 2008 dollars. The dependent variable 60-day delinquency is measured in the year after displacement. Credit Score Quin k refers to credit score quintile k, where credit score quintiles are based upon an individuals TransUnion bankruptcy score in the year prior to displacement. The symbol (d) indicates a dummy variable. Age and wealth controls include a quadratic in age, and deciles for lagged cumulative earnings. P-Value 2-Year Chg Earn Quin k refers to the p-value for the sum of the coefficients 2-Year Chg. Earn and 2-Year Chg. Earn x Credit Score Quin k.
Table 15: Earnings Losses and Debt Chargeoff by Credit Score In Year After Mass Layoff

<table>
<thead>
<tr>
<th></th>
<th>(1) Debt Chargeoff (d)</th>
<th>(2) Debt Chargeoff (d)</th>
<th>(3) Debt Chargeoff (d)</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>(Year After Mass Layoff)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(9.88e-08)</td>
<td>(3.42e-07)</td>
<td>(3.46e-07)</td>
</tr>
<tr>
<td>2 Yr. Chg. Earnings x Credit Score Quin 2 (d)</td>
<td>-3.15e-09</td>
<td>-2.31e-08</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(4.71e-07)</td>
<td>(4.69e-07)</td>
<td></td>
</tr>
<tr>
<td>2 Yr. Chg. Earnings x Credit Score Quin 3 (d)</td>
<td>2.85e-07</td>
<td>2.85e-07</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(4.20e-07)</td>
<td>(4.17e-07)</td>
<td></td>
</tr>
<tr>
<td>2 Yr. Chg. Earnings x Credit Score Quin 4 (d)</td>
<td>3.75e-07</td>
<td>4.32e-07</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(3.78e-07)</td>
<td>(3.76e-07)</td>
<td></td>
</tr>
<tr>
<td>2 Yr. Chg. Earnings x Credit Score Quin 5 (d)</td>
<td>3.09e-07</td>
<td>3.84e-07</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(3.59e-07)</td>
<td>(3.57e-07)</td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>0.179***</td>
<td>0.249***</td>
<td>0.319***</td>
</tr>
<tr>
<td></td>
<td>(0.00428)</td>
<td>(0.0117)</td>
<td>(0.0432)</td>
</tr>
<tr>
<td>Credit Score Quin 2 (d)</td>
<td>-0.0133</td>
<td>-0.0154</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.0159)</td>
<td>(0.0159)</td>
<td></td>
</tr>
<tr>
<td>Credit Score Quin 3 (d)</td>
<td>-0.0629***</td>
<td>-0.0625***</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.0151)</td>
<td>(0.0150)</td>
<td></td>
</tr>
<tr>
<td>Credit Score Quin 4 (d)</td>
<td>-0.150***</td>
<td>-0.146***</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.0137)</td>
<td>(0.0137)</td>
<td></td>
</tr>
<tr>
<td>Credit Score Quin 5 (d)</td>
<td>-0.195***</td>
<td>-0.189***</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.0129)</td>
<td>(0.0130)</td>
<td></td>
</tr>
<tr>
<td>Year FE</td>
<td>N</td>
<td>N</td>
<td>Y</td>
</tr>
<tr>
<td>Age and Wealth Controls</td>
<td>N</td>
<td>N</td>
<td>Y</td>
</tr>
<tr>
<td>R-Square</td>
<td>0.001</td>
<td>0.046</td>
<td>0.050</td>
</tr>
<tr>
<td>No of Indiv.</td>
<td>19000</td>
<td>19000</td>
<td>19000</td>
</tr>
</tbody>
</table>

Notes: Clustered SE in parenthesis, where the clustering is performed at the level of the firm where the worker was displaced. ***p < 0.01, **p < 0.05, *p < 0.1. The 2-year change in real annual earnings measures the change in earnings from the year after mass layoff relative to the year before mass layoff and is winsorized at the top and bottom at the 1 percent level. Earnings are measured in 2008 dollars. The dependent variable debt chargeoff is measured in the year after displacement. Credit Score Quin k refers to credit score quintile k, where credit score quintiles are based upon an individual's TransUnion bankruptcy score in the year prior to displacement. The symbol (d) indicates a dummy variable. Age and wealth controls include a quadratic in age, and deciles for lagged cumulative earnings. P-Value 2-Year Chg Earn Quin k refers to the p-value for the sum of the coefficients 2-Year Chg. Earn and 2-Year Chg. Earn x Credit Score Quin k.
Table 16: Earnings Losses and Derogatory Flag by Credit Score In Year After Mass Layoff

<table>
<thead>
<tr>
<th></th>
<th>Derogatory Flag (d)</th>
<th>Derogatory Flag (d)</th>
<th>Derogatory Flag (d)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(Year after Mass Layoff)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 Year Chg. Earnings</td>
<td>-1.03e-07</td>
<td>-5.60e-07**</td>
<td>-6.13e-07**</td>
</tr>
<tr>
<td></td>
<td>(6.86e-08)</td>
<td>(2.75e-07)</td>
<td>(2.77e-07)</td>
</tr>
<tr>
<td>2 Year Chg. Earnings x Credit Score Quin 2</td>
<td>1.84e-07</td>
<td>1.84e-07</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(3.52e-07)</td>
<td>(3.51e-07)</td>
<td></td>
</tr>
<tr>
<td>Chg. Earnings x Credit Score Quin 2</td>
<td>7.85e-08</td>
<td>7.12e-08</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(3.30e-07)</td>
<td>(3.30e-07)</td>
<td></td>
</tr>
<tr>
<td>Chg. Earnings x Credit Score Quin 2</td>
<td>3.57e-07</td>
<td>3.66e-07</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(2.98e-07)</td>
<td>(2.99e-07)</td>
<td></td>
</tr>
<tr>
<td>Chg. Earnings x Credit Score Quin 2</td>
<td>4.04e-07</td>
<td>4.08e-07</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(2.85e-07)</td>
<td>(2.86e-07)</td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>0.0572***</td>
<td>0.0940***</td>
<td>0.0444*</td>
</tr>
<tr>
<td></td>
<td>(0.00270)</td>
<td>(0.00864)</td>
<td>(0.0260)</td>
</tr>
<tr>
<td>Credit Score Quin 2 (d)</td>
<td>-0.0270**</td>
<td>-0.0269**</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.0111)</td>
<td>(0.0110)</td>
<td></td>
</tr>
<tr>
<td>Credit Score Quin 3 (d)</td>
<td>-0.0410***</td>
<td>-0.0405***</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.0106)</td>
<td>(0.0106)</td>
<td></td>
</tr>
<tr>
<td>Credit Score Quin 4 (d)</td>
<td>-0.0654***</td>
<td>-0.0641***</td>
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</tr>
<tr>
<td></td>
<td>(0.00982)</td>
<td>(0.00982)</td>
<td></td>
</tr>
<tr>
<td>Credit Score Quin 5 (d)</td>
<td>-0.0829***</td>
<td>-0.0810***</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.00920)</td>
<td>(0.00921)</td>
<td></td>
</tr>
<tr>
<td>Year Fixed Effects</td>
<td>N</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>Age and Wealth Controls</td>
<td>N</td>
<td>N</td>
<td>Y</td>
</tr>
<tr>
<td>R-Square</td>
<td>0.000</td>
<td>0.020</td>
<td>0.021</td>
</tr>
<tr>
<td>No of Indiv.</td>
<td>19000</td>
<td>19000</td>
<td>19000</td>
</tr>
<tr>
<td>P-Value Chg Earn Quin 2</td>
<td>0.0941</td>
<td>0.0592</td>
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</tr>
<tr>
<td>P-Value Chg Earn Quin 3</td>
<td>0.00830</td>
<td>0.00360</td>
<td></td>
</tr>
<tr>
<td>P-Value Chg Earn Quin 4</td>
<td>0.0978</td>
<td>0.0528</td>
<td></td>
</tr>
<tr>
<td>P-Value Chg Earn Quin 5</td>
<td>0.0441</td>
<td>0.0191</td>
<td></td>
</tr>
</tbody>
</table>

Notes: Clustered SE in parenthesis, where the clustering is performed at the level of the firm where the worker was displaced. ***, **, *p < 0.01, 0.05, 0.1. The 2-year change in real annual earnings measures the change in earnings from the year after mass layoff relative to the year before mass layoff and is winsorized at the top and bottom at the 1 percent level. Earnings are measured in 2008 dollars. The dependent variable derogatory public flag is measured in the year after displacement. Credit Score Quin k refers to credit score quintile k, where credit score quintiles are based upon an individual's TransUnion bankruptcy score in the year prior to displacement. The symbol (d) indicates a dummy variable. Age and wealth controls include a quadratic in age, and deciles for lagged cumulative earnings. P-Value 2-Year Chg Earn Quin k refers to the p-value for the sum of the coefficients 2-Year Chg. Earn and 2-Year Chg. Earn x Credit Score Quin k.
C Employed Value Functions

In this appendix we present the value functions for employed individuals, as well as lenders who are matched with an employed individual.

C.1 Bellman Equations for Employed Agents

In this appendix, we present the Bellman equations for an employed agent.

Every period employed individuals without a credit contract, decide whether or not to search for a credit contract:

\[ W_{i,t}^S(\omega, b, \vec{h}; 0, 0) = \max \{ -\kappa_S + W_{i,t}^A(\omega, b, \vec{h}; 0, 0); W_{i,t}^N(\omega, b, \vec{h}; 0, 0) \} \quad \forall t \leq T \]

\[ W_{i,T+1}^S(\omega, b, \vec{h}; 0, 0) = 0 \]

where:

\[ W_{i,t}^A(\omega, b, \vec{h}; 0, 0) = \max_{(b, r) \in \mathbb{B} \times \mathbb{R}} p^f(\theta_t^{c_{iW}}(\omega, b, \vec{h}; b, r)) W_{i,t}^C(\omega, b, \vec{h}; b, r) \]

\[ + \left( 1 - p^f(\theta_t^{c_{iW}}(\omega, b, \vec{h}; b, r)) \right) W_{i,t}^N(\omega, b, \vec{h}; 0, 0) \]

After the asset market closes, the agent makes their consumption and savings decisions. For an agent that did not not receive a credit contract, their consumption and savings problem is constrained in that the agent is not allowed to borrow. At the start of the next period with probability \( \delta \) the agent loses their job, and is immediately able to search for a job.\(^{36} \) The value function summarizing the payoffs of an employed agent without credit access is

\[ W_{i,t}^N(\omega, b, \vec{h}; 0, 0) = \max_{b' \geq 0} u(c) + \beta_i E \left[ (1 - \delta) W_{i,t+1}^S(\omega, b', \vec{h}'; 0, 0) + \delta \left( \max_{\omega} p(\theta_{i,t+1}(\vec{h})) W_{i,t+1}^S(\omega, b', \vec{h}'; 0, 0) \right) \right. \]

\[ \left. + \left( 1 - p(\theta_{i,t+1}(\vec{h})) \right) U_{i,t+1}^S(b', \vec{h}'; 0, 0) \right] \quad \forall t \leq T \]

\[ W_{i,T+1}^N(\omega, b, \vec{h}; 0, 0) = 0 \]

subject to the budget constraint,

\[ c + q(b', 0)b' \leq (1 - \tau) \omega f(\vec{h}) + b \]

\(^{36} \)Given the model period is 1 quarter we must allow individuals to search immediately in order for the model to match labor flows in the data.
and law of motion for employed individuals’ human capital,

\[ \vec{h}' = H(\vec{h}, W) \] (13)

As before, the bond price is given by: 

\[ q(b', r) = \mathbb{I}\{b' < 0\} \frac{1}{1+r} + \mathbb{I}\{b' \geq 0\} \frac{1}{1+r_f}. \]

For an agent with a credit contract, their consumption and savings problem is constrained by their borrowing limit \( b \). At the start of the next period with probability \( \delta \) the agent loses their job, and is immediately able to search for a job. The value function summarizing the payoffs of an employed agent with credit access is

\[
W_{i,t}^C(\omega, b, \vec{h}; b, r) = \max_{b' \geq b} u(c) + \beta \mathbb{E}\left[(1 - \delta)W_{i,t+1}^D(\omega, b', \vec{h}'; \bar{b}, r) + \delta \left( \max_{\vec{h}'} p(\theta, \omega, \vec{h}') W_{i,t+1}^D(\omega, b', \vec{h}'; \bar{b}, r) \right) + \left(1 - p(\theta, \omega, \vec{h}')\right) U_{i,t+1}^D(b', \vec{h}'; \bar{b}, r) \right] \quad \forall t \leq T
\]

\[ W_{i,T+1}(\omega, b, \vec{h}; 0, 0) = 0 \]

subject to the budget constraint,

\[ c + q(b', r)b' \leq (1 - \tau)\omega f(\vec{h}) + b \]

and the law of motion for human capital (equation (13)). After the labor market closes, the agent observes if their credit match has been exogenously ended. With probability \( \delta_c \) the agent loses their credit market access. After the realization of the credit separation shock the agent decides whether or not to default. The default decision and the resulting continuation value for an unemployed worker is given by

\[
W_{i,t+1}^D(\omega, b, \vec{h}; b, r) = \delta_c \max\{W_{i,t+1}^N(\omega, 0, \vec{h}; 0, 0) - \psi_D(b); W_{i,t+1}^N(\omega, b', \vec{h}; 0, 0)\} + (1 - \delta_c) \max\{W_{i,t+1}^N(\omega, 0, \vec{h}; 0, 0) - \psi_D(b); W_{i,t+1}^C(\omega, b', \vec{h}; \bar{b}, r)\}
\]

Let \( D_{i,t+1}^{N,W}(\omega, b', \vec{h}; \bar{b}, r) \) be an indicator function denoting an individual’s default decision when they are employed and are hit by the credit separation shock, (i.e. \( D_{i,t+1}^{N,W} = 1 \) when the individual defaults and is equal to zero otherwise). Let \( D_{i,t+1}^{C,W}(\omega, b', \vec{h}; \bar{b}, r) \) be an indicator function denoting an individual’s default decision when they are employed and are not hit by the credit separation shock.

**C.2 Bellman Equation for Lender Matched with Employed Worker**

In this appendix, we present the Bellman equations for a lender in a match with an employed worker.
Let $\Pi_{i,t}^W$ denote the profits to a lender of being matched with a type $i$, age $t$, employed individual. The profits to the lender of offering a contract with borrowing limit $b$, and interest rate $r$ is

$$
\Pi_{i,t}^W(\omega, b', \tilde{h}; b, r) = \beta_t b'_i t(\tilde{x}) \left( \frac{rf - r}{1 + r} + \mathbb{E} \left[ \delta_c \hat{D}_{i,t+1}^{NW}(\tilde{x}') + (1 - \delta_c) \hat{D}_{i,t+1}^{CW}(\tilde{x}') \right] \right) \times \mathbb{I}\{b'_i t(\tilde{x}) < 0\}
$$

$$
+ \beta_t (1 - \delta_c) \mathbb{E} \left[ \left( 1 - \hat{D}_{i,t+1}^{CW}(\tilde{x}') \right) \hat{\Pi}_{i,t+1}^W(\tilde{x}') \right]
$$

At the end of period $t$, the agent makes their consumption/savings decision $b'_i t$. If the individual is borrowing, $b'_i t < 0$, then in period $t+1$ the lender receives income from the difference between the interest rate $r$ and the risk free rate $r_f$. However the lender faces default risk on the outstanding loan $b'_i t$. The default risk faced by the lender incorporates the probability of the credit separation shock, as well as shocks to human capital and probability that the borrower loses their job. When the worker exogenously separates from the firm, the worker immediately is able to search again. The default probability when hit by the credit shock is

$$
\hat{D}_{i,t+1}^{NW}(\tilde{x}') = (1 - \delta) D_{i,t+1}^{NW}(\tilde{x}')
$$

$$
+ \delta \left[ p\left( \theta_{i,t+1}(\hat{\omega}, \tilde{h}) \right) D_{i,t+1}^{NW}(\hat{\omega}, b', \tilde{h}'; b, r) + \left( 1 - p\left( \theta_{i,t+1}(\hat{\omega}, \tilde{h}) \right) \right) D_{i,t+1}^{NW}(b', \tilde{h}'; b, r) \right]
$$

where $\hat{\omega}$ is the unemployed workers choice for where to search for a job. If the agent does not default and the credit match is not hit by the credit separation shock the match between the lender and borrower continues to the next period. The profits to the lender in period $t+1$, are denoted by $\hat{\Pi}_{i,t+1}^W(\tilde{x}')$, and take into account the probability that the agent loses their job. The continuation profits to the lender are

$$
\hat{\Pi}_{i,t+1}^W(\tilde{x}') = (1 - \delta) \Pi_{i,t+1}^W(\omega, b', \tilde{h}'; b, r)
$$

$$
+ \delta \left[ p\left( \theta_{i,t+1}(\hat{\omega}, \tilde{h}) \right) \Pi_{i,t+1}^W(\hat{\omega}, b', \tilde{h}'; b, r) + \left( 1 - p\left( \theta_{i,t+1}(\hat{\omega}, \tilde{h}) \right) \right) \Pi_{i,t+1}^U(b', \tilde{h}'; b, r) \right]
$$

Lenders pay cost $\kappa_C$ to enter the lending market. Free-entry in the lending market requires that the cost of entering the market is equal to the expected payout of entering the market:

$$
\kappa_C \geq \mathbb{E}_I \left[ \left( \theta_{i,t}^W(\omega, \tilde{b}, \tilde{h}; b, r) \right) \sum_i \chi_{i,t}^W(\omega, \tilde{b}, \tilde{h}; b, r) \Pi_{i,t}^W(\omega, \tilde{b}, \tilde{h}; b, r) \right]
$$

where $\chi_{i,t}^W(\omega, \tilde{b}, \tilde{h}; b, r)$ is the lenders belief for the share of individuals who arrive in market $(b, r)$ with states $(\omega, b, \tilde{h})$ that are age $t$,type $i$ and are employed. Note that individuals who are searching for credit contracts are not currently able to borrow, hence the free entry condition (equation (14)) holds for $b \geq 0$. 

64
D Equilibrium Definition

In this Appendix, we formally define an equilibrium for the model presented in Section 2.

Before defining the equilibrium, more notation is necessary. Define $B$ as the set of all potential credit contracts, and define $B_{c,t}^e(\omega, b, \bar{h})$ as the set of all contracts that are posted in equilibrium for an age $t$ agent with states $(\omega, b, \bar{h})$ where $e \in \{U, W\}$ denotes whether an individual is employed or unemployed. Additionally, let $\lambda_{e,t}(\omega, b, \bar{h}; b, r)$ denote the distribution of contracts posted in equilibrium for age $t$ agent with employment status $e$ and states $(\omega, b, \bar{h})$.

A competitive search equilibrium is a set of individual policy functions for savings and borrowing \(\{b_{i,e,t}(\omega, b, \bar{H}; b, r)\}_{t=1}^T\), credit applications \(\{S_{i,t}^e(\omega, b, \bar{H}; 0, 0)\}_{t=1}^T\), bankruptcy \(\{D_{i,t}^{e,0}(\omega, b, \bar{H}; b, r)\}_{t=1}^T\), job search choice \(\{\hat{\omega}_{i,t}(\omega, b, \bar{H}; b, r)\}_{t=1}^T\), a credit contract choice \(\{(r, b)_{i,e,t}(\omega, b, \bar{H}; 0, 0)\}_{t=1}^T\), a labor market tightness function \(\{\theta_{i,t}(\omega, \bar{h})\}_{t=1}^T\), a credit market tightness function \(\{\theta_{i,t}^c(\omega, b, \bar{h}; b, r)\}_{t=1}^T\), an unemployment insurance replacement rate $z$, and a proportional tax rate $\tau$ that satisfy the following conditions:

1. Profit Maximization and Free Entry.
   (a) Labor Market: For any labor market contract $(\omega, \bar{h})_{i,t}$, the firm’s free entry condition (equation (11)) is satisfied.
   (b) Credit Market: For any credit market contract $(b, r) \in B$
   \[
   \kappa_C \geq p_f \left( \theta_t^{e,c}(\omega, b, \bar{h}; b, r) \right) \sum_i \chi_{i,t}^e(\omega, b, \bar{h}; b, r) \Pi_{i,t}(\omega, b, \bar{h}; b, r)
   \]
   for $e \in \{W, U\}$, and with equality if $(b, r) \in B_{c,t}^e(\omega, b, \bar{h})$.

   (a) Labor Search: Let \(\{\hat{\omega}_{i,t}(\omega, b, \bar{H}; b, r)\}_{t=1}^T\) be defined such that:
   \[
   \hat{\omega}_{i,t}(\omega, b, \bar{h}; b, r) \in \arg \max_{\omega} \left\{ p(\theta_{i,t}(\omega, \bar{h})) W_{i,t}^P(\omega, b, \bar{h}; b, r) + \left(1 - p(\theta_{i,t}(\omega, \bar{h}))\right) U_{i,t}^P(\omega, b, \bar{h}; b, r) \right\}
   \]
   (b) Unemployed Credit Search: Let \(U_{i,t}(\omega, b, \bar{h}) = \max \{0, \max_{(b, r) \in B} p_f(\theta_{i,t}^{e,U}(\omega, b, \bar{h}; b, r)) U_{i,t}^C(\omega, b, \bar{h}; b, r) - p_f(\theta_{i,t}^{e,U}(\omega, b, \bar{h}; b, r)) U_{i,t}^N(\omega, b, \bar{h}; 0, 0) - \kappa_S\} \) and \(U_{i,t}(\omega, b, \bar{h}) = 0\) if \(B_{c,t}^e(\omega, b, \bar{h}) = \emptyset\). Then for any $(b, r) \in B$ and $\forall\theta_i:
   \]
   \[
   U_{i,t}(\omega, b, \bar{h}) \geq p_f(\theta_{i,t}^{e,U}(\omega, b, \bar{h}; b, r)) U_{i,t}^C(\omega, b, \bar{h}; b, r) - p_f(\theta_{i,t}^{e,U}(\omega, b, \bar{h}; b, r)) U_{i,t}^N(\omega, b, \bar{h}; b, r) - \kappa_S
   \]
   with equality if $\theta_{i,t}^{e,U}(\omega, b, \bar{h}; b, r) < \infty$ and $\chi_{i,t}^U(\omega, b, \bar{h}; b, r) > 0$. Moreover if $U_{i,t}^C(\omega, b, \bar{h}; b, r) < U_{i,t}^N(\omega, b, \bar{h}; 0, 0)$, either $\theta_{i,t}^{e,U}(\omega, b, \bar{h}; b, r) = \infty$ or $\chi_{i,t}^U(\omega, b, \bar{h}; b, r) = 0$.
(c) **Employed Credit Search:** Let \( W_{i,t}(\omega, b, \vec{h}) = \max \{0, \max_{(b, r) \in B} p^e(\theta^{eW}_t(\omega, b, \vec{h}; b, r)) W^{C}_i(\omega, b, \vec{h}; b, r) - p^e(\theta^{eW}_t(\omega, b, \vec{h}; b, r)) W^{N}_i(\omega, b, \vec{h}; 0, 0) - \kappa_S \} \) and \( \bar{W}_{i,t}(\omega, b, \vec{h}) = 0 \) if \( B^W_{i,t}(\omega, b, \vec{h}) = \emptyset \). Then for any \((b, r) \in B\) and \( \forall i \):

\[
\bar{W}_{i,t}(\omega, b, \vec{h}) \geq \max_{(b, r) \in B} \{ p^e(\theta^{eW}_t(\omega, b, \vec{h}; b, r)) W^{C}_i(\omega, b, \vec{h}; b, r) - p^e(\theta^{eW}_t(\omega, b, \vec{h}; b, r)) W^{N}_i(\omega, b, \vec{h}; b, r) - \kappa_S \}
\]

with equality if \( \theta^{eW}_t(\omega, b, \vec{h}; b, r) < \infty \) and \( \chi^{W}_i(\omega, b, \vec{h}; b, r) > 0 \). Moreover if \( W^{C}_i(\omega, b, \vec{h}; b, r) < W^{N}_i(\omega, b, \vec{h}; 0, 0) \), either \( \theta^{eW}_t(\omega, b, \vec{h}; b, r) = \infty \) or \( \chi^{W}_i(\omega, b, \vec{h}; b, r) = 0 \).

3. **Agents’ asset and default choices:**

   (a) **Asset choice:** \( \{b'_{i,e,t}(\omega, b, \vec{h}; b, r)\}_{t=1}^{T} \) solves the agent’s asset choice problem when they are employed \( e = W \), and unemployed \( e = U \).

   (b) **Default choice:** \( \{D_{i,a,t}^{e}(\omega, b, \vec{h}; b, r)\}_{t=1}^{T} \) solves agent’s default problem when they are employed \( e = W \), and unemployed \( e = U \), as well as when they have been hit by the credit shock \( a = N \), and have not been hit by the credit shock \( a = C \).

   (c) **Credit Search:** \( \{S^{e}_i(\omega, b, \vec{h}; b, r)\}_{t=1}^{T} \) solves the agent’s optimal credit application decision.

4. **Market Clearing (Consistency of Beliefs):** For \( e \in \{W, U\} \) and \( \forall t \)

\[
\int_{B^P} \frac{\chi^{e}_i(\omega, b, \vec{h}; b, r)}{\theta^{e}_i(\omega, b, \vec{h}; b, r)} d\lambda_{e,i}(\omega, b, \vec{h}; b, r) \leq \pi_i \ \forall i
\]

5. **Government Budget Balance:** The proportional tax \( \tau \) on wages clears the governments budget constraint (equation (12)).
E  Numerical Validity of Separating Equilibrium

In this appendix, we numerically check that in equilibrium we do not having pooling of types for the baseline economy presented in Section 3. Pooling occurs when individuals with the same employment status, age, and state \( \vec{x} = (\omega, b, \vec{h}; b, r) \), but different type \( i \in \{H, L\} \) apply for the same credit contract. We check in our simulations for instances of pooling and find that in equilibrium only 0.1% of individuals searching for a contract, search for a contract where there is pooling.

F  GSW Assumptions

In this appendix, we show that limiting cases of the search model defined in Section 2 satisfy the assumptions of Guerrieri et al. [2010].

F.1 Monotonicity

Let \( \vec{x} = (\omega, b, \vec{h}; b, r) \) denote the state of an individual.\(^{37}\) In this subsection, we show that the lender’s profit function is monotone \( \forall \vec{x}, \) and \( \forall t \)

\[
\Pi_{L,t}^{U}(\vec{x}) \leq \Pi_{H,t}^{U}(\vec{x}) \quad \text{and} \quad \Pi_{L,t}^{W}(\vec{x}) \leq \Pi_{H,t}^{W}(\vec{x})
\]

In showing that the lenders profit function is monotone we make the following assumptions:

1. Limited default assumption: \( D_{L,t}^{N,e}(\vec{x}) = D_{H,t}^{N,e}(\vec{x}) \approx 0, \) and \( D_{L,t}^{C,e}(\vec{x}) = D_{H,t}^{C,e}(\vec{x}) \approx 0 \) for \( e \in \{U,W\} \).

2. Homogeneous job finding probability: \( p(\theta_{i,t+1}(\vec{h})) = \lambda_0, \forall (\vec{h}, i, t) \)

3. There is a single wage rate \( \omega \)

4. All borrowing and saving occurs at the rate \( r \): \( q(b, r) = q(r) = \frac{1}{1+r} \)

5. Borrowing constraints do not bind: \( \forall \vec{x}: b_{i,t}(\vec{x}) > b \)

Before proving the monotonicity of the lender’s Bellman we state and prove the following lemma, which establishes the relationship between discount factors and asset choices. This relationship will play a key role in establishing the monotonicity of the lenders profit function. We prove the lemma for the case of an unemployed worker. The proof for an employed worker follows in the same manner.

\(^{37}\)Note for an unemployed individual their state does not include a firm, i.e. \( \vec{x} = (b, \vec{h}; b, r). \)
Lemma 1. An agent’s asset choice at $b'_{i,t}(\bar{x})$ is a weakly increasing function of their discount factor $\beta_i$ for any age $t$, i.e. $\frac{\partial b'_{i,t}(\bar{x})}{\partial \beta_i} \geq 0$.

Proof. The proof is performed recursively, by first considering the agent in period $T$ and period $T - 1$, and then finally in a general period $t$.

In period $T$, $b'_{i,T}(\bar{x}) = 0 \forall \bar{x}$, hence $\frac{\partial b'_{i,T}(\bar{x})}{\partial \beta_i} = 0$. Next, consider the individuals problem in period $T - 1$. The individual makes a consumption and savings decision to solve the following maximization problem:

$$U^C_{i,T-1}(b,\bar{h};b,r) = \max_{b' \geq b} \left[ u(c) + \beta_i \left[ \lambda_0 W^D_{i,T}(\omega, b', \bar{h}; b, r) + (1 - \lambda_0) U^D_{i,T}(b', \bar{h}; b, r) \right] \right]$$

subject to: $c + q(r)b' \leq z + g + b$. In the terminal period $T$, individuals set their asset choice to zero (i.e. $b'_{i,T}(\bar{x}) = 0 \forall \bar{x}$), which gives the following continuation values for the terminal period:

$$W^D_{i,T}(\omega, b, \bar{h}; b, r) = u \left( (1 - \tau) \omega f(\bar{h}) + g + b \right)$$
$$U^D_{i,T}(b, \bar{h}; b, r) = u (z + g + b)$$

To ease notation let $w(\omega, \bar{h}) = (1 - \tau) \omega f(\bar{h})$ denote an individuals wage when employed. Using the continuation values from the terminal period, and rewriting consumption in terms of the individual’s asset choice $b'$, the agent’s problem in period $T - 1$ is:

$$U^C_{i,T-1}(b, \bar{h}; b, r) = \max_{b' \geq b} \left[ u \left( z + g + b - q(r)b' \right) \right.$$  
$$+ \beta_i \left[ \lambda_0 u \left( w(\omega, \bar{h}) + b' \right) + (1 - \lambda_0) u \left( z + g + b' \right) \right]$$

With the assumption that the borrowing constraint is slack at the solution ($b' > b$) the first order condition governing the agent’s choice $b'$ is:

$$u' \left( z + g + b - q(r)b' \right) = \frac{\beta_i}{q(r)} \left[ \lambda_0 u' \left( w(\omega, \bar{h}) + b' \right) + (1 - \lambda_0) u' \left( z + g + b' \right) \right]$$

(15)

Since $u'(\cdot) > 0$, as $\beta_i$ increases, the right hand side of equation (15) increases. Since $u(\cdot)$ is concave, for the left hand side of the equation to increase $b'$ must increase. Hence, we have as the discount factor increases, $b'$ increases in period $T - 1$, i.e. $\frac{\partial b'_{i,t-1}(\bar{x})}{\partial \beta_i} \geq 0$.

Next, consider a general age $t$. The problem for an unemployed individual of age $t$ is:

$$U^C_{i,t}(b, \bar{h}; b, r) = \max_{b' \geq b} \left[ u(c) + \beta_i \left[ \lambda_0 W^D_{i,\tau+1}(\omega, b', \bar{h}; b, r) + (1 - \lambda_0) U^D_{i,\tau+1}(b', \bar{h}; b, r) \right] \right]$$

subject to: $c + q(r)b' \leq z + g + b$. Rewriting the consumption in terms of the individual’s asset
choice \( b' \), the problem is reformulated as:

\[
U^C_{i,t}(b, \bar{h}; \bar{b}, r) = \max_{b' \geq \bar{b}} u \left( z + g + b - q(r)b' \right) + \beta_i \left[ \lambda_0 W^D_{i,t+1}(\omega, b', \bar{h}; \bar{b}, r) + (1 - \lambda_0) U^D_{i,t+1}(b', \bar{h}; \bar{b}, r) \right]
\]

Assuming the borrowing constraint is slack at the solution \((b' > \bar{b})\), then the first order condition governing the agent’s choice \( b' \) is:

\[
u' \left( z + g + b - q(r)b' \right) = \frac{\beta_i}{q(r)} \left[ \lambda_0 W'^D_{i,t+1}(b', \bar{h}; \bar{b}, r) + (1 - \lambda_0) U'^D_{i,t+1}(b', \bar{h}; \bar{b}, r) \right]
\]

(16)

where \( W'^D_{i,t+1}(\cdot) \) and \( U'^D_{i,t+1}(\cdot) \) denote the derivatives of \( W^D_{i,t+1} \) and \( U^D_{i,t+1} \) with respect to next periods asset choice \( b' \). Note that the value functions \( W^D_{i,t+1} \) and \( U^D_{i,t+1} \) are the discounted sum of \( T - (t + 1) \) period utilities. Since \( u'(\cdot) > 0 \), we have that \( W'^D_{i,t+1} > 0 \) and \( U'^D_{i,t+1} > 0 \). Additionally, given that the period utility function \( u(\cdot) \) is concave, and the sum of concave functions is a concave function we have that \( W'^D_{i,t+1} \) and \( U'^D_{i,t+1} \) are concave in \( b' \). Hence, as \( \beta_i \) increases the right hand side of (16) increases. Since \( u(\cdot) \) is concave, for the left hand side of the equation to increase \( b' \) must increase. Thus, we have as the discount factor \( \beta \) increases, the agent’s asset choice \( b'_{i,t} \) increases for a general period \( t \), i.e. \( \frac{\partial b'_{i,t}(\bar{x})}{\partial \beta_i} \geq 0 \).

We next establish a condition for how lenders profits change with a borrowers initial level of assets. This will also aid in the proof that the lenders profits are monotone. Again this proof is for the profits of a lender matched with an unemployed worker, the proof for a lender matched with an employed worker follows in the same manner.

**Lemma 2.** The profits to a lender \( \Pi^U_{i,t}(b, \bar{h}; \bar{b}, r) \) are weakly decreasing in an agent’s initial level of assets \( b \), \( \frac{\partial \Pi^U_{i,t}(b, \bar{h}; \bar{b}, r)}{\partial \bar{b}} \leq 0 \).

**Proof.** We prove the claim using induction. As the base step, we will consider both age \( T \) and age \( T - 1 \). For an age \( T \) lender there are zero profits, so the statement is trivially satisfied. For an age \( T - 1 \) lender, with the limited default assumption, profits are given as:

\[
\Pi^U_{i,T-1}(b, \bar{h}; \bar{b}, r) = \frac{\beta_f b'_{i,T-1}(b, \bar{h}; \bar{b}, r) (r_f - r)}{1 + r} \times \mathbb{I}\{b'_{i,T-1}(b, \bar{h}; \bar{b}, r) < 0\}
\]

Since profits are equal to zero if \( b'_{i,T-1}(b, \bar{h}; \bar{b}, r) \geq 0 \), consider only cases where \( b'_{i,T-1}(b, \bar{h}; \bar{b}, r) < 0 \). Hence,

\[
\Pi^U_{i,T-1}(b, \bar{h}; \bar{b}, r) = \frac{\beta_f b'_{i,T-1}(b, \bar{h}; \bar{b}, r) (r_f - r)}{1 + r}
\]
Taking the derivative with respect to $b$ returns:

$$\frac{\partial \Pi_{i,T-1}^U(b, \vec{h}; b, r)}{\partial b} = \beta_{lf} \frac{(r_f - r)}{1 + r} \frac{\partial b_{i,T-1}'(b, \vec{h}; b, r)}{\partial b}$$

Since $r_f > r$, in order to establish that $\frac{\partial \Pi_{i,T-1}^U(b, \vec{h}; b, r)}{\partial b} \leq 0$, we need to show that $\frac{\partial b_{i,T-1}'(b, \vec{h}; b, r)}{\partial b} \geq 0$, that is an agent with a lower amount of assets today has a lower amount of assets in the next period. From equation (15), we can see that as $b$ decreases, for the first order condition to be satisfied $b'$ must decrease, i.e. $\frac{\partial b_{i,T-1}'(b, \vec{h}; b, r)}{\partial b} \geq 0$. This generates the desired condition for period $T - 1$.

For the induction step, consider a general period $t$, and assume $\frac{\partial \Pi_{i,t+1}^U(b, \vec{h}; b, r)}{\partial b} \leq 0$. With the limited default assumption, and again focusing on the region of the parameter space where $b_{i,t}'(b, \vec{h}; b, r) < 0$, profits to the lender in period $t$ are given by:

$$\Pi_{i,t}^U(b, \vec{h}; b, r) = \beta_{lf} b_{i,t}'(b, \vec{h}; b, r) \frac{(r_f - r)}{1 + r} + \beta_{lf} (1 - \delta_c) \hat{\Pi}_{i,t+1}^U(b', \vec{h}; b, r)$$

Taking the derivative with respect to $b$ returns:

$$\frac{\partial \Pi_{i,t}^U(b, \vec{h}; b, r)}{\partial b} = \beta_{lf} \frac{(r_f - r)}{1 + r} \frac{\partial b_{i,t}'(b, \vec{h}; b, r)}{\partial b} + \beta_{lf} (1 - \delta_c) \frac{\partial \hat{\Pi}_{i,t+1}^U(b', \vec{h}; b, r)}{\partial b} \frac{\partial b_{i,t}'(b, \vec{h}; b, r)}{\partial b}$$

From equation (16) as $b$ decreases, we have that $b'$ must decrease as well, that is $\frac{\partial b_{i,t}'(b, \vec{h}; b, r)}{\partial b} \geq 0$.38 Then along with the induction step, we have the desired result that $\frac{\partial \Pi_{i,t}^U(b, \vec{h}; b, r)}{\partial b} \leq 0$.\qquad $\square$

With Lemmas 1 and 2 established we now proceed to show that the lender’s Bellman equation is monotone. Here we prove the case of lending to an unemployed worker. The case for lending to an employed worker following in the same manner.

**Proposition.** Let $\vec{x} = (b, \vec{h}; b, r)$ denote the state of an unemployed individual. With the given assumptions on limited defaults, homogeneous job finding probabilities, a single wage rate, borrowing and saving occurring at the same interest rate, and slack borrowing constraints, then the profit function to lenders is monotone $\Pi_{L,t}^U(\vec{x}) \leq \Pi_{H,t}^U(\vec{x}) \forall \vec{x}$ and $\forall t$.

**Proof.** We prove the above proposition using a proof by induction starting from the last period of life.

**Base Case Age $T$ and Age $T - 1$:** For the base case we consider age $T$ and age $T - 1$.39 From equation (8), lenders earn zero profits from an age $T$ individual. Hence, trivially the condition $\Pi_{L,T}^U(\vec{x}) \leq \Pi_{H,T}^U(\vec{x})$ is satisfied. Next consider age $T - 1$.

38 This follows from $W_{i,t+1}^D$ and $U_{i,t+1}^D$ being concave in $b'$.

39 We consider age $T - 1$ in addition to age $T$, given that the condition is satisfied trivially for age $T$.
From equation (8) and using the limited default assumption, the difference in profits between lenders to the high and low type in period $T - 1$, denoted $\Delta \Pi_{T-1}^U$, is given by:

$$
\Delta \Pi_{T-1}^U(\vec{x}) = \Pi_{H,T-1}^U(\vec{x}) - \Pi_{L,T-1}^U(\vec{x})
$$

$$
= \frac{\hat{\beta}_f (r_f - r)}{1 + r} \left[ b_{H,T-1}^r(\vec{x}) \times \mathbb{I}\{b_{H,T-1}^r(\vec{x}) < 0\} - b_{L,T-1}^r(\vec{x}) \times \mathbb{I}\{b_{L,T-1}^r(\vec{x}) < 0\} \right]
$$

(17)

From equation (17) it is clear that if $b_{H,T-1}^r(\vec{x}) \leq b_{L,T-1}^r(\vec{x})$, then $\Delta \Pi_{T-1}^U(\vec{x}) \geq 0$. From Lemma 1 we have that since $\beta_H < \beta_L$, then $b_{H,T-1}^r(\vec{x}) \leq b_{L,T-1}^r(\vec{x})$, and hence $\Delta \Pi_{T-1}^U(\vec{x}) \geq 0$.

**Induction Step: Age $t$:** Now we consider a general age $t$, and assume that the condition $\Delta \Pi_{t+1}^U(\vec{x}) \geq 0$ is satisfied. From equation (8) and using the limited default assumption, the difference in profits between lenders to the high and low type in period $t$, is given by:

$$
\Delta \Pi_t^U(\vec{x}) = \Pi_{H,t}^U(\vec{x}) - \Pi_{L,t}^U(\vec{x})
$$

$$
= \frac{\hat{\beta}_f (r_f - r)}{1 + r} \left[ b_{H,t}^r(\vec{x}) \times \mathbb{I}\{b_{H,t}^r(\vec{x}) < 0\} - b_{L,t}^r(\vec{x}) \times \mathbb{I}\{b_{L,t}^r(\vec{x}) < 0\} \right]
$$

$$
+ \hat{\beta}_f (1 - \hat{\delta}_c) \left[ \hat{\Pi}_{H,t+1}^U(b_{H,t}^r, h; b, r) - \hat{\Pi}_{L,t+1}^U(b_{L,t}^r, h; b, r) \right]
$$

(18)

With the assumption of a constant job finding rate $\lambda_0$, recall that the continuation value of lenders profits is given by:

$$
\hat{\Pi}_{t+1}^U(b_{t,t}^r(\vec{x}), h; b, r) = \lambda_0 \Pi_{t+1}^W(\omega, b_{t,t}^r(\vec{x}), h; b, r) + (1 - \lambda_0) \Pi_{t+1}^U(b_{t,t}^r(\vec{x}), h; b, r)
$$

From the assumption of the induction step, as well as the fact that the proof for lending to an employed worker proceeds in the same manner we have: $\hat{\Pi}_{H,t+1}^U(b_{H,t}^r, h; b, r) \geq \hat{\Pi}_{L,t+1}^U(b_{L,t}^r, h; b, r)$. Thus, we have:

$$
\Delta \Pi_t^U(\vec{x}) \geq \frac{\hat{\beta}_f (r_f - r)}{1 + r} \left[ b_{H,t}^r(\vec{x}) \times \mathbb{I}\{b_{H,t}^r(\vec{x}) < 0\} - b_{L,t}^r(\vec{x}) \times \mathbb{I}\{b_{L,t}^r(\vec{x}) < 0\} \right]
$$

$$
+ \hat{\beta}_f (1 - \hat{\delta}_c) \left[ \hat{\Pi}_{H,t+1}^U(b_{H,t}^r, h; b, r) - \hat{\Pi}_{L,t+1}^U(b_{L,t}^r, h; b, r) \right]
$$

$$
\geq 0
$$

where the first inequality follows from $\hat{\Pi}_{H,t+1}^U(b_{L,t}^r, h; b, r) \geq \hat{\Pi}_{L,t+1}^U(b_{L,t}^r, h; b, r)$. The second inequality follows from Lemma 1 in the first line and Lemma 2 in the second line. This completes the proof that the lender’s Bellman equation is monotone. \[\square\]

\[40\]Recall that there is a spread between the rate lenders charge $r$, and the risk-free rate $r_f$ such that $r > r_f$.  

71
F.2 Sorting

Sorting requires that for all ages \( t \), all contracts \((r, b) \in B\), and \( \epsilon > 0 \), there exists a \((r', b') \in B_\epsilon(r', b')\) such that:

\[
U^C_{L,i}(b, \tilde{h}; b', r') > U^C_{L,i}(b, \tilde{h}; b, r) \quad \text{and} \quad U^C_{H,i}(b, \tilde{h}; b', r') < U^C_{H,i}(b, \tilde{h}; b, r)
\]  

(19)

This means that a contract can always be found that makes the type \( L \) agent (the patient agent) better off, and the type \( H \) agent (the impatient agent) worse off. Note an equivalent sorting condition applies to contracts that are offered to employed individuals.

In showing that the lenders profit function is monotone we make the following assumptions:

1. \( \beta_L > \beta_H = 0 \)
2. Homogeneous job finding probability: \( p(\theta_{i,T+1}(\tilde{h})) = \lambda_0, \forall (\tilde{h}, i, t) \)
3. There is a single wage rate \( \omega \)
4. The borrowing constraint of the patient agent \((i = L)\) does not bind

Note the sorting condition only holds for period \( T - 1 \) and earlier. We proceed as above and prove the condition recursively starting from period \( T - 1 \).

**Proposition.** With the given assumptions that \( \beta_L > \beta_H = 0 \), job finding rates are homogeneous, there is a single wage rate, and the borrowing constraint of the patient agent is slack, the sorting condition presented in equation (19) is satisfied for ages \( t = 1, ..., T - 1 \).

**Proof.** We prove the sorting condition recursively starting from individuals who are age \( T - 1 \).

**Age \( T - 1 \) individuals:** Note the sorting condition for individuals in period \( T - 1 \) only applies to individuals with states \( \bar{x} = (b, \tilde{h}; b, r) \) where both the high and low type agent will borrow.\(^{41}\) In period \( T - 1 \), the individual makes a consumption and savings decision to solve the following maximization problem:

\[
U^C_{i,T-1}(b, \tilde{h}; b, r) = \max_{\bar{b} \geq \tilde{b}} u(c) + \beta_i \left[ \lambda_0 W^P_{i,T}(\omega, b', \tilde{h}; b, r) + (1 - \lambda_0) U^D_{i,T}(b', \tilde{h}; b, r) \right]
\]

subject to: \( c + q(b', r)b' \leq z + g + b \). In the terminal period \( T \), individuals set their asset choice to zero (i.e. \( b_{i,T}(\bar{x}) = 0 \ \forall \bar{x} \)), which gives the following continuation values for the terminal period:

\[
W^P_{i,T}(\omega, b, \tilde{h}; b, r) = u \left( (1 - \tau)\omega f(\tilde{h}) + g + b \right)
\]

\[
U^D_{i,T}(b, \tilde{h}; b, r) = u (z + g + b)
\]

\(^{41}\)This is the relevant region to consider the sorting condition, because it is in this area of the state space that lenders are unable to ex-ante observe an agent type.
To ease notation let $w(\omega, \vec{h}) = (1 - \tau) \omega f(\vec{h})$ denote an individual's wage when employed. Using the continuation values from the terminal period, and rewriting consumption in terms of the agent's asset choice $b'$, the agent's problem in period $T - 1$ is:

$$U_{i,T-1}^{C_i}(b, \vec{h}; b', r) = \max_{b' \geq b} u' \left( z + g + b - q(b, r)b' \right)$$

$$+ \beta_i \left[ \lambda_0 u'(w(\omega, \vec{h}) + b') + (1 - \lambda_0) u' \left( z + g + b' \right) \right]$$

Let $\zeta$ be the multiplier on the individual's borrowing constraint. The first order condition which governs the individual's asset choice is given by:

$$u' \left( z + g + b - q(b, r)b' \right) = \frac{\beta_i}{q(b, r)} \left[ \lambda_0 u'(w(\omega, \vec{h}) + b') + (1 - \lambda_0) u' \left( z + g + b' \right) \right] + \zeta$$

First consider the patient agent ($i = L$). With the assumption that their borrowing constraint does not bind, the first order condition simplifies to:

$$u' \left( z + g + b - q(b, r)b' \right) = \frac{\beta_L}{q(b, r)} \left[ \lambda_0 u'(w(\omega, \vec{h}) + b') + (1 - \lambda_0) u' \left( z + g + b' \right) \right]$$

The patient agent chooses assets $b'_L$ to satisfy equation (21).

Next consider the impatient agent. Since the impatient agent has a discount factor $\beta_H = 0$, the agent will borrow until their borrowing constraint binds, i.e. $b'_H = b$. Consider an alternative contract $(r^\epsilon, b^\epsilon)$ where $b^\epsilon > b$ and $b^\epsilon < b'_L$, and $r^\epsilon < r$. We will show that at this alternative contract, the impatient agent is made worse off, while the patient agent is made better off. First, observe at the new contract the borrowing constraint for the type $H$ agent still binds. Additionally, the choice of $r^\epsilon$ will be made such that the decrease in the interest rate does not allow the impatient agent to have an increase in consumption that will offset the tightening of the borrowing constraint. For the impatient agent, with the original credit contract $(b, r)$ they select $b'_H = b$, which gives them the following consumption:

$$c_H = z + g + b - \frac{1}{1 + r} b$$

With the alternative contract, consumption for the high type is:

$$c_H^\epsilon = z + g + b - \frac{1}{1 + r^\epsilon} b^\epsilon$$

We restrict $r^\epsilon$ to ensure that $c_H > c_H^\epsilon$. Let $\epsilon \in (0, |b - b'_L|)$ be given, and set $b^\epsilon = b + \epsilon$. With this new borrowing limit the consumption of the impatient agent is:

$$c_H^\epsilon = z + g + b - \frac{1}{1 + r^\epsilon} (b + \epsilon)$$

73
Then as long as \( r^c < \frac{c(1+r)}{b} + r \), we have that \( c_H > c_H' \). Since the impatient agent has \( \beta_H = 0 \), consumption in the current period is the only criterion for their value function. Hence, since \( c_H > c_H' \), we have that: \( U_{H,T-1}^c(b, \tilde{h}; b^c, r^c) < U_{H,T-1}^c(b, \tilde{h}; b, r) \).

Next, we proceed to show that for the patient agent \( U_{L,T-1}^c(b, \tilde{h}; \tilde{b}, r^c) > U_{L,T-1}^c(b, \tilde{h}; \tilde{b}, r) \). Observe that since \( \tilde{b} < b \), and \( r^c < \frac{c(1+r)}{b} + r \), we have that \( r^c < r \). Additionally, since \( q(r) = \frac{1}{1+r} \), observe that \( q(r^c) > q(r) \). Consider the patient individual’s asset choice under the original credit contract, denoted \( \tilde{b}_L \), which was the solution to the Euler equation presented in equation (21). Consider this asset choice under the alternative credit contract \( (r^c, \tilde{b}^c) \). First, observe that this choice is still feasible given the choice of \( \epsilon \) above. Additionally, observe that since \( q(r^c) > q(r) \), from equation (20) we have that at the individual’s original asset choice \( \tilde{b}_L \), the agent receives a higher level of lifetime utility since:

\[
\tilde{U}_{L,T-1}^c(b, \tilde{h}; \tilde{b}_L, r^c) \geq \tilde{U}_{L,T-1}^c(b, \tilde{h}; \tilde{b}_L, r)
\]

Then since \( U_{L,T-1}^c(b, \tilde{h}; \tilde{b}_L, r^c) = \max_{b' \geq \tilde{b}} \tilde{U}_{L,T-1}^c(b, \tilde{h}; b^c, r^c) \), we have that \( U_{L,T-1}^c(b, \tilde{h}; \tilde{b}_L, r) > U_{L,T-1}^c(b, \tilde{h}; b, r) \).

Effectively, since when the agent chooses \( \tilde{b}_L \), they are better off with the new contract, when the agent makes their optimal savings decision under the new contract they are assured to be better off than under the original contract.

**General Age \( t \):** The problem for an unemployed individual of age \( t \) is:

\[
U_{i,t}^c(b, \tilde{h}; b, r) = \max_{b' \geq \tilde{b}} u(c) + \beta_i \left[ \lambda_0 W_{i,t+1}^D(\omega, b', \tilde{h}; b, r) + (1 - \lambda_0) U_{i,t+1}^c(b', \tilde{h}; b, r) \right]
\]

subject to: \( c + q(b', r)b' \leq z + g + b \). Rewriting the consumption in terms of the individual’s asset choice \( b' \), the problem is reformulated as:

\[
U_{i,t}^c(b, \tilde{h}; b, r) = \max_{b' \geq \tilde{b}} u \left( z + g + b - q(b, r)b' \right) + \beta_i \left[ \lambda_0 W_{i,t+1}^D(\omega, b', \tilde{h}; b, r) + (1 - \lambda_0) U_{i,t+1}^c(b', \tilde{h}; b, r) \right]
\]

Let \( \zeta \) be the multiplier on the agent’s borrowing constraint. The first order condition which

\footnote{Note this requires \( b'_{fr} < 0 \), however since individuals pay a search cost to apply for credit, in period \( T-1 \), only individuals who plan to borrow would be willing to pay the search cost.}
governs the individual’s asset choice is given by:

\[ u' \left( z + g + b - q(b, r)b' \right) = \frac{\beta_i}{q(b, r)} \left[ \lambda_0 W_{i,t+1}^D(\omega, b', \bar{h}; b, r) + (1 - \lambda_0) U_{i,t+1}^P(b', \bar{h}; b, r) \right] + \zeta \]

First, consider the patient agent \((i = L)\), and assume their borrowing constraint does not bind. The first order condition simplifies to:

\[ u' \left( z + g + b - q(b, r)b' \right) = \frac{\beta_i}{q(b, r)} \left[ \lambda_0 W_{i,t+1}^D(\omega, b', \bar{h}; b, r) + (1 - \lambda_0) U_{i,t+1}^P(b', \bar{h}; b, r) \right] \tag{22} \]

The patient agent chooses assets \(b'_L,t\) to satisfy equation (22).

Next consider the impatient agent. Since the impatient agent has a discount factor \(\beta_H = 0\), the agent will borrow until their borrowing constraint binds, i.e. \(b'_H = b\).

Consider an alternative contract \((r^\epsilon, b')\) where \(b^\epsilon > b\) and \(b^\epsilon < b'_L,t\), and \(r^\epsilon < r\). Following the same steps as in the case for the age \(T - 1\) agent by setting \(r^\epsilon < \frac{\epsilon(1+r)}{\lambda_0} + r\), we ensure that the impatient agent consumes less under the alternative contract relative to the original contract.

Since the impatient agent has \(\beta_H = 0\), consumption in the current period is the only criterion for their value function, and hence we have that: \(U_{H,t}^C(b, \bar{h}; b', r^\epsilon) < U_{H,t}^C(b, \bar{h}; b, r)\). Next we proceed to show that the patient agent is made better off under the alternative contract. With the alternative contract \(r^\epsilon < r\), which lowers the cost of borrowing for all individuals. Since the patient agent has chosen to search for a credit contract, then the agent puts a positive probability on borrowing in the future. In this state of the world, where the patient agent borrows, the lower interest rate will allow the agent to enjoy more consumption, raising the individual’s lifetime expected utility, holding their path of consumption/savings decisions fixed at their choices from the original contract. Since this path of asset choices raises the individual’s lifetime expected utility, when the agent re-optimizes their asset choices under the new contract, the agent is assured to have a higher level of lifetime expected utility relative to the original credit contract.  

\[\square\]
G Solution Algorithm

Solving the model proceeds in the following steps:

1. **Firms Bellman:** Update the value to a firm of being in a match in the terminal period $J_{i,T}(\omega, h)$. Using the value of a firm in the terminal period, invert the free entry condition to obtain labor market tightness $\theta_{i,T}(\omega, h)$.

2. **Individual Problem:** Solve the individual problem in the terminal period.
   
   (a) Update the value to the individual of being in a credit match and not in a credit match for both employed and unemployed individuals, $W_{i,T}^C(\omega, b, \vec{h}; b, r)$ and $W_{i,T}^N(\omega, b, \vec{h}; 0, 0)$, respectively.
   
   (b) Solve the individual’s default decisions, which returns the values $W_{i,T}^D(\omega, b, \vec{h}; b, r)$ and $U_{i,T}^D(b, \vec{h}; b, r)$. 

3. **Lenders Bellman:** Update the lenders Bellman equation in the terminal period, $\Pi_{i,T}^W(\omega, b, \vec{h}; b, r)$ and $\Pi_{i,T}^U(b, \vec{h}; b, r)$.

4. **Individual Credit Search:** For space constraints, we will use the policy function of an unemployed agent, superscripted by $U$. The individual’s credit search problem proceeds in the following steps.
   
   (a) **Solve for the low type’s full information credit contract.**
   
   i. Set $\chi_{U,L,T}^L(b, \vec{h}; b, r) = 1$ and $\chi_{U,H,T}^U(b, \vec{h}; b, r) = 0$ throughout the entire state space. Find the profits to the lender of offering contract $(b, r)$ to a worker with observable characteristics $(b, \vec{h})$ for an age $T$ unemployed individual.
   
   ii. Invert the free entry condition for lenders to obtain the credit market tightness for each credit contract $\theta_{i,T}^{c,U}(b, \vec{h}; b, r)$. Use $\theta_{i,T}^{c,U}(b, \vec{h}; b, r)$ to estimate the credit finding rate for each of these contracts.
   
   iii. Using the estimated credit finding rate solve the low type’s credit search problem for an unemployed worker. Store each individual’s chosen credit contract. This is the agent’s full information credit contract.
   
   (b) **Find contracts that violate the IC constraint where the low type agent mimics the high type agent.**
   
   i. Update $\chi_{U,L,T}^L(b, \vec{h}; b, r) = 1$ at the low type’s chosen contract from step (a), and set $\chi_{U,L,T}^U(b, \vec{h}; b, r) = 0$ at all other credit contracts. Set $\chi_{U,H,T}^U(b, \vec{h}; b, r) = 1$ for all states $(b, \vec{h}; b, r)$ such that $\chi_{U,L,T}^L(b, \vec{h}; b, r) = 0$, and set $\chi_{U,H,T}^U(b, \vec{h}; b, r) = 0$ for all states $(b, \vec{h}; b, r)$ such that $\chi_{U,L,T}^U(b, \vec{h}; b, r) = 1$. Update the estimate of the lender’s profits using the updated $\chi_{U,L,T}^L(b, \vec{h}; b, r)$ and $\chi_{U,H,T}^U(b, \vec{h}; b, r)$. Conceptually, when the lender
is estimating their profits for each contract, the lender believes that the low type will go to their full information credit contract, and that only high types will go to all remaining contracts.

ii. Invert the free entry condition to obtain an updated value of \( \theta^{e,U}_{c,T}(b, \vec{h}; b, r) \), as well as the credit finding rates.

iii. Solve the low type’s credit search problem for an unemployed worker. Store each individual’s chosen credit contract. There are two cases to consider:

A. If any agent has chosen a credit contract that is different than their full information credit contract, then set \( \chi^{U}_{L,T}(b, \vec{h}; b, r) = 1 \) and \( \chi^{U}_{H,T}(b, \vec{h}; b, r) = 0 \) for that contract, and repeat step (b).

B. If all low type individuals have chosen their full information credit contract, then we have found a set of lenders beliefs \( \chi^{U}_{L,T}(b, \vec{h}; b, r) \) and \( \chi^{U}_{H,T}(b, \vec{h}; b, r) \), and credit market tightness \( \theta^{c,U}_{c,T}(b, \vec{h}; b, r) \) that is consistent with the low type choosing their full information contract, and not mimicking the high type.

(c) **Solve the high type’s credit search problem.**

i. Using the beliefs \( \chi^{U}_{L,T}(b, \vec{h}; b, r) \) and \( \chi^{U}_{H,T}(b, \vec{h}; b, r) \), and credit market tightness \( \theta^{c,U}_{c,T}(b, \vec{h}; b, r) \), solve the credit choice problem for the high type, where the choice set includes the full-information contract of the low type as well as any contract where \( \chi^{U}_{H,T}(b, \vec{h}; b, r) = 1 \). This solution method may yield pooling or separation. There are two cases:

A. If the high-type does not choose the low-type’s full-information contract, then we have found a separating equilibrium where the lender offers two contracts: the low-type’s full-information contract and the high-type’s chosen contract.

B. If the high-type chooses the low-type’s full information contract, then we have found a pooling equilibrium which is inconsistent with the lender’s beliefs. We must then verify, as we do in Appendix E, that this does not occur in our calibrated economy. In our benchmark calibration, we find that fewer than .001 of agents who apply for credit choose a pooling contract.

(d) Repeat steps (a)-(c) for employed workers.

(e) Use the credit market tightness functions \( \theta^{e,e}_{c,T}(b, \vec{h}; b, r) \) to find the values of \( W^{a}_{i,T}(\omega, b, \vec{h}; 0, 0) \) and \( U^{a}_{i,T}(b, \vec{h}; 0, 0) \). Using these value functions, find each individual’s policy function for searching for a credit contract \( S^{e}_{i,T}(b, \vec{h}; 0, 0) \) as well as the value of \( W^{S}_{i,T}(\omega, b, \vec{h}; 0, 0) \) and \( U^{S}_{i,T}(b, \vec{h}; 0, 0) \).

5. **Individual’s Job Search:** Use the estimate of \( \theta_{i,T}(\omega, h) \) to solve the individual’s job search problem.

6. **Repeat for ages** \( T - 1, T - 2, ..., 1 \).
H Welfare Calculation

In this section, we describe our process for performing the welfare calculation.

Let \( \{c_j^t, D_j^t, S_j^t\}_{t=1}^{T_{max}} \) be the consumption, default, and credit search policy functions for an individual \( j \) over their lifetime under the baseline public insurance policy. Let \( \{\tilde{c}_j^t, \tilde{D}_j^t, \tilde{S}_j^t\}_{t=1}^{T_{max}} \) be the consumption, default, and credit search policy functions for an individual \( j \) under an alternative public insurance policy. We will perform welfare calculations by estimating the share of lifetime consumption an individual would be willing to forgo (or must receive) to leave the baseline economy and move to an economy with an alternative public insurance policy. Let \( i(j) \) denote the individual’s type. Formally, we estimate the scaling factor for consumption \( \lambda_j \) that makes individual \( j \) indifferent between living under either public insurance policy:\(^{43}\)

\[
\sum_{t=1}^{T} \beta^t_{i(j)} \left( \frac{(c_j^t)^{1-\sigma} - \psi_D(b_j^t) D_j^t - \kappa_S S_j^t}{1 - \sigma} \right) = \sum_{t=1}^{T} \beta^t_{i(j)} \left( \frac{(\tilde{c}_j^t)^{1-\sigma} - \psi_D(\tilde{b}_j^t) \tilde{D}_j^t - \kappa_S \tilde{S}_j^t}{1 - \sigma} \right)
\]

Solving equation (23) for \( \lambda_j \) returns:

\[
\lambda_j = \left[ \frac{\sum_{t=1}^{T} \beta^t_{i(j)} \left( \frac{(c_j^t)^{1-\sigma} - \psi_D(b_j^t) D_j^t - \kappa_S S_j^t}{1 - \sigma} \right)}{\sum_{t=1}^{T} \beta^t_{i(j)} \left( \frac{(\tilde{c}_j^t)^{1-\sigma} - \psi_D(\tilde{b}_j^t) \tilde{D}_j^t - \kappa_S \tilde{S}_j^t}{1 - \sigma} \right)} \right]^{\frac{1}{1-\sigma}}
\]

We use the model to simulate a large mass of individuals under a series of alternative public insurance policies. Let \( N \) denote the number of individuals that we simulate, and let \( P \) be the set of public insurance policies that we consider. For each simulated individual and policy \( p \in P \), we estimate \( \lambda_{j,p} \), the scaling factor for consumption that makes the individual indifferent between living under the alternative public insurance policy and the baseline policy. To convert the units of the scaling term \( \lambda_{j,p} \) into the percentage of lifetime consumption the individual would be willing to forgo (or must receive), hereafter referred to as lifetime consumption equivalents and denoted \( \tilde{\lambda}_{j,p} \), we perform the following transformation:

\[
\tilde{\lambda}_{j,p} = 100(\lambda_{j,p} - 1)
\]

Let \( \{\{\tilde{\lambda}_{j,p}\}_{j=1}^{N}\}_{p=1}^{P} \) denote the set of lifetime consumption equivalents from the simulation of alternative public policies. From the distribution of lifetime consumption equivalents, we measure the utilitarian welfare effect and median welfare effect for each policy \( p \in P \). The utilitarian welfare effect

\(^{43}\)Note the discount factor is specific to the agent \( j \), since individuals in our economy are heterogeneous in their discount factor.
effect for an alternative policy \( p \in P \), which is denoted \( Welfare_U(p) \), is measured as:

\[
Welfare_U(p) = \frac{1}{N} \sum_{j=1}^{N} \hat{\lambda}_{j,p}
\]

The optimal policy under the utilitarian welfare effect is the policy \( p^* \in P \) that maximizes the utilitarian welfare effect \( Welfare_U(p) \).

The median welfare effect (or median voter) for an alternative policy \( p \in P \), which is denoted \( Welfare_M(p) \), is measured as the median of the distribution \( \{\hat{\lambda}_{j,p}\}_{j=1}^{N} \). The optimal policy under the median welfare effect is the policy \( p^* \) that maximizes the median welfare gain \( Welfare_M(p) \).

### I Transition Path Experiment

In this appendix, we discuss the details of the transition path experiment presented in Section 4.2. The transition dynamics are very simply since the model is block recursive. Block recursivity means that the distribution of agent’s across states does not enter the equilibrium prices (in this setting, the prices are only the market tightnesses). The equilibrium prices still depend on the realized path of shocks, but not the path of the distribution of agents across states.

Let \( S = (z, \tau) \) denote the policy state, where \( z \) is the public insurance to the unemployed and \( \tau \) is the tax rate. In the transition path experiment, the policy state \( S \) follows the transition matrix in equation (25), with corresponding values for \( (z, \tau) \) in Table 17. The realizations of the Markov chain are such that the economy transitions from the interim stage to the new steady state after 4 quarters, as shown in Panel (b) of Figure 14.

| Table 17: Transfers and Taxes Along Transition Path |
|-----------------------------------|---------|---------|---------|
| Transfer (\( z \))               | 0.303   | 0.293   | 0.293   |
| Replacement Rate                 | 41.2%   | 39.8%   | 39.8%   |
| Tax Rate (\( \tau \))            | 2.11%   | 2.01%   | 2.00    |

\[
P_S = \begin{bmatrix}
1 & 0 & 0 \\
0 & 0.75 & 0.25 \\
0 & 0 & 1
\end{bmatrix}
\]

(25)

The transition path experiment begins in the steady state of the baseline economy with a 41.2% replacement rate to the unemployed. An unexpected and permanent decline in the generosity of public insurance to the unemployed then occurs, which lowers the replacement rate to 39.8%. For the government budget to balance the tax rate is lowered as well. In the first year after
the policy change, the tax rate declines to balance the government’s budget constraint. In all remaining years after the policy change, the tax rate from the steady state of the economy with a 39.8% replacement rate balances the government’s budget constraint. Along the transition path individuals have rational expectations for the path of the tax rate and the public insurance policy. Figure 14 shows the realization of the path of the replacement rate of public insurance (Panel (a)), the tax rate (Panel (b)), and the government’s budget constraint (Panel (c)).
Notes: Figure shows output from the steady state welfare experiment where the replacement rate of public insurance to the unemployed is adjusted.