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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 long-term credit relationships and credit-registries allow the unemployed to partially offset income losses using credit. We estimate the model and find that the optimal provision of public insurance is unambiguously lower with greater credit access. Using a utilitarian welfare criterion, the optimal steady-state policy is to lower the replacement rate of public insurance from the current US policy of 41.2% to 38.3%. Moreover, lowering the replacement rate to 38.3% yields welfare gains to the majority of workers along the transition path.

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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 document four facts which suggest that credit markets play an important role in the way workers self-insure: (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. 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 empirical results reconcile two literatures with seemingly conflicting results. Studies based on checking-account data 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], and Ganong and Noel [2015]). On the other hand, direct questions about borrowing among workers who lose their jobs and other survey data imply that roughly 20% of the unemployed borrow, and roughly 30% become delinquent on debt obligations (e.g. Sullivan [2008], Hurd and Rohwedder [2010], and Gerardi, Herkenhoff, Ohanian, and Willen [2015]).[1] 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 quantitative contribution is to compute optimal public insurance to the unemployed in an environment that replicates our empirical findings while also matching current levels of credit access in the U.S. We do so by integrating long-term credit lines (e.g. Mateos-Planas and Ríos-Rull [2010]) and employment risk (e.g. Moen [1997], Burdett, Shi, and Wright [2001], and Menzio and Shi [2011]) into a defaultable debt framework (e.g. Eaton and Gersovitz [1981], Chatterjee, Corbae, Nakajima, and Ríos-Rull [2007], and Livshits, MacGee, and Tertilt [2007]).

[1]Papers that show ex-post borrowing following job loss include Sullivan [2008], Hurd and Rohwedder [2010], Herkenhoff [2013], Collins, Edwards, and Schmeiser [2015]. Papers that show ex-post default include Hurd and Rohwedder [2010], Gerardi, Herkenhoff, Ohanian, and Willen [2015], Herkenhoff, Phillips, and Cohen-Cole [2015], and Keys [2018]. Surveys of bankruptcy also cite job loss as a factor (e.g. Sullivan, Warren, and Westbrook [1999]). Lastly, Baker and Yannelis [2015] illustrate significant differences in consumption losses between constrained and unconstrained individuals (see also Crossley and Low [2011]).

To generate the credit access and borrowing patterns we observe in the data, 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. Because the unemployed value future access to credit markets, most job losers repay, and therefore lenders offer credit contracts to individuals both before and after job loss. Conversely, in a model without credit lines, where debt is individually priced each period, unemployed agents would face a sudden change in borrowing capacity, which is inconsistent with the facts we establish. As Athreya, Tam, and Young [2009] have shown, credit markets are poor insurance markets in economies with one-period debt. It is the presence of credit lines which allows us to match both the level of credit access and the non-responsiveness of credit limits to layoff.

After estimating our framework to match aggregate credit access and borrowing moments in the early 2000s, we show that our model successfully replicates the non-targeted responses of borrowing, credit limits, and defaults upon job loss. Similar to the data, the model economy's borrowing limits do not respond to job loss, while defaults increase. Additionally, as in the data, the model generates heterogeneity in borrowing following job loss. 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 in our framework.

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 evaluate policies using a utilitarian welfare criterion, in which equal weight is placed on all individuals. We assume the government raises funds to cover transfers with a distortionary labor income tax. Therefore, the government faces an equity-efficiency tradeoff that is affected by the presence of a credit market. Simultaneously cutting taxes and public insurance improves efficiency (lower distortionary taxes) but also generates equity losses (larger consumption losses upon layoff). In the presence of a well-developed credit market, the ability to borrow mitigates consumption losses upon layoff and therefore lowers the equity losses if public insurance is cut. Given levels of credit access observed in the early 2000s, the utilitarian government's optimal steady-state replacement rate is 38.3%, which is lower than the current U.S. replacement rate of 41.2%. If credit markets were shut down, the optimal steady-state policy is an unambiguously higher replacement rate of 43.2%.

Our optimal policy exercise implies a low degree of substitutability between public insurance and private forms of self-insurance. There are two general equilibrium forces which limit the desire of the government to substitute out of public insurance. First, for low levels of public insurance, precautionary savings increase and individuals become less likely to borrow. Second, default rates rise and credit becomes more costly if public insurance becomes sufficiently low. In other words, public insurance and private self-insurance are complementary at the aggregate level (aggregate transfers and aggregate borrowing comove positively for low values of public insurance), 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.

Lastly, we compute welfare along the transition path when we reduce the replacement rate from 41.2% to 38.3%. Individuals who were alive at the time of this policy change have a utilitarian welfare gain of .05% of lifetime consumption after the transition. We find that the majority of individuals experience a welfare gain. However, while over 80% of individuals with the highest human capital (at the time of the policy change) experience a welfare gain, only 65% of individuals with the lowest human capital have a welfare gain. Even though our model does not have search effort in the labor market, directed search generates moral hazard. As a consequence, cutting transfers raises the employment rate by approximately .5% as workers search in areas of the job market with higher job finding rates.

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 provision, 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.[2] 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. We depart from Mateos-Planas and Ríos-Rull [2010] by modeling the labor market and we obtain tractability via competitive search over credit contracts.

Our paper is 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], Chaumont and Shi [2017], and Griffy [2017]).[3] Related papers by Shimer and Werning

[2]See Mateos-Planas and Seccia [2006], Mateos-Planas and Ríos-Rull [2010], and Mateos-Planas [2013] on models of credit lines; Chatterjee, Corbae, and Rios-Rull [2008a], Chatterjee, Corbae, and Rıos-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.

[3]Our paper also complements studies on optimal UI over the business cycle (Mitman and Rabinovich [2011],

[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 income-replacement or 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.

Our article is also related to the literature on private unemployment insurance (e.g. Chiu and Karni [1998] and Hendren [2015]). We contribute to this literature in two ways, (i) we focus on private self-insurance or income replacement through credit markets, and (ii) Hendren [2015] focuses on two-period models which abstract from reputation concerns and long-run interactions present in our data and model. While both papers take very different approaches to the question of how substitutable private and public forms of insurance are, our results are consistent with Hendren [2015] in the sense that the scope for private self-insurance is limited, even with long-term contracts and strong dynamic reputation concerns.

The paper proceeds as follows. Section 1 describes our main empirical 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 among workers who lose their jobs. Using the cross-section 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.

Birinci and See [2017], and references therein).

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 3 years of tenure prior to job loss. We show that much 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 (e.g. of 31k displaced workers only 19k have a loss 1 year after displacement), 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. Panel (A) 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, 44 percent of their income with unused revolving debt in the year before job loss.[7] The magnitude

[4] All sample sizes are rounded to the nearest thousand in compliance with Census Bureau disclosure rules.

[5] These 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.

[6] Rather than using a traditional credit risk score, we use the TransUnion bankruptcy score in the 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.

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

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.

Panel (B) 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 monotonically 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.[8] 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 α_i denote a set of individual fixed effects and γ_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:

$$Y_{i,t} = \alpha_i + \gamma_t + \sum_{j=-4}^{5} \beta_j D_{j,i,t} + \Gamma X_{i,t} + \varepsilon_{i,t} \tag{1}$$

The objects of interest are $\beta_0, \beta_1, ..., \beta_5$, 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. $\beta_{-4}, \beta_{-3}, .., \beta_{-1}$ are not statistically different from zero).

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

[8]Appendix A includes details on the identification of mass layoffs.

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].[9]

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 nondisplaced individuals. 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. As credit scores represents the marginal cost of borrowing, 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 is also 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, by the year following displacement, the borrowing limit declines to $25k, on average. These results indicate that following 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, on average, displaced individuals do not borrow more than nondisplaced individuals. This zero response of borrowing following job loss is consistent with the recent work of Gelman et al. [2015] and Ganong and Noel [2015].[10] However, the cross-sectional analysis in Section 1.4 reveals that there is significant heterogeneity among workers who lose their

[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] and Jarosch [2014].

[10] The results presented in Table 2 and Figure 1 include all types of revolving credit (HELOCs, etc.) rather than just credit cards. In Appendix B.2, we present results for credit card (bank card) balances as well as limits. The pattern of the results for credit card balances are nearly identical to revolving balances.

jobs as nearly two-thirds of workers alter their balances and default upon job loss, and a significant fraction use the credit market to borrow.

1.3.1 Default Following Job Loss

We now investigate whether individuals can use credit markets to relax their budget constraint by defaulting and not making 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 collections 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]

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

[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.

[12] The share of consumers in collections comes from the Federal Reserve Bank of New York's Quarterly Report on Household Debt and Credit. Accessed from "https://www.newyorkfed.org/microeconomics/databank.html" on 6/14/2017.

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.[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 more likely to be in collections. 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 through the use of defaults (e.g missed payments, chargeoffs, and collections). In the next section, we show that while there is zero borrowing on average, this result masks substantial heterogeneity in borrowing behavior following job loss.

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 now 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 *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 ($RR_{it} = \frac{-(debt_{i,t+1} - debt_{i,t-1})}{earnings_{i,t+1} - earnings_{i,t-1}}$).[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

[13] Individuals obtain a derogatory flag on their credit report for bankruptcy, tax liens, foreclosure, civil judgments, etc.

[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).[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 deliquency flag, it may be the case that the banks renegotiated the loan without charging it off (Adelino, Gerardi, and Willen [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.[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:

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

The objects of interest are $(\lambda_1, \lambda_2, \lambda_3, \lambda_4, \lambda_5)$. The coefficient λ_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

[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.

[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 income-replacement 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 across individuals with different credit scores. Let $\mathit{\Delta} e_{i,t+1,t-1} = e_{i,t+1} - e_{i,t-1}$ 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:

$$Y_{i,t+1} = \gamma_t + \eta + \mu \mathit{\Delta} e_{i,t+1,t-1} + \sum_{j=2}^{5} (\eta_j C_{j,i,t-1} + \mu_j C_{j,i,t-1} \times \mathit{\Delta} e_{i,t+1,t-1}) + \mathit{\Psi} X_{i,t} + \varepsilon_{i,t} \qquad (4)$$

The objects of interest are $(\mu, \mu_2, \mu_3, \mu_4, \mu_5)$. The coefficient μ 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 jth 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

[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 ($= -10,000 \times [0.0210 - 0.0749]$). 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. Thus, some component of the borrowing response to job loss may be consistent with contemporaneous and innovative work by Hundtofte and Pagel [2017] who use Icelandic data and attribute delevering upon job loss to heterogeneous preferences to smooth debt.

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 in response to job and income loss. 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 transfers to the unemployed (which we will also call 'public insurance') in an environment that replicates the borrowing behavior documented in Section 1.

Our framework is a labor search model (e.g. Menzio and Shi [2011]) with long-term credit lines (e.g. Mateos-Planas and Ríos-Rull [2010]). By modeling credit lines, we are able to replicate the non-responsiveness of credit access to job loss. In the calibrated model, when public insurance becomes sufficiently low, high asset individuals precautionary save, while low asset individuals become more likely to default, and the credit market endogenously contracts. This complementarity between public and private insurance limits the willingness of the government to substitute out of public insurance.

Time is discrete and runs forever. There is a unit measure of individuals, 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, Telyukova, and Visschers [2012]. Each individual lives T periods. Individuals have heterogeneous discount factors. Let β_i be a type i individual's discount factor, where $i \in \{H, L\}$ denotes an individual's type and types are both observable and permanent. We set $0 < \beta_H < \beta_L < 1$, i.e. type L individuals are more patient ('low profit' to lenders) than type H individuals ('high profit' to lenders). The share of type i individuals in the economy is π_i. Heterogeneous discount factors will allow us to match the cost of credit and use of credit observed in the U.S. data.

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 κ_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 an 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:

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

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 $b \in \mathcal{B} \equiv [\underline{B}, \bar{B}] \subset \mathbb{R}$ denote the net asset position of the individual, where $b > 0$ indicates saving and $b < 0$ indicates borrowing. Let $\vec{h} \in \mathcal{H} \equiv [\underline{\tilde{h}}, \bar{\tilde{h}}] \times [\underline{\epsilon}, \bar{\epsilon}] \subset \mathbb{R}^2$ 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 (ϵ). 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 $\underline{b} \in \underline{\mathcal{B}} \equiv [\underline{B}, 0]$ 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 ω 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), requested piece-rate (ω), and human capital $(\vec{h})$. Although individuals differ along other dimensions, an agent's age, 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 $\theta_t(\omega, \vec{h})$, such that $p(\theta_t(\omega, \vec{h})) = \frac{M(u_t(\omega,\vec{h}), v_t(\omega,\vec{h}))}{u_t(\omega,\vec{h})}$. 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 $p_f(\theta_t(\omega, \vec{h})) = \frac{M(u_t(\omega,\vec{h}), v_t(\omega,\vec{h}))}{v_t(\omega,\vec{h})}$. Once matched with a firm, a worker produces $f(\vec{h}) : \mathcal{H} \to \mathbb{R}_+$ and keeps a share ω of this production as their wage. Matches end exogenously each period with probability δ. 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 delevering.

Every period individuals without credit access choose whether or not to search for a credit line, which entails a utility cost κ_S. After incurring the utility cost, the agent then directs their search over the menu of credit lines, which specify a borrowing limit $\underline{b}$, 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. A submarket is defined by an agent's age (t), type (i), employment status $(e \in \{W, U\})$, piece-rate wage (ω), prior debt (b), human capital $(\vec{h})$, and the requested contract $(\underline{b}, r)$. In each submarket, the credit finding rate for individuals, $p^c(\cdot)$, is a function of the credit market tightness. For unemployed individuals, the tightness is given by $\theta^{c,U}_{i,t}(b, \vec{h}; \underline{b}, r)$ where $p^c(\theta^{c,U}_{i,t}(b, \vec{h}; \underline{b}, r))$ is the associated credit finding rate.[18] On the other side of the market, the probability a lender matches with a borrower, denoted $p^c_f(\cdot)$, is also a function of credit market tightness and is given by $p^c_f(\theta^{c,U}_{i,t}(b, \vec{h}; \underline{b}, r))$.[19] An

[18]For the unemployed, $p^c(\theta^{c,U}_{i,t}(b, \vec{h}; \underline{b}, r)) = \frac{M_C(u_{C,i,U,t}(b,\vec{h};\underline{b},r), v_{C,i,U,t}(b,\vec{h};\underline{b},r))}{u_{C,i,U,t}(b,\vec{h};\underline{b},r)}$. For the employed, the tightness depends on the wage piece-rate, $\theta^{c,W}_{i,t}(\omega, b, \vec{h}; \underline{b}, r)$ and $p^c(\theta^{c,W}_{i,t}(\omega, b, \vec{h}; \underline{b}, r)) = \frac{M_C(u_{C,i,W,t}(\omega,b,\vec{h};\underline{b},r), v_{C,i,W,t}(\omega,b,\vec{h};\underline{b},r))}{u_{C,i,W,t}(\omega,b,\vec{h};\underline{b},r)}$.

[19]For the unemployed, $p^c_f(\theta^{c,U}_{i,t}(b, \vec{h}; \underline{b}, r)) = \frac{M_C(u_{C,i,U,t}(\omega,b,\vec{h};\underline{b},r), v_{C,i,U,t}(\omega,b,\vec{h};\underline{b},r))}{v_{C,i,U,t}(\omega,b,\vec{h};\underline{b},r)}$. For the employed, the credit

individual remains matched with a lender until the individual defaults, or the match is destroyed exogenously at rate δ_C.

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 $U^S_{i,t}(b, \vec{h}; 0, 0)$ 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 $\underline{b} = 0$ and $r = 0$. This agent must decide whether to pay the utility cost κ_S of searching for a credit contract or remaining without credit,

$$U^S_{i,t}(b, \vec{h}; 0, 0) = \max\left\{-\kappa_S + U^A_{i,t}(b, \vec{h}; 0, 0),\ U^N_{i,t}(b, \vec{h}; 0, 0)\right\} \quad \forall t \leq T$$

$$U^S_{i,T+1}(b, \vec{h}; 0, 0) = 0$$

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

$$U^A_{i,t}(b, \vec{h}; 0, 0) = \max_{(\underline{b}, r) \in \underline{\mathcal{B}} \times \mathcal{R}} p^c(\theta^{c,U}_{i,t}(b, \vec{h}; \underline{b}, r)) U^C_{i,t}(b, \vec{h}; \underline{b}, r) + \left(1 - p^c(\theta^{c,U}_{i,t}(b, \vec{h}; \underline{b}, r))\right) U^N_{i,t}(b, \vec{h}; 0, 0)$$

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. 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 relative to the change in income for job losers. The transfer to unemployed individuals is funded through a proportional tax τ 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. In the model, home production proxies for other resources that individuals have access to following job loss, such as transfers from friends and family, or changes in spousal labor supply. We will calibrate the value of home production to

finding rate depends on the wage piece-rate, $p^c_f(\theta^{c,W}_{i,t}(\omega, b, \vec{h}; \underline{b}, r)) = \frac{M_C(u_{C,i,W,t}(\omega,b,\vec{h};\underline{b},r), v_{C,i,W,t}(\omega,b,\vec{h};\underline{b},r))}{v_{C,i,W,t}(\omega,b,\vec{h};\underline{b},r)}$.

match estimates of consumption following job loss.

After consuming, idiosyncratic human capital risk is realized. Unemployed individuals, on average, lose human capital, while employed individuals gain human capital. Individuals then enter the labor market where they direct their search over piece-rate wage contracts ω. At the end of the period, individuals without credit access enter the credit search stage. The continuation value of an unemployed agent without credit access is,

$$U^N_{i,t}(b,\vec{h};0,0) = \max_{b'\geq 0} u(c) + \beta_i \mathbb{E}\Big[\max_{\tilde{\omega}} p(\theta_{t+1}(\tilde{\omega},\vec{h}'))W^S_{i,t+1}(\tilde{\omega},b',\vec{h}';0,0) + \Big(1-p(\theta_{t+1}(\tilde{\omega},\vec{h}'))\Big)U^S_{i,t+1}(b',\vec{h}';0,0)\Big] \quad \forall t\leq T$$

$$U^N_{i,T+1}(b,\vec{h};0,0) = 0$$

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,

$$\vec{h}' = H(\vec{h},U) \tag{5}$$

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 $\underline{b}$. 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,

$$U^C_{i,t}(b,\vec{h};\underline{b},r) = \max_{b'\geq \underline{b}} u(c) + \beta_i \mathbb{E}\Big[\max_{\tilde{\omega}} p(\theta_{t+1}(\tilde{\omega},\vec{h}'))W^D_{i,t+1}(\tilde{\omega},b',\vec{h}';\underline{b},r) + \Big(1-p(\theta_{t+1}(\tilde{\omega},\vec{h}'))\Big)U^D_{i,t+1}(b',\vec{h}';\underline{b},r)\Big] \quad \forall t\leq T \tag{6}$$

$$U^C_{i,T+1}(b,\vec{h};0,0) = 0$$

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 relationship has been exogenously destroyed. With probability δ_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

$$\begin{aligned} U^D_{i,t+1}(b^{'}, \vec{h}^{'}; \underline{b}, r) = \delta_C \max\{U^N_{i,t+1}(0, \vec{h}^{'}; 0, 0) - \psi_D(b^{'}),\ U^N_{i,t+1}(b^{'}, \vec{h}^{'}; 0, 0)\} \\ + (1-\delta_C)\max\{U^N_{i,t+1}(0, \vec{h}^{'}; 0, 0) - \psi_D(b^{'}),\ U^C_{i,t+1}(b^{'}, \vec{h}^{'}; \underline{b}, r)\} \end{aligned} \tag{7}$$

Let $D^{N,U}_{i,t+1}(b^{'}, \vec{h}^{'}; \underline{b}, r)$ be an indicator function denoting an individual's default decision when they are unemployed and are hit by the credit separation shock ($D^{N,U}_{i,t+1}(b^{'}, \vec{h}^{'}; \underline{b}, r) = 1$ when the individual defaults and is equal to zero otherwise). Let $D^{C,U}_{i,t+1}(b^{'}, \vec{h}^{'}; \underline{b}, r)$ 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 as unemployed individuals. The two main differences between the employed and unemployed are that (1) with probability δ, employed individuals are laid off and must search for a new job, and (2) employed individuals pay a proportional labor income tax τ which is used to fund the public insurance transfer. The 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 $\beta_{lf} \in (0,1)$. Lenders offer credit contracts which specify a borrowing limit $\underline{b} < 0$ and an interest rate r. Let $\Pi^U_{i,t}(\vec{x})$ 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 $\vec{x} = (b, \vec{h}; \underline{b}, r)$.[20] Let $b^{'}_{i,t}(\vec{x})$ and $\hat{D}^{N,U}_{i,t+1}(\vec{x}^{'})$ denote the asset and default policy functions of the individual. The profits to the lender of offering a contract with borrowing limit $\underline{b}$, and interest rate r are given by,

$$\begin{aligned} \Pi^U_{i,t}(b, \vec{h}; \underline{b}, r) = \beta_{lf} b^{'}_{i,t}(\vec{x}) \left(\frac{(r_f - r)}{1+r} + \mathbb{E}\left[\delta_C \hat{D}^{N,U}_{i,t+1}(\vec{x}^{'}) + (1-\delta_C)\hat{D}^{C,U}_{i,t+1}(\vec{x}^{'})\right]\right) \times \mathbb{I}\{b^{'}_{i,t}(\vec{x}) < 0\} \\ + \beta_{lf}(1-\delta_C)\mathbb{E}\left[\left(1 - \hat{D}^{C,U}_{i,t+1}(\vec{x}^{'})\right) \hat{\Pi}^U_{i,t+1}(\vec{x}^{'})\right] \end{aligned} \tag{8}$$

At the end of the period an age t agent makes their savings decision, $b^{'}_{i,t}(\vec{x})$. If the individual is borrowing, $b^{'}_{i,t}(\vec{x}) < 0$, then in the next period the lender earns the spread between the interest

[20] For employed individuals the state is $\vec{x} = (\omega, b, \vec{h}; \underline{b}, r)$, and lender profits are defined analogously in Appendix C.2. Let $\vec{x}^{'}$ denote the state space of the individual in the next period.

rate r and the risk free rate r_f. However, the lender faces default risk on the outstanding loan $b'_{i,t}(\vec{x})$. 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 who receives the credit separation shock is denoted $\hat{D}^{N,U}_{i,t+1}(\vec{x}')$, and is given by:[21]

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

where $\hat{\omega}$ is the unemployed worker's choice of where to search for a job.[22] If the agent does not default and the credit match is not hit by the credit separation shock, then the match between the lender and borrower continues to the next period. The profits to the lender in the next period 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

$$\hat{\Pi}^U_{i,t+1}(\vec{x}') = p\left(\theta_{t+1}(\hat{\omega}, \vec{h}')\right) \Pi^W_{i,t+1}(\hat{\omega}, b', \vec{h}'; \underline{b}, r) + \left(1 - p\left(\theta_{t+1}(\hat{\omega}, \vec{h}')\right)\right) \Pi^U_{i,t+1}(b', \vec{h}'; \underline{b}, r)$$

Free entry determines the number of lenders who enter each submarket in equilibrium. The free entry condition is

$$\kappa_C \geq p^c_f\left(\theta^{c,U}_{i,t}(b, \vec{h}; \underline{b}, r)\right) \Pi^U_{i,t}(b, \vec{h}; \underline{b}, r) \tag{10}$$

The free entry condition binds for all submarkets such that $\theta^{c,U}_{i,t}(b, \vec{h}; \underline{b}, r) > 0$. Note that individuals who are searching for credit contracts are not currently able to borrow, $b \geq 0$.

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 δ. Firms have the same discount factor β_{lf} as lenders. The continuation value of a firm that has committed to pay piece rate ω to their age t employee with human capital $\vec{h}$ is

$$J_t(\omega, \vec{h}) = (1-\omega) f(\vec{h}) + \beta_{lf}\mathbb{E}\left[(1-\delta) J_{t+1}(\omega, \vec{h}')\right] \quad \forall t \leq T$$
$$J_{T+1}(\omega, \vec{h}) = 0$$

[21] 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 $D^{C,U}_{i,t+1}$.

[22] Note the choice of where to search for a job is a function of state variables which are suppressed for convenience.

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

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

Firms must pay cost κ to post a vacancy. A vacancy specifies a wage piece rate ω, as well as a human capital requirement $\vec{h}$, and age t. Free-entry requires that:

$$\kappa \geq p_f\left(\theta_t(\omega, \vec{h})\right) J_t(\omega, \vec{h}) \tag{11}$$

The free entry condition binds for all submarkets such that $\theta_t(\omega, \vec{h}) > 0$.

2.3 Government

The government determines the level of transfers to the unemployed, i.e. public insurance. 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, τ, which is levied on all employed individuals to satisfy

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

where $\hat{u}_{i,t}(\vec{x})$ is the share of individuals with state $\vec{x}$ that are type i and age t who are unemployed, and $\hat{e}_{i,t}(\vec{x}) = 1 - \hat{u}_{i,t}(\vec{x})$ is the share who are employed.[23]

2.4 Equilibrium

In equilibrium, individual decision rules are optimal, free entry holds in both the credit and labor market, the government balances its budget, and the distribution of individuals across states is consistent with the decision rules. The formal definition of equilibrium is given in Appendix D.

In Appendix D, we prove that if the government budget constraint is ignored and τ is exogenously given, then the model is *Block Recursive* (e.g. Menzio and Shi [2011]). Given an exogenous τ, Block Recursivity means that the individual, lender, and firm problems can be solved independently of the distribution of individuals across states.

The equilibrium tax rate that balances the government budget constraint will ultimately depend on the distribution of individuals across states and, in the case of transition dynamics, the path of tax rates will also depend on the path of the distribution of individuals across states. However, the fact that equilibrium prices and the distribution of individuals across states are only linked by τ greatly simplifies our computation of the transition path.

[23]There is a slight abuse of notation where $\vec{x} = (b, \vec{h}; \underline{b}, r)$ for the unemployed and $\vec{x} = (\omega, b, \vec{h}; \underline{b}, r)$ for the employed.

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 from the data.[24] We estimate our steady state to match moments from 1995 to 2007, although several of our moments are only available at different points in time.

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), $\beta_H = .632$, 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.[25]

We calibrate the fraction of individuals that are high types, denoted $\pi_H = 1 - \pi_L = .096$, 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.[26]

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 $\kappa = .995$ is estimated to target an unemployment rate of 5.0%, which is the average reported by the Bureau of Labor Statistics from 1995 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 ϵ denotes the transitory component. We assume the production function is linear and additive in the human capital of the worker, $f(\vec{h}) = \tilde{h} + \epsilon$. The process for the persistent component of human capital is governed by two parameters $p_{\tilde{h},L}$ and $p_{\tilde{h},H}$.

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

[24] Appendix E describes our solution algorithm in detail.

[25] Interest rates are made real by subtracting the CPI inflation rate in a given year.

[26] As in Herkenhoff et al. [2015], for each individual 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.

$$H_P(\vec{h}, W) = \tilde{h}' = \begin{cases} \tilde{h} + \Delta & \text{w/ pr. } p_{\tilde{h},H} \text{ if employed} \\ \tilde{h} & \text{w/ pr. } 1 - p_{\tilde{h},H} \text{ if employed} \end{cases}$$

The grid for the persistent component of human capital $\tilde{h} \in [0.6,\ 0.7,\ 0.8,\ 0.9,\ 1,\ 1.1,\ 1.2]$ 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 $p_{\tilde{h},H} = 0.083$, we target the semi-elasticity of earnings with respect to age using the 1995 to 2007 Current Population Surveys.[27] To estimate the probability that a worker's productivity decreases while unemployed $p_{\tilde{h},L} = 0.651$, 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 $p_{\tilde{h},L}$ considered in earlier drafts of this paper resulted in greater substitutability between credit and public insurance.

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

$$H_T(\tilde{h}', W) = \epsilon' = \begin{cases} \Delta_\epsilon(\tilde{h}') & \text{w/ pr. } p_{\epsilon,H} \\ 0 & \text{w/ pr. } 1 - p_{\epsilon,L} - p_{\epsilon,H} \\ -\Delta_\epsilon(\tilde{h}') & \text{w/ pr. } p_{\epsilon,L} \end{cases} \tag{13}$$

The step size $\Delta_\epsilon(\tilde{h}') = 0.095\tilde{h}'$ is taken as given, and we estimate the parameters $p_{\epsilon,H} = 0.252$ and $p_{\epsilon,L} = 0.111$ to target the share of employed workers who experience a 9.5% wage increase and decrease over a given year, respectively, as reported in Kurmann and McEntarfer [2017].[28] 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 $z = .327$ is estimated to match the 41.2% public

[27] 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: $ln(Y_{i,t}) = \alpha + \beta_{age}Age_{i,t} + \varepsilon_{i,t}$,where $Y_{i,t}$ denotes the earnings of individual i in year t, and $Age_{i,t}$ denotes the age of individual i in year t. The coefficient β_{age} estimates the average increase in log earnings associated with an increase in age. Using data from the CPS for the years 1995-2007 among full-time workers between the ages of 25 and 54, we estimate a relative gain in earnings with a 1-year increase in age of 0.93%. We additionally include educational attainment dummies, as well as industry and year dummies in the estimation.

[28] Kurmann and McEntarfer [2017] report that between 2009 and 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% during that year. They report 19% of job stayers experienced a wage increase of 9.5% or higher during that year.

transfer replacement rate (change in public transfers divided by change in annual income) among laid-off workers observed in the PSID between 2001 and 2013.[29] 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 $g = 0.146$ 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.[30]

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 [2015]. For the credit market matching function, we again use a constant returns to scale matching function that yields well-defined credit finding probabilities:

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

The matching elasticity parameter is chosen to be $\zeta_C = 0.37$ as measured in Herkenhoff [2013].

There is an exogenously given grid of interest rates for credit contracts over the interval $[\underline{r}, \bar{r}]$. We set the minimum annual interest rate ($\underline{r}$) 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 [2014] for individuals with FICO scores greater than 800. We set the maximum interest rate ($\bar{r}$) to be 22.5%, which is the 99th percentile of the real credit card interest rate distribution in the SCF from 1995 to 2007.

Credit contracts also specify a borrowing limit which must lie in the interval $[\underline{B}, 0)$, where $\underline{B} < 0$ is the minimum value of the asset grid. We estimate $\underline{B} = -1.149$, 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.[31] The credit posting cost $\kappa_C = 2.214 \times 10^{-5}$ is estimated so that the

[29] 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 [2017] estimate a replacement rate (changes in transfers over changes in earnings) of 43.6%.

[30] 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.

[31] Using the SCF from 1995-2007, we estimate an unused credit to income ratio of 23%.

credit finding rate in the model matches the new-borrower credit approval rate of 65.0%, which can only be measured in the 2007 to 2009 SCF panel. The utility cost of searching for a credit contract $\kappa_S = 1.272 \times 10^{-4}$ 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 $T = 120$ quarters (30 years). Newly born individuals enter as unemployed workers, with zero assets and without a credit contract. Their initial persistent human capital is drawn from an exponential distribution with parameter λ_H. We calibrate the parameter λ_H to match the P75-P25 earnings ratio of young workers (workers between 25 and 29), which we measure as $\frac{\tilde{earnings}_{p75} - \tilde{earnings}_{p25}}{earnings_{avg}}$, where $\tilde{earnings}_j$ is the jth percentile of residualized earnings.[32] Using the CPS from 1995 to 2007 we measure the P75-P25 earnings ratio among workers age 25 to 29 to be 0.4843. 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 $\psi = 14.771$ to match the bankruptcy rate in the U.S. from 1998-2007 of 0.145% per quarter.[33]

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 measure 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. 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 in order to be in either the treatment or control samples.

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 simula-

[32] We residualize earnings by removing year and industry fixed effects, and controlling for the years of education.

[33] This is computed using the SCF from 1998 (the date they first record bankruptcies) to 2007. We measure that 0.58% of individuals with a credit card report having filed for bankruptcy within the past year.

tion. Similar to the data, displaced individuals' earnings drop by approximately 30%, 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 prior to job loss and thus borrowing limits are unresponsive to job loss, similar to the data. The change in credit limits is effectively zero in the model. In the data, credit limits fall in years 1 and 2, but are insignificantly different from zero elsewhere. This stands in contrast to models which have one period debt, e.g. Herkenhoff [2013] and Athreya et al. [2009].

Borrowing follows a similar pattern. Panel (c) reveals that debt is largely unresponsive to job loss in both the model and data. Borrowing increases marginally in the model. In the data, borrowing is indistinguishable from zero in all years.

Panel (d) examines the propensity of individuals to default in the model following job loss. When we compare the model to the data, we consider default to be any derogatory public flag which includes 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. Between the year before layoff (t=-1) and the year after layoff (t=1), the default rate rises by .261% in the model and by .639% in the data. Thus, the model accounts for nearly 41% (=.261/.639) of the rise in defaults following job loss.

Lastly, 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.

The relatively weak deleveraging response is driven by too little net and gross borrowing among the employed, which is a common problem in consumer credit models (e.g. Herkenhoff [2013]). Upon job loss, too few individuals have debts which limits how many job losers default or pay down existing debt. Our framework partially addresses this issue by allowing human capital and wages to grow over the lifecycle, generating a role for borrowing among young, employed workers. In our baseline calibration 6.2% of job losers delever after job loss, whereas in the SCF data, 24% of job losers delever over the same period.[34] Therefore our model captures roughly 25% of

[34]In the SCF, we identify an individual to be unemployed in a given wave if they are either unemployed at the time of the survey or have had an unemployment spell of longer than 4 weeks within the past year. We measure the replacement rate and share of individuals deleveraging among household heads and their spouses who were not identified as unemployed in the 2007 wave, but were identified as unemployed in the 2009 wave and had an earnings loss between the 2007 and 2009 waves.

observed delevering among job losers.

Overall, we view Figures 6 and 7 as evidence that the model generates similar unemployed borrowing and default patterns as the data. We view the model's ability to reproduce unresponsive borrowing among job losers, despite featuring strong precautionary motives and rising defaults, as providing validation of the model.

4 Optimal Public Insurance to the Unemployed

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. We first compute optimal transfers in steady state. When assessing optimality in steady-state, we use a utilitarian welfare criterion, which is an equally weighted average of newly born individuals' consumption-equivalent gains of moving to the new policy.[35] We find that the optimal replacement rate of public insurance is 38.3%.

Second, we compute the general equilibrium transition path from current U.S. policy to the new optimum. When assessing welfare along the transition path, we compute the consumption-equivalent gains of all individuals alive at the time of the policy reform.[36] We find that there are small positive welfare gains along the transition path when the replacement rate of public insurance is lowered from 41.2% to 38.3%.

4.1 Optimal Policy in Steady State

We first compute optimal transfers to the unemployed in steady state. We do so by comparing utilitarian welfare across steady states of the model with differing levels of public transfers, z. As we have done throughout the paper, instead of reporting z, we report the replacement rate of public transfers which is the average fraction of lost earnings replaced by a given level of z. Table 8 summarizes our findings. Column (1) replicates the baseline U.S. calibration in which 41.2% of lost earnings is replaced by the government, 19.6% of individuals borrow, the default rate is .142% per quarter, and annual consumption falls by 6.0% for individuals who have an unemployment spell.

Column (2) reports the optimal replacement rate in the baseline U.S. calibration, where all parameters except for z are held fixed at their values in Table 6. Welfare is maximized when the public insurance transfer, z, replaces 38.3% of lost earnings. The fraction of individuals who borrow increases to 20.4%, and annual consumption falls by 6.1% for individuals who have an unemployment spell, which are both marginally greater than in the baseline calibration. With

[35] See Appendix F for details on the estimation of the share of lifetime consumption an individual would be willing to give up to move across economies.

[36] See Appendix F.2 for details on the estimation of welfare along the transition path.

a weaker safety net, workers now find jobs faster, and the unemployment rate declines by .5%. Although our environment does not feature search effort, the model still features moral hazard because of directed search. With lower public transfers, individuals direct their search into submarkets where they find jobs more quickly.

At a moderately lower public insurance replacement rate of 38.3%, the default rate declines. In our framework, the cost of default is preclusion from future credit access. In an economy with a marginally weaker safety net, individuals value future credit access more. Therefore, they are less likely to default and the quarterly default rate declines to .135%. Importantly for our exercise, the default rate is non-monotonic in the replacement rate of public transfers. We will illustrate this property of the default rate in the next section.

On average, individuals are willing to give up 0.129% of lifetime consumption to be born in an economy with a 38.3% replacement rate as opposed to our baseline economy with a 41.2% replacement rate. Figure 8 graphically illustrates steady-state utilitarian welfare for various replacement rates. Welfare is single peaked with respect to the replacement rate. Lowering the replacement rate too much generates significant welfare losses. We discuss the mechanisms behind this result in the next section.

We now counterfactually shut down credit markets (i.e. no borrowing, $\underline{\mathcal{B}} = \{0\}$ and thus $\underline{b} = 0$ for all contracts) and redo our optimal steady-state policy analysis. This exercise allows us to study how optimal policy interacts with the presence of a well-developed credit market. Column (3) of Table 8 reports our results. The optimal replacement rate increases to 43.2% when credit markets are shut down. This replacement rate exceeds the current U.S. replacement rate of 41.2%.

Without credit, there is limited private self-insurance for low asset individuals. A consequence is that the government can partially complete the market by raising the public insurance replacement rate from 41.2% to 43.2%. Because of moral hazard, however, when the safety net expands, the unemployment rate increases by .1%. The relatively weak moral hazard effects from expanding the safety net are in line with existing quantitative and empirical exercises (e.g. see Nakajima [2012b] for a recent summary). To cover the cost of the expanded safety net, the equilibrium labor tax rate increases by .15%.[37]

Public insurance replacement rates can only be cut by 4.9 percentage points (=43.2-38.3) as we move from a steady state in which 0% of individuals have access to credit (Column (3) of Table 8) to a steady state in which 70.5% of individuals have access to credit (Column (2) of Table 8). Therefore our steady state results suggest a limited scope for substitution between public and private insurance. In what follows, we explore which features of the environment generate this lack of substitutability.

[37] We find that the effects of taxation are close to linear in our framework. In results available upon request, we endow the government with necessary spending level G in order to generate reasonable initial labor income tax levels. We find very similar results to what is reported in the text.

4.2 What limits the substitutability of public and private insurance?

Despite extremely well developed credit markets in the U.S., Column (2) of Table 8 reveals that it is only optimal to moderately cut public insurance. What limits further substitution out of public insurance and into borrowing? When public insurance is cut, there are two effects. First, those who enter unemployment with zero assets have a much weaker safety net and borrow more, ceteris paribus. This is what we refer to as *micro substitutability* between public insurance and borrowing. Second, in general equilibrium, individuals save more in order to avoid entering unemployment with zero assets. Fewer job losers borrow, and this is what we refer to as *macro complementarity* between public insurance and borrowing.

We measure the micro substitutability between public insurance and credit by analyzing the borrowing patterns of unemployed individuals with zero net worth. By conditioning on zero net worth, we are able to measure how borrowing responds to public insurance separately from precautionary shifts in the wealth distribution. Let $\bar{b}'_0$ denote the asset choice of a typical unemployed individual with zero net worth. Panel (A) of Figure 9 plots $\bar{b}'_0$ as a function of the public insurance replacement rate. As the government replaces less income with public insurance, individuals with zero net worth monotonically borrow more ($\bar{b}'_0$ becomes more negative). With a weaker safety net, individuals with zero net worth optimally replace a greater share of their lost income through borrowing. Therefore, we call public insurance and credit *micro substitutes*. This property holds globally.

At the center of the optimal public insurance decision is the endogenous cost of credit. Panel (B) of Figure 9 plots the default rate, which is the key determinant of the cost of credit. The relationship between public insurance and the default rate is non-monotonic. First, consider the region with public insurance replacement rates greater than 38%. In this region, the default rate rises when the public insurance replacement rate *increases* from 38% to 42%. To understand why this is the case, consider the default punishment. Households borrow to smooth consumption, and if they do not repay, they are excluded from future credit markets for a stochastic period of time. Exclusion from credit markets is significantly less costly when the safety net expands, and therefore the default rate rises when transfers increase.

Now consider the region with public insurance replacement rates less than 38%. In this region, the default rate rises when the public insurance replacement rate *decreases* from 38% to 28%. With a smaller safety net, smaller income shocks trigger default. Consequently, default rates rise in this region.

Panel (C) of Figure 9 plots the interest rate, and Panel (D) of Figure 9 plots the credit finding rate. Profit maximizing lenders understand the relationship between the default rate and the safety net.[38] In an environment with higher overall default rates, they adjust their behavior

[38] The negative relationship between defaults and UI replacement rates, whether internalized by lenders or not, is quite strong in the data, e.g. Hsu, Matsa, and Melzer [2014].

accordingly by providing credit offers (v_C) in submarkets with higher interest rates as well as reducing the number of credit offers. The individual credit finding rate falls, and the cost of credit, conditional on obtaining credit, rises. Panel (C) illustrates that the interest rate follows the same non-monotonic pattern as the default rate. Panel (D) illustrates that the individual credit finding rate declines when public insurance replacement rates fall beyond 38%. The higher interest rate and lower credit finding rate both represent an increasing cost to credit as public transfers are cut.

We now turn to the macro complementarity of public transfers and credit. We measure the macro complementarity between public insurance and credit by analyzing the fraction of individuals who borrow. When public insurance is cut, individuals save more in order to avoid large consumption losses following an income shock. The fraction of individuals who borrow summarizes how strong these general equilibrium precautionary motives are.

Panel (E) of Figure 9 plots the fraction of individuals borrowing as a function of the public insurance replacement rate. At high levels of public insurance which replace more than 36.9% of lost earnings, public insurance and credit are aggregate substitutes. Increasing the replacement rate from 38% to 42% lowers the fraction of individuals who borrow. However, at low levels of public insurance which replace less than 36.9% of lost earnings, the fraction of individuals who borrow declines as replacement rates are cut. The size of the credit market begins to contract for further cuts to public insurance. Therefore, for low levels of public insurance, we call credit and public insurance *macro complements*. The macro complementarity between credit and public insurance at low levels of replacement rates is ultimately what prevents the government from substituting further out of public insurance and into credit.

Two key drivers of the macro complementarity are precautionary credit line accumulation and precautionary savings. Panel (F) of Figure 9 plots the unused credit limit to income ratio which rises monotonically as benefits are cut. Despite a falling fraction of borrowers, individuals' precautionary motives dominate, and more individuals pay the utility cost of applying for credit. Since so many more individuals apply for credit, the fraction of individuals with credit access rises despite the lower credit finding rate. As a consequence, aggregate unused credit limits rise.

In terms of precautionary saving, Panel (G) of Figure 9 plots the top and bottom deciles of the wealth distribution. A result of lower replacement rates is rising wealth dispersion. Conditional on borrowing, individuals must borrow more since there is a weaker safety net. The 10th percentile of the wealth distribution falls. On the other hand, employed individuals now save more in order to avoid borrowing at higher rates. The 90th percentile of the wealth distribution rises. The net effect is significantly more wealth dispersion as the safety net is weakened.

Ultimately, the overall substitutability between public insurance and credit is quite low and the consumption of job losers declines as the replacement rate is cut. Panel (H) of Figure 9 plots the year-over-year consumption loss of individuals who are displaced. Even thought there is increased saving, the rising cost of credit and lower credit approval rate imply larger consumption losses upon layoff as transfers are cut.

What Panels (A) through (H) of Figure 9 establish is that despite micro substitutability between credit and public insurance, public insurance and credit are macro complements at low levels of public insurance replacement rates. This limits the government's willingness to substitute out of public insurance and into private borrowing. A consequence is that moderate amounts of public insurance are necessary to keep the costs of borrowing low.

Distribution of gains and losses. While the policy of decreasing the replacement rate of public insurance from 41.2% to 38.3% raises welfare on average, it is not Pareto-improving. Figure 10 presents the welfare change of moving from a 41.2% to 38.3% replacement rate by the persistent component of an individual's initial human capital. The majority of individuals with the lowest initial level of human capital have a welfare loss when public insurance is cut. On the other hand, the majority of individuals with the highest initial level of human capital have a welfare gain when public insurance is cut. In our framework, human capital and assets are highly correlated. Low asset, low human capital individuals must increasingly rely on more costly debt when public insurance is cut, and thus they have welfare losses from the policy change.

4.3 Transition Path

In this section, we compute welfare gains along the transition path when public insurance replacement rates are cut from current U.S. levels of 41.2% to 38.3%. We measure welfare along the transition path for all individuals alive at the time of the policy reform.[39]

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 38.3%. After the initial unexpected decline, individuals in the economy have rational expectations that the lower replacement rate is permanent. What makes the transition experiment tractable is the fact that our model is Block Recursive conditional on τ (see Section 2.4 and Appendix D). We allow the labor income tax rate, τ, to adjust non-linearly during the transition to the new steady state. See Appendix G for computational details of the transition path experiment.

Panel (A) of Figure 11 illustrates the path of the public insurance replacement rate. We let $t = 0$ correspond to the year in which public insurance is cut from 41.2% to 38.3%. Panel (B) of Figure 11 illustrates the path of the labor income tax, τ, which is levied on employed individuals to fund the public transfer. The tax rate declines by .27% in the first year after the policy change, and then marginally declines thereafter to the new steady state.

Panel (C) of Figure 11 plots the fraction of individuals borrowing. Since the initial U.S. steady state prior to date $t = 0$ features a high public insurance transfer, when benefits are cut, the fraction of individuals borrowing increases by roughly 1 percentage point. As Panel (E) of

[39]See Appendix F.2 for details on the estimation of welfare effects in the transition experiment.

Figure 9 made clear, the government cuts transfers up until the point where fraction of individuals borrowing reaches it maximum. Further cuts to public insurance would reduce borrowing.

Panel (D) of Figure 11 illustrates that the unemployment rate declines along the transition path with a weaker safety-net. What drives the decline in unemployment is that individuals direct their search toward submarkets with greater job finding rates since they are less able to smooth consumption through either public or private means. Even though our framework features wealth accumulation, our model produces very fast transition dynamics, which is common in linear-utility Diamond-Mortensen-Pissarides models as well as frameworks that incorporate risk aversion (Krusell et al. [2010]).

We find that the average individual who is alive at the time that the transition occurs has a 0.05% consumption equivalent gain. Figure 12 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 at the time of the policy change. The figure shows that at higher (lower) levels of persistent human capital, approximately 80% (65%) of individuals have a welfare gain from the policy change. In summary, 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 38.3% replacement rate.

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 public insurance to the unemployed?

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. Thus credit markets are important for both sets of workers in their borrowing and consumption decisions.

To answer the second question, we develop a new framework that integrates credit lines (e.g. Mateos-Planas and Ríos-Rull [2010]) into a competitive labor search model with employment risk (e.g. Moen [1997], Burdett et al. [2001], and Menzio and Shi [2011]). Our quantitative contribution is to measure the optimal degree of public insurance in an economy that features current levels of U.S. credit access, and matches the responsiveness of credit access following job loss.

We validate our model using our new micro facts, and we find that the optimal provision of public insurance is unambiguously lower as credit access expands. In our benchmark economy, the utilitarian government would prefer to have the income replacement rate from public unemployment insurance lowered from the current US policy of 41.2% to 38.3%. We find this policy change would generate welfare gains both in the new steady state as well as along the transition path.

We then use the framework to explore the factors that limit the ability to further substitute out of public insurance and into private borrowing. We find that for low levels of public insurance, there is a strong *macro-complementarity* between credit markets and public insurance: credit markets and public insurance comove positively. Cutting public insurance too much increases the cost of credit and individuals precautionarily save. Consumption losses upon layoff increase and individuals are strictly worse off. Individuals default more and thus, in anticipation of default, lenders increase interest rates and provide fewer credit offers. Despite reputation concerns and significant expansions of long-term credit, the U.S. government is quite close to the optimal public insurance replacement rate.

Beyond the contributions made in this paper, this paper documents basic facts regarding job loss, default, and borrowing. These new facts can also be used to calibrate or examine policy relevant mechanisms in incomplete-market frameworks. Moreover, the long-term credit model developed in this paper is extremely flexible and allows us to better characterize the interaction between credit and income. In concurrent work, we are using credit bureau data and modifying the model framework to (i) identify permanent and transitory income processes (Braxton et al. [2019]), and (ii) study the impact of credit access on earnings mobility (in progress).

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Tables and Figures

Table 1: Summary Statistics

(A) Panel Sample (Year Prior to Mass Layoff)		
	(1) Treatment	(2) Control
Annual Earnings	$44,230	$49,260
Credit Score	427	437
Age	40.6	41.3
Revolving Credit Balance	$10,680	$11,200
Revolving Credit Limit	$26,910	$28,580
Unused Revolving Credit to Income	0.44	0.41
Observations (Rounded to 000s)	31000	30000

(B) Cross Sectional Sample (Year Prior to Mass Layoff)	
	Avg. Unused Revolving Debt to Income
Credit Score Quintile 1	0.06
Credit Score Quintile 2	0.12
Credit Score Quintile 3	0.27
Credit Score Quintile 4	0.58
Credit Score Quintile 5	1.04

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

	(1) Earnings	(2) Credit Score	(3) Revolving Credit Limit	(4) Revolving Credit Balance
4 Years Before Displacement	1,169***	0.0699	-217.5	39.66
	(167.2)	(1.664)	(232.3)	(149.9)
3 Years Before Displacement	2,757***	-0.964	-363.8	-49.26
	(220.1)	(2.013)	(334.7)	(202.9)
2 Years Before Displacement	5,049***	1.019	-365.1	-36.50
	(262.8)	(2.210)	(403.0)	(240.8)
1 Year Before Displacement	5,157***	-4.488*	-347.4	47.28
	(296.8)	(2.427)	(473.4)	(281.0)
Year of Displacement	-2,850***	-6.352**	-996.4*	-473.2
	(353.5)	(2.595)	(533.7)	(315.8)
1 Year After Displacement	-13,830***	-15.79***	-1,738***	-583.7*
	(410.6)	(2.714)	(572.3)	(336.9)
2 Years After Displacement	-9,735***	-15.40***	-1,503**	-455.1
	(429.0)	(2.966)	(624.8)	(368.3)
3 Years After Displacement	-7,246***	-12.52***	-1,223*	-211.5
	(446.3)	(3.216)	(693.2)	(414.8)
4 Years After Displacement	-5,293***	-11.99***	-1,423*	-186.9
	(491.2)	(3.554)	(783.8)	(474.0)
5 Years After Displacement	-3,081***	-9.055**	-1,667*	-653.4
	(556.1)	(4.146)	(889.9)	(552.1)
Individual Fixed Effects	Y	Y	Y	Y
Year Fixed Effects	Y	Y	Y	Y
Age and Wealth Controls	Y	Y	Y	Y
R-squared	0.153	0.019	0.026	0.017
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 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 3: Average Response of Default Measures to Displacement

	(1) 60 Day Delinq. (d)	(2) Chargeoff (d)	(3) Collections (d)	(4) Derogatory Public Flag (d)
4 Years Before Displacement	0.000733	0.00274	0.00353	-0.00147
	(0.00428)	(0.00350)	(0.00388)	(0.00230)
3 Years Before Displacement	-0.000547	0.00445	-0.000502	-0.000245
	(0.00473)	(0.00357)	(0.00408)	(0.00237)
2 Years Before Displacement	-0.0118**	-0.00644*	0.00228	0.000440
	(0.00490)	(0.00354)	(0.00424)	(0.00245)
1 Year Before Displacement	-0.00520	-0.00171	0.00351	0.000849
	(0.00516)	(0.00374)	(0.00452)	(0.00253)
Year of Displacement	0.00688	0.00872**	0.0109**	0.00385
	(0.00544)	(0.00391)	(0.00480)	(0.00262)
1 Year After Displacement	0.0308***	0.0287***	0.0278***	0.00724***
	(0.00563)	(0.00406)	(0.00495)	(0.00270)
2 Years After Displacement	0.0186***	0.0151***	0.0298***	0.00743**
	(0.00618)	(0.00438)	(0.00538)	(0.00297)
3 Years After Displacement	0.00993	0.00666	0.0251***	0.00408
	(0.00685)	(0.00483)	(0.00585)	(0.00322)
4 Years After Displacement	-0.00834	0.00111	0.0187***	0.00267
	(0.00771)	(0.00535)	(0.00649)	(0.00354)
5 Years After Displacement	-0.0190**	-0.00704	0.0123	-0.00284
	(0.00947)	(0.00648)	(0.00776)	(0.00423)
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: The Fraction of Displaced Workers who Delever or Default in the Year of Layoff

Fraction of Displaced Workers with...	
Decline in Revolving Credit Balances	0.39
Decline in Revolving Credit Balances and 60-day Delinquency	0.17
Decline in Revolving Credit Balances and Debt Chargeoff	0.08

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

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

	(1) OLS Replacement Rate (2-Year)	(2) Predicted Value Replacement Rate (2-Year)
Credit Score Quintile 1		-0.0359***
		(0.00435)
Credit Score Quintile 2	-0.00804	-0.0439***
	(0.00651)	(0.00502)
Credit Score Quintile 3	0.0319***	-0.00395
	(0.00790)	(0.00660)
Credit Score Quintile 4	0.124***	0.0883***
	(0.00823)	(0.00696)
Credit Score Quintile 5	0.184***	0.148***
	(0.00822)	(0.00685)
Constant	-0.0742*	
	(0.0390)	
Year FE	Y	Y
Age and Wealth Controls	Y	Y
R squared	0.040	NA
No Obs.	19000	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 individuals 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

Variable	Value	Description
	Non-estimated	
Variable	Value	Description
r_f	0.04	Risk free rate
β_{lf}	0.99	Discount factor: lenders and firm
β_L	0.99	Discount factor low worker type
δ	0.1	Exogenous job destruction rate
ζ	1.6	Labor match elasticity
δ_C	0.026	Exogenous credit destruction rate
ζ_C	0.37	Credit match elasticity
$\underline{r}$	10.5%	Minimum (annualized) interest rate
$\bar{r}$	22.5%	Maximum (annualized) interest rate
σ	2	Risk aversion
T	120	Lifespan in quarters
	Jointly-estimated	
Variable	Value	Description
z	0.327	Public insurance transfer to unemployed
κ	0.995	Firm entry cost
κ_C	2.214×10^{-5}	Lender entry cost
κ_S	1.272×10^{-4}	Utility penalty of searching for credit
ψ_D	14.771	Utility penalty of default
$p_{\tilde{h},L}$	0.651	Prob. persistent human capital decrease
$p_{\tilde{h},H}$	0.083	Prob. persistent human capital increase
$p_{\epsilon,L}$	0.111	Prob. transitory human capital low
$p_{\epsilon,H}$	0.252	Prob. transitory human capital high
λ_H	2.943	Exponential parameter initial persistent human capital
g	0.146	Home production
$\underline{B}$	-1.149	Lower bound for borrowing limit
β_H	0.632	Discount factor: high worker type
π_L	0.904	Share of low type individuals

Table 7: Model Calibration

Variable	Value	Target	Model	Data	Source
z	0.327	Transfer to Income Loss	41.2%	41.2%	PSID 2001-2013
κ	0.995	Unemployment Rate	5.3%	5.0%	BLS 1995-2007
κ_C	2.214×10^{-5}	Credit Finding Rate	64.1%	65.0%	SCF 2007-2009
κ_S	1.272×10^{-4}	Share of Individuals w/ Credit Access	69.9%	69.8%	SCF 1995-2007
ψ	14.771	Bankruptcy Rate	0.142%	0.145%	SCF 1998-2007
$p_{\tilde{h},L}$	0.651	Earnings Loss 5 Yr. After Layoff	6.6%	6.9%	LEHD/TU 2003-2008
$p_{\tilde{h},H}$	0.083	Earnings Gain With Age	0.92%	0.93%	CPS 1995-2007
$p_{\epsilon,L}$	0.111	Share of Indiv. w/ 9.5% Wage Decline	8.6%	7.65%	KM (2017)
$p_{\epsilon,H}$	0.252	Share of Indiv. w/ 9.5% Wage Increase	17.2%	19.0%	KM (2017)
λ_H	2.943	P75-P25 Earnings Ratio Among Young Workers	0.479	0.484	CPS 1995-2007
g	0.146	Consumption After Layoff	94.0%	93.8%	PSID 2005-2013
$\underline{B}$	-1.149	Unused Credit Limit to Income	23.5%	23.0%	SCF 1995-2007
β_H	0.632	P95 Real Credit Card Interest Rate	16.0%	19.0%	SCF 1995-2007
π_L	0.904	Share of Individuals w/ Net Liquid Assets to Income $< 1\%$	31.6%	31.4%	SCF 1995-2007

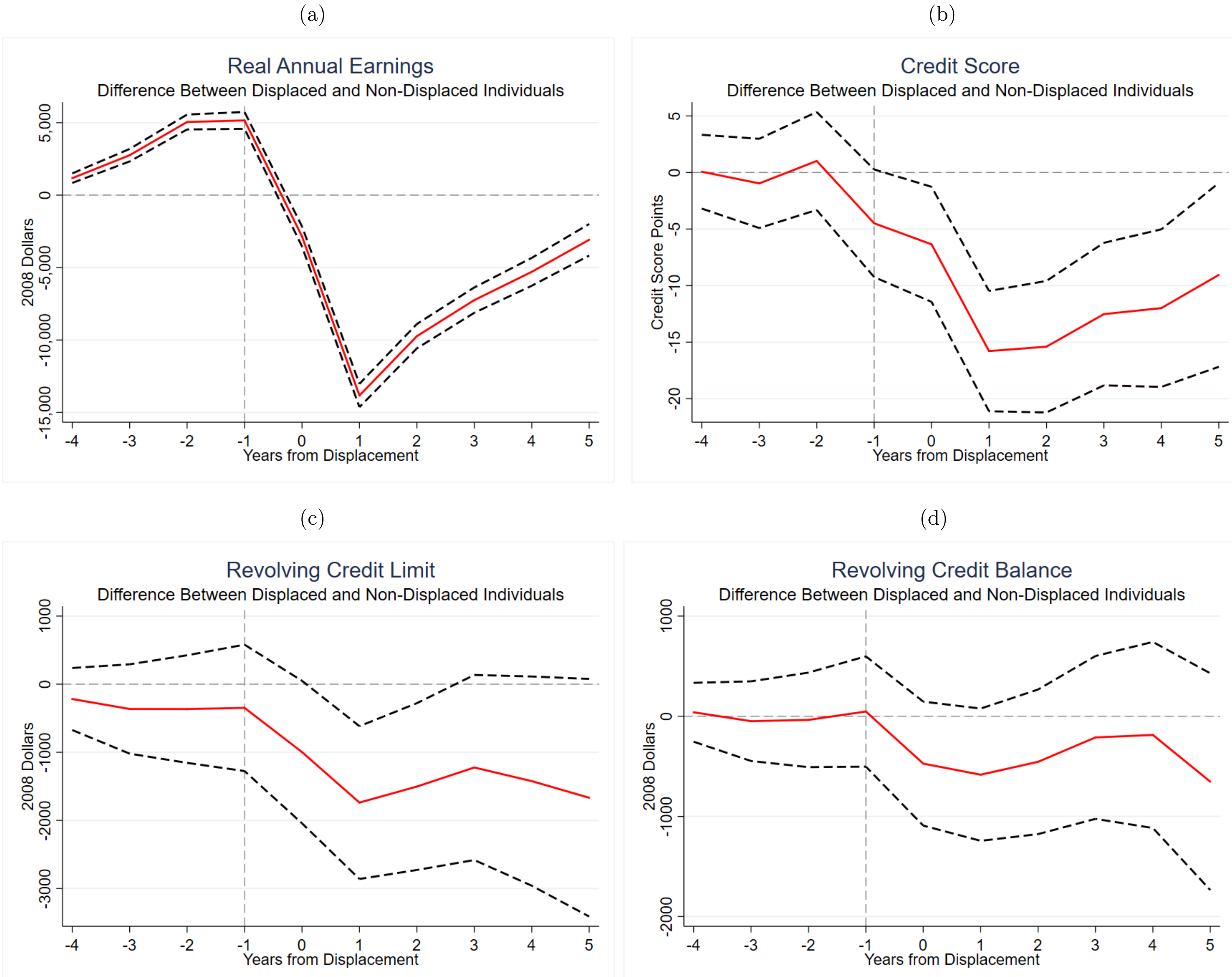
Notes: KM (2017) refers to Kurmann and McEntarfer [2017].

Table 8: Optimal Public Insurance to the Unemployed

	(1) Baseline	(2) Optimal Policy w/ Credit	(3) Optimal Policy w/o Credit
Transfer/Income Loss	41.2%	38.3%	43.2%
Mean Welfare Chg.	-	0.129%	0.084%
Unemployment Rate	5.3%	4.8%	5.4%
Fraction of Individuals Borrowing	19.6%	20.4%	-
Default Rate	0.142%	0.135%	-
Fraction of Individuals w/ Credit Access	69.9%	70.5%	-
Consumption Loss 1Q After Job Loss	94.0%	93.9%	94.0%
Marginal Tax rate	2.12%	1.77%	2.27%

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 mean welfare change of* 0.129% *indicates that an individual, on average, would give up* 0.129% *of lifetime consumption to have a* 38.3% *replacement rate as opposed to a* 41.2% *replacement rate. See Appendix F for details on the estimation of the welfare effect.*

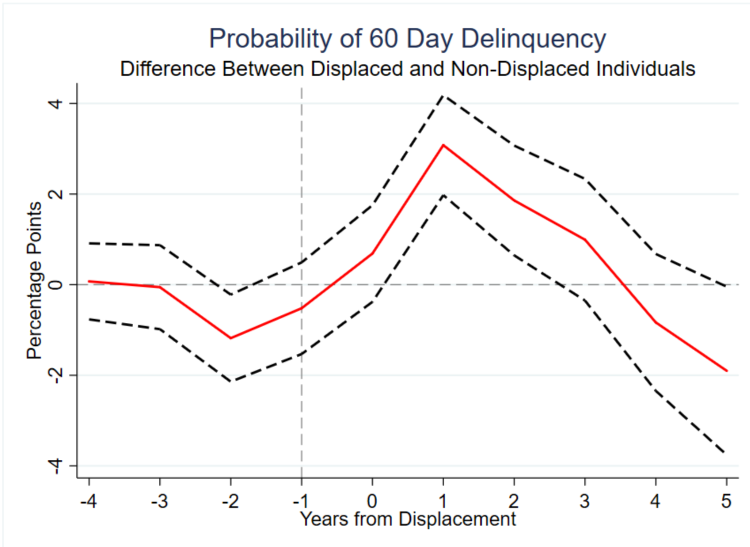
Figure 1: Average Response of Earnings and Credit Variables to Displacement



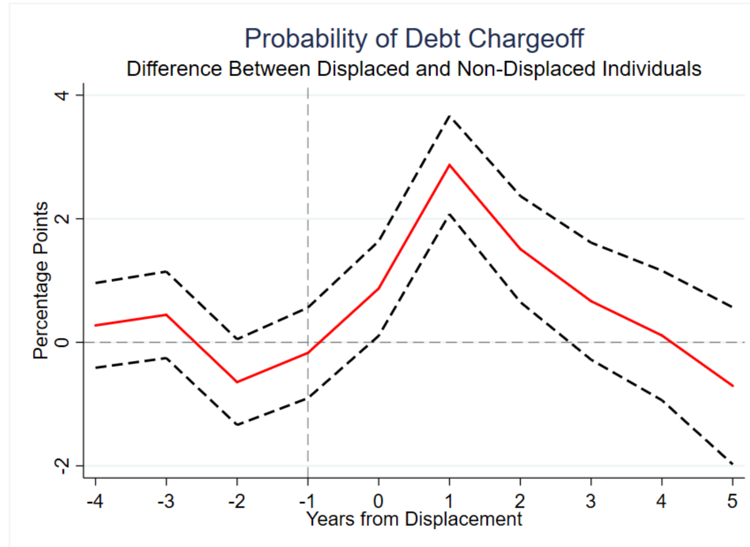
Notes: Figure presents estimates of the effect of job loss on earnings and credit variables. Solid line is the difference in the outcome variable between displaced and nondisplaced individuals. Dashed line represents a 95 percent confidence interval. Figures present coefficient estimates from Table 2.

Figure 2: Average Response of Default Measures to Displacement

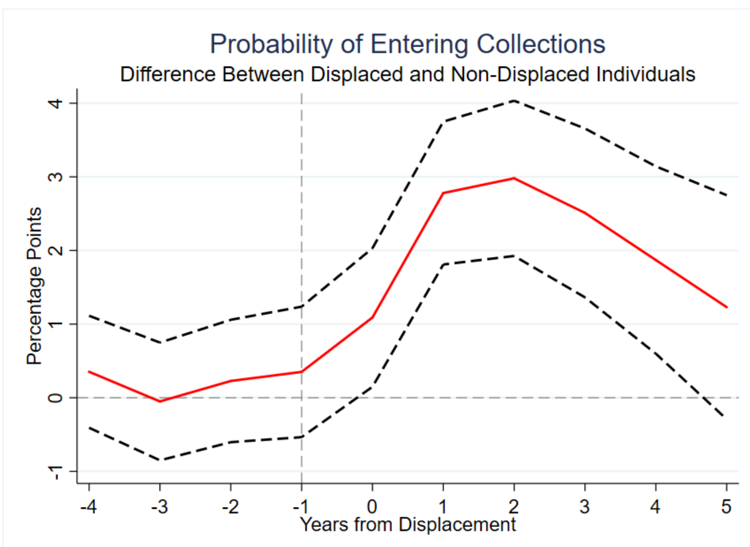
(a)



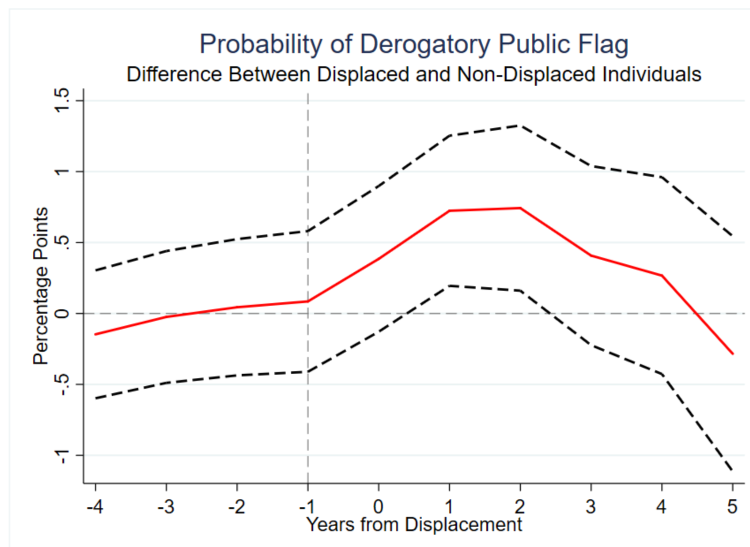
(b)



(c)

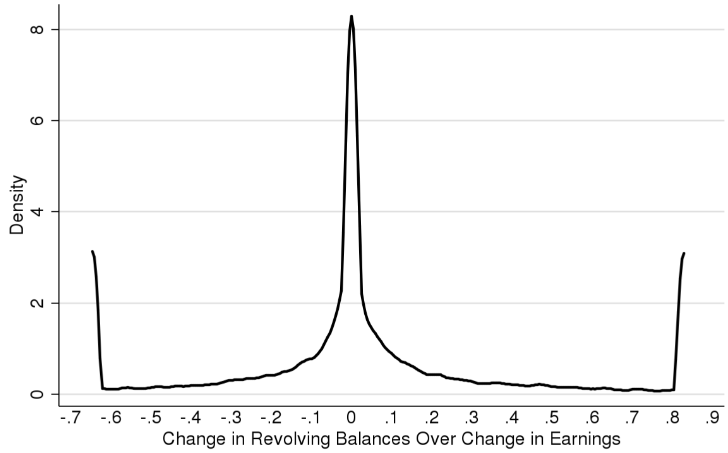


(d)



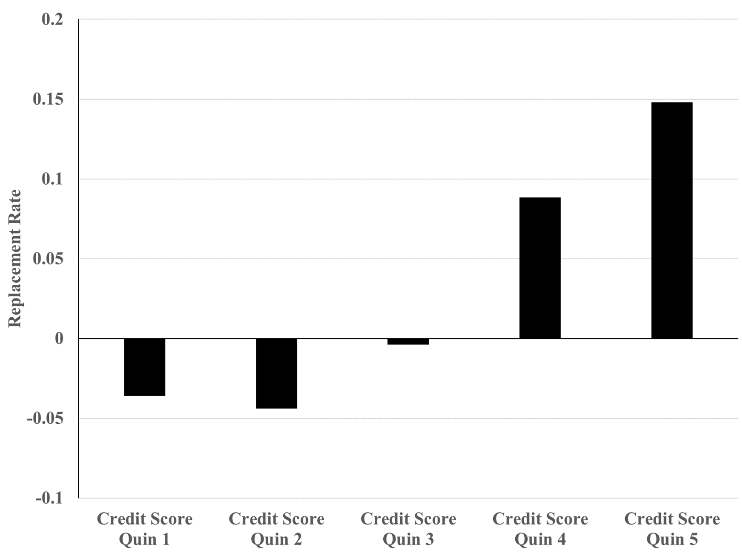
Notes: Figure presents estimates of the effect of job loss on measures of default and delinquency. Solid line is the difference in the outcome variable between displaced and nondisplaced individuals. Dashed line represents a 95 percent confidence interval. Figures present coefficient estimates from Table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

Figure 3: Replacement Rate of Lost Earnings with Revolving Credit



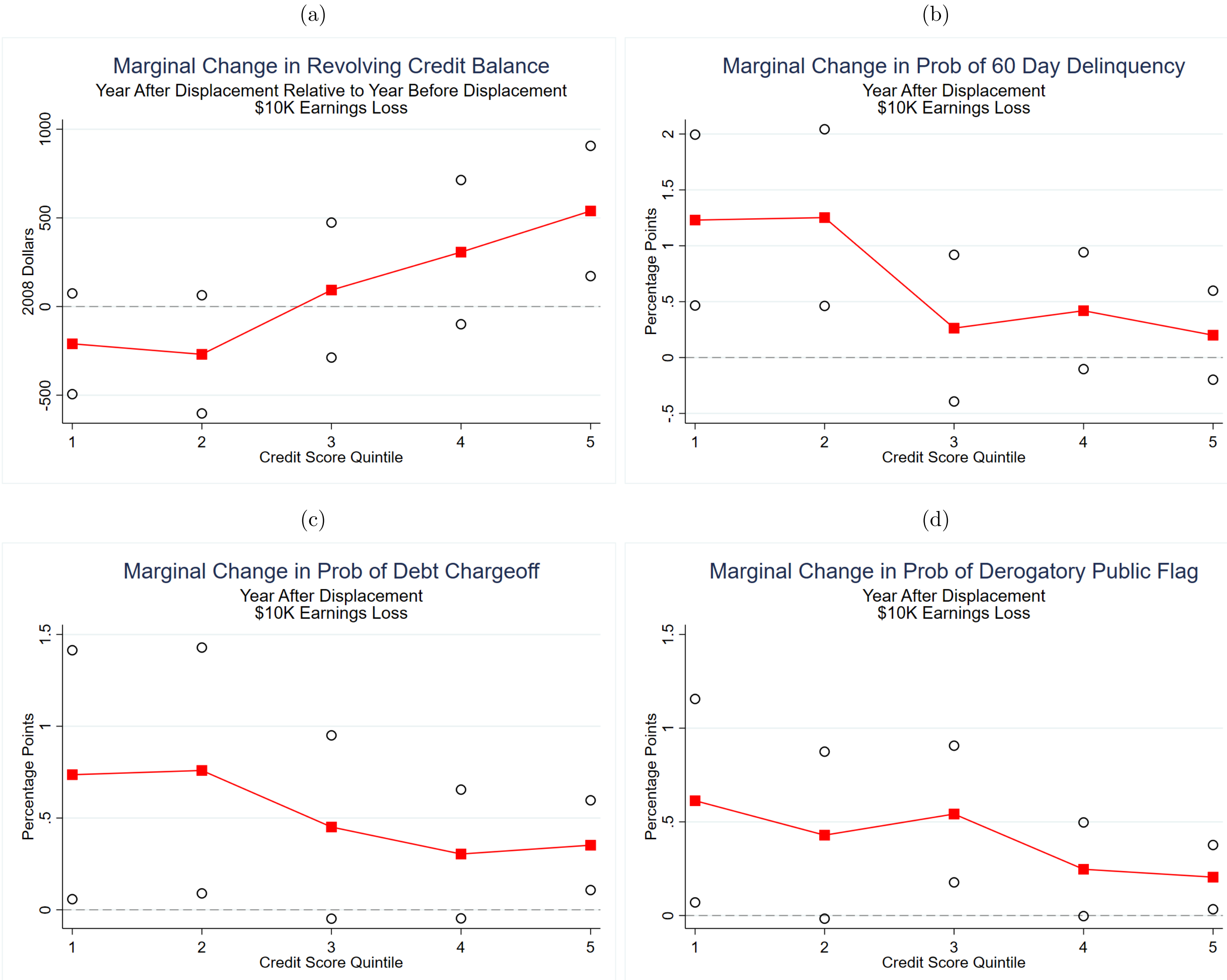
Notes: Figure shows the distribution of replacement rates using a kernel density. Replacement rate is the negative of the change in revolving credit balance over the change in earnings, where the change in earnings and the change in borrowing are measured from the year after displacement relative to 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



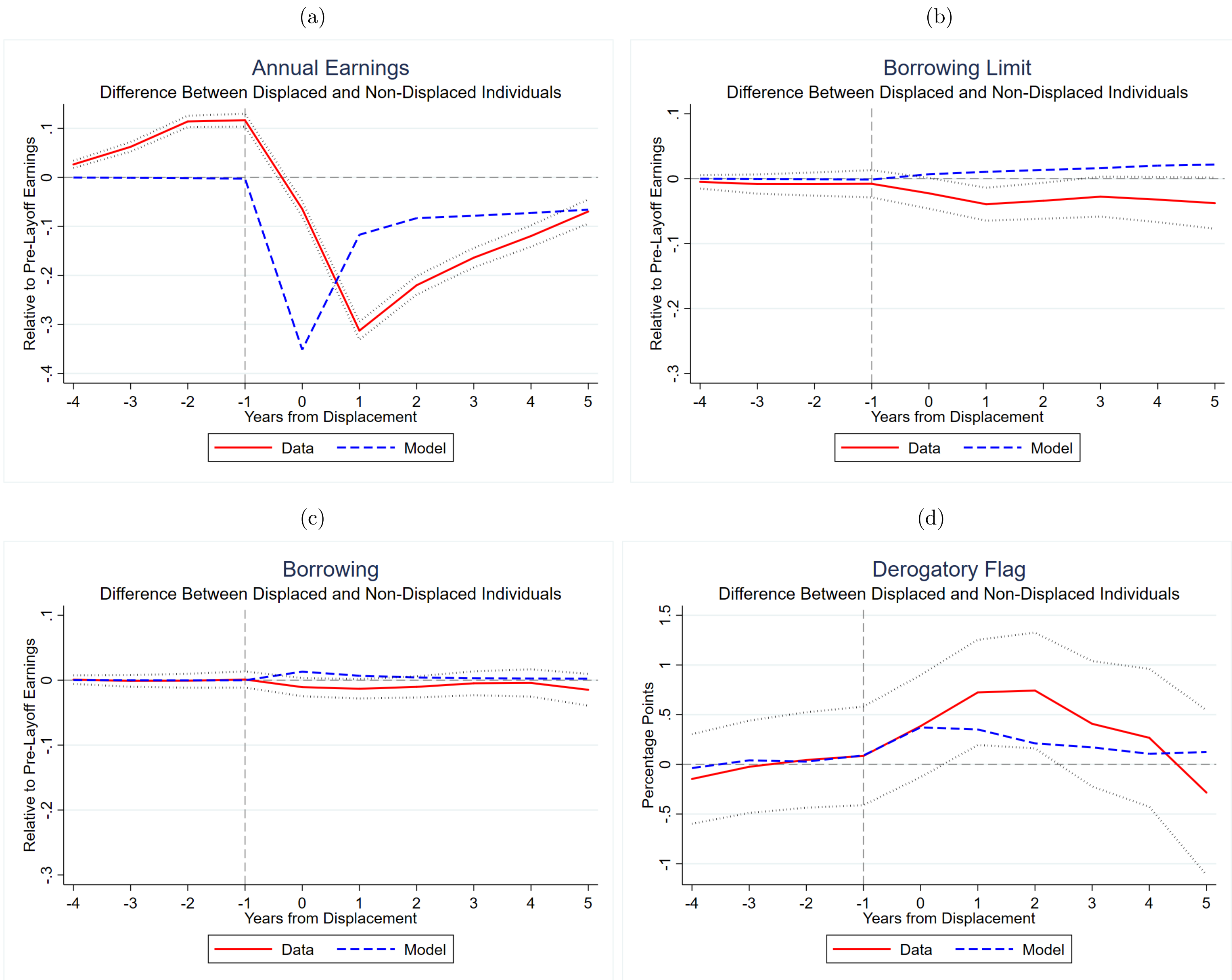
Notes: Replacement rate estimates are from Column (2) of Table 5. See notes to Figure 3 for definition of replacement rate. Credit score quintiles are based upon an individual's TransUnion bankruptcy score in the year prior to displacement.

Figure 5: Marginal Effect of Earnings Loss on Borrowing and Default Activity



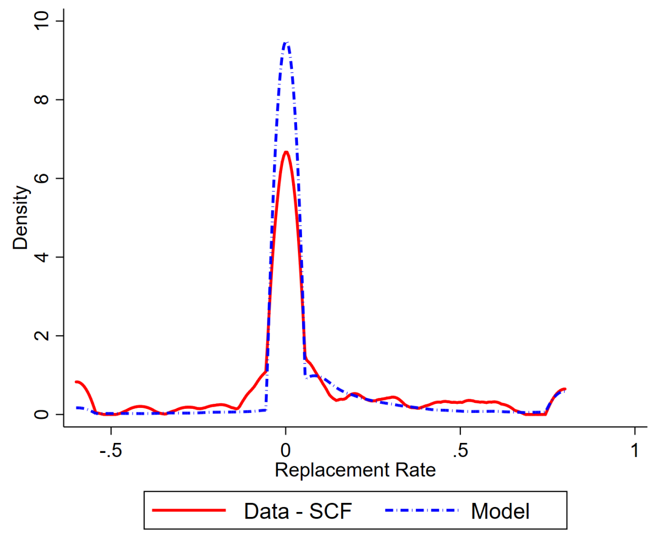
Notes: Squares in the figures present the marginal effect of earnings loss on the variable of interest. Earnings loss is measured as the difference in real annual earnings in the year after displacement relative to the year before displacement. The estimates are taken from Column (3) of Tables 12-15. The coefficient for Credit Score Quintile 1 correspond to the coefficient 2 Yr. Chg. Earnings from the table, while the coefficient for Credit Score Quintile k corresponds to the sum of the coefficients 2 Yr. Chg. Earnings and 2 Yr. Chg. Earnings Credit Quin k. The dots represent a 95 percent confidence interval.

Figure 6: Model Predictions of the Average Response of Earnings and Credit Variables to Displacement



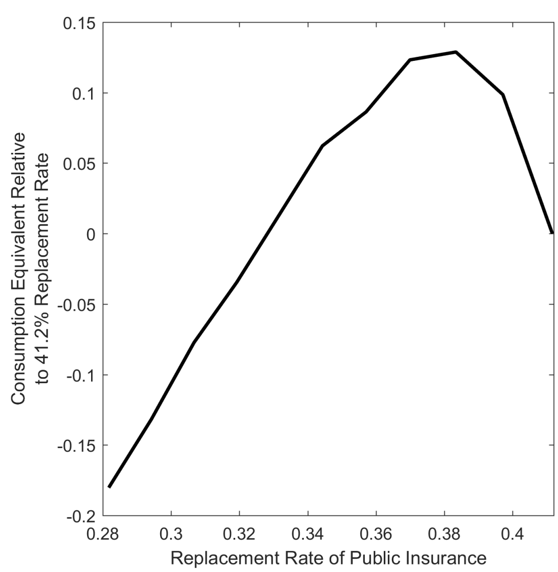
Notes: Figure presents estimates of the effect of job loss on earnings and credit variables comparing estimates from the data (red solid line) to estimates from the model (blue dashed line). The gray finely dashed lines represent 95 percent confidence intervals of data estimates.

Figure 7: Kernel Density of Replacement Rates, Model versus Data



Notes: Figure presents the models estimate of the replacement rate of credit (blue 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 (red solid line).

Figure 8: Welfare Effect of Change in Public Transfer to Unemployed

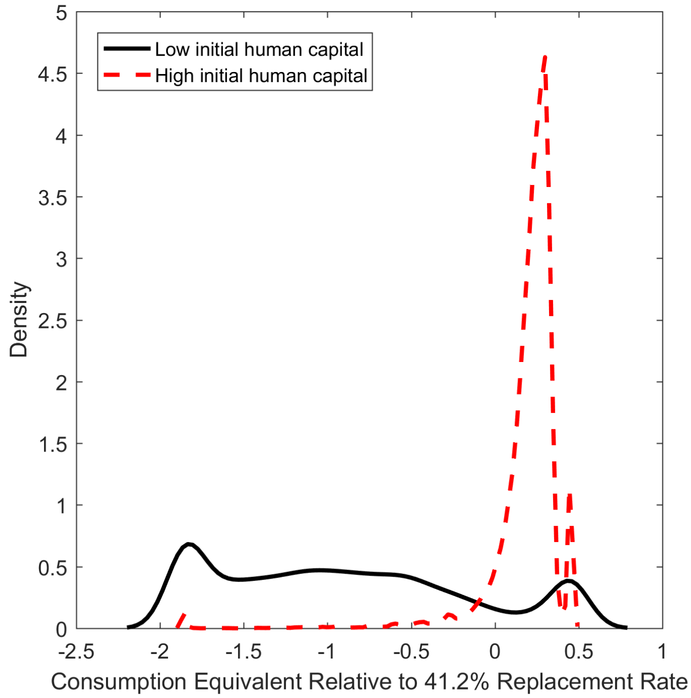


Notes: 'Welfare' is the consumption equivalent of leaving an economy with the US policy of a 41.2% *replacement rate to an economy with an alternate replacement rate. For example, the welfare change of* 0.129% *indicates that an individual, on average, would give up* 0.129*% of lifetime consumption to have a* 38.3% *replacement rate as opposed to a* 41.2% *replacement rate. See Appendix F for details on the estimation of the welfare effect.*

Figure 9: Steady State Welfare Experiment

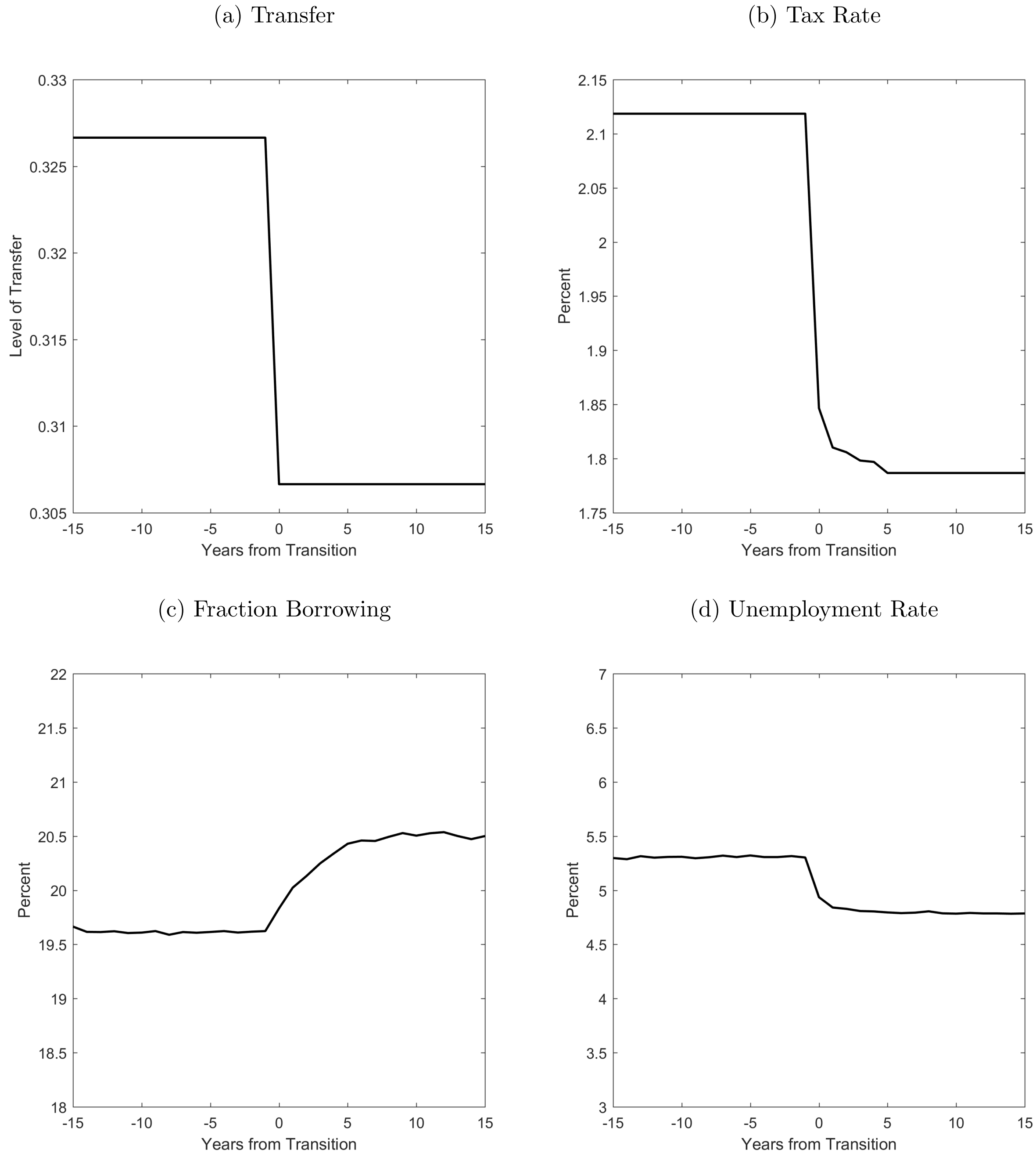
Notes: Figure shows output from the steady state welfare experiment where the replacement rate of public insurance to the unemployed is adjusted.

Figure 10: Distribution of Welfare Changes from Changing Public Transfer to Unemployed



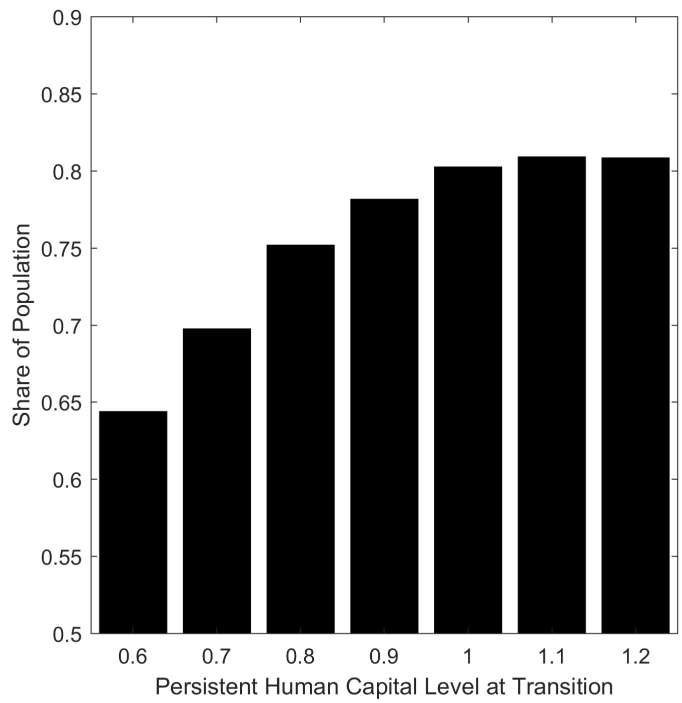
Notes: 'Welfare' is the consumption equivalent of leaving an economy with the US policy of a 41.2% *replacement rate to an economy with a* 38.3% *replacement rate. See Appendix F for details on the estimation of the welfare effect.*

Figure 11: Transition Path Experiment



Notes: Figure shows output from the transition path welfare experiment where the replacement rate of public insurance to the unemployed is adjusted.

Figure 12: Welfare Gains by Persistent Human Capital Along Transition Path



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 38.3%, 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 the 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 9 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 10), and then examine the impact on measures of default (Table 11). The coefficients in Tables 10 and 11 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 13 plots the coefficient estimates from Tables 10 and 11 along with 95 percent confidence intervals for bank card limits and balances, as well as 60 day delinquencies and bankruptcy flags.

Table 9: Summary Statistics: Bank Cards and Total Credit

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

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 10 documents the average response of additional measures of credit access and usage following job loss. Column (1) of Table 10 and Panel (a) of Figure 13 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 10 and Panel (b) of Figure 13 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 10 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 11 documents the average response of additional measures of default activity following job loss.

Column (1) of Table 11 and Panel (c) of Figure 13 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 11 and Panel (d) of Figure 13 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 11 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 11 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 10: Average Response of Additional Credit Variables to Displacement: Credit Access and Usage

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

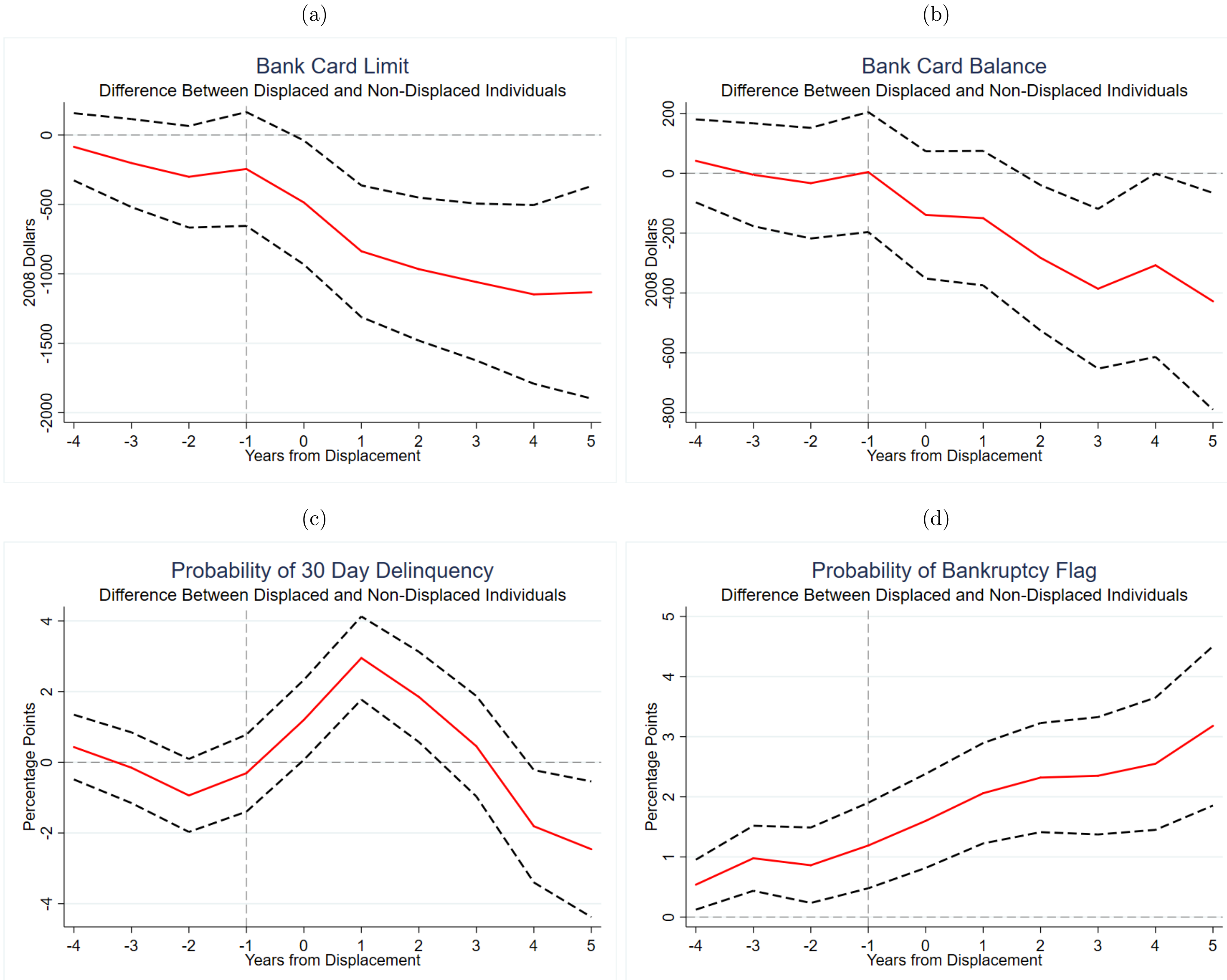
Notes: Clustered SE in parenthesis, where the clustering is performed at the level of the firm where the worker was displaced. ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$. *Age and wealth controls include a quadratic in age, and deciles for lagged cumulative earnings. The symbol (d) indicates a dummy variable.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

Table 11: Average Response of Additional Credit Variables to Displacement: Measures of Default

	(1) 30 Day Delinq. (d)	(2) Bankruptcy Flag (d)	(3) Foreclosure (d)	(4) 60 Day Mort. Delinq. (d)
4 Years Before Displacement (d)	0.00430	0.00539**	0.00114	-0.000562
	(0.00467)	(0.00212)	(0.000782)	(0.00164)
3 Years Before Displacement (d)	-0.00153	0.00978***	0.00104	0.00293
	(0.00510)	(0.00276)	(0.000786)	(0.00186)
2 Years Before Displacement (d)	-0.00938*	0.00862***	0.00110	-0.000114
	(0.00527)	(0.00320)	(0.000822)	(0.00196)
1 Year Before Displacement (d)	-0.00308	0.0119***	0.00154*	0.00128
	(0.00556)	(0.00363)	(0.000895)	(0.00215)
Year of Displacement (d)	0.0120**	0.0160***	0.00247**	0.00405*
	(0.00577)	(0.00399)	(0.000966)	(0.00227)
1 Year After Displacement (d)	0.0295***	0.0206***	0.00468***	0.00792***
	(0.00600)	(0.00426)	(0.00103)	(0.00243)
2 Years After Displacement (d)	0.0185***	0.0232***	0.00347***	0.00172
	(0.00651)	(0.00463)	(0.00106)	(0.00260)
3 Years After Displacement (d)	0.00455	0.0235***	0.00287**	0.000879
	(0.00725)	(0.00498)	(0.00121)	(0.00287)
4 Years After Displacement (d)	-0.0181**	0.0255***	0.00172	-0.00396
	(0.00811)	(0.00561)	(0.00136)	(0.00328)
5 Years After Displacement (d)	-0.0246**	0.0318***	0.000127	-0.00762*
	(0.00979)	(0.00676)	(0.00159)	(0.00414)
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 13: 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 10 and 11.

B.3 Heterogeneous Response to Earnings Changes

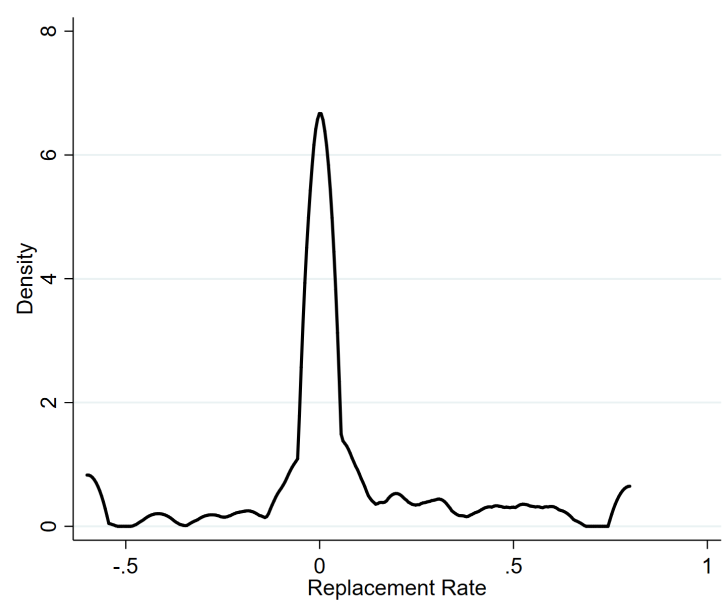
In this Appendix we present the estimation results of equation (4) for: (1) changes in revolving credit balances (Table 12); (2) 60 day delinquencies (Table 13); (3) debt chargeoffs (Table 14); and (4) derogatory public flags (Table 15). These results underlie the graphs presented in Figure 5.

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 14, 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 the SCF, we identify an individual to be unemployed in a given wave if they are either unemployed at the time of the survey or have had an unemployment spell of longer than 4 weeks within the past year. We measure the replacement rate and share of individuals deleveraging among household heads and their spouses who were not identified as unemployed in the 2007 wave, but were identified as unemployed in the 2009 wave and had an earnings loss between the 2007 and 2009 waves. Among these individuals, we estimate the change in non-mortgage debt over the change in income in order to measure the replacement rate. Figure 14 reveals a similar pattern on the borrowing activity of the unemployed as our LEHD/TransUnion sample (Figure 3).

Figure 14: Credit Replacement Rate of Unemployed from SCF



Notes: Figure presents the credit replacement rate using the 2007-2009 waves of the SCF.

Table 12: Earnings Losses and Change in Revolving Credit Balances by Credit Score

	2 Yr. Chg. Revolving Bal.	2 Yr. Chg. Revolving Bal.	2 Yr. Chg. Revolving Bal.
2 Yr. Chg. Earnings	-0.0304***	0.0330**	0.0210
	(0.00853)	(0.0135)	(0.0145)
2 Yr. Chg. Earnings x Credit Score Quin 2		0.00454	0.00595
		(0.0209)	(0.0209)
2 Yr. Chg. Earnings x Credit Score Quin 3		-0.0299	-0.0303
		(0.0234)	(0.0235)
2 Yr. Chg. Earnings x Credit Score Quin 4		-0.0515**	-0.0517**
		(0.0241)	(0.0241)
2 Yr. Chg. Earnings x Credit Score Quin 5		-0.0737***	-0.0749***
		(0.0222)	(0.0223)
Constant	324.6	-627.7**	-4,587**
	(246.3)	(305.0)	(1,991)
Credit Score Quin 2 (d)		-359.7	-321.1
		(504.3)	(507.9)
Credit Score Quin 3 (d)		-335.3	-220.1
		(595.6)	(596.9)
Credit Score Quin 4 (d)		3,220***	3,369***
		(704.6)	(699.9)
Credit Score Quin 5 (d)		6,365***	6,618***
		(754.6)	(749.5)
Year Fixed Effects	N	N	Y
Age and Wealth Controls	N	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 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 13: Earnings Losses and 60 Day Delinquency by Credit Score In Year After Mass Layoff

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

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 14: Earnings Losses and Debt Chargeoff by Credit Score In Year After Mass Layoff

	(1) Debt Chargeoff (d)	(2) Debt Chargeoff (d)	(3) Debt Chargeoff (d)
	(Year After Mass Layoff)		
2 Yr. Chg. Earnings	3.88e-07***	-3.62e-07	-7.36e-07**
	(9.88e-08)	(3.42e-07)	(3.46e-07)
2 Yr. Chg. Earnings x Credit Score Quin 2 (d)		-3.15e-09	-2.31e-08
		(4.71e-07)	(4.69e-07)
2 Yr.Chg. Earnings x Credit Score Quin 3 (d)		2.85e-07	2.85e-07
		(4.20e-07)	(4.17e-07)
2 Yr. Chg. Earnings x Credit Score Quin 4 (d)		3.75e-07	4.32e-07
		(3.78e-07)	(3.76e-07)
2 Yr. Chg. Earnings x Credit Score Quin 5 (d)		3.09e-07	3.84e-07
		(3.59e-07)	(3.57e-07)
Constant	0.179***	0.249***	0.319***
	(0.00428)	(0.0117)	(0.0432)
Credit Score Quin 2 (d)		-0.0133	-0.0154
		(0.0159)	(0.0159)
Credit Score Quin 3 (d)		-0.0629***	-0.0625***
		(0.0151)	(0.0150)
Credit Score Quin 4 (d)		-0.150***	-0.146***
		(0.0137)	(0.0137)
Credit Score Quin 5 (d)		-0.195***	-0.189***
		(0.0129)	(0.0130)
Year FE	N	N	Y
Age and Wealth Controls	N	N	Y
R-Square	0.001	0.046	0.050
No of Indiv.	19000	19000	19000
P-Value 2-Year Chg Earn Quin 2		0.278	0.0263
P-Value 2-Year Chg Earn Quin 3		0.756	0.0767
P-Value 2-Year Chg Earn Quin 4		0.941	0.0893
P-Value 2-Year Chg Earn Quin 5		0.631	0.00478

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 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 Derogatory Flag by Credit Score In Year After Mass Layoff

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

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 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 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.*

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 Individuals

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:

$$W^S_{i,t}(\omega, b, \vec{h}; 0, 0) = \max\left\{-\kappa_S + W^A_{i,t}(\omega, b, \vec{h}; 0, 0),\ W^N_{i,t}(\omega, b, \vec{h}; 0, 0)\right\} \quad \forall t \leq T$$
$$W^S_{i,T+1}(\omega, b, \vec{h}; 0, 0) = 0$$

where:

$$\begin{aligned} W^A_{i,t}(\omega, b, \vec{h}; 0, 0) = \max_{(\underline{b}, r)\in\underline{\mathcal{B}}\times\mathcal{R}} & p^c(\theta^{c,W}_{i,t}(\omega, b, \vec{h}; \underline{b}, r))W^C_{i,t}(\omega, b, \vec{h}; \underline{b}, r) \\ & + \left(1 - p^c(\theta^{c,W}_{i,t}(\omega, b, \vec{h}; \underline{b}, r))\right) W^N_{i,t}(\omega, b, \vec{h}; 0, 0) \end{aligned}$$

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 δ the agent looses their job, and is immediately able to search for a job.[40] The value function summarizing the payoffs of an employed agent without credit access is

$$\begin{aligned} W^N_{i,t}(\omega, b, \vec{h}; 0, 0) = \max_{b'\geq 0} u(c) + \beta_i\mathbb{E}\Big[(1-\delta)W^S_{i,t+1}(\omega, b', \vec{h}'; 0, 0) + \delta\Big(\max_{\tilde{\omega}} p(\theta_{t+1}(\tilde{\omega}, \vec{h}'))W^S_{i,t+1}(\tilde{\omega}, b', \vec{h}'; 0, 0) \\ +(1 - p(\theta_{t+1}(\tilde{\omega}, \vec{h}')))U^S_{i,t+1}(b', \vec{h}'; 0, 0)\Big)\Big] \quad \forall t \leq T \end{aligned}$$

$$W^N_{i,T+1}(\omega, b, \vec{h}; 0, 0) = 0$$

subject to the budget constraint,

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

[40] 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,

$$\vec{h}' = H(\vec{h}, W) \tag{14}$$

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 $\underline{b}$. At the start of the next period with probability δ 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

$$\begin{aligned} W^C_{i,t}(\omega, b, \vec{h}; \underline{b}, r) = \max_{b' \geq \underline{b}} u(c) + \beta_i \mathbb{E}\Big[(1-\delta)W^D_{i,t+1}(\omega, b', \vec{h}'; \underline{b}, r) + \delta \Big(\max_{\tilde{\omega}} p(\theta_{t+1}(\tilde{\omega}, \vec{h}'))W^D_{i,t+1}(\tilde{\omega}, b', \vec{h}'; \underline{b}, r) \\ + \Big(1 - p(\theta_{t+1}(\tilde{\omega}, \vec{h}'))\Big) U^D_{i,t+1}(b', \vec{h}'; \underline{b}, r)\Big)\Big] \quad \forall t \leq T \end{aligned}$$

$$W^C_{i,T+1}(\omega, b, \vec{h}; 0, 0) = 0$$

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 (14)). After the labor market closes, the agent observes if their credit match has been exogenously ended. With probability δ_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

$$\begin{aligned} W^D_{i,t+1}(\omega, b', \vec{h}'; \underline{b}, r) = \delta_C \max\{W^N_{i,t+1}(\omega, 0, \vec{h}'; 0, 0) - \psi_D(b'),\ W^N_{i,t+1}(\omega, b', \vec{h}'; 0, 0)\} \\ + (1-\delta_C)\max\{W^N_{i,t+1}(\omega, 0, \vec{h}'; 0, 0) - \psi_D(b'),\ W^C_{i,t+1}(\omega, b', \vec{h}'; \underline{b}, r)\} \end{aligned}$$

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

$$\Pi_{i,t}^{W}(\omega, b, \vec{h}; \underline{b}, r) = \beta_{lf} b_{i,t}^{'}(\vec{x}) \left(\frac{(r_f - r)}{1+r} + \mathbb{E}\left[\delta_C \hat{D}_{i,t+1}^{N,W}(\vec{x}^{'}) + (1-\delta_C)\hat{D}_{i,t+1}^{C,W}(\vec{x}^{'}) \right] \right) \times \mathbb{I}\{b_{i,t}^{'}(\vec{x}) < 0\}$$
$$+ \beta_{lf}(1-\delta_C)\mathbb{E}\left[\left(1 - \hat{D}_{i,t+1}^{C,W}(\vec{x}^{'})\right) \hat{\Pi}_{i,t+1}^{W}(\vec{x}^{'}) \right]$$

At the end of the period an age t agent makes their consumption/savings decision $b_{i,t}^{'}$. If the individual is borrowing, $b_{i,t}^{'} < 0$, then in the next period 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[41]

$$\hat{D}_{i,t+1}^{N,W}(\vec{x}^{'}) = (1-\delta) D_{i,t+1}^{N,W}(\vec{x}^{'})$$
$$+ \delta \left[p\left(\theta_{t+1}(\hat{\omega}, \vec{h}^{'})\right) D_{i,t+1}^{N,W}(\hat{\omega}, b^{'}, \vec{h}^{'}; \underline{b}, r) + \left(1 - p\left(\theta_{t+1}(\hat{\omega}, \vec{h}^{'})\right)\right) D_{i,t+1}^{N,U}(b^{'}, \vec{h}^{'}; \underline{b}, r) \right]$$

where $\hat{\omega}$ is the unemployed worker's 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, then the match between the lender and borrower continues to the next period. The profits to the lender in the next period are denoted by $\hat{\Pi}_{i,t+1}^{W}(\vec{x}^{'})$, and take into account the probability that the agent loses their job. The continuation profits to the lender are

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

Lenders pay cost κ_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:

$$\kappa_C \geq p_f^c\left(\theta_{i,t}^{c,W}(\omega, b, \vec{h}; \underline{b}, r)\right) \Pi_{i,t}^{W}(\omega, b, \vec{h}; \underline{b}, r) \tag{15}$$

Note that individuals who are searching for credit contracts are not currently able to borrow, hence the free entry condition (equation (15)) holds for $b \geq 0$.

[41] Note the default probability when an individual is not hit by the credit separation shock, denoted $\hat{D}_{i,t+1}^{C,W}(\vec{x}^{'})$, is defined analogously.

D Equilibrium Definition

Let $\mu : \{e, a, i, \omega, b, \vec{h}, \underline{b}, r, t\} \to [0, 1]$ be the distribution of individuals across states. Let $\vec{x}$ summarize the state vector of a individual, where with a slight abuse of notation, $\vec{x} = (b, \vec{h}; \underline{b}, r)$ for the unemployed and $\vec{x} = (\omega, b, \vec{h}; \underline{b}, r)$ for the employed.

Definition. A recursive equilibrium in this economy is a set of individual policy functions for savings and borrowing $\{b'_{i,e,t}(\vec{x})\}_{t=1}^{T}$, credit applications $\{S_{i,e,t}(\vec{x})\}_{t=1}^{T}$, bankruptcy $\{D_{i,t}^{a,e}(\vec{x})\}_{t=1}^{T}$, job search choice $\{\hat{\omega}_{i,t}(\vec{x})\}_{t=1}^{T}$, credit contract choice $\{(r, \underline{b})_{i,e,t}(\vec{x})\}_{t=1}^{T}$, labor market tightness function $\{\theta_t(\omega, \vec{h})\}_{t=1}^{T}$, credit market tightness function $\{\theta_{i,t}^{c,e}(\vec{x})\}_{t=1}^{T}$ for employed $e = W$ and unemployed $e = U$ individuals as well as patient $i = L$ and impatient $i = H$ individuals, a public insurance transfer to the unemployed z, a proportional tax rate τ, and a distribution of individuals across states μ:

i. Households' decision rules are optimal.

ii. The labor market tightness satisfies the free entry condition in the labor market (equation (11)).

iii. The credit market tightnesses satisfy the free entry conditions for lenders entering into credit contracts with unemployed workers (equation 10) and employed workers (equation 15).

iv. The distribution of individuals across states μ is consistent with individual policy functions.

v. The tax rate τ balances the government budget.

Suppose τ is given and the government budget constraint is not required to balance (i.e. equilibrium condition *v.* is not imposed). Then the individual, lender, and firm problems can be solved independently of the distribution of individuals across states μ (i.e. equilibrium conditions *i.* through *iii.* depend on the aggregate distribution of individuals across states only through τ). We will refer to this property of the model as *Block Recursivity.* Ultimately, the equilibrium tax rate τ depends on μ, but this intermediate form of Block Recursivity allows us to solve the transition path. We state this property formally below.

Proposition 1. *Suppose τ is given and the government budget does not need to balance (i.e. equilibrium condition v. is not imposed). Assume that the utility function meets standard conditions ($u' > 0, u'' < 0, \lim_{c\to\infty} u'(c) = 0$ and u is invertible), the labor and credit matching functions are invertible and constant returns to scale, and there are compact supports for the choice set of interest rates $r \in \mathcal{R} \equiv [\underline{r}, \bar{r}]$, borrowing limits $\underline{b} \in \underline{\mathcal{B}} \equiv [\underline{B}, 0]$, and the piece rate of wages $\omega \in [0, 1]$, then individual policy functions, the credit market tightness, and the labor market tightness do not depend on the distribution of individuals across states, μ.*

Proof. The proof is performed using backward induction. Let $t = T$ and consider an unemployed individual for the sake of brevity (the proof follows in an identical manner for employed individuals). Since the individuals' continuation value is zero for $T+1$ onward, the individual dynamic programming problem does not depend upon the aggregate distribution of individuals across states μ.

In the terminal age T, individuals set their asset choice to zero (i.e. $b'_{i,T}(b, \vec{h}; \underline{b}, r) = 0$), which gives the following continuation values for the terminal period:

$$U^a_{i,T}(b, h; \underline{b}, r) = u\left(z + g + b\right)$$

This holds for both unemployed individuals with credit access $a \in C$, and individuals without credit access $a \in N$. This does not depend on μ.

Individuals with credit access make a default decision in the terminal period, which does not depend upon the aggregate distribution μ,

$$\begin{aligned} U^D_{i,T}(b, \vec{h}; \underline{b}, r) = \delta_C \max\{&U^N_{i,T}(0, h; 0, 0) - \psi_D(b), U^N_{i,T}(b, h; 0, 0)\} \\ + (1 - \delta_C) \max\{&U^N_{i,T}(0, h; 0, 0) - \psi_D(b), U^C_{i,T}(b, h; \underline{b}, r)\} \end{aligned}$$

Let $D^{a,U}_{i,T}(b, \vec{h}; b, r)$ denote the default policy of the individual. Since there is a utility penalty of defaulting, debt can be supported in equilibrium, and the default decision policy will not be trivially equal to one.

Lender's profits also do not depend upon the aggregate distribution μ. Lenders make zero profits in the terminal period since $b'_{i,T}(b, \vec{h}; \underline{b}, r) = 0$ for all states. This implies $\theta^{c,U}_{i,T}(b, \vec{h}; \underline{b}, r) = 0$, which does not depend upon the aggregate distribution μ. Given the credit finding rate is zero all individuals will choose not to search in the credit market, and we have $U^A_{i,T}(b, \vec{h}; 0, 0) = U^N_{i,T}(b, \vec{h}; 0, 0)$, and thus $U^S_{i,T}(b, \vec{h}; 0, 0) = U^N_{i,T}(b, \vec{h}; 0, 0)$. Hence, the payoffs to individuals who do not have a credit contract, and would be searching for one also does not depend upon the aggregate distribution μ.

In the labor market, the firm's value function is independent of the aggregate distribution μ as well, and is given by,

$$J_T(\omega, \vec{h}) = (1 - \omega) f(\vec{h})$$

Given this value to the firm of a match, the labor market tightness will also be independent of the aggregate distribution μ, and is given by,

$$\theta_T(\omega, \vec{h}) = p_f^{-1}\left(\frac{\kappa}{J_T(\omega, \vec{h})}\right)$$

An unemployed individual at age $T-1$ makes a labor market search choice over piece rates ω:

$$\max_{\tilde{\omega}} p(\theta_T(\tilde{\omega}, \vec{h}'))W^a_{i,T}(\tilde{\omega}, b', \vec{h}'; \underline{b}, r) + \Big(1 - p(\theta_T(\tilde{\omega}, \vec{h}'))\Big) U^a_{i,T}(b', \vec{h}'; \underline{b}, r)$$

As long as $\tilde{\omega}$ is chosen within a closed, bounded interval, the extreme value theorem guarantees at least one solution to this problem.

The same holds true for employed individuals since τ is given.

Working backwards from $t = T-1, ..., 1$, and repeating the above procedure completes the proof. □

E Solution Algorithm

We solve the model using value function iteration on a discrete grid. Assets lie on the grid $[-1.1492, 3.5]$ with 56 grid points including the ends of the grid. The grid points are spaced symmetrically around zero using exponential spacing.[42] The grid contains 16 grid points below zero, a grid point at 0, and 39 grid points above zero.[43] We set the curvature parameter for the exponential spacing of the asset grid to $\frac{1}{1.25}$. Borrowing limits lie on the grid $[-1.1492, -0.0359]$ with 5 evenly spaced grid points including the end of the grid. We set the highest value of the borrowing limit grid to -0.0359 as it is the largest strictly negative grid point in asset grid. Annualized interest rates lie on the grid $[10.5\%, 22.5\%]$ with 15 grid points. The grid points are exponentially spaced with curvature parameter 1.5. Persistent human capital lies on the grid $[0.6, 1.2]$ with 7 evenly spaced grid points including the ends of the grid. The grid for transitory human capital is given by equation 13 where the step size is given by $\Delta_\epsilon(\tilde{h}') = 0.095\tilde{h}'$ for persistent human capital $\tilde{h}'$. The piece rate for wages lie on the grid $[0.60, 0.90]$ with 10 grid points including the ends of the grid. The grid points are exponentially spaced with curvature parameter $c = 5$. In the simulation to check the government's budget balance we simulate 125,000 individuals for 260 periods, 10 times, burning the first 120 periods. We report averages over the 10 simulations.

Solving the model proceeds in the following steps:

1. **Taxes:** Guess τ.

2. **Firms Bellman:** Compute the value to a firm of being in a match in the terminal period $J_T(\omega, h)$. Using the value of a firm in the terminal period, invert the free entry condition to obtain labor market tightness $\theta_T(\omega, h)$.

[42] Let $y_{grid} = [y_1, y_{2,}, ..., y_N]$ be the desired exponential spaced grid with N grid points inclusive of the end points. Define $y_i = x_i^{1/c}$, where i denotes a point in the grid and c is referred to as the curvature parameter. Inverting the expression we have $x_i = y_i^c$. To create the exponentially spaced grid, we pick y_1 and y_N, as well as the curvature parameter c, and with these values calculate x_1 and x_N. We then define a linearly spaced grid with N points from x_1 to x_N. Then define the elements of y_{grid} by using $y_i = x_i^{1/c}$. When $c > 1$ points at the top of the grid are closer to one another than grid points at the bottom of the grid. When $c < 1$ grid points at the bottom of the grid are closer together than points at the top of the grid. When $c = 1$ the grid is evenly spaced.

[43] Recall the value of lowest value of the asset grid (and hence the number of grid points in the negative asset region) is a calibrated parameter of the model

3. **Individual Problem:** Solve the individual problem in the terminal period.

   (a) Compute the value to the individual of being in a credit match and not in a credit match for both employed and unemployed individuals, $W^C_{i,T}(\omega, b, \vec{h}; \underline{b}, r)$, $U^C_{i,T}(b, \vec{h}; \underline{b}, r)$ and $W^N_{i,T}(\omega, b, \vec{h}; 0, 0)$, $U^N_{i,T}(b, \vec{h}; 0, 0)$ respectively.

   (b) Solve the individual's default decisions, which returns the values $W^D_{i,T}(\omega, b, \vec{h}; \underline{b}, r)$ and $U^D_{i,T}(b, \vec{h}; \underline{b}, r)$.

4. **Lenders Bellman:** Compute the lender's Bellman equation in the terminal period, $\Pi^W_{i,T}(\omega, b, \vec{h}; \underline{b}, r)$ and $\Pi^U_{i,T}(b, \vec{h}; \underline{b}, r)$. Invert the free entry condition for lenders to obtain the credit market tightness for each credit contract $\theta^{c,W}_{i,T}(\omega, b, \vec{h}; \underline{b}, r)$ and $\theta^{c,U}_{i,T}(b, \vec{h}; \underline{b}, r)$.

5. **Individual Credit Search:** Use the credit market tightness functions $\theta^{c,e}_{i,T}(b, \vec{h}; \underline{b}, r)$ 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, compute 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 $U^S_{i,T}(b, \vec{h}; 0, 0)$.

6. **Individual's Job Search:** Use the estimate of $\theta_T(\omega, h)$ to solve the individual's job search problem.

7. **Repeat for ages** $T-1$, $T-2, ..., 1$.

8. **Budget Balance:** Simulate a mass of individuals and check that the government's budget constraint is satisfied. Update guess of τ until the government budget is balanced.

F Welfare Calculation

In this section, we describe our process for performing the welfare calculation. We first discuss the welfare calculation for the steady state experiment, and then discuss the welfare calculation for the transition path experiment.

F.1 Steady State 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 λ_j that makes individual j indifferent between living under either public insurance policy:[44]

$$\sum_{t=1}^{T} \beta_{i(j)}^{t} \left(\frac{\left(\lambda_j c_t^j\right)^{1-\sigma} - 1}{1-\sigma} - \psi_D(b_t^j) D_t^j - \kappa_S S_t^j \right) = \sum_{t=1}^{T} \beta_{i(j)}^{t} \left(\frac{\left(\tilde{c}_t^j\right)^{1-\sigma} - 1}{1-\sigma} - \psi_D(\tilde{b}_t^j) \tilde{D}_t^j - \kappa_S \tilde{S}_t^j \right) \tag{16}$$

Solving equation (16) for λ_j returns:

$$\lambda_j = \left[\frac{\sum_{t=1}^{T} \beta_{i(j)}^{t} \left(\frac{\left(\tilde{c}_t^j\right)^{1-\sigma}}{1-\sigma} - \left(\psi_D(\tilde{b}_t^j)\tilde{D}_t^j - \psi_D(b_t^j) D_t^j \right) - \left(\kappa_S \tilde{S}_t^j - \kappa_S S_t^j \right) \right)}{\sum_{t=1}^{T} \beta_{i(j)}^{t} \left(\frac{\left(c_t^j\right)^{1-\sigma}}{1-\sigma} \right)} \right]^{\frac{1}{1-\sigma}} \tag{17}$$

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 pubic 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 for an alternative policy $p \in P$, which is denoted $Welfare_U(p)$, is measured as:

$$Welfare_U(p) = \frac{1}{N} \sum_{j=1}^{N} \tilde{\lambda}_{j,p}$$

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

[44] Note the discount factor is specific to the agent j, since individuals in our economy are heterogeneous in their discount factor.

F.2 Transition Path Welfare Calculation

In the transition path experiment, we perform welfare calculations by estimating the share of *remaining* lifetime consumption an individual would be willing to forgo (or must receive) to leave the baseline economy and move to an economy where there is an unexpected and permanent policy change. Let $(\{c_t^j, D_t^j, S_t^j\}_{t=1}^{t_{max}})$ be the consumption, default, and credit search policy functions for an individual j over their lifetime under the baseline public insurance policy. Let $(\{\tilde{c}_t^j, \tilde{D}_t^j, \tilde{S}_t^j\}_{t=1}^{t_{max}})$ be the consumption, default, and credit search policy functions for an individual j under an alternative public insurance policy. Assume that for individual j, the policy change occurs at age $\hat{t}_j$. Note that because the policy change is unexpected, individual j makes identical consumption, default, and credit search decisions for the first $\hat{t}_j - 1$ periods of their life. Thus to measure the welfare effects of the policy, we only consider an individuals behavior in the remaining $T - \hat{t}$ periods of their life.[45] Let $i(j)$ denote the type of individual j. Formally, we estimate the scaling factor for consumption η_j that makes individual j indifferent between living the remaining periods of their life under either public insurance policy:

$$\sum_{t=\hat{t}_j}^{T} \beta_{i(j)}^t \left(\frac{\left(\eta_j c_t^j\right)^{1-\sigma} - 1}{1-\sigma} - \psi_D(b_t^j) D_t^j - \kappa_S S_t^j \right) = \sum_{t=\hat{t}_j}^{T} \beta_{i(j)}^t \left(\frac{\left(\tilde{c}_t^j\right)^{1-\sigma} - 1}{1-\sigma} - \psi_D(\tilde{b}_t^j) \tilde{D}_t^j - \kappa_S \tilde{S}_t^j \right) \tag{18}$$

Solving equation (18) for η_j returns:

$$\eta_j = \left[\frac{\sum_{t=\hat{t}_j}^{T} \beta_{i(j)}^t \left(\frac{\left(\tilde{c}_t^j\right)^{1-\sigma}}{1-\sigma} - \left(\psi_D(\tilde{b}_t^j) \tilde{D}_t^j - \psi_D(b_t^j) D_t^j \right) - \left(\kappa_S \tilde{S}_t^j - \kappa_S S_t^j \right) \right)}{\sum_{t=\hat{t}_j}^{T} \beta_{i(j)}^t \left(\frac{\left(c_t^j\right)^{1-\sigma}}{1-\sigma} \right)} \right]^{\frac{1}{1-\sigma}} \tag{19}$$

To convert the units of the scaling term η_j into the percentage of remaining lifetime consumption the individual would be willing to forgo (or must receive), hereafter referred to as remaining lifetime consumption equivalents and denoted $\tilde{\eta}_j$, we perform the following transformation:

$$\tilde{\eta}_j = 100(\eta_j - 1)$$

As we discuss in greater detail in Section G, we simulate a large mass of individuals and unexpectedly lower the public insurance to the unemployed. Let N denote the number of simulated individuals who are alive at the time of the policy transition. We track the consumption, default, and credit search behavior of individuals, and estimate the share of remaining lifetime consumption that makes each agent indifferent between the policy transition and no policy transition. Let $\{\tilde{\eta}_j\}_{j=1}^{N}$ denote the set of lifetime consumption equivalents from the simulation of the transition ex-

[45] Note we also only consider the welfare of individuals who are alive at the time of the policy transition.

periment. The utilitarian welfare effect of the transition experiment, which is denoted $Welfare_T$, is measured as:

$$Welfare_T = \frac{1}{N}\sum_{j=1}^{N}\tilde{\eta}_j$$

G Transition Path Experiment

In this appendix, we discuss the details of the transition path experiment presented in Section 4.3. The transition dynamics are very simple since the model is Block Recursive, conditional on τ (see Appendix D). Given a path of τ's, 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). In other words, only through the path of τ's do policy functions and prices depends on the distribution of individuals across states. Given a path of τ's, we solve the individual problem and simulate a mass of individuals along the transition path. We then compute the government budget balance and iterate on τ's until the government budget constraint holds at each point along the transition path.

Let $S = (z, \tau)$ denote the aggregate policy state, where z is the public insurance to the unemployed and τ is the tax rate. In the transition path experiment, the aggregate policy state S follows the transition matrix in equation (20), with corresponding values for (z, τ) in Table 16. The realizations of the Markov chain are such that the economy transitions from the interim stage to the new steady state after 20 quarters, as shown in Panel (b) of Figure 11. Individuals rationally understand the law of motion for S, and all equilibrium prices depend on S. For example, an employed individual takes S and the Markov transition matrix for S as given, where the expectation operator now realizes the aggregate policy shocks:

$$\begin{aligned} W^C_{i,t}(\omega, b, \vec{h}; \underline{b}, r, S) = \max_{b' \geq \underline{b}} u(c) + \beta_i \mathbb{E}\Big[(1-\delta)W^D_{i,t+1}(\omega, b', \vec{h}'; \underline{b}, r, S') + \delta\Big(\max_{\tilde{\omega}} p(\theta_{t+1}(\tilde{\omega}, \vec{h}', S'))W^D_{i,t+1}(\tilde{\omega}, b', \vec{h}'; \underline{b}, r, S') \\ + \Big(1 - p(\theta_{t+1}(\tilde{\omega}, \vec{h}', S'))\Big) U^D_{i,t+1}(b', \vec{h}'; \underline{b}, r, S')\Big)\Big] \quad \forall t \leq T \end{aligned}$$

$$W^C_{i,T+1}(\omega, b, \vec{h}; 0, 0, S') = 0$$

subject to the budget constraint,

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

and the transition matrix for the aggregate state S (20), and the law of motion for human capital (14).

Table 16: Transfers and Taxes Along Transition Path

	Transfer (z)	Replacement Rate	Tax Rate (τ)
Initial Steady State	0.327	41.2%	2.12%
1st Year After Policy Change	0.307	38.3%	1.85%
2nd Year After Policy Change	0.307	38.3%	1.81%
3rd Year After Policy Change	0.307	38.3%	1.81%
4th Year After Policy Change	0.307	38.3%	1.80%
5th Year After Policy Change	0.307	38.3%	1.80%
New Steady State	0.307	38.3%	1.79%

$$P_S = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0.75 & 0.25 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0.75 & 0.25 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0.75 & 0.25 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0.75 & 0.25 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0.75 & 0.25 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix} \tag{20}$$

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 each of the first five-years after the policy change, the tax rate adjusts 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.[46] Along the transition path individuals have rational expectations for the path of the tax rate and the public insurance policy.

Estimation Details We solve the transition path on a discrete grid using value function iteration. The grid for assets, borrowing limits, persistent and transitory human capital, and wage piece rates are identical to the grids used in the baseline estimation of the model (see Appendix E for details). To tractably estimate the transition path annualized interest rates lie on a grid from $[10.5\%, 22.5\%]$ with 7 grid points rather than 15 as in the baseline estimation of the model.

[46] The tax rate in the new steady state following the transition is 1.79%, while the tax rate in the new steady state in the welfare experiment presented in Section 4 is 1.77%. The discrepancy is due to a slight government deficit in years 6 through 9 following the introduction of the policy, which requires a higher tax rate in future periods. If we allowed the tax rate to adjust in years 6 through 9, and then have the economy enter into the new steady state the government budget would balance. However, adding additional years to the transition significantly expands the state-space of the problem. Due to computational requirements of allowing the transition to occur over a longer period of time, we impose that the transition period only last 5 years before entering the new steady state. Due to the fast convergence properties of this class of models, this restriction is effectively non-binding.

The grid points are exponentially spaced with a curvature parameter of 1.5. In Table 17 we show that steady state predictions of the model are virtually identical with 7 grid points for interest rates and 15 grid points for interest rates. The aggregate policy state contains both the transfer to unemployed workers z and the tax rate on labor income τ. The aggregate policy state has 7 grid points, and the values of the aggregate policy state are given in Table 16. Individuals beliefs about the path of the aggregate state are given by the transition matrix in equation 20.

To perform the transition path experiment we simulate 125,000 individuals for 380 periods, 20 times, burning the first 120 periods. We report averages over the 20 simulations. The path of the aggregate policy state in the simulation is such that we are in the initial steady state for 260 periods (including the burn), then we are in the "1st Year After Policy Change" state for 4-quarters where the values for the aggregate policy state parameters are given in Table 16. For each year after the policy change K where $K \in \{2, 3, 4, 5\}$, we are in the "K Years After Policy Change" state for 4-quarters where the values for the aggregate policy state parameters are given in Table 16. Finally, the aggregate policy state is in the "New Steady State" for the final 100 periods of the simulation.

Solving the transition path of the economy proceeds in the following steps:

1. **Taxes** Guess a sequence of taxes $\tau = [\tau_o, \tau_1, \tau_2, \tau_3, \tau_4, \tau_5, \tau_{new}]$ where τ_o is the tax rate in the initial steady state, τ_K is the tax rate K years after the policy change, and τ_{new} is the tax rate in the new steady state following the transition.

2. **Model Estimation** Solve the model following the steps presented in Appendix E using the taxes guessed in Step 1, the transfers to unemployed workers from Table 16, and the transition matrix for the aggregate policy state given by equation 20.

3. **Simulation and Budget Balance**: Simulate a mass of individuals, perform the policy transition and check the government's budget constraint in each of the 7 aggregate policy states. Iterate until the government's budget is balanced in each aggregate policy state.

Table 17: Comparison of Model Predictions

Moment	Model with 7 Interest Rates	Model with 15 Interest Rates
Transfer to Income Loss	41.2%	41.2%
Unemployment Rate	5.3%	5.3%
Credit Finding Rate	64.1%	64.1%
Share of Individuals w/ Credit Access	69.9%	69.9%
Bankruptcy Rate	0.141%	0.142%
Earnings Loss 5 Yr. After Layoff	6.5%	6.6%
Earnings Gain With Age	0.92%	0.92%
Share of Indiv. w/ 9.5% Wage Decline	8.6%	8.6%
Share of Indiv. w/ 9.5% Wage Increase	17.2%	17.2%
P75-P25 Earnings Ratio Among Young Workers	0.479	0.479
Consumption After Layoff	94.0%	94.0%
Unused Credit Limit to Income	23.6%	23.5%
P95 Real Credit Card Interest Rate	15.9%	16.0%
Share of Individuals w/ Net Liquid Assets to Income $<$ 1%	31.6%	31.6%