Online Appendix, Not For Publication

"How Credit Constraints Impact Job Finding Rates, Sorting & Aggregate Output"

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A Data Appendix

Employer reports are based on the ES-202 which is collected as part of the Covered Employment and Wages (CEW) program (run by BLS). One report per establishment per quarter is filed. On this form, wages subject to statutory payroll taxes are reported.

The employment records are associated with a firm's State Employment Identification Number (SEIN). This is an identifier based on an employer within a given state, and it is, in general, not an identifier of the establishment of the worker. Minnesota is the only state to collect establishment identifiers, and in all other states, an imputation based on place-of-work is used to generate establishment level identifiers. In general, workers are included in the dataset if they earn at least one dollar from any employer.

The Quarterly Census of Employment and Wages (QCEW) contains firm level data which is collected in each state. This dataset includes information on industry, ownership, and worksite.

The demographic data in the LEHD comes from the 2000 census as well as social security records, and tax returns. These are linked by social security number with the unemployment insurance data. In the LEHD, social security numbers are not present, rather there is a scrambled version called a Protected Identification Key (PIK).

The main demographic information database is the Person Characteristic File (PCF). Information on sex, date of birth, place of birth, citizenship, and race are included here.

A.1 Employment and Duration Definitions

Our main concept of employment is end of quarter employment, as in Abowd et al. [2009]. For example, to be counted as employed at the end of quarter 1 at employer X, the worker in question must have had positive earnings at employer X in quarter 1 and quarter 2. Our earnings threshold is $500 in each quarter, and we find no significant impact on our results for greater earnings thresholds. If a mass displacement occurs at employer X in quarter 2 (i.e. 30% of their employees leave or they close, see the following section), and the worker separates from employer X (meaning the worker is not end of quarter employed at employer X in quarter 2), then we count the worker as mass displaced. If the worker becomes end of quarter employed at employer Y in quarter 2, then the non-employment duration spell is marked as a zero. If the worker is end of quarter employed at employer Y in quarter 3, then the duration is 1 quarter, and so on. We truncate durations at 9 quarters. In Section C.1, we adjust these spells for partial quarters of non-employment duration using the earnings gap method, and we also adjust for self-employment. We have also used other measures of employment, and we find no significant impact on our results.

A.2 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.

A.3 TransUnion Variables

The unsued revolving credit limit ratio is defined as,

$$\frac{\text{(Total Revolving Credit Limit - HELOC credit limit) - (Total Revolving Balance - HELOC balance)}}{\text{Lagged Annual Earnings}}$$

'Total Revolving Credit Limit' corresponds to the TransUnion variable 'Revolving High Credit/Credit Limit.' 'Revolving High Credit/Credit Limit' is constructed as the sum of the 'High Credit/Credit Limit' across all types of revolving debt. The 'High Credit/Credit Limit' is defined as the actual credit limit if such a limit is recorded or the highest historical balance if no credit limit is recorded. 'HELOC credit limit' is the sum across all available HELOC credit limits, and 'HELOC balance' is the sum across all available HELOC balances.

B Robustness Checks

B.1 Verifying Assumptions for Bankruptcy Flag Removal Regressions

For the simple difference estimator used in the bankruptcy flag removal regressions to be valid, we must verify that the treatment and control group have similar means prior to layoff. Let $t = 0$ denote the year of removal, let $Y_{i,t}$ denote outcome variables of interest (wage growth, time spent unemployed, etc.), and let $treat_{i,t}$ be an indicator if the household is in the treatment group. Let $X_{i,t}$ include the same baseline demographic controls as the regressions in the text. We therefore run the following regressions for $t = -1$ (the year before layoff) and $t = -2$ (two years before layoff):

$$Y_{i,t} = \gamma_{i,t} Treat_{i,t} + \beta X_{i,t} + \epsilon_{i,t}$$

We show in Table 14 that the treatment and control group have insignificant mean differences in the outcome variables of interest for both $t = -1$ and $t = -2$. This implies that the two groups have identical trends and levels leading up to the flag removal. Therefore, the assumptions underlying the simple difference estimator hold, and our estimates should, in theory, be unbiased.

Table 14: Testing Identical Means and Parallel Trends for Bankrupt Sample, Treatment vs. Control.

Comparison of treatment and control group 1 year prior to layoff			
	Reject equal means at X% sig. level?		
	X=1%	X=5%	X=10%
Dependent variable is wage growth (w(t)/w(t-1))	N	N	N
Dependent variable is indicator if non-employed in Q1	-	-	-
Dependent variable is indicator if non-employed in Q2	-	-	-
Dependent variable is indicator if non-employed in Q3	-	-	-
Dependent variable is indicator if non-employed in Q4	-	-	-
Dependent variable is firm size	N	N	N
Depdent variable is firm productivity	N	N	N

Comparison of treatment and control group 2 years prior to layoff			
	Reject equal means at X% sig. level?		
	X=1%	X=5%	X=10%
Dependent variable is wage growth (w(t)/w(t-1))	N	N	N
Dependent variable is indicator if non-employed in Q1	N	N	N
Dependent variable is indicator if non-employed in Q2	N	N	N
Dependent variable is indicator if non-employed in Q3	N	N	N
Dependent variable is indicator if non-employed in Q4	N	N	N
Dependent variable is firm size	N	N	N
Depdent variable is firm productivity	N	N	N

Notes. Robust standard errors. Sample conditions on employment 1 year prior to layoff, so time spent non-employed is the same (by construction) in the year before layoff.

B.2 House Prices and the Relationship Between Credit, Non-Employment Durations, and Replacement Rates

Table 15 illustrates the main OLS regressions with direct house price controls. The house price control we include in the regression is the OFHEO All-Transaction House Price Index for MSAs.[37] Column (1) shows the baseline OLS result with no equity proxies or house prices, and the coefficient implies that being able to replace 10% more of prior annual income allows a household to take .3 weeks longer to find a job (=.258*.1*12). Column (2) adds in the house price index, and the coefficient remains the same. Column (3) includes both the equity proxies used in the text as well as the house price index, and the coefficient still remains the same. Columns (4) through (6) illustrate the same results for the replacement rate among the sample of households who found a job in the year after layoff. In each case, the replacement rate 1 year after layoff is hardly impacted by the inclusion of house price controls.

These results suggest that whether the house is worth 200k or 220k does not affect short term job search decisions directly. Only if the job loser can use the equity of the home to smooth consumption, should the value of the home impact short term job search decisions. While one may argue that households can sell their house to tap equity, since the average job loss spell in our data is quite short, it is unlikely that a worker who is laid off will be able to secure additional home equity lines, refinance or vacate the home immediately and sell the house. As Piazzesi et al. [2015] show empirically, even in the best of markets, it takes over 1 quarter for the median homeowner to sell their home, once it is listed. Empirically, in our dataset, we do not see households disproportionately taking out mortgages or paying off mortgages around displacement.

The fact that house price increases do not necessarily imply households are wealthier, nor that they should consume more, is actively debated in the literature (see both sides of the literature in Calomiris et al. [2009], among others). As most theoretic studies show, a household may attempt to sell the house, but they must buy a new one or rent thereafter, mitigating housing wealth effects. There is also mixed evidence regarding housing lock (see both sides of the literature discussed in Karahan and Rhee [2011]), suggesting that housing wealth may not matter for selling decisions as well. We find very little evidence of interstate movers or intrastate movers in our sample around job loss. If we drop movers, our IV regression results remain unchanged in terms of sign, significance, and magnitude.

[37] This is publicly avaiable from the OFHEO website. The index is normalized to 100 in 1995.

Table 15: Baseline OLS regressions with Direct Controls for OFHEO House Prices (Source: LEHD/TransUnion 2002-2006)

	(1) Duration	**(2)** Duration	**(3)** Duration	**(4)** Replacement Rate	**(5)** Replacement Rate	**(6)** Replacement Rate
Unused Revolving Credit to Income Ratio	0.258***	0.248***	0.242***	0.0335***	0.0327***	0.0324***
	(0.0257)	(0.0258)	(0.0259)	(0.00344)	(0.00344)	(0.00345)
Demographic, Industry, MSA, & Lagged Earnings Controls	Y	Y	Y	Y	Y	Y
OFHEO HPI Index	N	**Y**	**Y**	N	**Y**	**Y**
HELOC Limits and Equity Proxy	N	N	**Y**	N	N	**Y**
R2	0.047	0.048	0.049	0.082	0.083	0.083
Round N	32000	32000	32000	21000	21000	21000

*Notes. Clustered standard errors at MSA level in parentheses, *** p<0.01, ** p<0.05, * p<0.1. OFHEO HPI Index is the OFHEO All-Transaction House Price Index measured in the year prior to layoff. Revolving Unused Credit to Income measured 1 year prior to layoff. Demographic controls include quadratic in age & tenure, race, sex and education dummies as well as year & auto loan dummies. Industry controls include 1-digit SIC dummies. MSA controls include real per capita GDP and the MSA unemployment rate. Lagged earnings controls include both lagged real annual earnings, and cumulative lagged real annual earnings to proxy for assets.*

B.3 Correlation of Unemployment Durations and Credit Limits in the SCF, Controlling for Assets

In the SCF between 1998 and 2007 (which includes the 1998, 2001, 2004, and 2007 surveys), we can compute the raw correlation between unused credit limits and unemployment durations, controlling for a host of assets, including home values. Figure 12 plots the raw correlation between unemployment duration and credit limits in the SCF, and it reveals a similar pattern to the LEHD/TransUnion dataset. Table 16 provides a more formal analysis, including controls for the entire portfolio of a household's assets. Table 16 demonstrates a strong correlation between unused credit card limits and unemployment durations, subject to time aggregation bias (the unused credit limit is measured as of the survey date whereas unemployment duration is measured over the last year). The 'Unused Unsecured Limit to Income' refers to unused credit card limits (as of the survey date) over annual gross family income (over the prior year). Unemployment duration measures weeks spent unemployed over the past 12 months prior to the survey. It is measured in weeks, and does not distinguish individual unemployment spells.

Column 1 of Table 16 shows that simple regressions of unemployment duration on unused credit card limits reveal a strong positive correlation, even after controlling for income and liquid assets. Columns 2 and 3 impose age restrictions and add basic demographic controls, but the positive and significant relationship persists. Column 4 adds in all available categories of illiquid assets, and finally Column 5 restricts the dataset to mortgagors (as is the case in the LEHD/TransUnion sample considered in the text). The strong positive and significant relationship between unused credit limits and unemployment durations persists. An unused credit limit worth 10% of prior annual family income is associated with 1 week longer unemployment spells, very similar to the IV estimate in the LEHD/TransUnion sample considered in the text.

Figure 12: **Survey of Consumer Finances:** Correlation of Unemployment Durations (in Weeks) on Unused Credit (Source: 1998-2007 SCF)

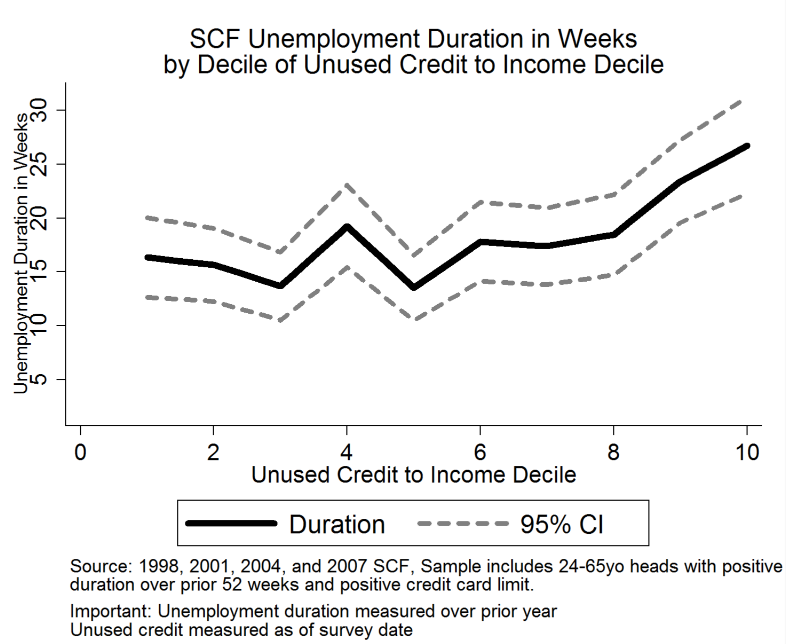


Table 16: **Survey of Consumer Finances:** OLS Regressions of Unemployment Durations (in Weeks) on Unused Credit, Controlling for Assets (Source: 1998-2007 SCF)

	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
	Dep. Var. is SCF Unemployment Durations in Weeks					
Unused Unsecured Limit to Income	12.334***	10.430***	8.733***	9.338***	8.155***	7.854***
	(5.85)	(4.87)	(4.02)	(4.31)	(3.75)	(2.66)
Year Dummies	N	Y	Y	Y	Y	Y
Demographics and Income	N	Y	Y	Y	Y	Y
Liquid Assets to Inc (Checking/Savings plus Stocks and Bonds)	N	N	**Y**	N	**Y**	**Y**
Illiquid Assets to Inc (Homes, Vehicles, etc.)	N	N	N	**Y**	**Y**	**Y**
Mortgagors Only	N	N	N	N	N	**Y**
Observations	764	764	764	759	759	421
R-squared	0.052	0.130	0.144	0.137	0.148	0.157

Notes: SCF 24 to 65yo Heads of Household with Positive Unemployment Spell over Prior 12 months and Positive Limit. Restrict to Mortgagors in Col 6. Demographics include quadratic in age, dummies for education, and dummies for race and Income refers to gross annual family income. Liquid Assets include cash, checking, money market funds, CDS, corporate bonds, government saving bonds, stocks, and mutual funds less credit card debt. Unused Credit Limit to Income refers to total credit card limits less credit card balances. Illiquid Assets includes Homes, Vehicles, Retirement, Annuities, Life Insurance at self-reported market values.

B.4 Over-Identification Tests

In this section we discuss the assumptions underlying the Gross and Souleles instrument, and we use the fact that we have two different instruments in order to conduct over-identification tests. In summary, the Saiz and Gross and Souleles instruments pass over identification tests at the 5% significance level, suggesting that they are satisfying exclusion restrictions. However, there is no true test of exogeneity.

For the Gross and Souleles instrument to be valid, it must be both relevant and exogenous. What makes the Gross and Souleles instrument relevant is that a large component, approximately 15%, of a credit score is solely based on length of credit history.[38] By simply having an account open, you credit score increases and affects your credit limits.[39] Empirically, the first stage is very strong, as evidenced by the small p-values in the Stock-Yogo weak identification tests ('Weak Id'), where the null is that the instruments are weak.

For the age of the oldest account to be a valid instrument for credit limits, it must not only be a strong determinant of credit limits, but it can only have an impact on employment prospects through credit limits (exogeneity). The main challenge to exogeneity is that the age of an account is related to the physical age of the individual. Since the age of an account is how scoring companies proxy for physical age, by conditioning on physical age (which we observe but scoring companies do not), we are able to isolate changes in credit scores simply due to variation in account age, that have nothing to do with physical age.[40]

Lastly, since we have multiple instruments, we show that both the Gross and Soueles instrument and Saiz instrument pass over-identification tests. For individual i, $l_{i,t}$ is unused credit, $g_{i,t}$ is the age of the oldest account, $s_{i,t}$ is the supply elasticity, and $X_{i,t}$ is a vector of characteristics including quadratics in age and tenure. To conduct the over-identification tests, we implement the following specifications:

$$l_{i,t-1} = \pi_1 s_{i,t} + \pi_2 g_{i,t} + BX_{i,t} + u_{i,t} \tag{10}$$

[38] See 'Your Credit Score,' prepared by Fair Isaac Corporation and available from http://www.consumerfed.org/pdfs/yourcreditscore.pdf

[39] Limits are then revised upward as credit scores increase. As Gross and Souleles [2002] explain, credit issuers revise account limits regularly, and the length of time an account was open is a determinant of these credit limit revisions. They write, "many issuers will not consider (or are less likely to consider) an account for a line change if it has been less than six months or less than one year since the last line change" (p.7).

[40] The reason they do this is that the Equal Credit Opportunity Act bans the use of age, race, or sex in determining credit score, and so the credit scoring companies use account age as a proxy for physical age.

These first-stage estimates of π_1, π_2 and B are used to isolate the exogenous component of the unused credit limit ratio, $\hat{l}_{i,t-1}$. The second stage regression is then used to estimate how this exogenous variation in credit impacts employment outcomes such as duration, $D_{i,t}$.

$$D_{i,t} = \gamma \hat{l}_{i,t-1} + \beta X_{i,t} + \epsilon_{i,t} \tag{11}$$

The main idea behind the over-identification tests is to predict $\hat{l}_{i,t-1}$ using one instrument, e.g. $s_{i,t}$, and then verify that the other instrument, $g_{i,t}$, is uncorrelated with the resulting residuals.

Table 17 illustrates the main results using both the Saiz and Gross and Souleles instruments in the first stage. We see that the instruments pass the over-identification tests (in particular, we implement Hansen's J-test). The null is that the instruments are valid, and so larger p-values indicate the fact that we cannot reject the null that the instruments are valid. The instruments pass the J-test at both 1% and 5% significance levels. In terms of point estimates, Table 17 shows that our main results hold: credit limits positively impact durations (Column (1)), earnings replacement rates (Column (2)), and firm productivity (Column (4)).

Table 17: Over Identification Tests with Saiz and Gross & Souleles instrument. (Source: 2002-2006 LEHD/TransUnion)

	(1)	**(2)**	**(3)**	**(4)**
	Over ID Tests with Saiz-IV and GS-IV			
Dep Var	Duration	Replacement Rate	Large Firm Dummy	Productive Firm Dummy
Unused Revolving Credit to Income Ratio	0.656***	0.0970***	0.0860	0.0987*
	(0.112)	(0.0157)	(0.0534)	(0.0521)
Demographic, Industry, MSA, & Lagged Earnings Controls	Y	Y	Y	Y
HELOC Limits and Equity Proxy	Y	Y	Y	Y
R2 (1st Stage for IVs)	0.137	0.120	0.120	0.120
Angirst Pischke FStat Pval	0	0	0	0
Pval Weak Id Null Weak	6.41e-05	4.46e-05	4.46e-05	4.46e-05
Jtest Pval Null Valid	0.134	0.290	0.0622	0.230
Round N	32000	21000	21000	21000

*Notes. Clustered std. errors at MSA level in parentheses, *** p<0.01, ** p<0.05, * p<0.1. Same control definitions as Table 2.*

B.5 Alternate Measures of Personal Financial Constraints: Total Credit, Revolving Credit Including HELOCs, and Credit Scores

In Table 18, we use alternate endogenous regressors: (i) unused revolving credit to income, including HELOCs (ii) total unused credit, including all types of secured (including HELOCs and mortgage debt) and unsecured debt (we define 'total unused credit to income' as the total credit limit less the amount currently borrowed over annual earnings, where the ratio is measured 1 year prior to layoff)[41], and (iii) credit scores (this corresponds to TransUnions bankruptcy model, and ranges from 0 to 1000, with higher scores indicating less credit risk).

Columns (1) and (2) of Table 18 illustrate that revolving unused credit, inclusive of HELOCs, has a similar effect on duration and replacement rates (conditional on being employed at $t+1$), respectively, as the baseline definition in the text (which excludes HELOCs). Likewise, Columns (3) and (4) of Table 18 illustrate that total unused credit has a similar effect on duration and replacement rates. Columns (5) and (6) of Table 18 are more difficult to interpret, since the units are in terms of the TU bankruptcy model ('credit score'), but in general, if an individual has a higher score prior to layoff, they take longer to find a job, and they find higher replacement rates, conditional on finding a job.

[41]The Total Credit Limit is formally the TransUnion variable "Total High Credit/Credit Limit" which is sum of actual credit limits across all types of debt, or if the credit limit is not stated, it is the highest observed prior balance. This measure of credit includes secured credit lines like home equity lines of credit and installment credit, as well as auto loans, and other personal finance loans.

Table 18: Alternate Measures of Access to Credit. IV estimates using the Saiz Instrument. (Source: 2002-2006 LEHD/TransUnion)

	Saiz House Supply Elasticity					
	(1)	(2)	(3)	(4)	(5)	(6)
Dep Var	Duration	Replacement Rate (Among Employed at t+1)	Duration	Replacement Rate (Among Employed at t+1)	Duration	Replacement Rate (Among Employed at t+1)
Unused Revolving Credit to Income Ratio (Incl. HELOCs)	1.269**	0.162**				
	(0.525)	(0.0755)				
Total Unused Credit to Income Ratio			1.508**	0.134**		
			(0.589)	(0.0616)		
Credit Score					0.00238**	1.087***
					(0.000957)	(0.0665)
Demographic, Industry, MSA, & Lagged Earnings Controls	Y	Y	Y	Y	Y	Y
HELOC Limits and Equity Proxy	Y	Y	Y	Y	Y	Y
R2 (1st Stage for IVs)	0.137	0.0896	0.104	0.117	0.110	0.113
Angirst Pischke FStat Pval	2.13e-05	1.39e-05	7.32e-05	4.48e-06	2.32e-05	2.78e-06
Round N	32000	21000	32000	21000	32000	21000

*Notes. Clustered Std. errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1. Displaced mortgagor sample in Cols. (1), (3), and (5). Displaced mortgagor sample, conditional on employment at t+1, in Cols. (2), (4), and (6). Credit score is the TU bankruptcy score prior to layoff. Unused Revolving Credit to Income Ratio and Total Unused Credit to Income Ratio measured prior to layoff. Same control definitions as Table 2.*

C Replacement Earnings 2 Years After Layoff

Consider the set of households who find a job 1 year after layoff. In the main text, Table 4 illustrates the impact of credit on the wages of job finders 1 year after layoff. To assess the impact of consumer credit access on longer term wage outcomes, Table 19 analyzes wages 2 years after layoff for this same sample. Within this sample, the OLS estimates in Column (1) imply that replacement earnings are .3% higher, 2 years after layoff, for households who can replace 10% more of their lost income with unused credit. The Saiz instrument in Column (2) and the bankruptcy flag removal in Column (3) yield insignificant results, whereas the Gross and Souleles estimates in Column (3) imply that within this sample, replacement earnings are .9% higher, 2 years after layoff, for households who can replace 10% more of their lost income with unused credit. While the results are mixed, the earnings gains in Table 4 persist 2 years after layoff for at least 2 of the specifications considered in the main text.

Table 19: Dependent Variable is Replacement Rate, Measured 2 Years After Layoff Relative to 1 Year Before Layoff. Sample Restricted to **Job Finders 1 Year After Layoff**. (Source: 2002-2006 LEHD/TransUnion)

	(1)	**(2)**	**(3)**	**(4)**
	DV is Replacement Rate at **t+2**, Among Employed Sample			
	OLS	IV-Saiz	IV-GS	OLS-Flag Drop
Unused Revolving Credit to Income Ratio	0.0383***	0.180	0.0916***	
	(0.00441)	(0.122)	(0.0171)	
Flag Drop (d)				-0.00598
				(0.0136)
Demographic, Industry, MSA, & Lagged Earnings Controls	Y	Y	Y	Y
HELOC Limits and Equity Proxy	Y	Y	Y	Y
R2 (1st Stage for IVs)	0.078	0.0872	0.117	0.120
Angirst Pischke FStat Pval	-	2.48e-05	0	-
Round N	21000	21000	21000	12000

Notes. Same as Table 2.

C.1 Self-Employment and the Earnings Gap Method

Table 20 redoes the main analysis in two different ways. Column (1) is a regression of duration on unused credit where the self-employed with more than 5k in annual Schedule C earnings are counted as employed. Column (2) infers the length of unemployment duration using the earnings gap method. Using quarterly earnings prior to layoff as the base (E_{q-1}), then those who find a job within the first quarter of layoff will have spent $1 - E_q/E_{q-1}$ fraction of the quarter unemployed. Table 20 illustrates that the main results are robust to these alternate definitions.

Table 20: Column (1) is duration of non-employment, counting the self-employed who earn more than 5k in a year as employed, and Column (2) is duration of non-employment with partial duration values inferred using the earnings gap method. (Source: LEHD / TransUnion)

	(1) Duration (Self-Employment)	**(2)** Duration (Earnings Gap Method)
Unused Revolving Credit to Income Ratio	1.334**	1.532**
	(0.646)	(0.623)
Demographic, Industry, MSA, & Lagged Earnings Controls	Y	Y
HELOC Limits and Equity Proxy	Y	Y
R2 (1st Stage for IVs)	0.101	0.101
Angirst Pischke FStat Pval	0.000138	0.000138
Round N	32000	32000

*Notes. Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1. Revolving Unused Credit to Income measured 1 year prior to layoff. Demographic controls include quadratic in age & tenure, race, sex and education dummies as well as year & auto loan dummies. Industry controls include 1-digit SIC dummies. MSA controls include real per capita GDP and the MSA unemployment rate. Lagged earnings controls include lagged real annual earnings.*

D Employed Value Functions

For employed households, value functions are denoted with a W, and at the end of every period, employed households face layoff risk δ. If they are laid off, since the period is 1 quarter, we must allow the workers to search immediately for a new job.[42]

$$
\begin{aligned}
W_t^G(b,h,k;\Omega) = &\max_{b' \geq \underline{b}} u(c,0) + \beta \mathbb{E}\Big[(1-\delta) W_{t+1}(b',h',k;\Omega') \\
&+ \delta \Big\{ \max_{\tilde{k}} p(\theta_{t+1}(h',\tilde{k};\Omega')) W_{t+1}(b',h',\tilde{k};\Omega') \\
&\qquad + \big(1 - p(\theta_{t+1}(h',\tilde{k};\Omega'))\big) U_{t+1}(b',h',k;\Omega') \Big\}\Big], \quad t \leq T
\end{aligned}
$$

$$
W_{T+1}^G(b,h,k;\Omega) = 0
$$

Such that the aggregate laws of motion are given by equation (4), human capital evolves according to the law of motion: $h' = H(h,W)$, and the budget constraint holds,

$$
c + q_{W,t}(b',h,k;\Omega) b' \leq \alpha f(y,h,k) + b
$$

The value functions for employed borrowers who default as well as the discrete default decision are formulated in an identical fashion to that of the unemployed.

$$
\begin{aligned}
W_t^B(b,h,k;\Omega) = u(c,0) + &\lambda \beta \mathbb{E}\Big[(1-\delta) W_{t+1}(0,h',k;\Omega') \\
&+ \delta \Big\{ \max_{\tilde{k}} p(\theta_{t+1}(h',\tilde{k};\Omega')) W_{t+1}(0,h',\tilde{k};\Omega') \\
&\qquad + \big(1 - p(\theta_{t+1}(h',\tilde{k};\Omega'))\big) U_{t+1}(0,h',k;\Omega') \Big\}\Big] \\
&+ (1-\lambda)\beta \mathbb{E}\Big[(1-\delta) W_{t+1}^B(0,h',k;\Omega') \\
&+ \delta \Big\{ \max_{\tilde{k}} p(\theta_{t+1}(h',\tilde{k};\Omega')) W_{t+1}^B(0,h',\tilde{k};\Omega') \\
&\qquad + \big(1 - p(\theta_{t+1}(h',\tilde{k};\Omega'))\big) U_{t+1}^B(0,h',k;\Omega') \Big\}\Big], \quad t \leq T
\end{aligned}
$$

$$
W_{T+1}^B(b,h,k;\Omega) = 0
$$

[42]This allows the model to match labor flows in the data.

Such that the aggregate laws of motion are given by equation (4), human capital evolves such that $h' = H(h, W)$ and the budget constraint is given by,

$$c \leq \alpha f(y, h, k)$$

For employed households in good standing, at the start of every period, they must make the following default decision,

$$W_t(b, h, k; \Omega) = \max \left\{ W_t^G(b, h, k; \Omega), W_t^B(b, h, k; \Omega) - \chi \right\}$$

Let $D_{W,t}(b, h, k; \Omega)$ denote the employed household's default decision.

E Characterizing Existence and Uniqueness

In this section, we characterize both the existence and uniqueness of a block recursive equilibrium for the model economy. These propositions are useful for numeric exercises since they will establish that (i) all equilibria are block recursive, and (ii) for certain classes of utility, matching, and production functions, the equilibrium is unique. The proofs use a similar methodology to Menzio et al. [2012], extended to an environment with two-sided heterogeneity. We begin with Proposition E.1 which is the existence result for a Block Recursive Equilibrium. Without loss of generality, we set the firm fixed cost f_c to zero.

Proposition E.1. *Assume that the utility function meets standard conditions ($u' > 0, u'' < 0, \lim_{c \to 0} u'(c) = \infty, \lim_{c \to \infty} u'(c) = 0$, and u is invertible), the matching function is invertible and constant returns to scale, and there is a bounded support (which can be non-binding) for the choice set of debt $b \in \mathbb{B} \subseteq [\underline{b}, \overline{b}]$ and the capital of firms $k \in \mathcal{K} \subseteq [\underline{k}, \overline{k}]$, then a Block Recursive Equilibrium exists.*

Proof. The proof will follow backward induction. Let $t = T$, and consider an unemployed household for the sake of brevity (an identical argument follows for employed households). Since the household's continuation value is zero from $T + 1$ onward, the household dynamic programming problem trivially does not depend on the aggregate distribution μ across states in the last period of life,

$$\begin{aligned} U_T^G(b,h,k;\Omega) &= u(z(k)+b,1)+\beta\cdot 0 \\ &= U_T^G(b,h,k;y,\underline{b}) \end{aligned}$$

$$\begin{aligned} W_T^G(b,h,k;\Omega) &= u(\alpha f(y,h,k)+b,1)+\beta\cdot 0 \\ &= W_T^G(b,h,k;y,\underline{b}) \end{aligned}$$

In this last period of life, the saving and borrowing policy function $b'_{e,T}(b,h,k;y,\underline{b})$ is trivially zero (for both employed $e=W$ and unemployed agents $e=U$). Likewise, for households in bad standing in the last period of life, the value of unemployment (and nearly identical conditions hold for the employed, and so are omitted) is given by,

$$U_t^B(b,h,k;y,\underline{b}) = u(z(k),1)+\beta\cdot 0$$

Stepping back to the default decision, U_T will also not depend on the aggregate distribution μ,

$$U_T(b,h,k;y,\underline{b}) = \max\left\{U_T^G(b,h,k;y,\underline{b}), U_T^B(0,h,k;y,\underline{b})-\chi\right\}$$

Let $D_{U,T}(b,h,k;y,\underline{b})$ denote the policy function of the household. Since there is a utility penalty χ of defaulting, debt can be supported in equilibrium, and $D_{U,T}$ will not be trivially zero.

Now stepping back to the labor search problem, the firm's value function will be independent of μ as well,

$$\begin{aligned} J_T(h,k;\Omega) &= (1-\alpha)f(y,h,k)+\beta\cdot 0 \\ &= J_T(h,k;y,\underline{b}) \end{aligned}$$

And the labor market tightness will also be independent of μ,

$$
\begin{aligned}
\theta_T(h,k;\Omega) &= p_f^{-1}\left(\frac{\kappa+(1+r_f)k}{J_T(h,k;y,\underline{b})}\right)\\
&= \theta_T(h,k;y,\underline{b})
\end{aligned}
$$

The household at age $T-1$ (note that the primes below simply note that age $T-1$ risk over y and $\underline{b}$ has already been realized and human capital has already evolved to h') must therefore make the following labor market search choice over k, the capital of firms,

$$
\max_{k\in\mathcal{K}}\; p(\theta_T(h',k;y',\underline{b}'))W_T(b',h',k;y',\underline{b}') + \big(1-p(\theta_T(h',k;y',\underline{b}'))\big)U_T(b',h',k;y',\underline{b}') \tag{12}
$$

So long as k lies in a bounded interval, the extreme value theorem guarantees at least one solution to this problem. As we will see below, for certain classes of production functions, only one solution exists. For the current exposition, assume the production function lies within this class, and a unique solution exists.

Given the household policy functions for labor search $k'_{T-1}(h',k;y',\underline{b}')$ and default $D'_{e,T}(h',k;y',\underline{b}')$, the bond price $q_{U,T}(b',h,k;\Omega)$ is given by,

$$
\begin{aligned}
q_{U,T-1}(b',h,k;\Omega) &= \frac{\mathbb{E}\Big[1-D_{e',T}(b',h',k';y',\underline{b}')\Big]}{1+r_f}\\
&= q_{U,T-1}(b',h,k;y,\underline{b})
\end{aligned}
$$

Clearly the bond price does not depend on the aggregate distribution μ.

Stepping back from $t=T-1,\ldots,1$, and repeating the above procedure completes the proof.

□

A simple corollary follows in which one can establish the existence of an equilibrium with debt.

Corollary E.2. *Under the hypotheses of Proposition E.1, so long as $\chi>0$ and $\mathcal{B}$ contains a neighborhood of debt around 0, a Block Recursive Equilibrium with credit exists.*

Proof. Because of the inada conditions, for every positive $\chi \in \mathbb{R}_+$, there exists a sufficiently small debt in an ϵ-neighborhood around zero, $b \in N_\epsilon(0)$, such that the household strictly prefers repayment in the last period of life. The households repayment choice is given by,

$$\max \left\{ U_T^G(b, h, k; y, \underline{b}), U_T^B(0, h, k; y, \underline{b}) - \chi \right\}$$

This holds with equality at the cutoff debt b^*,

$$U_T^G(b^*, h, k; y, \underline{b}) = U_T^B(0, h, k; y, \underline{b}) - \chi$$

Substituting,

$$u(z(k) + b^*, 1) = u(z(k), 1) - \chi$$

The minimum supportable debt is given by,

$$b^* = u^{-1}(u(z(k), 1) - \chi, 1) - z(k) < 0$$

□

Now, we turn to uniqueness. In Lemma (E.3) we provide sufficient conditions for the economy to admit a unique, Block Recursive Equilibrium. Lemma E.3 demonstrates that for a broad range of production functions and utility functions, the model admits a unique solution, and so there is no equilibrium selection implicitly taking place in the numeric exercises. Removing uncertainty in the proof is only for the sake of closed form solutions to the firm problem, and as long as the utility function of the household is additively separable in leisure, the proof holds.

Lemma E.3. *In addition to the assumptions in Proposition E.1, let the production function be Cobb-Douglas, i.e.* $f(y, h, k) = yh^{1-a}k^a$ $(0 < a < 1)$*, let the matching function be given by* $M(u, v) = u^{\frac{1}{2}}v^{\frac{1}{2}}$*, let* $\chi \to \infty$ *(no default for households), the value of leisure is zero, and assume there is no uncertainty over human capital* h*, aggregate productivity* y*, or the borrowing limit* $\underline{b}$*. Then if the utility function is negative, increasing, and concave (e.g.* $\frac{c^{1-\sigma}-1}{1-\sigma}$ *for* $\sigma > 1$ *or* $u(c) = -e^{-c}$*), the household labor search problem (equation (12)) admits a unique solution.*

Proof. The non-stochastic firm problem can be solved by hand, and under the hypotheses of the present lemma, it is directly proportional to capital,

$$J_t(h,k) = \frac{(1-\alpha)f(y,h,k)}{1-\beta(1-\delta)} - \frac{(\beta(1-\delta))^{T-t+1}(1-\alpha)f(y,h,k)}{1-\beta(1-\delta)} \propto k^a$$

Under the assumption $M(u,v) = u^{\frac{1}{2}}v^{\frac{1}{2}}$, the equilibrium market tightness $\theta_t(h,k)$ can be solved by hand.

$$\kappa = \theta_t(h,k;\Omega)^{-\frac{1}{2}}\left[J_t(h,k;\Omega) - (1+r_f)\cdot\frac{k}{\theta_t(h,k;\Omega)^{-\frac{1}{2}}}\right]$$

Solving for θ_t yields,

$$\left(\frac{\kappa+(1+r_f)k}{J_t(h,k;\Omega)}\right)^{-2} = \theta_t(h,k;\Omega)$$

The household job finding rate is therefore given by,

$$\left(\frac{J_t(h,k;\Omega)}{\kappa+(1+r_f)k}\right) = p(\theta_t(h,k;\Omega))$$

For κ and r_f sufficiently small,

$$p(\theta_t(h,k;\Omega)) \propto k^{a-1}$$

The constant worker share α in combination with the non-negative and increasing production function implies that the wage a worker receives is concave and increasing in k. Note that the composition of two non-decreasing concave functions in k preserves concavity in k, i.e. $\tilde{u}(k) = u(w(h,k)+\mu)$ is concave in k for arbitrary μ. Let $\underline{u}$ be the outside option of the household if they remain unemployed. Since the probability of finding a job is directly proportional to k^{a-1}, the household chooses k to maximize

$$k^{a-1}\tilde{u}(k) + (1-k^{a-1})\underline{u}$$

Since $-k^{a-1}$ is concave, we ignore the second term (the idea will be to show the first term is concave, and then use the fact that the sum of two concave functions is concave). The condition for the first term to be concave is given by,

$$\underbrace{(a-1)(a-2)k^{a-3}\tilde{u}(k)}_{(-)} + \underbrace{2(a-1)k^{a-2}\tilde{u}'(k)}_{(-)} + \underbrace{k^{a-1}\tilde{u}''(k)}_{(-)} < 0$$

Under the hypotheses that $u < 0$, $u' > 0$, $u'' < 0$ (note, these properties transfer to $\tilde{u}$), and $0 < a < 1$, the labor search problem of the household is strictly concave and one solution exists for k.

□

Table 21: Business Cycle Moments for Model During Main Simulation (1974 to 2012) vs. Data

Model							
x	u_1	v	θ	y	$\tilde{k}$	UE Rate	Default Rate*
SD(x)/SD(y)	2.69	1.66	1.91	1.00	0.97	1.66	0.00
Autocorr(x)	0.73	0.39	0.78	0.82	0.79	0.40	0.13
Corr(·,x)							
u	1.00	-0.19	-0.74	-0.72	-0.73	-0.87	-0.14
Data							
x	u_1	v	θ	y	$\tilde{k}$	UE Rate	Default Rate*
SD(x)/SD(y)	9.50	10.10	19.10	1.00	-	5.90	6.07
Autocorrelation	0.94	0.94	0.94	0.88	-	0.91	0.92
Corr(·,x)							
u_1	1.00	-0.89	-0.97	-0.41	-	-0.95	0.55

Notes: HP filtered with smoothing parameter 10^5 to be consistent with Shimer [2005]. Data are from Shimer [2005], except (*) the default rate which is taken from Equifax (1999-2012). As in the data, u_1 is calculated as the fraction of unemployed households at the end of a quarter. $\theta = \frac{v}{u_1+u_2}$ includes the measure of households that immediately found jobs (u_2), hence the low volatility as that mass is quite large and very stable.

F Business Cycle Moments

Table 21 displays the business cycle moments for the main model in the text versus the data. The table makes the shortcomings of the model quite clear: the model is unresponsive to productivity shocks (Shimer [2005] and more recently Chodorow-Reich and Karabarbounis [2013]). Why does the Hagedorn and Manovskii [2008] calibration not work in this context? They noticed that the flow utility from non-employment must be large enough to make workers nearly indifferent between working and not working: workers then become sensitive to small movement in productivity and wages. It is impossible to make every type of worker indifferent between working and not working with significant heterogeneity and a constant unemployment benefit or flow utility of leisure. The only paper to our knowledge to address this issue is Lise and Robin [2013] who make the flow utility of non-employment a function of the workers type, the workers type squared, the aggregate state, and interactions between the workers type and the aggregate state.

G Calculating Model Elasticities

In this section, we use the model generated policy functions to estimate the duration and replacement earnings elasticities with respect to credit access.[43] Since the debt pricing schedule does not have an explicit credit limit, we define the credit limit to be the maximum of either the level of debt where the bond interest rate first exceeds 30% per quarter (denote this level of debt $b_{30}(\cdot)$) or the exogenous debt limit $\underline{b}$.[44] Therefore, we define the credit limit for an agent with state vector $\mathbf{x}$ as $L(\mathbf{x}) = \min\{-b_{30}(\mathbf{x}), -\underline{b}\}$. We isolate newly laid off agents (let I_δ denote this set of agents, and let N_δ denote its cardinality), and then we compute each agent's optimal search decision under loose ($\underline{b} = \underline{b}_L$) and tight exogenous debt limits ($\underline{b} = \underline{b}_H > \underline{b}_L$), ceteris paribus. What makes this calculation feasible is that the policy function of each agent is contingent on the realization of Ω which includes the exogenous debt limit $\underline{b}$. So at each decision node, encoded in this policy function is the search decision of the agent if debt limits tighten as well as if debt limits remain slack. What makes this experimental design valid is the block recursive nature of the model; the menu of job choices faced by the household is not a function of $\underline{b}$. This allows us to determine the impact of changing debt limits, holding all else constant, including the set of jobs from which households can choose.[45]

We compute the change in unemployment duration, weighted by the distribution of job

[43] We calculate the duration and replacement elasticities using 30,000 agents simulated for 270 periods (burning the first 100 periods), while holding the aggregate state fixed at $y = 1$, and defining $\underline{b}_H$=-.1 and $\underline{b}_L$=-.5. Agents hold the same rational beliefs over the transition rate $P_{\underline{b}}$ between $\underline{b}_H$ and $\underline{b}_L$ as Section 7.

[44] Only .03% of the agents in the model will ever borrow at real quarterly rates above 30%. The results are robust to alternate definitions of this effective debt limit.

[45] The intuition is simple and is formally shown in the existence proof. $J_T(h, k; y) = f(y, h, k)$ does not depend on $\underline{b}$, and working back, neither does $J_t(h, k; y)$ for arbitrary t. Therefore, using the free entry condition, $\theta_t(h, k; y)$, which pins down the menu of operating submarkets, will not either.

losers after moving from an exogenous limit $\underline{b} = \underline{b}_L$ to $\underline{b} = \underline{b}_H$ as follows,[46]

$$\Delta Dur_t = \sum_{i \in I_\delta} \frac{Dur(b_{i,t}, h_{i,t}, k_{i,t}; y_t, \underline{b}_H) - Dur(b_{i,t}, h_{i,t}, k_{i,t}; y_t, \underline{b}_L)}{N_\delta}$$

Define $\frac{\Delta(L_t+b_t)}{Y_{t-1}}$ as the change in the unused credit to income ratio that the agent faces if the exogenous debt limit is tightened.[47] The model implied duration elasticity is therefore given by,

$$\epsilon_{dur} = \frac{\Delta Dur_t}{\left(\frac{\Delta(L_t+b_t)}{Y_{t-1}}\right)} = 0.608$$

In other words, if unused credit to income increased by 10%, then agents would take .72 weeks longer to find a job. This falls in the mid-range of our IV estimates. However, the elasticity calculated in the model is a 'global' elasticity and is conceptually different from the local average treatment effect identified by the IV.

Next, we calculate the elasticity of replacement earnings with respect to credit, including households who do not find a job and thus have a replacement rate of zero. Let $e_i \in \{W, U\}$ denote employment status and $\mathbb{I}$ be the indicator function. Then define $R_t(\underline{b})$ as the earnings replacement rate, $R_t(\underline{b}) = \frac{1}{N_\delta} \sum_{i \in I_\delta} \frac{\mathbb{I}(e_i=W)*4\alpha f(y_t, h_{i,t}, k^*(b_{i,t}, h_{i,t}, k_{i,t}; y_t, \underline{b})) + 0*(\mathbb{I}(e_i=U))}{4\alpha f(y_{i,t-1}, h_{i,t-1}, k_{i,t-1})}$ The model implied replacement earnings elasticity is therefore given by,

$$\epsilon_{Rep} = \frac{R_t(\underline{b}_H) - R_t(\underline{b}_L)}{\left(\frac{\Delta(L+b)}{Y_{t-1}}\right)} = -.024$$

Similar to data replacement rate (inclusive of 0s) in Table 5, the model replacement rate (inclusive of 0s) produces a small, slightly negative, earnings replacement rate elasticity of -.024. To understand why this is the case, we can decompose earnings losses into two offsetting components: (i) access to additional credit depresses job finding rates which tends to lower replacement earnings, and (ii) access to additional credit increases the capital intensity of submarkets searched by agents which tends to raise replacement earnings. We can compute each of these components separately. Define the job finding rate for agents as $JF_t(\underline{b}) =$

[46] The expected duration is based on the 1-quarter ahead implied job finding rate, based on the search policy function. In quarters, for large M, the expected duration is given by, $Dur(b_t, h_t, k_t; y_t, \underline{b}_H) = \sum_{m=1}^{M} mp(\theta_t(h_t, k^*(b_t, h_t, k_t; y_t, \underline{b}_H); y, \underline{b}_H)) * (1 - p(\theta_t(h_t, k^*(b_t, h_t, k_t; y_t, \underline{b}_H); y_t, \underline{b}_H)))^{(m-1)}$.

[47] Let Y_{t-1} denote earnings prior to layoff. Define $\frac{\Delta(L_t+b_t)}{Y_{t-1}} = \frac{1}{N_\delta} \sum_{i \in I_\delta} \frac{(L(h_{i,t}, k_{i,t}; y_t, \underline{b}_H) + b_{i,t} * \mathbb{I}(b_{i,t} < 0)) - (L(h_{i,t}, k_{i,t}; y_t, \underline{b}_L) + b_{i,t} * \mathbb{I}(b_{i,t} < 0)))}{4\alpha f(y_{i,t-1}, h_{i,t-1}, k_{i,t-1})}$

$\frac{1}{N_\delta}\sum_{i\in I_\delta} p(\theta_t(h_{i,t}, k^*(b_{i,t}, h_{i,t}, k_{i,t}; y_t, \underline{b}); y_t, \underline{b}))$. Then the model implied job finding elasticity is given by,

$$\epsilon_{JF} = \frac{JF_t(\underline{b}_H) - JF_t(\underline{b}_L)}{\left(\frac{\Delta(L+b)}{Y_{t-1}}\right)} = -0.11$$

This implies that when debt limits expand by 10% of prior annual income, job finding rates fall by 1.1% as workers can better self-insure while searching more thoroughly for jobs. This tends to decrease the replacement earnings of agents, since unemployed workers have an earnings replacement rate of zero.

Turning to the second component of replacement earnings, define the capital intensity rate of submarkets in which agents search as $K_t(\underline{b}) = \frac{1}{N_\delta}\sum_{i\in I_\delta} k^*(b_{i,t}, h_{i,t}, k_{i,t}; y_t, \underline{b})d\mu$. Then the model implied capital intensity elasticity is given by,

$$\epsilon_K = \frac{K_t(\underline{b}_H) - K_t(\underline{b}_L)}{\left(\frac{\Delta(L+b)}{Y_{t-1}}\right)} = .27$$

In other words, being able to replace 10% more of prior income with credit allows agents in the model to search in submarkets with 2.7% greater intellectual or physical capital intensity. This tends to increase the replacement earnings of agents. The combination of the two effects, namely the negative influence of job finding rates and positive influence of capital intensity on replacement earnings, yields the near-zero replacement earnings elasticity observed in the model.

Next, we calculate the elasticity of replacement earnings with respect to credit among job finders. By isolating job finders, we implicitly drop zeros from the replacement rate calculation. Let $I_e(\underline{b})$ denote the set of job finders at the end of period t. Let $N_{\delta,e}$ denote the cardinality of $I_\delta \cap I_e(\underline{b})$, which is the set of laid off households who find a job at the end of period t. Define replacement earnings among this set of households as $R_{t,e}(\underline{b}) = \frac{1}{N_{\delta,e}}\sum_{i\in I_\delta \cap I_e(\underline{b}_L)} \frac{4\alpha f(y_t, h_{i,t}, k^*(b_{i,t}, h_{i,t}, k_{i,t}; y_t, \underline{b}))}{4\alpha f(y_{i,t-1}, h_{i,t-1}, k_{i,t-1})}$. Lastly, define $\frac{\Delta(L_{t,e}+b_{t,e})}{Y_{t-1,e}}$ to be the change in credit limits to income of those who find a job at the end of period t under borrowing limit $\underline{b}_L$.[48] The model implied replacement earnings elasticity, among the employed, is therefore given

[48] $\frac{\Delta(L_{t,e}+b_{t,e})}{Y_{t-1,e}} = \frac{1}{N_{\delta,e}}\sum_{i\in I_\delta \cap I_e(\underline{b}_L)} \frac{(L(h_{i,t}, k_{i,t}; y_t, \underline{b}_H) + b_{i,t} * \mathbb{I}(b_{i,t}<0)) - (L(h_{i,t}, k_{i,t}; y_t, \underline{b}_L) + b_{i,t} * \mathbb{I}(b_{i,t}<0)))}{4\alpha f(y_{i,t-1}, h_{i,t-1}, k_{i,t-1})}$. The results are insensitive to our choice of denominator, and are very similar using $\frac{\Delta(L_t+b_t)}{Y_{t-1}}$.

by,

$$\epsilon_{Rep,e} = \frac{R_{t,e}(\underline{b}_H) - R_{t,e}(\underline{b}_L)}{\left(\frac{\Delta(L_{t,e}+b_{t,e})}{Y_{t-1,e}}\right)} = .18$$

This implies that in the model, among job finders, being able to replace 10% more of prior income with credit results in a 1.8% greater earnings replacement rate, which falls toward the high end of our IV estimates. In summary, the model's self-insurance mechanism generates replacement rate elasticities (both inclusive and exclusive of 0s) as well as duration elasticities that are in line with our IV estimates.

G.1 Bankruptcy Flag Removal in Model v. Data

We further explore non-targeted moments in this section by comparing the response of duration and replacement rates to bankruptcy flag removal. We do so by isolating the set of newly laid off agents with prior bankruptcies in the model (i.e. agents in bad standing), I_b. Each of these agents' policy function includes their optimal search decision if their flag is removed and their optimal search decision if the flag is not removed (i.e. they remain in bad standing). Let $Dur_{no\ bk}$ denote the duration of agents if their flag is removed (where duration is computed based on their search decisions as in Section F), and let Dur_{bk} denote the duration of agents if their flag remains on their record. We then compute $\Delta Dur = Dur_{no\ bk} - Dur_{bk} = .066$, which implies that following bankruptcy flag removal, agents take about $\frac{3}{4}$ of a week longer to find, relative to the counterfactual of not having their flag removed. In Section 4 we showed that following flag removal, individuals in the data take 2 weeks longer to find a job relative to the control group of those whose flags are not removed.

If we do the same for replacement earnings, $\Delta Rep = Rep_{no\ bk} - Rep_{bk} = .007$. In Section 4 we showed that following flag removal, there is an insignificant impact on replacement earnings relative to the control group of those whose flags are not removed. We find a relatively small impact on replacement earnings in the model, implying a .7% increase in replacement earnings following flag removal. We cannot rule this effect out based on our empirical point estimates.

H Welfare

To compute the welfare implications of tighter debt limits (and the subsequent greater amounts of sorting), we measure what fraction of lifetime consumption a newly born agent would be willing to give up in order to live in a world with looser debt limits ($\underline{b} = -.5$) as opposed to living in a world with debt limits which are initially loose and then tighten in 2008 to $\underline{b} = -.1$. Let c_t, e_t, and D_t denote consumption, employment, and default decisions when the debt limit is loose from 1970 to 2012. Let c_t^b, e_t^b, and D_t^b denote consumption, employment, and default decisions when the debt limit is loose until 2008, after which it permanently tightens to $\underline{b} = -.1$. We compute the welfare gain as follows:

$$\Delta_W = \left[\frac{\sum_{t=0}^{\infty}\beta^t[\frac{(c_t^b)^{1-\sigma}}{1-\sigma} + \eta\mathbb{I}(e_t^b = U) - \chi D_t^b] - \sum_{t=0}^{\infty}\beta^t[\eta\mathbb{I}(e_t = U) - \chi D_t]}{\sum_{t=0}^{\infty}\beta^t[\frac{(c_t)^{1-\sigma}}{1-\sigma}]}\right]^{1/(1-\sigma)} - 1$$

For the cohort of agents 'born' (i.e. enter the workforce) between 1989 and 1994 and are of prime age during the crisis, we compute that this cohort of agents would be willing to give up .09% of lifetime consumption

I Alternate Measures of Sorting and Mismatch

In this appendix we describe three measures of 'sorting', broadly defined. The first comes from Lise and Robin [2013], which is to measure the distance from the optimal surplus maximizing match. Let $S_t^a(b,h,k;\Omega) = W_t^a(b,h,k;\Omega) + J_t(h,k;\Omega) - U_t^a(b,h,k;\Omega)$ denote surplus of worker h matched to firm k. Since the cost of capital is paid up-front, the surplus maximizing capital (in any match) is $\bar{k}$ (the upper bound on capital). The distance from the surplus maximizing match is therefore proportional to $D = \int_k \frac{\bar{k}-k}{\bar{k}}\mu_e(k)dk$ where $\mu_e(k)$ is the marginal distribution of employed workers across capital levels. We also compute measures of productivity dispersion including the coefficient of variation of capital per worker, $CV_k = \frac{\int_k k^2\mu_k dk - (\int_k k\mu_e(k))dk)^2}{\int_k k\mu_e(k)dk}$, and the coefficient of variation of labor productivity $CV_l = \frac{\int_k\int_h (h^a k^{a-1})^2\mu_e(k,h)\ dh\ dk - (\int_k\int_h h^a k^{a-1}\mu_e(k,h)\ dh\ dk)^2}{\int_k\int_h h^a k^{a-1}\mu_e(k,h)\ dh\ dk}$ where $\mu_e(k,h)$ is the joint pdf of employed individuals over capital and human capital. Figures 13 and 14 illustrate the sorting measures in the economy in which credit limits are constant during the recession and an economy in which credit limits tighten. There are two key points to take away from the figures, 1.

these measures of mismatch and productivity dispersion are countercyclical, similar to Lise and Robin [2013] (who also include both measures – surplus maximizing distance and labor productivity dispersion), and 2. these measure deteriorate even more when credit limits tighten, i.e. there truly is more mistmatch when limits tighten.

Figure 13: Recession Experiment: Alternate Measure of Sorting, Loose Limits $\underline{b} = -.5$

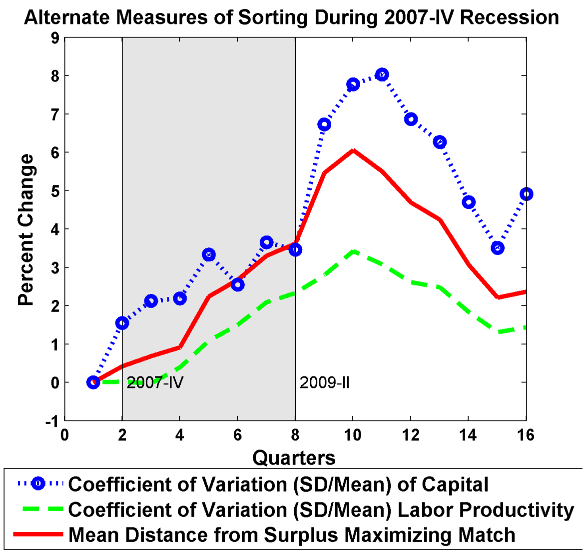
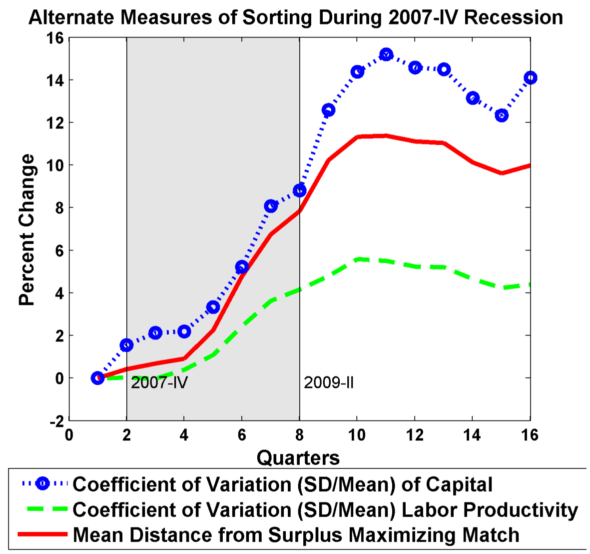


Figure 14: Recession Experiment: Alternate Measure of Sorting, Tight Limits $\underline{b} = -.1$ (Source: LEHD/TransUnion)



J Model Robustness: Capital Investment and Liquidation

J.1 Model with Firm Investment

Now assume that Firms can invest in capital, depending on the worker's type. The problem of an unemployed household is unchanged. The value functions for employed borrowers who default as well as the discrete default decision are formulated in an identical fashion to that of the unemployed, except workers must now forecast the investment decision of the firm.

Timing assumption: New capital is not operable immediately.

The Bellman equation for a household in bad standing is given below (good standing is extremely similar):

$$
\begin{aligned}
W_t^B(b,h,k;\Omega) = u(c,0) + &\lambda\beta\mathbb{E}\Big[(1-\delta)W_{t+1}(0,h',\mathbf{k'};\Omega') \\
&+\delta\Big\{\max_{\tilde{k}} p(\theta_{t+1}(h',\tilde{k};\Omega'))W_{t+1}(0,h',\tilde{k};\Omega') \\
&\qquad + \big(1-p(\theta_{t+1}(h',\tilde{k};\Omega'))\big)U_{t+1}(0,h',\mathbf{k};\Omega')\Big\}\Big] \\
&+(1-\lambda)\beta\mathbb{E}\Big[(1-\delta)W_{t+1}^B(0,h',\mathbf{k'};\Omega') \\
&+\delta\Big\{\max_{\tilde{k}} p(\theta_{t+1}(h',\tilde{k};\Omega'))W_{t+1}^B(0,h',\tilde{k};\Omega') \\
&\qquad + \big(1-p(\theta_{t+1}(h',\tilde{k};\Omega'))\big)U_{t+1}^B(0,h',\mathbf{k};\Omega')\Big\}\Big], \quad t \le T
\end{aligned}
$$

$$W_{T+1}^B(b,h,k;\Omega) = 0$$

Such that the aggregate laws of motion are given by equation (4), human capital evolves such that $h' = H(h,W)$ and the budget constraint is given by,

$$c \le \alpha f(y,h,k)$$

And, additionally

$$k' = k_t^{*'}(h,k;\Omega)$$

This final condition $k' = k_t^{*'}(h,k;\Omega)$ means that households have rational expectations over what the entrepreneurs' optimal investment decisions are.

J.2 Lenders

Lenders' bond prices are update to reflect changes in capital, since it may affect the wage of the worker and hence their repayment probability.

J.3 Entrepreneurs

We now allow entrepreneurs to invest in capital subject to an adjustment cost $\Gamma(k'-k)$. Therefore the value function for the firm is given by,

$$J_t(h,k;\Omega) = \max_{k'}(1-\alpha)f(y,h,k) - i - \Gamma(k'-k) - f_c + \beta\mathbb{E}\big[(1-\delta)J_{t+1}(h',k';\Omega')\big]$$

Subject to a unit investment cost (i.e. the MRT of output and capital is 1, excluding the adjustment cost),

$$i = k' - k$$

$$J_{T+1}(h,k;\Omega) = 0$$

In the results below, we choose a quadratic adjustment cost $\Gamma(x) = x^2$. We see that the presence of firm investment does not significantly alter the main set of results. Figure 15 illustrates employment with the quadratic adjustment cost, Figure 16 illustrates sorting (the correlation between human capital and capital), Figure 17 illustrates firm capital, and Figure 18 illustrates labor productivity. Figure 17 shows that firm capital recovers much faster as firms invest in more capital per worker as productivity recovers and human capital grows.

Figure 15: Allowing for Capital Investment: Employment

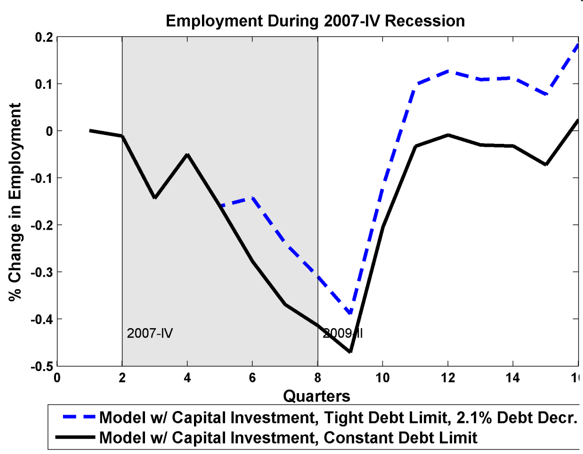


Figure 16: Allowing for Capital Investment: Corr. B/w Human Capital (h) and Firm Capital (k)

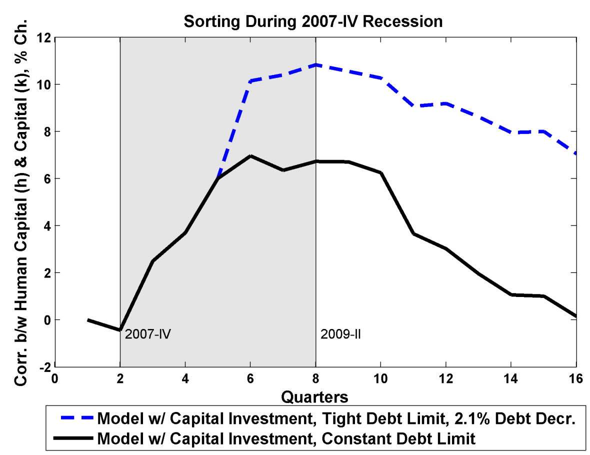


Figure 17: Allowing for Capital Investment: Agg. Firm Capital, 2007-2009 Recession

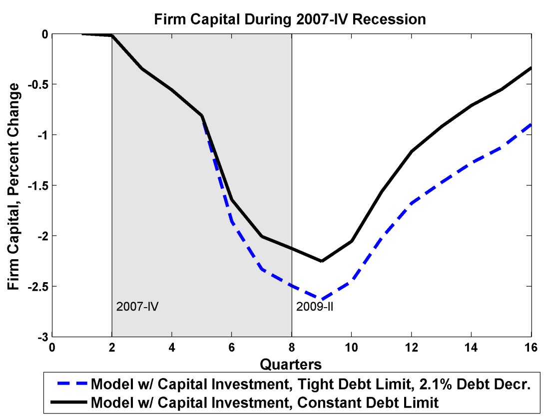
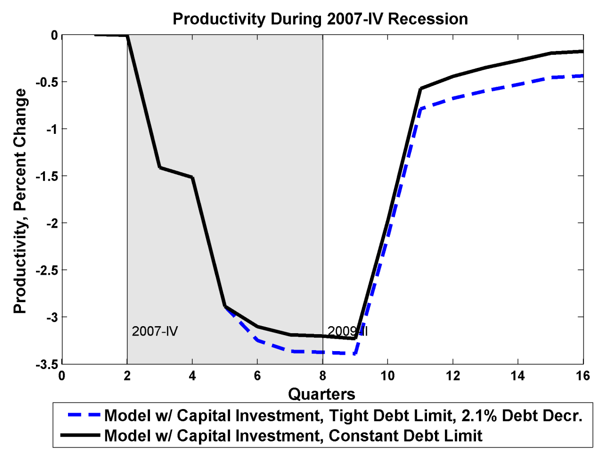


Figure 18: Allowing for Capital Investment: Labor Productivity, 2007-2009 Recession



J.4 Liquidation

We also allow for the baseline model to have a liquidation value of capital, χ_f. The continuation value of the firm becomes,

$$J_t(h, k; \Omega) = (1 - \alpha) f(y, h, k) - f_c + \beta \mathbb{E}\big[(1 - \delta) J_{t+1}(h', k; \Omega') + \delta \chi_f k\big]$$

In the results below, we choose $\chi_f = .25$ which is relatively low, but it allows us to preserve the calibration, approximately. For larger values of χ_f, the same aggregate patterns emerge, except we must significantly expand the capital grid to a point that it becomes computationally infeasible. Figures 19 and 20 illustrate the model's main results with liquidation values. Employment rises while productivity falls in both cases, which is the same pattern that emerged when tighter debt limits were imposed in an economy with no liquidation value.

Figure 19: Liquidation Value Experiment: Employment, 2007-2009 Recession

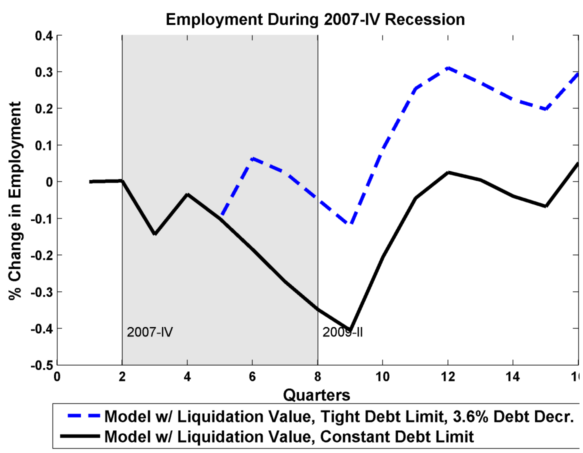
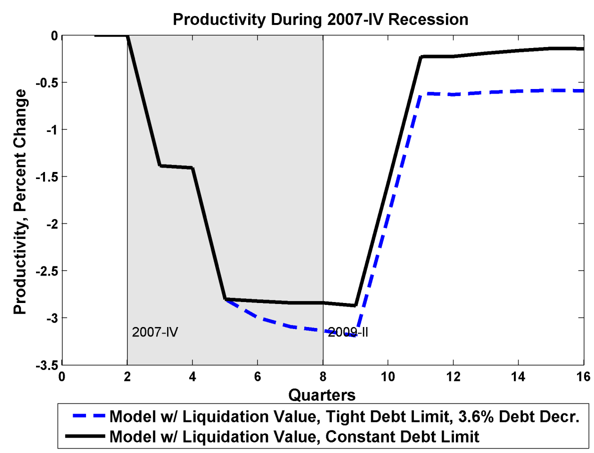


Figure 20: Liquidation Value Experiment: Labor Productivity, 2007-2009 Recession



K Solution Algorithm

We solve the model using value function iteration on a discrete grid. Capital lies between [0.025,1] with 40 evenly spaced grid points including the ends of the grid. Bonds lie on the grid [-.5,1.5] with 81 evenly spaced grid points. The human capital grid is 6 evenly spaced grid points including the end of the grid over [.5,1]. The aggregate shock is discretized with 4 states using Rouwenhorst's method. The aggregate bond limit is discretized with 2 possible values $\underline{b} \in \{-.5, -.1\}$.

Starting at $t = T$ and working backwards, the solution method is given below:

i. Recover $J_t(h, k; \Omega)$ using value function iteration.

ii. Recover $\theta_t(h, k; \Omega)$, the market tightness, by free entry, $\theta_t(h, k; \Omega) = p_f^{-1}\left(\frac{\kappa+(1+r_f)k}{J_t(h,k;\Omega)}\right)$

iii. Solve the household default decision to recover $D_{e,t}(b, h, k; \Omega)$.

iv. Solve the household maximization problem over the grid of k's to recover $k_t(b, h, k; \Omega)$ using the market tightness and the implied job finding rates in step ii.

v. Use realized search behavior and default outcomes to recover the bond price $q_{e,t}(b, h, k; \Omega)$ (in the last period of life, this is simply zero).

vi. Solve the household maximization problem over the grid of b's to recover $b'_{e,t}(b, h, k; \Omega)$, taking the bond price from step v as given.

vii. Repeat i to vi until t=1.

viii. Fix the aggregate shock path for all simulations (in the main experiment we feed in actual TFP realizations approximated on the grid). Use policy functions from the household problem to simulate 30,000 households for 270 periods, 10 times, burning the first 100 periods. We report averages over the 10 simulations.