Consumer Credit, Unemployment, and Aggregate Labor Market Dynamics*

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Abstract

This paper studies the relationship between unemployment and consumer credit, at the micro and macro-level. Using micro-level data, I identify a negative effect of job loss on households' use-of and access-to consumer credit. Job losers increase applications for credit, get denied more frequently, and experience significant reductions in debt outstanding and monthly charges. I extend the canonical Mortensen and Pissarides (1994) model of unemployment to include liquidity shocks and financial frictions. The model features strategic complementarities between unemployment, consumer credit and aggregate demand. I calibrate the model to match micro-evidence on unemployment and credit and quantify its impact on macroeconomic variables.

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1 Introduction

Between the late 1970s and 2007, the U.S. experienced a rapid increase in households' use of debt to finance consumption. At its peak, borrowing on consumer credit accounted for nearly twenty percent of personal consumption expenditures.[1] This trend was abruptly reversed during the 2007-2009 Great Recession, which featured a large contraction in the consumer credit market, coinciding with a dramatic decline in consumption spending and historically high unemployment.[2] A growing body of research suggests that consumer debt is an important channel through which shocks to households get amplified leading to large and persistent responses in consumption. Empirically, this literature finds considerable cross-sectional evidence that regions of the U.S. that had the largest declines in household borrowing during the Great Recession also experienced the largest declines in consumption and employment (e.g. Mian and Sufi, 2010, Midrigan and Philippon, 2011, Mian *et al.*, 2013, Mian and Sufi, 2014). Recent theoretical work has examined the role of shocks to aggregate credit and liquidity constraints as a mechanism that prevents households from smoothing consumption.[3]

In this paper, I empirically and theoretically examine the effects of credit constraints for a salient group during downturns, job losers. Credit constraints are likely to be relevant for this group as unemployed households experience declines in income and likely have high marginal propensities to consume. Additionally, employment status and income are key criteria used by lenders in evaluating the credit-worthiness of borrowers (Crossley and Low, 2013). First, using household-level data from the 2007-2009 panel of the Survey of Consumer Finances (SCF), I find a *negative* effect of entering job loss on a household's use of and access to consumer credit. I find that upon job loss, households increase demand for credit as

[1] Source: Federal Reserve Board's Consumer Credit G.19 Release and NIPA Table 2.1. Consumer credit is mostly comprised of credit cards, auto loans and student debt.

[2] The fall in consumption during the Great Recession has been extensively documented in the literature. For instance, see de Nardi *et al.* (2012) and Petev and Pistaferri (2012).

[3] These include Midrigan and Philippon (2011), Hall (2011), Guerrieri and Lorenzoni (2011), among others. Additionally, there is considerable evidence that households are credit or liquidity constrained. Early work by Zeldes (1989) finds that households in the Panel Study of Income Dynamics with low liquid assets are indeed those households in which the test of the permanent income hypothesis fails. Others include Jappelli *et al.* (1998), Japelli (1990), Gross and Souleles (2002), and Agarwal *et al.* (2007). See Jappelli and Pistaferri (2010) for a review of this literature.

measured by the number of applications, get denied more frequently conditional on applying, and experience significant reductions in both debt outstanding and average monthly charges compared to households that maintained employment between 2007 and 2009. This effect is particularly pronounced for borrowing on credit cards. While I cannot directly observe if the decline in credit for these households translated into a fall in consumption, I do find that there is a significant positive effect of job loss on the likelihood of having zero liquid assets, which suggests that these households are limited in replacing their lost income by dis-saving.[4]

I interpret the effect of the fall in consumer borrowing as a tightening of credit constraints for job losers and examine if this micro-level relationship can help explain the aggregate co-movement of consumer credit, employment and consumption over the business cycle. To do so, I develop a model that features frictional unemployment in the style of Mortensen and Pissarides (1994), hereafter MP, a frictional goods market in the style of Petrosky-Nadeau and Wasmer (2013), and household's need for liqudity as random shocks to preferences in the style of Diamond (1990) or Shi (1996).[5] Households rely on unsecured credit to finance a fraction of consumption needs within the period, however since they lack commitment the extent of borrowing depends on the ability of lenders to enforce debt contracts. I assume enforcement constraints are a function of both aggregate credit market conditions, similar to those used in the literature on firm financial constraints (i.e. Jermann and Quadrini, 2012 and Monacelli *et al.*, 2011), as well as idiosyncratic household income. Similar to MP, a worker that enters into unemployment experiences a fall in their income. This fall causes the enforcement constraint to become tighter which in turn may lead to a fall in borrowing.

The model features an aggregate demand channel that links household credit and unemployment. Firm revenues depend on the extent to which households are credit constrained; a fall in borrowing in the event of a job loss decreases the demand for the output of a labor match. This in turn reduces the incentive for firms

[4]I use a broad measure of liquid assets and consider balances in checking, savings, and CD accounts as well as any treasury bills. See Section 2.

[5]Liquidity needs modeled as random shocks to utility have been used extensively in the literature on bank runs (e.g. Diamond and Dybvig, 1983), money (e.g. Lagos and Wright, 2005), asset market dyanmics (e.g. Rocheteau and Wright, 2013), and over-the-counter financial markets (e.g. Duffie *et al.*, 2005).

to post vacancies and create jobs which leads to an increase in unemployment.[6] Since job losers face tighter credit constraints, the increase in unemployment reduces aggregate demand further. Hence, if household credit constraints are related to employment status and income, there exists a strategic complementarity between aggregate unemployment and aggregate consumer credit.

The model is calibrated to match the micro-level relationship between credit and job-loss during the Great Recession in order to quantify the importance of this channel in amplifying the response of macroeconomic variables to productivity and aggregate financial shocks. In order to discipline the extent of household financial shocks, I use an approach outlined by Jermann and Quadrini (2012) with regards to firm credit. Using data on consumer credit and household income from the Flow of Funds, I construct a time series for household financial shocks using the model's enforcement constraint under the assumption that it is always binding. This methodology is analogous to the standard approach of identifying productivity shocks using Solow residuals from the production function. I compare the response of unemployment and other labor market variables in the model to shocks to labor productivity and financial conditions. As first pointed out in Shimer (2005), and more recently in Hall (2014), productivity shocks in the context of the MP model do a poor job of generating sufficient movement in labor market variables. Similarly, I find that the credit effect of unemployment does not improve the performance of the model in this dimension. However, I do find that aggregate financial shocks contribute significantly to the observed dynamics of the labor market. Consumer financial episodes are particularly pronounced in recessions of the 1980s and 1990s, but surprisingly less so in the Great Recession.

This paper is closely related to the literature on financial frictions and unemployment. Wasmer and Weil (2004), Monacelli *et al.* (2011), Petrosky-Nadeau and Wasmer (2013), and Petrosky-Nadeau (2014) consider how financial frictions facing firms affects hiring and unemployment in the context of the MP framework. I differ in that my focus is on credit to households and financial frictions arise as a consequence of limited commitment and enforcement constraints, whereas in

[6]The model shares this feature with other paper that feature frictional goods markets, such as Berensten *et al.* (2011), Petrosky-Nadeau and Wasmer (2013), Bethune *et al.* (2015), and Kaplan and Menzio (2016).

these papers financial frictions are in the form of search frictions. On the household side, recent empirical and theoretical work (including Mian and Sufi (2010), Keys (2010), Mian *et al.* (2013), Hsu *et al.* (2014), Haltenhof *et al.* (2014), Gropp *et al.* (2014), Athreya *et al.* (18), Mian and Sufi (2014), among others) stresses the importance of the household debt channel in accounting for movements in the labor market, particularly during the Great Recession. This paper is the first to connect how credit constraints depend on an individual's job status and show that these constraints have implications on the labor market during business cycles.[7] Bethune *et al.* (2015) model household credit according to self-enforcing debt limits, as in Kehoe and Levine (1993), as opposed to enforcement constraints. A key implication of the theory is that credit availability is homogeneous across employment status and income levels. In this paper, heterogeneity in credit access is the key to generating amplification. Additionally, Bethune *et al.* (2015) focus on the low-frequency relationship between revolving consumer credit and unemployment while this paper is interested in the business cycle relationship. The mechanism in this paper is closely related to that in Kaplan and Menzio (2016) who show that heterogeneity in demand between the employed and unemployed, caused by differences in income and search intensity, can create strategic complementarities between entry and unemployment. Instead, this paper focuses on the credit effects of job loss on generating heterogeneity in demand. Further, in the quantitative section I find no evidence of multiple equilibria and so the focus is on amplification of exogenous shocks.

In terms of empirical evidence of credit constraints among the unemployed, this paper is closest to work by Sullivan (2008) and Crossley and Low (2013). Sullivan (2008) finds that low-asset households, or those in the bottom decile of the asset distribution, do not borrow from unsecured credit markets in response to job loss.[8]

[7]Additionally there is a growing literature that shows that job loss is associated with long-term earnings losses and consumption declines (e.g. Jacobson *et al.*, 1993, Farber, 2005, Stephens, 2001, Browning and Crossley, 2008, Davis and von Wachter, 2011, and Ganong and Noel (2016)). Krebs (2007) illustrates that cyclical variation in long-term earnings losses can lead to large welfare costs of business cycles. This paper differs in that, in the context of the MP model without credit frictions, a job loss is a temporary shock to earnings. I show that in the presence of credit constraints, these temporary losses lead to consumption declines as well as further increases in the severity of the credit constraint.

[8]Sullivan (2008) finds that households in the second and third deciles do replace lost income,

Using Canadian data, Crossley and Low (2013) find that a quarter of recent job losers could not borrow to increase consumption. I further this work by showing similar patterns for the U.S. as well as by quantifying the aggregate effects of the credit-unemployment channel. Using the Panel Study of Income Dynamics, Saporta-Eksten (2014) finds that consumption declines by 8% upon job loss and does not recover even 6 years after. Ganong and Noel (2016) find a similar effect using bank account data that job loss is associated with a 6% decline in consumption. Finally, this paper is complementary to work by Herkenhoff (2013) and Herkenhoff *et al.* (2016) that considers the impact of consumer credit access on search decisions and outcomes. The current paper differs in that I consider the reverse, the impact of unemployment on consumer credit access. I show that an income shock, in the form of a job loss, is also a significant, negative credit shock which, in the aggregate, also leads amplified business cycles.

This paper proceeds as follows. Section 2 analyzes the relationship between consumer credit use and unemployment both in the aggregate and at the micro-level. Section 3 outlines the model. Section 4 discuses the calibration, which includes identifying household financial shocks and shows the results of the quantitative experiments. Finally, Section 5 concludes.

2 Evidence on Unemployment and Consumer Credit

This section presents evidence on the relationship between consumer credit and unemployment at the household level. I use data from the Federal Reserve Board's Survey of Consumer Finances (SCF). The SCF is the preeminent data source used to study household finances in the United States. Regarding consumer credit, it contains detailed information about levels of debt outstanding, credit limits, whether a household applied for credit, and whether they were denied. While the SCF is typically a triennial cross-sectional survey, respondents from the 2007 survey were re-interviewed in 2009, creating a two-period panel data set which allows me to observe changes in both employment and credit at a household level.

however they only do so by 11.5 to 13.4 percent.

Sample Selection and Experimental Design In order to examine how unemployment affects a household's access to credit I use a difference-in-difference approach to compare changes in credit for households that entered into unemployment over the 2007 to 2009 period versus those that remained employed. This time period corresponds to the largest recession in the U.S. since the Great Depression. The aggregate unemployment rate increased from 4.6% to 9.3%. The rate of monthly job layoffs increased from 1.3% of total employment to 1.7%. This equates to an additional five-hundred-thousand jobs lost per month due to involuntary reasons.[9] The timing of the survey allows me to examine both the effect of the Great Recession on all households' credit access and use as well as the differential effect from entering into unemployment.

The SCF contains observations at a household level. Since the goal of the experiment is to identify the effect of a change in an *individual's* labor market state, in the baseline sample I only examine single households defined as those that reported not having a spouse or partner as well as not sharing finances with any other person.[10] Additionally, I only consider households that stayed single throughout the survey. This sampling procedure is one way to control for changes in family structure, such as member earnings, and also allows classifying observations into employment states easier.[11]

I use a broad definition of employment and classify households as employed if they reported that they were either currently working, accepted a job and waiting to start, or were on sabbatical or extended leave and expected to go back to work.[12] My treatment group consists of households that were employed at the 2007 survey date but reported being unemployed at the 2009 survey date. I compare this group to

[9]Data from the Job Openings and Labor Turnover Survey (JOLTS). JOLTS defines layoffs and discharges as separations initiated by the employer. These include layoffs with no intent to rehire, formal layoffs lasting or expected to last more than 7 days, discharges resulting from mergers, downsizing or closings, firings or other discharges for cause, terminations of permanent or short-term employees, and terminations of seasonal employees.

[10]The SCF defines a household as a primary economic unit (PEU). The PEU is defined as the core individual or core couple in a household plus any minor children or other financially interdependent individuals with the core individual or couple. See Bricker *et al.* (2011) for more details on the design of the 2007-2009 panel survey.

[11]As a robustness check I also consider a sample that includes heads of household and control for family size. Results are available in the Supplementary Appendix.

[12]The survey question asked households about their job status at the date of the interview.

those households that reported being employed in both the 2007 and 2009 surveys and also reported not having any unemployment spell in the year previous to the 2009 survey date. This limits the potential for respondents that were unemployed between 2007 and 2009, but found work close to the 2009 survey date.[13] Finally, I restrict the analysis to households in which the head is between 20 and 70 years of age. This results in a sample of 3,820 households.

Consumer Credit and Household Labor, 2007-2009 First, in Table 1, I describe the change in credit and labor market variables for the sample as a whole during the initial two years of the Great Recession. The mean of the variables of interest are reported for 2007 and 2009 in columns (1) and (2), respectively. Column (3) reports the difference in means between the two time periods. In regard to certain variables, the experiences of the sample between 2007 and 2009 coincide with the patterns observed in aggregate data. For instance, I find significant reductions in several measures of credit card use. The fraction of households with at least one credit card fell by 4.3 percentage points, average monthly charges on credit cards fell by \$53, and the average debt limit fell by \$1,240. Average credit card debt outstanding also fell by \$212, though not statistically significant. Surprisingly, opposed to the behavior in the aggregate, automotive loans increased for the sample between 2007 and 2009.

It is difficult to conclude from the evidence in Table 1 if household credit was systematically more difficult to obtain in 2009 compared to 2007 or if households simply decreased their demand for debt. Perhaps the cleanest measure the SCF provides that helps differentiate the two channels is by directly asking respondents (i) if they applied for any credit in the two years previous to the survey and (ii) given they applied for credit, if they were denied. On average, households both applied for less credit and got denied more frequently during the Great Recession. The fraction of households applying for credit fell from 63% to 43%. While we still can not be sure how much of the fall in the rate of credit applications is driven by

[13]The SCF only asks respondents if they experienced any unemployment spell in the previous 12 months. It is possible that I classify some households as having not entered unemployment but that experienced an unemployment spell between the two survey dates but longer than a year before the last survey date. I drop all households that were employed in 2009, but reported having an unemployment spell in the previous year.

demand, given that a household might withhold applying for credit if they think they will be denied, we can conclude that those households that wanted credit experienced a fall in their access to it. Conditional on applying for credit, the likelihood of being denied increased from 19% to 25%.[14]

The final two rows of Table 1 show that households' total income was decreasing, as well as average weekly hours. During a time when income and hours of work are falling, a consumption smoothing motive would suggest that borrowing should increase. However, this is the opposite of what we see in the Great Recession, as consumer debt declined. In the next section, I ask if the large increase in the number of unemployed households can provide any clarification of the trends we observe in Table 1.

The Effect of Unemployment on Household Credit, Assets, and Income This section illustrates the difference in credit, asset, and labor market outcomes for households that entered into unemployment during the initial two years of the Great Recession versus those that did not. To do so, I estimate the following difference-in-difference model:

$$y_{it} = \beta_0 + \beta_1 \mathrm{EU}_i + \beta_2 \mathbb{I}\{t = 2009\} + \beta_3 \mathrm{EU}_i \times \mathbb{I}\{t = 2009\} + \beta_4 \mathbf{X}_{it} + \epsilon_{it} \qquad (1)$$

The variable EU_i indicates if the household entered into unemployment between 2007 and 2009. The variable $\mathbb{I}\{t = 2009\}$ is a dummy for the year 2009. The vector $\mathbf{X}_{it}$ includes observable household characteristics such as age, education, race and sex. The coefficient of interest is β_3. It identifies the effect of unemployment on changes in the variable of interest.

The identification relies on the parallel-trends assumption, or that without entering into unemployment, the changes in outcomes for the treatment group would coincide with that for the control group. I argue that the parallel-trends assumption is likely to be valid for two reasons. First, I show in Table 2 the results of a balancing test which suggests the two groups have similar observable characteristics and pre-treatment outcomes. Individuals in the sample who lost their jobs

[14] I classify a household as having been denied credit if they reported ever being denied a credit application *and* if they never received that loan upon future applications.

between 2007 and 2009 are no more likely to be male or black, and are weakly more educated than those who maintained employment. Additionally, there is no evidence that either debt outstanding or the incidence of credit use differed between the two groups in 2007. Labor income is also comparable, around $28,000. The notable difference is that those in the treatment group are younger, with an average age of 43 compared to 48 for the control group. This age gap partially explains the differences in total household income, weekly hours worked, and credit card debt limits as younger workers tend to have less non-labor income, work longer hours and have lower credit card limits.[15] Secondly, the time period under consideration consisted of a large, exogenous aggregate increase in an individuals' likelihood of being unemployed. The rate of monthly job layoffs increased from 1.3% to 1.7%, or around five-hundred-thousand jobs lost each month for involuntary reasons. This implies that any unobserved characteristics that are correlated with both credit and labor risk are mitigated.[16]

Tables 3 through 6 report the estimated coefficient of interest, $\hat{\beta}_3$, for different outcome variables. Table 3 shows the results for consumer credit variables. There is a strong negative unemployment effect for changes in total consumer debt outstanding. For households that lost their job, credit fell by $2,809. This represents a fall of 60% of debt, on average. This decline is dominated by a fall in credit card debt which decreased by $2,504 more for the treatment group. Table 4 further illustrates the effect of unemployment on credit cards. There is a consistent negative unemployment effect for both the likelihood of having a credit card and the likelihood of using it in a given month. Further, average monthly charges on credit cards fell by $250 more for households that entered into unemployment. These effects are in addition to the evidence that credit use was falling for all households during this time period. There was no significant unemployment effect on the amount of debt outstanding on automotive loans.

[15]One might worry that younger borrowers have higher credit risk as they are the least experienced financially and so would have greater changes in credit constraints during the Great Recession. However, Debbaut *et al.* (2013) show that young borrowers are among the *least likely* to experience a serious credit card default.

[16]The public version of the SCF data does not include information such as geography or the characteristics of the employer. As a result, it is difficult to use common approaches to instrument for job loss, such as mass layoffs or Bartik-type instruments.

Table 5 shows that not only was there a significant negative unemployment effect on the use of consumer credit debt, but that these decreases cannot be explained by a fall in demand. I find that there was a positive unemployment effect on the demand for credit. Households who lost their jobs increased their rate of credit applications by 14% relative to those that maintained employment. However, we see that the rate at which households were being denied for credit, conditional on applying, increased significantly more for the unemployed. Consumer credit became more difficult to acquire, precisely for the group that should value it the most.

I further test for the possibility of a selection effect driving the rate of credit denials by examining the reason given to the borrower in the event they were denied credit. If we believe the reduction in credit was based on characteristics other than a change in employment status, for instance negative credit history, and if the probability of a household being in the treatment group is correlated with these characteristics, then I could be potentially identifying the selection of households into this group. Columns (3) and (4) of Table 5 show the rate of credit denials for what I term 'credit-related' reasons, including having a low credit score and having a history of bankruptcy, and 'income/employment-related' reasons, which include lacking a job or insufficient income.[17] The rate of denials for credit related reasons showed no differential response for the treatment group. However, there is a positive unemployment effect on the rate of denials for income or employment related reasons. This result, combined with the fact that there are were no differences in any pre-treatment credit denial outcomes, suggests that households who lost their jobs in the Great Recession decreased their credit use as a direct result of facing higher constraints and the primary reason for the increased constraints was (un)employment related.

Finally, Table 6 reports the effect of unemployment on income and assets. First, households who lost their jobs were not able to smooth their income using forms other than labor. Total income for these households fell by $20,000 more than for the control group.[18] This decline was only partially offset by an increase unemployment

[17] See Appendix 6.5 for further details.

[18] Total income includes wages and salaries, income from sole proprietorships, and interest and dividend income.

benefits of $1,188. Secondly, there is consistent evidence that these households were dis-saving as a result of losing their job. Total liquid assets, measured as all balances in checking, savings, and CD accounts as well as any treasury bills, fell by $5,292 for the unemployed, around half of the 2007 average. Additionally, the unemployment effect explains the entire increase in the fraction of households that were liquidity constrained. I consider a strong measure of liquidity constraints as those households reporting having zero liquid assets at the time of the survey.[19] Consistent with the evidence in Kaplan *et al.* (2014), there is a considerable amount of hand-to-mouth households in the sample. In 2007, 13% of the control group had no liquid wealth and the difference for the treatment group was not significant. During the Great Recession the fraction of all households that had no liquid wealth doubled to 26%, which is entirely explained by those households in the sample that lost their jobs.

3 Model of Unemployment and Consumer Credit

In this section, I present a model of consumer credit and unemployment. Firms and workers meet in a decentralized labor market with search and matching frictions in the style of Mortensen and Pissarides (1994). These firm-worker pairs then sell a fraction of their output in a decentralized goods market with search frictions similar to Diamond (1990). I follow Diamond (1990) in assuming that trades in the decentralized goods market occur with pairwise credit. The key friction in the model is that households lack commitment to repay debt. The amount of borrowing depends on the ability of lenders to enforce debt contracts. I assume enforcement constraints are a function of both aggregate credit market conditions, similar to those used in the literature on firm financial constraints (i.e. Jermann and Quadrini, 2012 and Monacelli *et al.*, 2011), as well as idiosyncratic income. Similar to Mortensen and Pissarides (1994), a worker that enters into unemployment experiences a decrease in their income. This decrease causes the enforcement constraint to become tighter which leads to a fall in borrowing.

[19] Holdings of currency is not reported in the SCF. However, the 2010 Survey of Consumer Payment Choice from the Federal Reserve Bank of Boston, suggests that the average amount of cash holdings is $340 and the median is $70. See Foster *et al.* (2013).

In the model, firm revenues depend on the extent to which households are credit constrained. A fall in borrowing in the event of a job loss, decreases demand for the output of a labor match. In equilibrium, this causes a lower number of firms to post vacancies and an increase in unemployment. Household credit constraints generate strategic complementarities, which if strong enough will lead to multiple equilibria as in Kaplan and Menzio (2016) or Bethune *et al.* (2015).

3.1 Environment

The model is in discrete time that continues forever. There exists a measure one of households and a large measure of firms. Each period is divided into three stages. In the first stage, households and firms trade indivisible labor services in a labor market (LM). In the second stage, they trade consumption goods with credit in a decentralized market (DM) with search frictions. Finally, in the last stage, wages are paid, debts are settled and trade occurs in a frictionless, competitive market (CM). The consumption good in the CM is treated as the numeraire.

Each household is endowed with one indivisible unit of labor and has expected, lifetime discounted utility of

$$\mathbb{E}\sum_{t=0}^{\infty}\beta^{t}\left[\ell(1-e_{t})+v(y_{t})+c_{t}\right], \tag{2}$$

where β is the period discount factor, $y_t \in \mathbb{R}^+$ is consumption in the DM, $c_t \in \mathbb{R}$ is consumption in the CM, $e_t \in \{0,1\}$ is time devoted to working and $\ell \in \mathbb{R}$ can be interpreted as a utility flow from leisure or home production. The utility function in the DM, $v(y)$, is twice continuously differentiated, strictly increasing, and concave. Further, v is assumed to satisfy $v'(0) = \infty$ and $v(0) = 0$.[20] Households earn wages, w_t, if employed ($e_t = 1$) and non-labor income, b_t, if unemployed ($e_t = 0$), both in units of the numeraire.

A firm is composed of one job and posses a technology to transform one unit of labor into $\bar{z}_t \in \mathbb{R}^+$ units of intermediate good in the LM. Production occurs at the end of the LM, after matching takes place. Intermediate goods can be costlessly

[20]The first assumption is sufficient to guarantee an interior solution to the bargaining problem in the DM. The second assumption is a normalization and helps simplify algebra.

transformed into $y_t \in [0, \bar{z}_t]$ units of the DM good (determined endogenously) and $\bar{z}_t - y_t$ units of the CM good.[21] In order to hire in the LM in period t, a firm must post a vacancy at cost $k > 0$, in units of the numeraire in period $t-1$.

The LM follows Mortensen and Pissarides (1994) in which households and firms match bilaterally to trade labor services. Let the measure of matches between s_t searching workers and o_t job openings be given by $m(s_t, o_t)$. I assume that the measure of job seekers in period t is equal to the measure of unemployed households at the end of period $t-1$, $s_t = u_{t-1}$. The matching function, $m(s, o)$, has constant returns to scale and is strictly increasing and strictly concave in both of its arguments. Moreover, $m(0, o) = m(s, 0) = 0$ and $m(s, o) < \min\{s, o\}$. Given these assumptions, a worker's job finding probability is defined as $m(s_t, o_t)/s_t = m(1, \theta_t) \equiv p(\theta_t)$, where $\theta_t = s_t/o_t$ is labor market tightness. Similarly, the job filling probability for firms is given by $m(s_t, o_t)/o_t = m(1/\theta_t, 1) \equiv f(\theta_t)$. Matches formed in the LM are exogenously destroyed at rate δ at the end of the CM.

The DM has a similar structure to the LM. A measure $n_t = 1 - u_t$ of retailers (productive firms) and a measure one of households form random bilateral meetings according to the matching technology $\alpha(n_t)$. Therefore, the probability a household meets a retailer in the DM is $\alpha(n_t)$ and the probability a retailer meets a household is $\alpha(n_t)/n_t$. The matching technology is assumed to satisfy $\alpha'(n) > 0$, $\alpha''(n) < 0$, $\alpha(n) \leq \min\{n, 1\}$, $\alpha(0) = 0$, and $\alpha(1) = 1$. DM matches are destroyed with probability one at the end of the period.[22]

Households trade in the DM through borrowing, but lack commitment to repay their debt. In order to sustain credit relationships, the borrower must face a potential cost of default. I assume that lenders have access to an enforcement technology, which in the event of default allows them to recover up to a fraction ν of a household's current income.[23] In the model, ν represents aggregate financial con-

[21] For now, I maintain the assumption of no aggregate uncertainty and perfect foresight. In the numerical section, labor productivity will be assumed to follow an AR(1) process $ln(\bar{z}_t) = \rho_{\bar{z}} ln(\bar{z}_{t-1}) + \epsilon_{\bar{z},t}$, where $0 < \rho_{\bar{z}} < 1$ and $\epsilon_{\bar{z},t} \sim N(0, \sigma_{\bar{z}}^2)$.

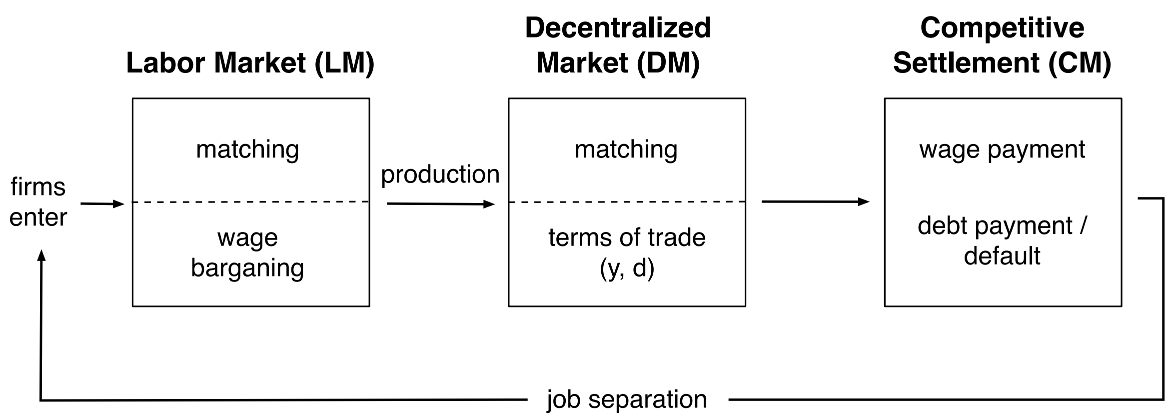
[22] There are many motivations for search frictions in the goods market. One interpretation is that they are liquidity or expenditure shocks, as in the literature on banking (e.g. Diamond and Dybvig, 1983) or monetary theory (e.g Lagos and Wright, 2005).

[23] It is equivalent to assume that ν is the probability that the lender can recover the entire amount of the loan. With probability $1-\nu$, the recovery value is zero. For now I assume that ν is constant. In Section 4, I let ν be time-varying and follow an AR(1) process and consider aggregate financial

ditions that affect all households regardless of employment status.[24] Therefore, in the model households are constrained by two dimensions: the ability of lenders to enforce debt contracts, ν, and the household's current income.

Figure 1 shows the timing of the model.

Figure 1: Timing



3.2 Equilibrium

Centralized Market (CM) Consider a household entering the CM in period t. Let $W_t(d_t, e_t)$ be this household's value function. Upon entering the CM, a household's state is comprised of debt obligations d_t owed from trade in the previous DM and employment status e_t. Let $U_t(e_t)$ be their value function at the beginning of the LM in period t given by

$$W_t(d_t, e_t) = \max_{c_t} \; c_t + \ell(1 - e_t) + \beta U_{t+1}(e_t) \tag{3}$$

$$s.t. \; c_t + d_t = w_t e_t + b(1 - e_t) + \Delta. \tag{4}$$

shocks as innovations to that process.

[24]These types of financial frictions could arise from many sources, for instance Herkenhoff and Ohanian (2012) stress the increase in congestion in the foreclosure process during the Great Recession. In general, ν captures household leverage as in Kiyotaki and Moore (1997) or Fostel and Geanakoplos (2008).

Households maximize discounted lifetime utility choosing CM consumption, c_t, subject to their budget constraint which states that consumption and debt repayment must equal labor income plus any firm profits, Δ. Substituting the budget constraint (4) into (3), the household's value function becomes

$$W_t(d_t, e_t) = -d_t + \hat{w}_t(e_t) + \ell(1 - e_t) + \Delta + \beta U_{t+1}(e_t) \tag{5}$$

where $\hat{w}_t(e_t)$ represents labor income, $w_t e_t + b(1 - e_t)$. The use of linearity helps simplify the model in two important dimensions. First, notice from (5) that a household's lifetime utility is linear in debt, d_t. This will help simplify the credit contract in the DM since the surplus from trade will also be linear function of d_t. Secondly, linearity implies a household has no desire to smooth the repayment of debt over time and so with-in period debt contracts are weakly optimal in this environment.

The value function of a firm with a filled position at the beginning of the CM with x_t unsold inventories from the previous DM, d_t debt promises, and w_t wage obligations is given by

$$\Pi(x_t, d_t, w_t) = x_t + d_t - w_t + \beta J_{t+1} \tag{6}$$

where J_{t+1} is the value function of the firm at the beginning of the LM in period $t + 1$.

Decentralized Market (DM) Trade Next, consider a match between a household and a firm in the DM. The terms of trade are given by the pair (y_t, d_t) which states the amount of DM good the firm transfers to the household, y_t, in exchange for d_t units of numeraire to be paid in the subsequent CM.

There are many ways to determine the terms of trade (i.e. proportional or Nash bargaining, Walrasian price setting, etc.). For the benchmark model, I assume that the solution is given by proportional bargaining which guarantees that trade is (pairwise) Pareto efficient and leads to an endogenous firm markup that is convenient in calibrating the degree of firm's market power.[25] The proportional bargain-

[25]Further, the proportional solution is monotonic in that each individual's surplus is increasing with the size of the total trade surplus. From Gu *et al.* (2013), it is known that other, non-monotonic trading mechanisms (i.e. Nash or competitive pricing) can lead to endogenous credit cycles in

ing solution is given as the solution to the following problem

$$\max_{y_t, d_t} \quad v(y_t) + W_t(d_t, e_t) - W_t(0, e_t) \tag{7}$$

$$s.t. \;\; v(y) + W_t(d_t, e_t) - W_t(0, e_t) = \frac{\mu}{1-\mu}[\Pi_t(\bar{z} - y_t, d_t, w_t) - \Pi_t(\bar{z}, 0, w_t)] \tag{8}$$

$$d_t \leq \nu_t \hat{w}_t(e_t). \tag{9}$$

The maximization problem (7)-(8) above is given by Kalai (1977). The solution maximizes the household's surplus from trade while keeping fixed a proportional split of the total surplus between households and firms. The parameter $\mu \in (0, 1)$ can be interpreted as the household's bargaining power. Equation (9) is the enforcement constraint. Higher labor income or a better aggregate enforcement technology relaxes the constraint. Notice while $\hat{w}$ is endogenous, the household and the firm take it as given in the credit contract since wages are determined before the DM.

The bargaining problem (7) -(9) can be simplified by substituting in for W_t and Π_t from (5) and (6) and combining (7) and (8).

$$\max_{y_t} \mu[v(y_t) - y_t] \tag{10}$$

$$s.t. \;\; d_t = (1-\mu)v(y_t) + \mu y_t \leq \nu_t \hat{w}_t(e_t) \tag{11}$$

The maximand in (10) represents the household's share, μ, of the total surplus, $v(y_t) - y_t$ from DM trade. Equation (11) gives the pricing rule for the transfer from the household to the firm. It says that the wealth the household transfers to the firm is a non-linear function, $(1-\mu)v(y_t) + \mu y_t$, of the firm's DM output. Let y^* be the first-best level of output defined as $v(y^*) = 1$. The solution to (10) - (11) is given by

$$y_t = y(e_t, w_t) = \begin{cases} y^* & \text{if } \; (1-\mu)v(y^*) + \mu y^* \leq \nu_t \hat{w}_t(e_t) \\ y_t & \text{s.t. } (1-\mu)v(y_t) + \mu y_t = \nu_t \hat{w}_t(e_t) \end{cases} \tag{12}$$

limited commitment economies. With proportional bargaining, it is guaranteed that any endogenous cycles that arise are not due to the trading protocol. See Dutta (2012) for the strategic foundations of the proportional bargaining solution.

From (11) - (12), we can completely determine the terms of trade from knowledge of the household's payment capacity $\hat{w}_t(e_t)$, which depends on their current employment status, e_t, and equilibrium wage, w_t. If the payment capacity is above a certain threshold, $(1-\mu)v(y^*) + \mu y^*$, then the solution to the bargaining problem is to trade the first best level, y^*. Otherwise, households borrow up to their constrained limit and the terms of trade are given by $\{y(e_t, w_t), \hat{w}_t(e_t)\}$.[26] In order to simplify notation, I denote the DM consumption of employed and unemployed agents as $y^1 = y(1, w)$ and $y^0 = y(0, w)$, respectively.

Let $V_t(e_t)$ be the household's lifetime utility upon entering the DM at date t with employment status e_t. V_t satisfies

$$V_t(e_t) = \alpha(n_t)[v(y_t) + W_t(d_t, e_t)] + (1 - \alpha(n_t))W_t(0, e_t) \tag{15}$$

$$= \alpha(n_t)\mu[v(y_t) - y_t] + W_t(0, e_t) \tag{16}$$

where I use (5) and (12) to substitute in for $W_t(d_t, e_t)$ and d_t respectively. A household entering the DM gets matched with a firm with probability $\alpha(n_t)$, upon which they consume a fraction, μ of the total surplus from the bilateral relationship. With probability, $1 - \alpha(n_t)$, the household does not get matched and enters the CM without any debt. In (16), the household takes the terms of trade (11) - (12) as given. The value function of a firm at the beginning of the DM along the equilibrium path, F_t, is given by

$$F_t = \frac{\alpha(n_t)}{n_t}\Big[n_t\Pi_t(\bar{z}_t - y_t^1, d_t, w_t) + (1-n_t)\Pi_t(\bar{z}_t - y_t^0, 0, w_t)\Big] + \Big[1 - \frac{\alpha(n_t)}{n_t}\Big]\Pi_t(\bar{z}, 0, w_t) \tag{17}$$

$$= \frac{\alpha(n_t)}{n_t}(1-\mu)\big\{n_t[v(y_t^1) - y_t^1] + (1-n_t)[v(y_t^0) - y_t^0]\big\} + \bar{z} - w_t + \beta J_{t+1} \tag{18}$$

The firm matches with a household in the DM with probability $\alpha(n_t)/n_t$ and trades

[26] The bargaining contract must also satisfy the household and firm participation constraints given by

$$v(y_t) + W_t(d_t, e_t) \geq W_t(0, e_t) \tag{13}$$

$$\Pi_t(\bar{z}_t - y_t, d_t, w_t) \geq \Pi_t(\bar{z}_t, 0, w_t) \tag{14}$$

which never bind given the bargaining solution above.

y_t^e, $e = \{0, 1\}$. With probability n_t, they meet an employed household and with probability $1 - n_t$ they meet an unemployed household. Further, with probability $1 - \alpha(n_t)/n_t$, the firm doesn't meet a trading partner and carries the full amount of intermediate good, $\bar{z}_t$, into the CM.

Substituting Π_t from (6) and using the terms of trade (11) - (12), equation (18) gives F_t as the sum of the firm's total expected revenue from trade in the CM and DM in terms of the numeraire minus wages, w_t, plus the discounted continuation value of the firm in the following LM, J_{t+1}. Define the expected revenue as z_t, given by

$$z_t \equiv \frac{\alpha(n_t)}{n_t}(1-\mu)\{n_t[v(y_t^1) - y_t^1] + (1-n_t)[v(y_t^0) - y_t^0]\} + \bar{z} \tag{19}$$

Notice that z_t depends positively on the level of DM trade described by y^e, which is itself a function of wages, w_t.[27]

Labor Market (LM) Moving to the LM, the value function for a household with access to credit, given employment status, e_t, is given by

$$U_t(1) = (1-\delta)V_t(1) + \delta V_t(0) \tag{20}$$

$$U_t(0) = (1-p(\theta_{t-1}))V_t(0) + p(\theta_{t-1})V_t(1). \tag{21}$$

If employed, with probability δ the household transitions to unemployment. Likewise, if unemployed, with probability $p(\theta_t)$, the household finds a job and transitions into employment. Substituting in for $V_t(e_t)$ in (20)-(21) from (16), yields

$$U_t(1) = \alpha(n_t)\mu[v(y_t^1) - y_t^1] + (1-\delta)W_t(0,1) + \delta W_t(0,0) \tag{22}$$

$$U_t(0) = \alpha(n_t)\mu[v(y_t^0) - y_t^0] + (1-p(\theta_t))W_t(0,0) + p(\theta_t)W_t(0,1) \tag{23}$$

Households have an expected surplus from DM trade equal to the first term in (22)-(23). Otherwise, the progression of a household through the labor market is similar to that in Mortensen and Pissarides (1994). If employed, with probability $(1-\delta)$ the household maintains their job or with probability δ they get separated.

[27] Sometimes I will make explicit the dependence of z_t on wages and refer to $z(w_t)$.

If unemployed, a household finds employment with probability $p(\theta_t)$ and with probability $1 - p(\theta_t)$ they have to continue searching in the following period. The firm's value function follows similarly. Let J_t be the expected lifetime value of a firm with a filled vacancy at the beginning of the LM, given by

$$J_t = (1 - \delta)F_t + \delta V_t \tag{24}$$

where V_t is the value function of a vacant firm. From (24), a firm gets exogenously destroyed with probability δ and must wait a period before searching for a worker. Otherwise, the firm enters the DM with expected value F_t. Free entry of firms to the matching process guarantees that the value of a vacancy must be zero for all t, $V_t = 0$. Substituting in for F_t from (18), we can write

$$J_t = z_t - w_t + \beta(1 - \delta)J_{t+1} \tag{25}$$

Notice, z_t is a function of DM trades, (y_t^0, y_t^1), and the current measure of employed workers, n_t. A higher level of DM trade leads to higher expected firm revenue; $\partial z_t / \partial y_t^e \geq 0$. On the other hand, firm entry has an ambiguous effect on z_t. With constant returns to scale matching, the probability an individual firm is matched with a worker is decreasing in the measure of firms, n_t. Higher unemployment is good for vacant firms because it becomes more likely to find a match in the LM. However, higher unemployment is bad for firms that stay filled because a higher fraction of unemployed workers implies that firms are more likely to meet a consumer in the DM that is more credit constrained. Hence, the sign of $\partial z_t / \partial n_t$ is ambiguous.

Wage Determination I assume wages are chosen such that the surplus generated in an employment match is proportionally split between the household and firm according to exogenous shares λ and $1 - \lambda$, respectively. That is, I assume wages in period t are given by

$$V_t(1) - V_t(0) = \frac{\lambda}{1 - \lambda} J_t \tag{26}$$

The wage outcome in (26) is given as the solution to the proportional bargaining problem in Kalai (1977) where $V_t(1) - V_t(0)$ is the household's surplus from being employed and J_t is the firm's surplus from having a filled position. Using (16) and (18), Appendix 6.2 derives the equilibrium wage equation

$$w_t = \lambda[z_t(w_t) + \theta_t k] + (1-\lambda)(b + \ell - \alpha(n_t)\mu[S^1(w_t) - S^0]) = \Gamma_t(w_t) \tag{27}$$

where $S^0 = v(y_t^0) - y_t^0$ and $S^1 = v(y_t^1) - y_t^1$ represent the joint surplus from a DM match with unemployed and employed households, receptively. Notice in (27), I make explicit the dependence of y_t^1 on wages through the loan contract (12). The wage is a weighted average of the firm's revenue augmented by average recruiting costs per vacancy, θk, and a household's flow utility from being unemployed augmented by the net utility cost of potentially losing access to credit. The equilibrium wage is a fixed point of $w_t = \Gamma_t(w_t)$.

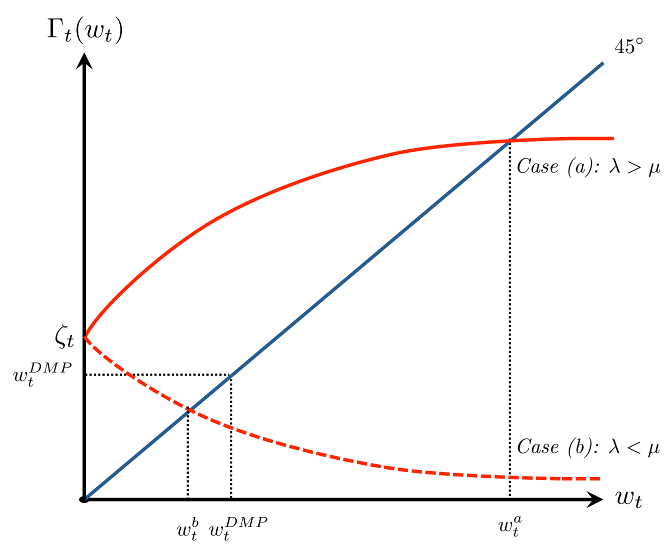
A higher wage relaxes credit constraints for employed workers, which has two effects on $\Gamma_t(w_t)$. First, higher credit implies more trade in the DM between firms and employed workers, $\partial y^1/\partial w > 0$, which increases a firms' expected revenue, z_t. This effect leads to a larger surplus in a labor match which puts upward pressure on wages. Secondly, as credit expands for employed workers, the household's outside option in labor bargaining is negatively effected. Unemployment not only coincides with a fall in income, but also a shock to credit constraints. Which effect dominates depends on the relative bargaining power of households in labor and goods markets. To see this, we can substitute in for $z(w_t)$ using (19) and express $\Gamma_t(w_t)$ as

$$\Gamma_t(w_t) = \lambda\Big[\frac{\alpha(n_t)}{n_t}(1-\mu)[n_t S^1(w_t) + (1-n_t)S^0] + \bar{z}_t + \theta_t k\Big] + \tag{28}$$
$$(1-\lambda)\big[(\ell + b) - \alpha(n_t)\mu[S^1(w_t) - S^0]\big]$$
$$= w_t^{DMP} + (\lambda - \mu)\alpha(n_t)[S^1(w_t) - S^0] + \lambda\frac{\alpha(n_t)}{n_t}(1-\mu)S^0 \tag{29}$$

where $w_t^{DMP} = \lambda(\bar{z} + \theta_t k) + (1-\lambda)(\ell + b)$ is the equilibrium wage in Pissarides (2000), or the equilibrium wage in this model if there were no credit (i.e. $\nu = 0$). The first and last term in (29) are constant with respect to the wage in the match.

The second term depends on the surplus in the goods market between a firm and an employed worker. The sign depends on the bargaining power of the household as a worker in the LM relative to their bargaining power as a consumer in the DM. If λ is higher, then the first effect discussed above dominates and wages are inflated due to the positive effect on firm revenue. However, in the opposite case when a household's bargaining power is higher in the goods market, the second effect dominates which creates downward pressure on wages. If this negative effect is large enough, the wage could fall below w_t^{DMP}. Under this scenario, the introduction of household credit creates a 'liquidity discount' on wages equal to the additional value households place on employment by increasing their access to credit. Figure 2 illustrates the determination of wages under the two cases discussed above.

Figure 2: Wage Determination



If $w_t = 0$, then $\Gamma_t(0) = w_t^{DMP} + \left[\lambda \frac{(1-n_t-\mu)}{n_t} + \mu\right]\alpha(n_t)S^0$, denoted as ζ_t in the figure. In Case (a), $\lambda > \mu$ and the equilibrium wage is higher than in an environment without credit, $w_t^a > w_t^{DMP}$. Case (b) illustrates the opposite when $\lambda < \mu$ and the equilibrium wage is lower than in an environment without credit, $w_t^b < w_t^{DMP}$.[28] Lemma 1 makes this precise.

Lemma 1. *There exists a unique, positive solution to* (27). *Additionally,*

[28]Notice it is also possible under case (b) that the third term in (29) is large enough such that wages are higher than w_t^{DMP}.

(a) If $\lambda > \mu$, then $w_t \in [\zeta_t, \bar{w}_t]$ where $\bar{w}_t = w^{DMP} + \frac{\alpha(n_t)}{n_t}(1-\mu)[v(y^*) - y^*]$. Hence, $w_t \geq w^{DMP}$ for any (u, θ) combination since $\zeta_t \geq w^{DMP}$.

(b) If $\lambda < \mu$, then $w_t \in [\underline{w}_t, \zeta_t]$ where $\underline{w}_t = w^{DMP} - (\mu - \lambda)\alpha(n_t)[u(y^*) - y^*]$. If $\zeta_t - w^{DMP} < (\mu - \lambda)\alpha(n_t)S^1(w^{DMP})$, then $w_t < w^{DMP}$. Otherwise, $w_t \geq w^{DMP}$ as in (a).

If household's have more bargaining power as workers than as consumers, then there is a positive credit externality on wages. In the other case, if households have more bargaining power as consumers than as workers, and the net surplus of credit to unemployed households in the labor match isn't too big, $\zeta_t - w^{DMP} < (\mu - \lambda)\alpha(n_t)S^1(w^{DMP})$, then there is a negative credit externality on wages.

Firm Entry and Unemployment Plugging in the wage from (27) into (25) we can derive the difference equation for the value of a filled job as

$$J_t = S^f(n_t, \theta_t) + \beta(1-\delta)J_{t+1} \tag{30}$$

Equation (30) gives a familiar law of motion for the value of a filled job. The function S^f represents the firms share the total surplus from a labor match equal to

$$S^f(n_t, \theta_t) = (1-\lambda)[\bar{z}_t - (b + \ell)] - \lambda\theta_t k \\ + (1-\lambda)\frac{\alpha(n_t)}{n_t}(1-\mu)[n_t S^1 + (1-n_t)S^0] + (1-\lambda)\alpha(n_t)\mu[S^1 - S^0] \tag{31}$$

where S^1 is a function of n and θ through its dependence on the wage given by (27).[29] The first two terms in (31) are standard and equal to the firms share of exogenous output minus a worker's outside option in an environment with no credit, $b + \ell$, adjusted for the costs of vacancy creation. The last two terms are novel. The first is equal to the firm's share of the additional expected revenue of a labor match from operating in the DM. The second term represents rents the firm collects through wage bargaining, equal to their share of the the household's

[29] S^0 is a function of non-employment income b and other exogenous parameters, such as aggregate financial conditions, ν. See equation (12).

cost of loosing access to credit upon unemployment. Lemma 2 characterizes the comparative statics when $\lambda > \mu$.[30]

Lemma 2 (Comparative Statics of $S^f(n,\theta)$)**.** *Let $S^f(n,\theta)$ be given by (31).*

(i) $\partial S^f/\partial\theta \leq 0$ *for all n.*

(ii) Suppose $S^0 = 0$ (i.e. $b = 0$). Then $\partial S^f/\partial n \geq 0$ for all n.

(iii) Suppose $S^0 \neq 0$. Then the sign of $\partial S^f/\partial n$ is in general ambiguous, but must change sign from positive to negative.

The value of the firm's labor surplus is weakly decreasing in labor market tightness. In the extreme case, if unemployed households are completely denied credit, $S^0 = 0$, the effect of higher employment on the labor match is always positive. This is because higher employment unambiguously leads to a larger surplus in the DM. If $S^0 > 0$, there are two forces at play when employment increases. First the rate of finding a trading partner in the DM for the firm declines. The sign of $\partial(\alpha(n)/n)/\partial n$ is negative given a constant returns to scale matching function. However in general, and increase in n, increases wages which has a positive effect on S^f.

The law of motion for unemployment also follows the standard difference equation

$$u_{t+1} = (1 - p(\theta_t))u_t + \delta(1 - u_t). \tag{32}$$

From (32), the measure of unemployed households in period $t+1$ is equal to the fraction of unemployed households in period t that did not get matched in the previous LM, $(1 - p(\theta_t))u_t$, plus the fraction of employed households that became separated from their job $\delta(1 - u_t)$ between periods. We are now ready to define the equilibrium for the perfect-foresight economy.

Definition 1. *A discrete-time perfect-foresight equilibrium is given by the sequence $\{u_t, J_t\}_{t=0}^{\infty}$ satisfying (30) and (32) such that u_0 is given and $\lim_{t\to\infty} J_t$ is finite.*

[30]This case is informative for the quantitative section because under all of the calibrations considered, $\lambda > \mu$.

Given a series for J_{t+1}, we can determine labor market tightness, θ_t, as the solution to the free entry condition, $V_t = 0 \; \forall \; t$. This implies that $k = \beta f(\theta_t) J_{t+1}$ in every period, where $\partial \theta_t / \partial J_t > 0$. Wages are determined by (27) which, given b, pin down the level of trade in DM, (y^1, y_0).

4 Quantitative Analysis

The primary experiment considered in this section examines if the negative effect of unemployment on consumer credit identified in Section 2 has an impact on business cycles in the aggregate. I consider two sources of exogenous fluctuations. The first are standard: shocks to aggregate labor productivity as in Shimer (2005) and the large search and matching literature that follows. The second source are aggregate financial shocks that affect all households. These shocks have been stressed in the literature on credit frictions on the side of firms. For instance Jermann and Quadrini (2012) find that shocks to a firm's ability to raise funds through debt markets contributes significantly to the dynamics of macroeconomic aggregates. I consider a similar shock, though now on households' ability to finance consumption, through an exogenous change in lenders' ability to enforce financial contracts. I illustrate the aggregate amplification effect of job-related credit shocks through impulse response functions and then examine the ability of the baseline model to match the data.

4.1 Calibration

The period in the model is set to a month and I set agent's discount factor to $\beta = 0.995$, which implies an annual discount rate of 95%. All empirical targets represent monthly averages over the time period 1978 Q1 to 2007 Q4. The model is first solved by a projection algorithm in which expectations are computed using Gauss-Hermite quadrature.[31] I then simulate the model to compute the moments for the calibration.

[31] As stressed in Petrosky-Nadeau and Zhang (2013), it is important to use a global solution algorithm in quantifying the dynamics of the MP model as log-linearization understates the mean and volatility of unemployment.

Labor Market The calibration of parameters governing the labor market follows closely to the search literature following Shimer (2005) and more recently the literature on financial frictions and unemployment (i.e. Petrosky-Nadeau and Wasmer (2013), Petrosky-Nadeau (2014), and Monacelli *et al.* (2011)). First, I assume aggregate labor productivity fluctuates over time according to an AR(1) process,

$$ln(\bar{z}_{t+1}) = \rho_{\bar{z}_t} ln(\bar{z}_t) + (1-\rho_{\bar{z}}) ln(\mu_{\bar{z}}) + \epsilon_{\bar{z},t} \quad \text{s.t. } \epsilon_{\bar{z},t} \sim N(0, \sigma^2_{\bar{z}}). \tag{33}$$

I normalize $\mu_{\bar{z}} = 1.0$. Using the Bureau of Labor Statistics series on quarterly output per worker, I estimate $\rho_{\bar{z}} = 0.962$ and $\sigma_{\bar{z}} = 0.0075$.[32] For the matching technology, I use a constant returns to scale function as suggested in den Haan *et al.* (2000), $m(s,o) = so/(s^{\eta_L} + o^{\eta_L})^{1/\eta_L}$, which has the nice property of binding matching probabilities between zero and one. Using data on job finding rates, unemployment, and vacancies, Schaal (2015) estimates $\eta_L = 1,6$. I set the exogenous job destruction rate, δ, to match a quarterly job destruction rate of 10% and vacancy costs, k, to match an unemployment rate of 7%. The household's bargaining power corresponds to an egalitarian solution, $\lambda = 0.5$.

The remaining two parameters associated with the labor market are the value of leisure, ℓ, and non-employment income, b. In an equilibrium with binding debt constraints, the fall in credit upon job loss coincides with the fall in labor income. To see this, suppose (9) holds with equality for both employed and unemployed households. We can measure the proportional fall in credit as $1 - (d^0/d^1) = 1 - (b/w)$. Non-employment income is crucial in disciplining the strength of the complementarities between credit and unemployment in the model. To set b, I use the evidence discussed in Section 2 and target a 60.4% decline in a household's access to credit in the event of a job loss. I then set the value of leisure such that the total labor surplus is 71% of the average wage as in Hall and Milgrom (2008).

Credit and Goods Market In general, the frictions in the goods and credit market are designed to capture the inefficiencies of the process of getting produced products into the hands of consumers. Fluctuations in these inefficiencies are what

[32] I estimate a quarterly persistence parameter of $\rho^q_{\bar{z}} = 0.889$ and a quarterly standard deviation of $\sigma^q_{\bar{z}} = 0.0056$. Then, I find the monthly persistence and standard deviation to match these targets.

induce fluctuations in unemployment. In the model, matching frictions, α, determine the frequency of a household's liquidity needs. Alternatively, credit frictions capture the difficultly households face in financing the purchases of goods once the liquidity shock is realized. To calibrate the parameters of the credit and goods market, I use data on household consumer credit use and firms market power in the retail sector.

The matching technology in the DM is also chosen such that the short-end of the market is always matched, $\alpha(n) = \min\{1, n\} = n$. Utility over DM consumption is given by, $v(y) = \Gamma y^{1-\gamma}/(1-\gamma)$. The elasticity parameter is set to target the marginal propensity to consume (MPC) out of an increase in debt limits of 14%, as given in Gross and Souleles (2002). In the model the MPC of an agent in employment state e is given by $MPC^e = \mu[v'(y^e) - y^e]/[(1-\mu)v'(y^e) + \mu]$. The aggregate MPC is then given by $MPC = nMPC^1 + (1-n)MPC^0$. I set the $MPC = 0.14$, which implies $\gamma = 0.4$. I set the level parameter, Γ, to target the ratio of consumer credit outstanding to quarterly output. During the sample period, this averaged 9.47%. In the model, total debt is $D = \alpha(n_t)[nd_t^1 + (1-n)d_t^0]$. Total output, across the DM and CM, is $Y = n_t z_t - \theta_t u_t k$. Hence I set $D/Y = 0.097$, which results in $\Gamma = 1.4$. The household's bargaining weight, μ, is set to match an aggregate markup of 10%, given in Faig and Jerez (2005).

To discipline aggregate financial conditions, ν_t, I follow the approach outlined in Jermann and Quadrini (2012). I first construct a series for ν_t using the enforcement constraint (9) under the assumption that is it always binding. That is, I assume

$$d_t^1 = \nu_t w_t \tag{34}$$

$$d_t^0 = \nu_t b \tag{35}$$

In the aggregate, this implies that total debt, D_t, is equal to

$$D = \alpha(n_t)[n_t d_t^1 + (1-n_t)d_t^0] = \nu_t \alpha(n_t)[n_t w_t + (1-n_t)b] = \nu_t \alpha(n_t) I \tag{36}$$

Replacing d_t^1 and d_t^0, we can express total debt as a fraction of total income as

$$\alpha(n_t)\nu_t = \frac{\alpha(n_t)[n_t d_t^1 + (1-n_t)d_t^0]}{[n_t w_t + (1-n_t)b]} \tag{37}$$

The numerator is equal to total borrowing in meetings with employed and unemployed agents, multiplied by the measure of agents taking loans, $\alpha(n)n$ and $\alpha(n)(1-n)$, respectively. The denominator is total labor income, $n_t w_t$, plus unemployment benefits, $(1-n_t)b$. Empirically, for the numerator I use the aggregate time series for consumer credit outstanding, minus education loans, in the household sector from the Flow of Funds Accounts.[33] For the denominator, I use the aggregate time series for disposable personal income from the BEA.[34] Given the matching function $\alpha(n) = n$, I am able to fully identify ν_t from (37). After constructing the series for, ν_t, I estimate the autoregressive process

$$ln(\nu_{t+1}) = \rho_\nu ln(\nu_t) + (1-\rho_\nu) ln(\mu_\nu) + \epsilon_{\nu,t} \quad \text{s.t. } \epsilon_{\nu,t} \sim N(0, \sigma_\nu^2) \tag{38}$$

The estimation yields $\mu_\nu = 0.987$, $\rho_\nu = 0.960$, and $\sigma_\nu = 0.0165$. The top two panels of Figure 4 show the constructed series for $\bar{z}_t$ and ν_t, respectively. The bottom two panels show the innovations, $\epsilon_{\bar{z},t}$ and $\epsilon_{\nu,t}$. Since 1978, labor productivity has fluctuated around 3-4% of its long-run average. Those fluctuations mostly arise from the persistence parameter in the AR(1) process. However, similar to what Jermann and Quadrini (2012) find with respect to business credit, I find that household financial conditions are largely driven by innovations in the process. Table 7 summarizes the choice of functional forms and Table 8 gives the calibrated parameters.

MP Calibration In the experiments below, I compare the baseline model with job-related credit shocks to a benchmark MP model in which the output of a labor match is sold in a frictionless, competitive market. To do so, I keep the parameters fixed from the baseline calibration, but I assume that firm revenue is given by $S^f_{MP}(n_t, \theta_t) = S^f_{MP} = (1-\lambda)[\zeta + \bar{z} - (b+\ell)] - \lambda\theta_t k$. Hence, I set the term $\zeta = 1.54$ such that steady state unemployment in both models match.

[33]Total consumer credit covers most short and intermediate-term credit arrangements. However, data on student loans suggests many of these loans are deferred for several years. Since the objective of the quantitative exercise is to see how borrowing in the current quarter affects sales for same quarter, I exclude this type of debt from the exercise.

[34]See NIPA Table 2.1 Personal Income and Its Disposition. This measure of income is broader than that in the model. It includes income from other, non-labor, sources including receipts on assets, dividend or interest payments, and other transfer receipts besides unemployment insurance (i.e. social security). I could alternatively only use data on wages and salaries plus unemployment benefits. Doing so would only increase the estimated volatility in aggregate financial conditions.

4.2 The Amplifying Effects of Job-related Credit Shocks

This section quantitatively examines if job-related credit shocks are a reasonable amplifying mechanism in labor market variables over the business cycle. Figure 5 illustrates the comparative statics of steady state variables with respect to changes in fixed, aggregate productivity $\bar{z}$. The blue-solid lines represent the baseline model with job-related credit shocks, while the green-dashed lines represent the MP model. Qualitatively, the model with job-related credit shocks behaves in the same way as the standard MP model, however quantitatively the effects of productivity are amplified. The bottom-right panel illustrates the percentage difference between steady-state variables between the two models. This difference arises only due to the feedback effect of unemployment on aggregate demand through credit constraints. The effect on steady state unemployment and labor market tightness of a -15% productivity shock are amplified by 10% relative to the MP model. The effect are unsymmetrical; the effect on unemployment of a positive 15% productivity shock is less than 5% while the effect on tightness is 7%.

Figure 6 illustrates the impulse responses of a one-standard-deviation negative aggregate productivity shock at time 1, $\epsilon_{\bar{z},1} = \pm\sigma_{\bar{z}}$, starting from the deterministic steady state. From time $t = 1$ on, aggregate productivity evolves according to (33). The blue-dotted line in each panel represents the response in the baseline model while the green-triangled line represents the response in the MP model. In the baseline MP model, a negative productivity shock decreases firm revenue (bottom-left panel) by -0.8%. This leads to a fall in vacancy creation causing labor market tightness (top-right-panel) to fall by -2.0% on impact and unemployment to rise by 1.1% over five months. In the baseline model, an increase in unemployment causes firm revenue to fall even further. The total instantaneous effect decreases revenue by -1.4% causing labor market tightness to fall by -3.3% and unemployment to rise by nearly 2.0%. The bottom-left panel illustrates the percentage-point difference (amplification) between the impulse response functions for each variable. The amplification in the response of unemployment peaks 5 months after the shock at 0.8 percentage points. The initial response of tightness is amplified by 1.3 percentage points while firm revenue is amplified by 0.6 percentage points, peaking two months after the initial shock.[35]

Job-related credit shocks serve as a meaningful amplification mechanism and can generate larger movements in unemployment, vacancies, and other aggregate labor market conditions (including wages) than the standard MP model. Notice that the baseline model does not only allow us to examine the effect that heterogenous credit constraints have on aggregate productivity shocks, but also embeds a role for *aggregate* credit shocks, through changes in ν_t. Aggregate credit shocks affect the ability of households to leverage their labor earnings. Figure 7 illustrates the impulse response of a one-standard deviation negative leverage shock at time 1. The effect on unemployment is larger than a one standard-deviation aggregate productivity shock and is more persistent. This explains the result, in Section 4.3, of the ability of financial shocks to generate the large movements in aggregate labor market variables in recent recessions.

4.3 Aggregate Shocks and Matching Macroeconomic Time Series

In this section, I use the calibrated model to examine to what extent job-related credit shocks provide enough amplification to explain the co-movement of consumer credit debt, unemployment, and other labor market variables in the aggregate. I consider two exogenous sources of fluctuations: aggregate productivity, $\bar{z}_t$ and aggregate financial conditions, ν_t. For each case, I feed the estimated shock process, $\epsilon_{\bar{z},t}$ or $\epsilon_{\nu,t}$ into the model while keeping constant the other variable at its unconditional mean, $\mu_{\bar{z}}$ or μ_{ν}.

Productivity Shocks Figure 8 illustrates the effects of measured productivity shocks on the unemployment rate, vacancies, firm revenue, consumer credit debt, job finding rates and wages. The baseline and MP model series are in blue and green, respectively, and their empirical counterparts are in black. First, productivity shocks have a limited effect on the cyclical movement of unemployment, both in the baseline model and in the standard MP model, as has been well documented since

[35] A quantitatively similar amplification effect arises if I assume that the productivity shock only lasts one period, however the dynamic response is short lived and the maximum distance between the impulse response of the baseline model and that in the MP model is maximized in period 1.

Shimer (2005). Despite the additional amplification illustrated in Section 4.2, productivity shocks are not enough, by themselves to generate substantial volatility. The predictions for vacancy creation are slightly more in line with the data, though still under represent the magnitude of the deviations. For both series, the model completely misses the expansion between 1991 and 2000. Movements in labor productivity alone imply an increasing unemployment rate and falling vacancy creation in this time period.

A similar story follows with regards to firm revenue and household debt outstanding. The model implied series and the data coincide in sign for the recessions of the early 1980s, though again misses on the magnitude of the deviations. Each of the recessions post-1990 are not only shallow, but also short lived. For instance, the data suggest that after the 1990 recession, revenue stagnated relative to trend only until 1992 while the reversal in the data happened around 1995. Debt also shows no significant volatility. Again, the model suggests that movements in labor productivity miss the contraction of consumer credit in both the mid-1990s and after the Great Recession. This leads to the conclusion (and verification of many results in the literature) that productivity shocks cannot independently explain either the movement in aggregate labor market variables or the movement of consumer credit.

Credit Shocks Figure 9 illustrates a similar exercise but feeding in exogenous fluctuations in aggregate financial conditions, ν_t, as illustrated in Figure 4. The baseline and MP model implied series are represented in blue and green, respectively, and their empirical counterpart in black. Household financial shocks in the model come much closer to explaining the movements in the both the consumer credit and aggregate labor market. The movement in the unemployment rate in the data is in line with the model's predictions, although the volatility is still below that in the data. Surprisingly, the model has a difficult time explaining the movements of unemployment during the Great Recession. In the data, unemployment started to increase in the early part of 2007. Movements in household financial conditions lead to an increase only beginning in 2009, after the majority of the change in the data occurred.

Credit shocks also do a better job explaining the demand for labor. The model predicts the entire fall in vacancies during the early 1980s and over-predicts the fall in the 1990s. Regarding the Great Recession, vacancies also fall by the same magnitude though the model predicts that fall starting only in 2009. An additional dimension credit shocks improve on are the persistence of labor market variables, particularly after the 1990s. For instance the slow decline of the unemployment rate and slow rise in vacancy creation in the model, coincide well with the data.

The middle two panels serve as a key litmus test for the mechanism in the baseline model. The methodology used to construct the series ν_t will imply that the model generates a reasonable volatility in consumer credit debt outstanding, as illustrated in the middle-right panel. The model predicts that the volatility in consumer credit hurts job creation through an aggregate demand effect, seen through its effect on firm revenue. As can be seen in the middle-left panel, the model does a good job matching the empirical series of firm revenue (taken from retail sales data), particularly in the 1980's and 90s. A puzzle arises in that the recession that the model does the worst in matching is the 2007 financial crises. However, notice that either from the middle-right panel of Figure 9 that illustrates consumer credit outstanding or from the bottom-left panel in Figure 4 illustrating aggregate credit shocks, that the 1980 and 1990 recessions featured larger and more persistent shocks to consumer credit than in the Great Recession.

5 Conclusion

There is consistent evidence that households face constraints in financing consumption in the face of income shocks. The starting point for this paper was illustrating the fact that an income shock, in the form of a job loss, is also a significant credit shock. Credit constraints increase precisely for the group that values credit access the most, the unemployed. I then investigate to what extent do these job-related credit shocks affect the labor market over the business cycle. I propose a model that generates an increase in credit constraints for the unemployed that is both analytically tractable, easily quantifiable, and nests into the workhorse model of unemployment, Mortensen and Pissarides (1994). This easily allows comparison to other studies in the literature. I calibrate the model to match the fall in credit for the unemployed and show that job-related credit shocks are a meaningful source of amplification. However, despite the additional amplification, productivity shocks continue to do a poor job of generating the patterns in the data, both qualitatively and quantitatively. However, I show that shocks to aggregate household financial conditions amplify the drop in credit upon job loss and contribute significantly to the dynamics of both real and financial variables.

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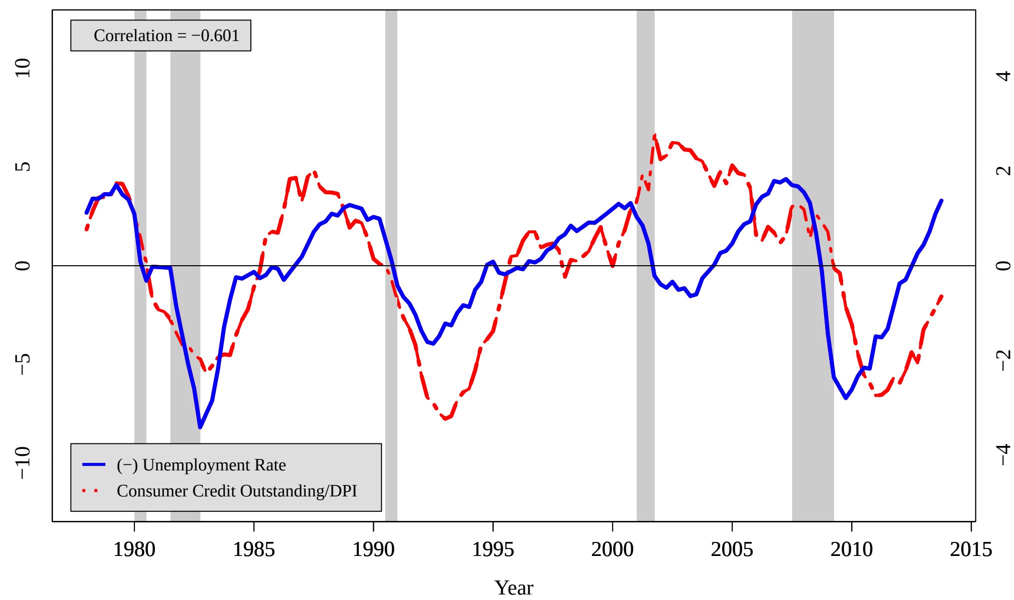
6 Appendix

6.1 Figures and Tables

Figure 3: Consumer credit outstanding to disposable personal income and the civilian unemployment rate. 1978 Q1-2013 Q4.



Note: Series are detrended with a Hodrick-Prescott filter with smoothing parameter $\lambda = 100,000$. Sources: Federal Reserve Board Flow of Funds Accounts. Table B.100 and Bureau of Labor Statistics. NBER recessions are shown in grey.

Figure 4: Stochastic processes of labor productivity and aggregate financial conditions.

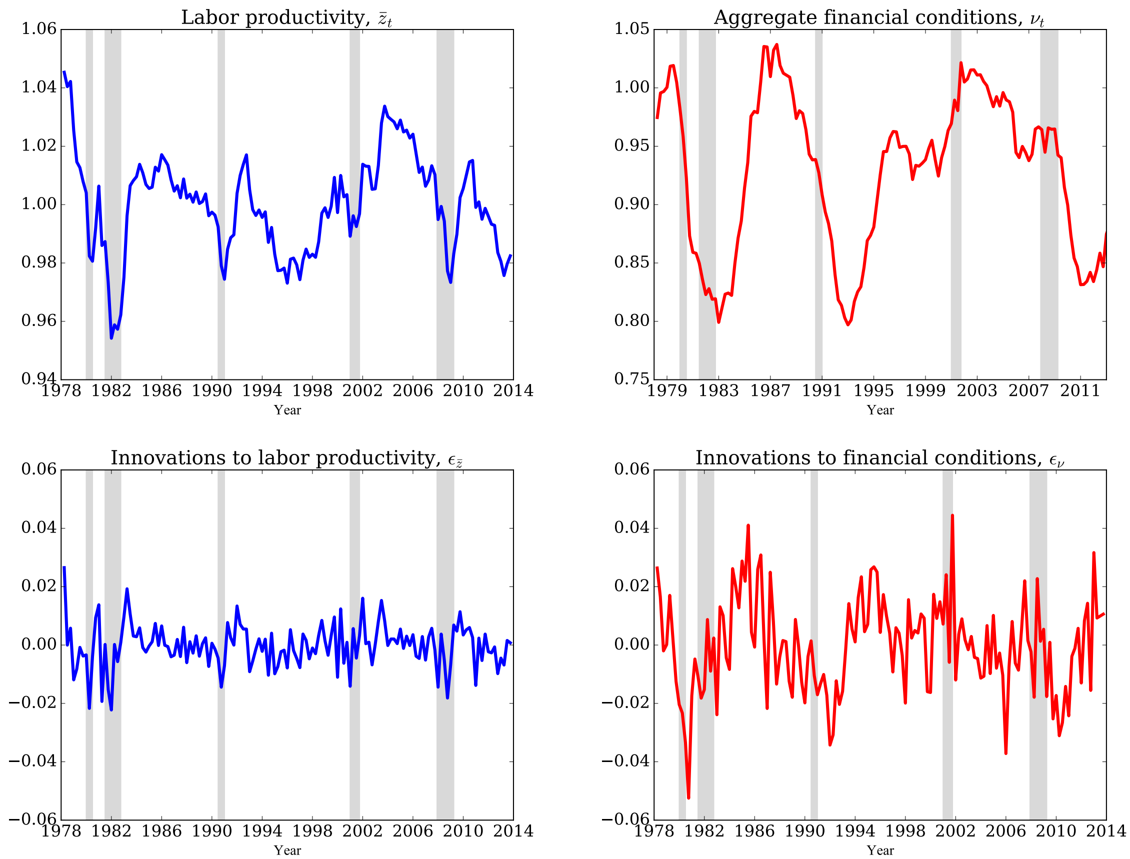


Figure 5: Steady state comparative statics with respect to aggregate productivity, $\bar{z}$ (top and bottom-left). Percentage difference in steady state values between the baseline model and the MP model (bottom-right).

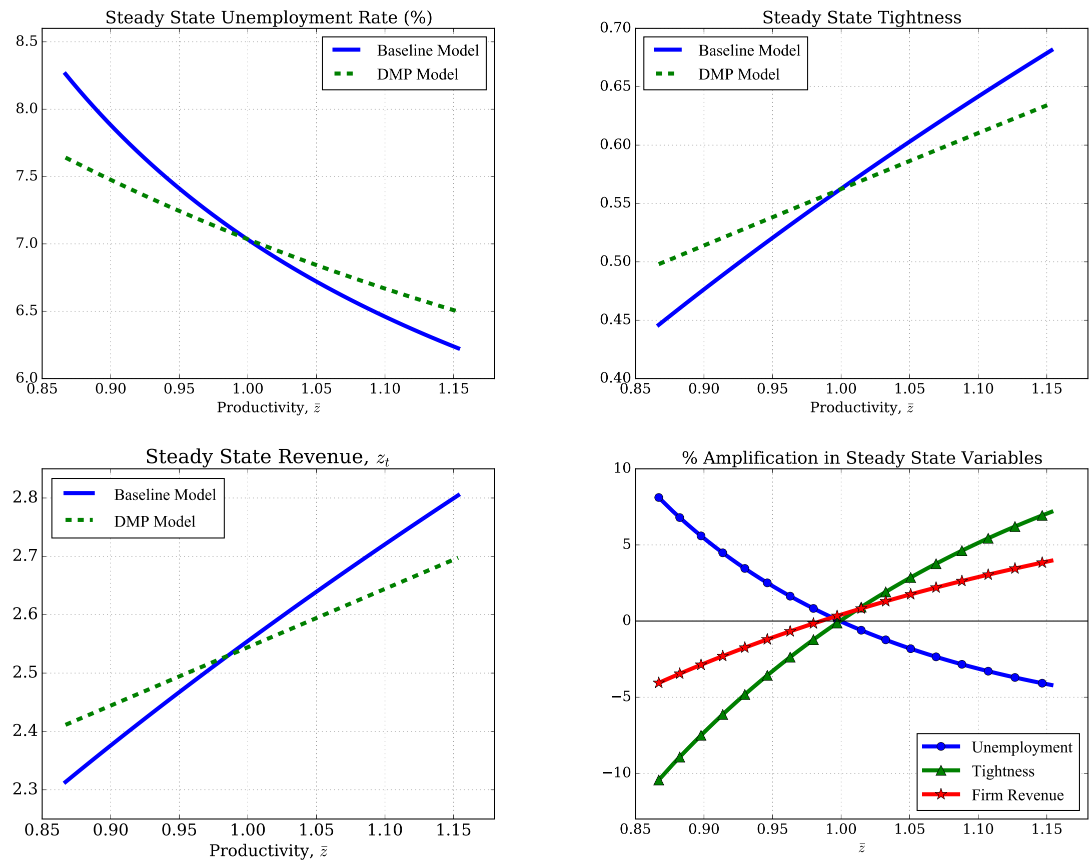


Figure 6: Impulse response functions to a one-standard deviation labor productivity shock (top and bottom-left). Percentage point difference (in absolute value) between the impulse response functions (bottom-right).

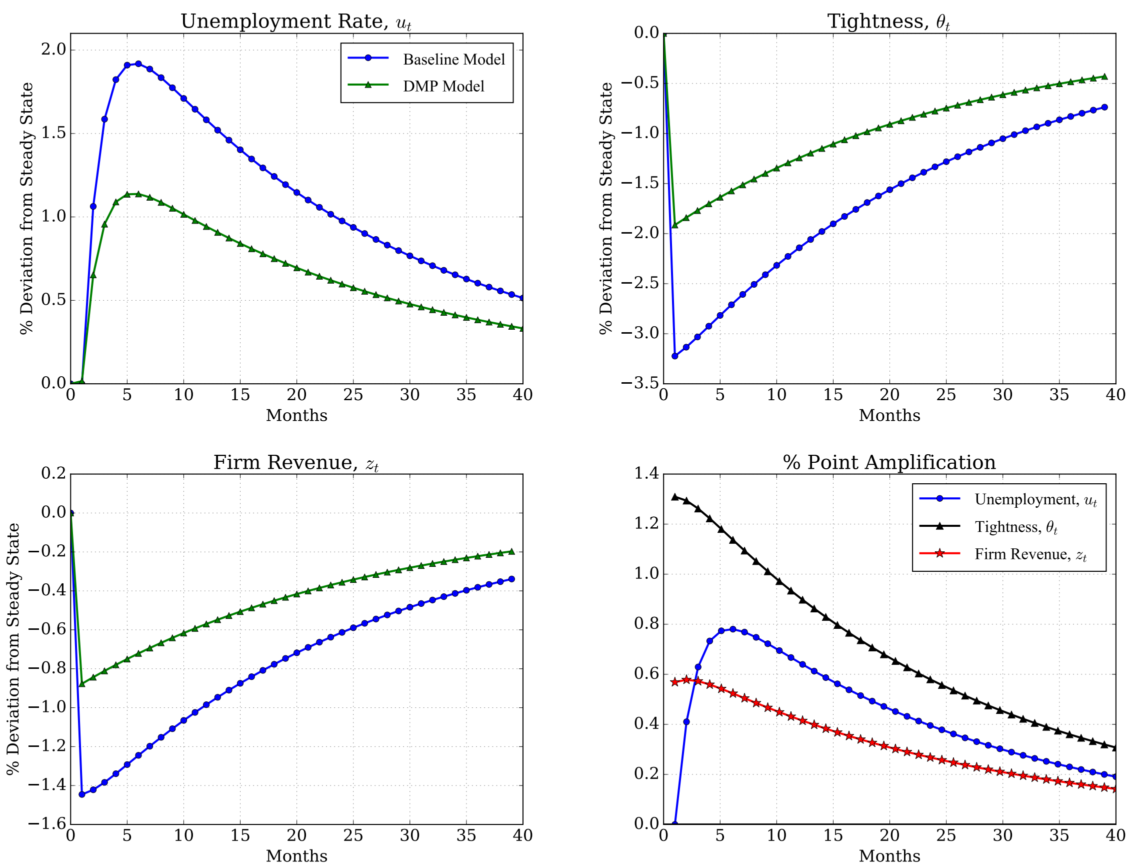


Figure 7: Impulse response functions to a one-standard deviation leverage shock.

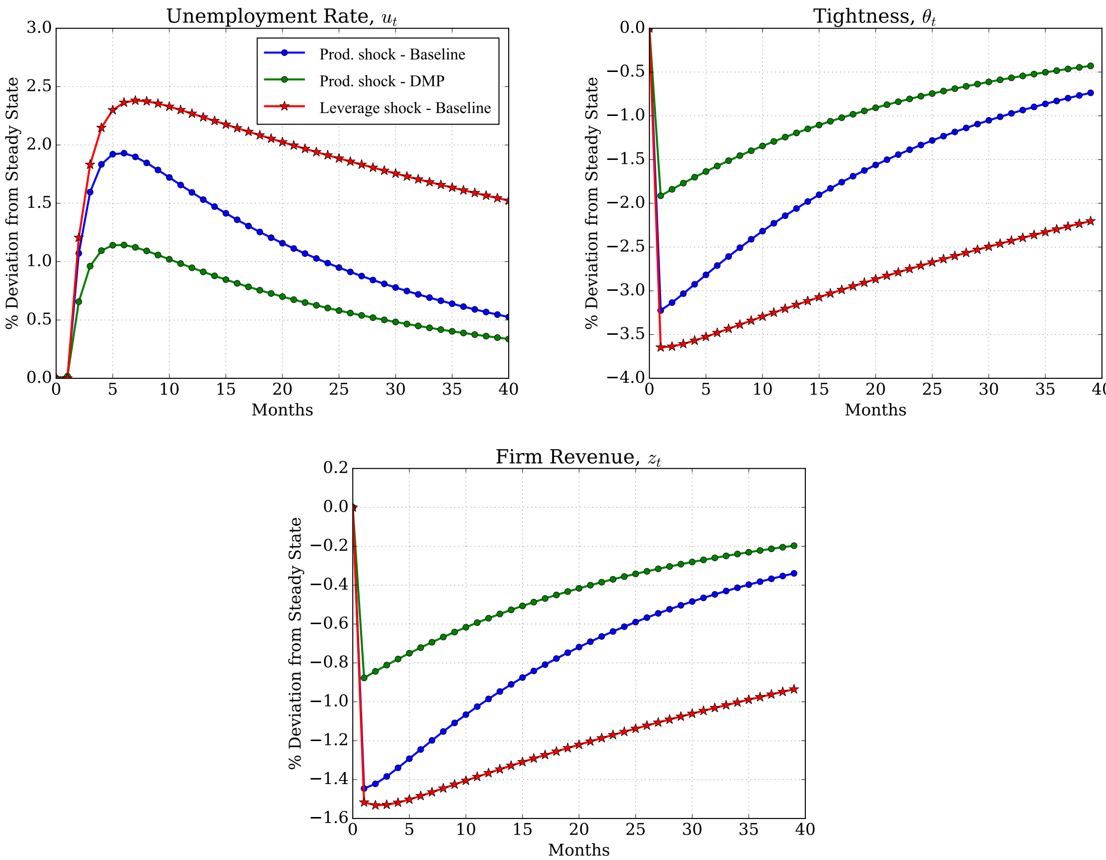
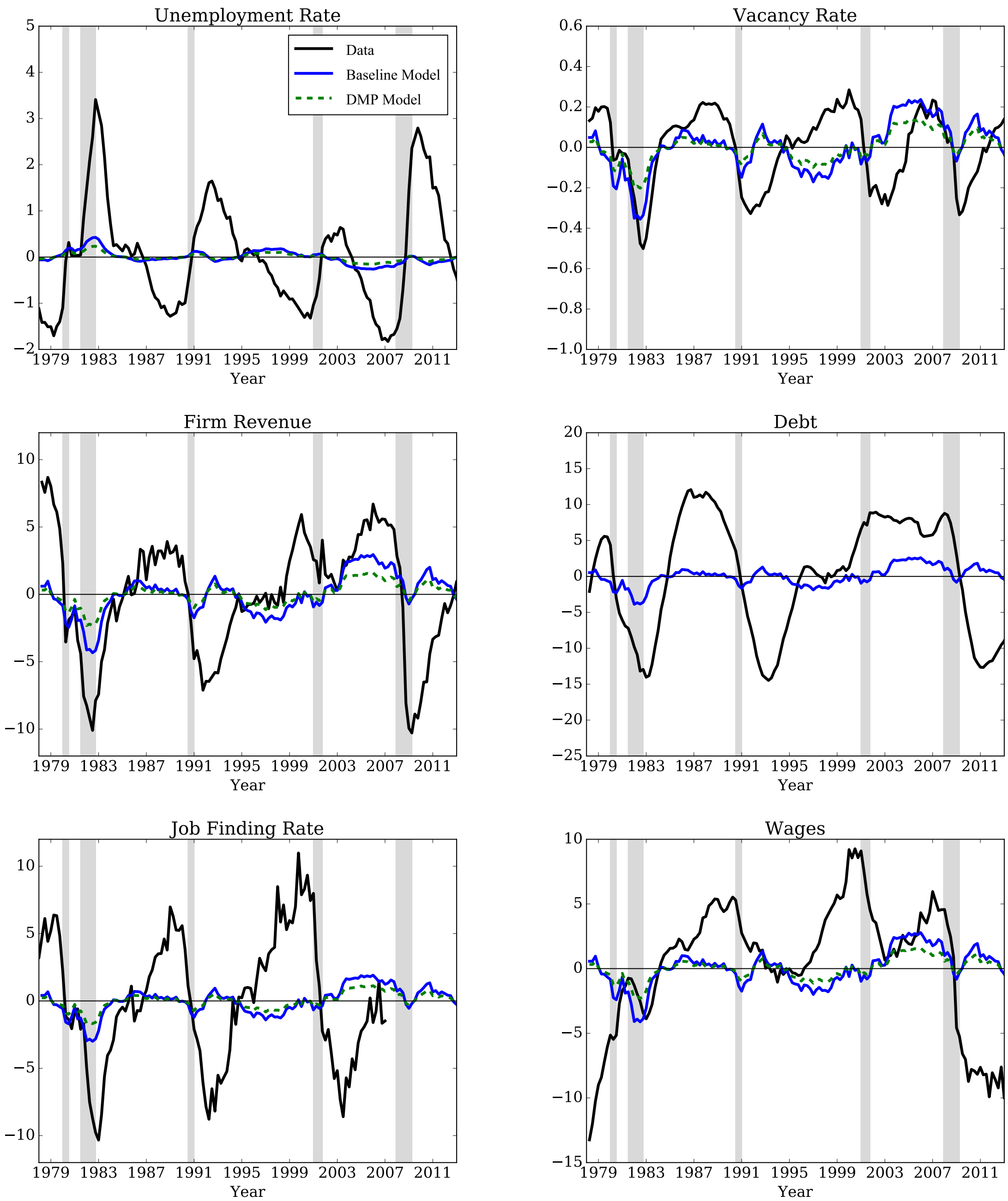
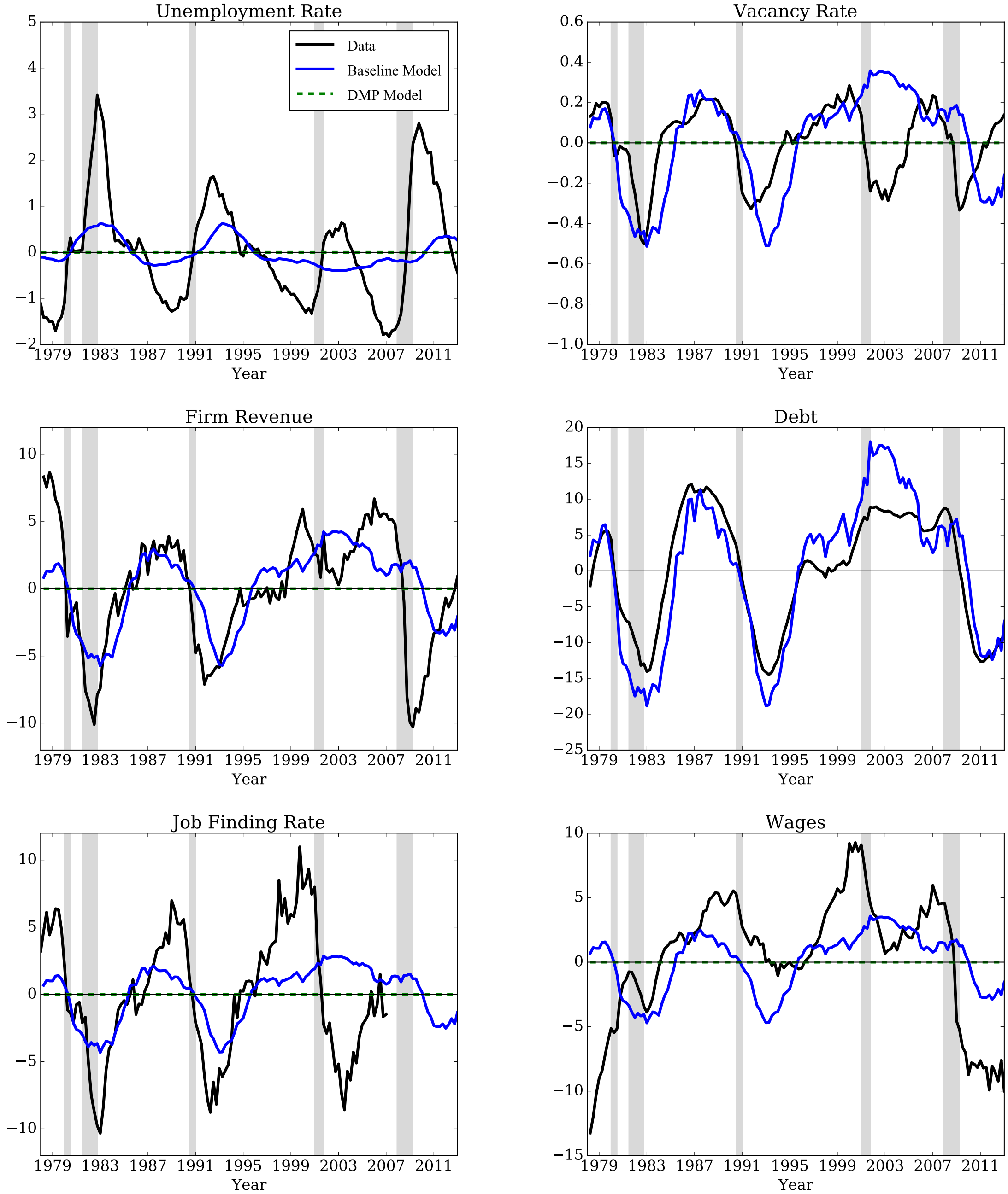


Figure 8: Aggregate productivity shocks.



Notes: All series have been logged then detrended with the Hodrick-Prescott filter with a smoothing parameter of 100,000. Data on the unemployment rate is the civilian unemployment rate (FRED Series: UNRATE). Vacancies correspond tot he composite Help-Wanted Index calculated in Barnichon (2010). Revenue corresponds to retail trade sales given by the OECD Main Economic Indicators (FRED Series: SLRTTO02USA189N). Debt is given as total consumer credit outstanding from the Federal Reserve Board's Flow of Funds, Table B.100 (FRED Series: TOTALSL). The job finding rate was constructed by Robert Shimer. For additional details please see Shimer (2012). Wages correspond to total compensation of employees from the BEA (FRED Series: A576RC1). NBER recessions are shown in grey.

Figure 9: Aggregate financial shocks.



Notes: All series have been logged then detrended with the Hodrick-Prescott filter with a smoothing parameter of 100,000. Data on the unemployment rate is the civilian unemployment rate (FRED Series: UNRATE). Vacancies correspond tot he composite Help-Wanted Index calculated in Barnichon (2010). Revenue corresponds to retail trade sales given by the OECD Main Economic Indicators (FRED Series: SLRTTO02USA189N). Debt is given as total consumer credit outstanding from the Federal Reserve Board's Flow of Funds, Table B.100 (FRED Series: TOTALSL). The job finding rate was constructed by Robert Shimer. For additional details please see Shimer (2012). Wages correspond to total compensation of employees from the BEA (FRED Series: A576RC1). NBER recessions are shown in grey.

Table 1: Unemployment and Consumer Credit, 2007-2009

	(1) 2007	(2) 2009	(3) Difference (2)-(1)
Consumer Debt ($)	4,780	5,441	661*
	(150)	(340)	
Credit Card Debt ($)	2,438	2,226	-212
	(113)	(113)	
Auto Debt ($)	2,513	3,086	573*
	(97)	(283)	
Credit Card {0,1}	0.67	0.62	-0.43***
	(0.01)	(0.01)	
CC Monthly Charges ($)	447	393	-54**
	(16.5)	(14.4)	
CC Debt Limit ($1,000)	15.74	14.50	-1.24*
	(0.52)	(0.48)	
Applied	0.63	0.43	-0.20***
	(0.01)	(0.01)	
Denied | Applied	0.21	0.27	0.06***
	(0.01)	(0.01)	
Income ($1000)	44.72	42.82	-1.90*
	(0.61)	(0.61)	
Weekly Hours	29.96	25.64	-4.32***
	(0.34)	(0.34)	
Observations	764	764	

Note: Significance levels: *** $p < 0.01$, ** $p < 0.05$, *$p < 0.1$. Observations are weighted using SCF 2007-2009 probability weights. The sample consists of all primary economic units (PEUs) that were single in both 2007 and 2009 and were employed in 2007. Dollar values represent real 2007 dollars adjusted using the CPI.

Table 2: Balancing Test, Pre-Treatment 2007

	(1) $EU = 0$	(2) $EU = 1$	(3) Difference (2)-(1)
Individual Characteristics			
Male	0.34	0.33	-0.01
	(0.01)	(0.03)	
Black	0.20	0.23	0.03
	(0.01)	(0.03)	
Age	48.0	43.1	-4.88***
	(0.25)	(0.77)	
High School	0.41	0.39	-0.02
	(0.01)	(0.03)	
Some College	0.22	0.19	-0.03
	(0.01)	(0.02)	
College Degree	0.37	0.42	0.05*
	(0.01)	(0.03)	
Outcome Variables			
Consumer Debt ($)	4,711	5,525	814
	(148)	(784)	
Credit Card Debt ($)	2,457	3,304	946
	(102)	(756)	
Auto Debt ($)	2,540	2,221	-319
	(102)	(305)	
Credit Card {0,1}	0.67	0.65	-0.02
	(0.01)	(0.03)	
CC Monthly Charges {0,1}	0.53	0.58	0.05
	(0.01)	(0.03)	
CC Monthly Charges ($)	441	507	66.4
	(16.1)	(89.1)	
CC Debt Limit ($1,000)	16.20	10.75	-5.45***
	(0.56)	(1.08)	
Applied	0.64	0.56	-0.08**
	(0.01)	(0.01)	
Denied $\mid$ Applied	0.21	0.20	-0.01
	(0.01)	(0.03)	
Income ($1000)	45.43	37.10	-8.33***
	(0.76)	(2.36)	
Labor Income ($1000)	28.43	27.85	-0.47
	(0.66)	(2.03)	
Weekly Hours	29.42	35.87	6.45***
	(0.37)	(1.09)	
Observations	703	703	

Note: Significance levels: *** $p < 0.01$, ** $p < 0.05$, *$p < 0.1$. Observations are weighted using SCF 2007-2009 probability weights. The sample consists of all primary economic units (PEUs) that were single in both 2007 and 2009 and were employed in 2007. Dollar values represent real 2007 dollars adjusted using the CPI.

Table 3: Impact of Unemployment on Changes in Consumer Debt, 2007-2009

	(1)	(2)	(3)
	ΔConsumer Debt ($)	ΔCredit Card Debt ($)	ΔAuto Debt ($)
EU$\times \mathbb{I}\{t = 2009\}$	-2,809**	-2,504***	-173
	(941)	(771)	(550)
Observations	1528	1528	1528
R^2	0.01	0.03	0.03
Demographic Controls	Y	Y	Y

Note: Significance levels: *** $p < 0.01$, ** $p < 0.05$, *$p < 0.1$. Observations are weighted using SCF 2007-2009 probability weights. The sample consists of all primary economic units (PEUs) that were single in both 2007 and 2009 and were employed in 2007. The omitted group consists of white college graduates in 2007 that maintained employment in 2009. Dollar values represent real 2007 dollars adjusted using the CPI.

Table 4: Impact of Unemployment on Credit Card Use, 2007-2009

	(1)	(2)	(3)
	ΔCredit Card {0,1}	ΔCC Charges {0,1}	ΔCC Charges ($)
EU$\times \mathbb{I}\{t = 2009\}$	-0.06***	-0.15***	-250*
	(0.04)	(0.04)	(89.5)
Observations	1528	1528	1528
R^2	0.20	0.18	0.07
Demographic Controls	Y	Y	Y

Note: Significance levels: *** $p < 0.01$, ** $p < 0.05$, *$p < 0.1$. Observations are weighted using SCF 2007-2009 probability weights. The sample consists of all primary economic units (PEUs) that were single in both 2007 and 2009 and were employed in 2007. The omitted group consists of white college graduates in 2007 that maintained employment in 2009. Dollar values represent real 2007 dollars adjusted using the CPI.

Table 5: Impact of Unemployment on Credit Applications and Denials, 2007-2009

	(1)	(2)	(3)	(4)
	ΔApplied(A)	ΔDenied(D)|A	$\Delta D_{Credit}\|A$	$\Delta D_{Emp./Inc.}\|A$
$EU \times \mathbb{I}\{t = 2009\}$	0.14***	0.05***	-0.07	0.07**
	(0.04)	(0.02)	(0.05)	(0.03)
Observations	1528	822	822	822
R^2	0.10	0.08	0.07	0.02
Demo. Controls	Y	Y	Y	Y

Note: Significance levels: *** $p < 0.01$, ** $p < 0.05$, *$p < 0.1$. Observations are weighted using SCF 2007-2009 probability weights. The sample consists of all primary economic units (PEUs) that were single in both 2007 and 2009 and were employed in 2007. The omitted group consists of white college graduates in 2007 that maintained employment in 2009. Dollar values represent real 2007 dollars adjusted using the CPI.

Table 6: Impact of Unemployment on Income and Assets, 2007-2009

	(1)	(2)	(3)	(4)
	ΔIncome	ΔUnemp. Benefits	ΔLiquid Assets	ΔNo Liquid Assets {0,1}
$EU \times \mathbb{I}\{t = 2009\}$	-20,000***	1,188***	-5,292*	0.15***
	(2,957)	(212)	(3,184)	(0.03)
Observations	1528	1528	1528	1528
R^2	0.20	0.18	0.07	0.07
Demographic Controls	Y	Y	Y	Y

Note: Significance levels: *** $p < 0.01$, ** $p < 0.05$, *$p < 0.1$. Observations are weighted using SCF 2007-2009 probability weights. The sample consists of all primary economic units (PEUs) that were single in both 2007 and 2009 and were employed in 2007. The omitted group consists of white college graduates in 2007 that maintained employment in 2009. Dollar values represent real 2007 dollars adjusted using the CPI.

Table 7: Functional Forms and Stochastic Processes

labor market matching	$m(s,o) = \frac{so}{(s^{\eta_L}+o^{\eta_L})^{1/\eta_L}}$
goods market matching	$\alpha(n) = n$
DM utility	$u(y) = \Gamma\frac{y^{1-\gamma}}{1-\gamma}$
aggreagte productivity	$\hat{\hat{z}}_{t+1} = \rho_z \hat{z}_t + \epsilon_{z,t}$ where $\epsilon_{z,t} \sim N(0, \sigma_z^2)$
aggregate financial frictions	$\hat{\nu}_{t+1} = \rho_\nu \hat{\nu}_t + \epsilon_{\nu,t}$ where $\epsilon_{\nu,t} \sim N(0, \sigma_] nu^2)$

Table 8: Calibration Summary: Parameters and Stochastic Steady State Targets

Description	Value	Source/Target
Labor Market Parameters		
matching curvature, η_L	1.600	Schaal (2015)
separation rate, δ	0.034	10% quarterly job destruction rate
vacancy posting costs, k	1.889	7% unemployment rate
labor bargaining weight, λ	0.500	normalization
utility from leisure, ℓ	0.591	Hall and Milgrom (2008)
unemployment income, b	0.710	average decline in credit upon job loss, estimated in Section 2, SCF
Goods/Credit Market Parameters		
mean of labor productivity, μ_z	1.000	normalization
persistence of labor productivity, ρ_z	0.962	output per job, BLS
s.d. of labor productivity shock, σ_z	0.0075	output per job, BLS
mean of agg. financial conditions, μ_ν	0.928	FRB Z.1 Flow of Funds
persistence of agg. financial conditions, ρ_ν	0.987	FRB Z.1 Flow of Funds
s.d. of agg. financial conditions, σ_ν	0.017	FRB Z.1 Flow of Funds
utility curvature, γ	0.590	MPC out of credit limit, Gross and Souleles (2002)

6.2 Wage equation

From (16), we can write $V_t(1)$ and $V_t(0)$ combining (5) and (22) as

$$V_t(1) = \alpha(n_t)\mu[v(y_t^1) - y_t^1] + w_t + \beta\big[(1-\delta)V_{t+1}(1) + \delta V_{t+1}(0)\big] \quad (39)$$

$$V_t(0) = \alpha(n_t)\mu[v(y_t^0) - y_t^0] + (\ell + b) + \beta[p(\theta_t)V_{t+1}(1) + (1 - p(\theta_t))V_{t+1}(0)]. \quad (40)$$

Subtracting $V_t(0)$ from $V_t(1)$ in (39) obtains the surplus of an employed worker

$$\begin{aligned} V_t(1) - V_t(0) = \alpha(n_t)\mu\big\{[v(y_t^1) - y_t^1] - [v(y_t^0) - y_t^0]\big\} + w_t - (\ell + b) \\ +\beta(1 - \delta - p(\theta_t))[V_{t+1}(1) - V_{t+1}(0)]. \end{aligned} \quad (41)$$

From (26) and the free entry condition $k = \beta f(\theta_t)J_{t+1}$, we can write (41) as

$$\begin{aligned} V_t(1) - V_t(0) = \alpha(n_t)\mu\big\{[v(y_t^1) - y_t^1] - [v(y_t^0) - y_t^0]\big\} + w_t - (\ell + b) \\ +(1 - \delta - p(\theta_t))\frac{\lambda}{1-\lambda}\frac{k}{f(\theta_t)}. \end{aligned} \quad (42)$$

Similarly, from (25), (26), and the free entry condition we can write the value of a filled job as

$$J_t = z_t - w_t + (1-\delta)\frac{k}{f(\theta_t)}. \quad (43)$$

Combining (42) and (43) using (26) we obtain

$$(1-\lambda)[\alpha(n_t)\mu\big\{[v(y_t^1) - y_t^1] - [v(y_t^0) - y_t^0]\big\} + w_t - (\ell + b)] = \lambda[z_t - w_t + \theta_t k], \quad (44)$$

where we have used the result that $p(\theta_t) = \theta_t f(\theta_t)$. Rearranging (44) yields the wage equation (27)

$$w_t = \lambda[z_t(w_t) + \theta_t k] + (1-\lambda)(b + \ell - \alpha(n_t)\mu[S^1(w_t) - S^0]) = \Gamma_t(w_t). \quad (45)$$

6.3 Proofs of Lemmas and Propositions

Proof of Lemma 2: Part (i): Taking the derivative with respect to θ in (31) we have

$$\frac{\partial S^f}{\partial \theta} = -\lambda k + \frac{(1-\lambda)\alpha(n)\nu[v'(y^1)-1]}{(1-\mu)v'(y^1)+\mu}\frac{\partial w}{\partial \theta} \tag{46}$$

Taking derivative of (29) with respect to θ yields

$$\frac{\partial w}{\partial \theta} = \frac{\lambda k}{1-(\lambda-\mu)\alpha(n)\frac{\nu[v'(y^1)-1]}{(1-\mu)v'(y^1)+\mu}} \tag{47}$$

Evaluated at the equilibrium wage, the denominator in (47) is positive, hence $\partial w/\partial \theta > 0$. Let $\partial S^1/\partial w = nu[v'(y^1)-1]/[(1-\mu)v'(y^1)+\mu]$. Combining (46) and (47) we can write $\partial S^f/\partial \theta$ as

$$\frac{\partial S^f}{\partial \theta} = -\lambda k \frac{1-(1-\mu)\alpha(n)\partial S^1/\partial w}{1-(\lambda-\mu)\alpha(n)\partial S^1/\partial w} \tag{48}$$

The sign of (48) depends on the magnitude of $\partial S^1/\partial w$. Its maximum value is $\nu\mu/(1-\mu)$ when $y^1 = 0$. Since $(1-\mu)\alpha(n)\nu\mu/(1-\mu) \leq 1$, then $\partial S^f/\partial \theta \leq 0$ for any n.

Part (ii and iii): Taking the derivative with respect to n in (31) yields

$$\frac{\partial S^f}{\partial n} = (1-\lambda)\alpha'(n)[S^1 - S^0] + (1-\lambda)(1-\mu)\xi S^0 + (1-\lambda)\alpha(n)\frac{\partial S^1}{\partial w}\frac{\partial w}{\partial n} \tag{49}$$

where $\xi = \frac{\alpha'(n)n-\alpha(n)}{n^2} < 0$. If $S^0 = 0$ the result in part (ii) immediately follows. Taking the derivative of (29) with respect to n yields.

$$\frac{\partial w}{\partial n} = \frac{(\lambda-\mu)\alpha'(n)S^1 + \lambda(1-\mu)\xi S^0}{1-(\lambda-\mu)\alpha(n)\partial S^1/\partial w} \tag{50}$$

The sign of the denominator is positive at the equilibrium wage. However, the sign of the numerator is ambiguous since $\xi < 0$. Plugging (50) into (49) yields

$$\frac{\partial S^f}{\partial n} = (1-\lambda)\alpha'(n)[S^1 - S^0] + (1-\lambda)(1-\mu)\xi S^0 + \frac{(1-\lambda)\alpha(n)(\lambda-\mu)\alpha'(n)S^1\frac{\partial S^1}{\partial w} + (1-\lambda)\lambda(1-\mu)\xi\alpha(n)S^0\frac{\partial S^1}{\partial w}}{1-(\lambda-\mu)\alpha(n)\partial S^1/\partial w} \tag{51}$$

Proof of Lemma ??: From Lemma 2, we know $\partial S^f/\partial\theta \leq 0$ which implies $\partial S^f/\partial J \leq 0$. Let $\bar{S}_t$ be the solution to $S^f(1-u, 0)$. From (31), $\bar{S}_f > 0$ for any u. Since the right-hand side of (**??**) is strictly increasing and crosses through the origin, there exists a unique fixed point of the problem. Further since S^f is bounded below by $(1-\lambda)(\bar{z}-\ell) - \lambda\theta k$, $J^* > J^{DMP}$.

6.4 Continuous Time Derivation

To derive equation (**??**), consider the law of motion for unemployment, (32), over a period of time from t to $t+\Delta$, for $\Delta \in (0,1]$. Over a period of Δ, an unemployed worker matches with a firm in the LM with probability $p(\theta_t)\Delta$ and an employed worker separations with probability $\delta\Delta$. Hence (32) becomes

$$u_{t+\Delta} = [1 - p(\theta_t)\Delta]u_t + \delta\Delta(1-u_t). \tag{52}$$

The limit as $\Delta \to 0$ is (**??**). To derive (**??**), consider (30) from t to $t+\Delta$. Firms match with households in the DM with probability $\alpha(n_t)\Delta/n_t$, pay wages $w_t\Delta$, and entry costs $k\Delta$. Hence, (30) becomes

$$J_t = S^f(n_t, \theta_t) + \frac{(1-\delta\Delta)}{1+r\Delta}J_{t+\Delta} \tag{53}$$

where the discount factor over a period of length Δ is given by $1/(1+r\Delta)$. The limit as $\Delta \to 0$ is (**??**).

6.5 Data Appendix

6.5.1 Survey of Consumer Finances, 2007-2009 'Denied' Variable Definitions

Denied because of credit related reasons includes households that were told they haven't established a credit history, credit rating service reports, credit records/history from another institution, bankruptcy, amounts of debt, size of other payments, or ability to repay loan too high, insufficient credit references, or other credit characteristics of the borrower.

Denied because of asset related reasons includes lack of assets, collateral, property to secure the loan or insufficient collateral or equity.

Denied because of income related reason includes lack of assets, collateral or property to secure the loan, time on current job, the type of job or work (i.e. steady or secure, a good job), lack of job or not working, amount of income or the source of income for retired households, and any other financial characteristics of the household.

7 Supplementary Appendix:

7.1 Additional Results on Unemployment and Consumer Credit Access and Use in Baseline Sample

Table 9: Impact of Unemployment on Credit Card Use, 2007-2009 continued

	(1) ΔNo. of Cards	(2) ΔCC Debt to Income
EU$\times\mathbb{I}\{t = 2009\}$	-0.284*	-0.038***
	(0.173)	(0.013)
Observations	1528	1528
R^2	0.20	0.16
Demographic Controls	Y	Y

Note: Significance levels: *** $p < 0.01$, ** $p < 0.05$, *$p < 0.1$. Observations are weighted using SCF 2007-2009 probability weights. The sample consists of all primary economic units (PEUs) that were single in both 2007 and 2009 and were employed in 2007. The omitted group consists of white college graduates in 2007 that maintained employment in 2009. Dollar values represent real 2007 dollars adjusted using the CPI.

Table 10: Impact of Unemployment on Credit Card Debt Limits, 2007-2009

	(1) ΔCC Debt Limit ($)	(2) ΔCC Debt Limit to Income	(3) ΔDebt Limit per Card ($)
EU×$\mathbb{I}\{t = 2009\}$	-924.5	-0.097	171.3
	(1,333)	(0.160)	(361.8)
Observations	1528	1528	1528
R^2	0.18	0.042	0.21
Demographic Controls	Y	Y	Y

Note: Significance levels: *** $p < 0.01$, ** $p < 0.05$, *$p < 0.1$. Observations are weighted using SCF 2007-2009 probability weights. The sample consists of all primary economic units (PEUs) that were single in both 2007 and 2009 and were employed in 2007. The omitted group consists of white college graduates in 2007 that maintained employment in 2009. Dollar values represent real 2007 dollars adjusted using the CPI.

7.2 Robustness: Sample of all heads of household

Table 11: Impact of Unemployment on Changes in Consumer Debt, 2007-2009

	(1) ΔConsumer Debt ($)	(2) ΔCredit Card Debt ($)	(3) ΔAuto Debt ($)
EU×$\mathbb{I}\{t = 2009\}$	-3,691***	-1,938***	-1,522***
	(894)	(623)	(558)
Observations	2687	2687	2687
R^2	0.03	0.02	0.01
Demographic Controls	Y	Y	Y

Note: Significance levels: *** $p < 0.01$, ** $p < 0.05$, *$p < 0.1$. Observations are weighted using SCF 2007-2009 probability weights. The sample consists of all heads of primary economic units (PEUs) that were were employed in 2007. The omitted group consists of white college graduates in 2007 that maintained employment in 2009. Dollar values represent real 2007 dollars adjusted using the CPI. Controls include demographics and household size.

Table 12: Impact of Unemployment on Credit Card Use, 2007-2009

	(1)	(2)	(3)
	ΔCredit Card {0,1}	ΔCC Charges {0,1}	ΔCC Charges ($)
EU$\times\mathbb{I}\{t = 2009\}$	-0.09***	-0.15***	-128**
	(0.02)	(0.03)	(58.6)
Observations	2687	2687	2687
R^2	0.18	0.17	0.09
Demographic Controls	Y	Y	Y

Note: Significance levels: *** $p < 0.01$, ** $p < 0.05$, *$p < 0.1$. Observations are weighted using SCF 2007-2009 probability weights. The sample consists of all heads of primary economic units (PEUs) that were were employed in 2007. The omitted group consists of white college graduates in 2007 that maintained employment in 2009. Dollar values represent real 2007 dollars adjusted using the CPI. Controls include demographics and household size.

Table 13: Impact of Unemployment on Credit Applications and Denials, 2007-2009

	(1)	(2)	(3)	(4)
	ΔApplied(A)	ΔDenied(D)$\|$A	$\Delta D_{Credit}\|A$	$\Delta D_{Emp./Inc.}\|A$
EU$\times\mathbb{I}\{t = 2009\}$	0.02	-0.07**	-0.05*	0.002
	(0.03)	(0.02)	(0.03)	(0.002)
Observations	2687	1717	1717	1717
R^2	0.11	0.09	0.08	0.02
Demo. Controls	Y	Y	Y	Y

Note: Significance levels: *** $p < 0.01$, ** $p < 0.05$, *$p < 0.1$. Observations are weighted using SCF 2007-2009 probability weights. The sample consists of all heads of primary economic units (PEUs) that were were employed in 2007. The omitted group consists of white college graduates in 2007 that maintained employment in 2009. Dollar values represent real 2007 dollars adjusted using the CPI. Controls include demographics and household size.

Table 14: Impact of Unemployment on Income and Assets, 2007-2009

	(1)	(2)	(3)	(4)
	ΔIncome	ΔUnemp. Benefits	ΔLiquid Assets	ΔNo Liquid Assets {0,1}
EU$\times\mathbb{I}\{t = 2009\}$	-27,451***	1,763***	-1,801	0.07***
	(2,408)	(183)	(2,657)	(0.02)
Observations	1528	1528	1528	1528
R^2	0.03	0.05	0.03	0.11
Demographic Controls	Y	Y	Y	Y

Note: Significance levels: *** $p < 0.01$, ** $p < 0.05$, *$p < 0.1$. Observations are weighted using SCF 2007-2009 probability weights. The sample consists of all heads of primary economic units (PEUs) that were were employed in 2007. The omitted group consists of white college graduates in 2007 that maintained employment in 2009. Dollar values represent real 2007 dollars adjusted using the CPI. Controls include demographics and household size.