Anatomy of a Credit Crunch: from Capital to Labor Markets

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Abstract

Why are financial crises associated with a sustained rise in unemployment? In this paper we provide a tractable model that integrates credit and labor market frictions, and use it to study the aggregate and micro-implications of a credit crunch, modeled as a tightening of collateral constraints. In the model, the credit crunch, calibrated to match the observed decline in the stock of credit market debt to non-financial assets of the US business sector following the 2008 crisis, leads to a sharp decline in output, explained by a drop in TFP and investment, and a protracted increase in unemployment. We then explore the micro-level consequences of the credit shock, tracking the dynamics employment across firms conditional on size, age, and size-age. We find that credit crunches are associated with a reduction in the net employment growth rates of young-small establishments relative to old-large producers, which is consistent with the empirical findings in the literature.

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1 Introduction

Financial crises are associated with severe economic contractions, and in particular, with sharp deteriorations of labor market outcomes. The experience during the Great Depression and the 2007-8 recession and financial crisis are dramatic examples of these events. The evidence in Reinhart and Rogoff (2009) provides a broader picture of related phenomena. Despite the close connection between financial crisis and sustained rise in unemployment, there are very few attempts at integrating models with credit and labor market frictions. This is the goal of this paper.

We build a model where production is done by entrepreneurs that are heterogeneous with respect to their net-worth and total factor productivity, with the former being endogenously determined by their saving decisions. Entrepreneurs rent capital and labor from competitive factor markets, subject to a collateral constraint that limits the amount of capital invested to be proportional to their financial wealth. We assume that there is a centralized labor market where hiring entrepreneurs compete for available unemployed workers. The arrival of unemployed workers to this centralized hiring market is where the labor market frictions are, and is modeled with a simple matching function, which maps the number of unemployed individuals and an aggregate of the hiring investments by entrepreneurs to the number of unemployed workers reaching this hiring market. Depending on their wealth and productivity, individuals choose to be entrepreneurs or to participate in the frictional labor market.

We use a quantitative version of our theory to trace out the effects of a credit crunch, modeled as a tightening of the collateral constraint. In the model, the tightening in the collateral constraint leads to a sharp decline in output, explained by a sharp drop in TFP, a smaller decline in investment, and a protracted increase in unemployment. The credit contractions result in a reallocation of capital from entrepreneurs with low collateral, relative to their unconstrained level of capital, towards unconstrained entrepreneurs. The reallocation of credit and capital is accompanied by a reallocation of labor across entrepreneurs, a process that is gradually mediated by the matching function. In this process, resources tend to be reallocated from productive but constrained entrepreneurs towards those who are unconstrained and relatively unproductive. As a result, the aggregate TFP declines. The gradual reallocation of labor through the frictional labor market results in a protracted rise in unemployment.

We also explore the behavior of the economy when subjected to an aggregate TFP shock. We find that the implications for the dynamics of unemployment during such shock are different from those of a credit crunch: the unemployment rate does not change at all. The reason is that unlike a decline in aggregate productivity, which affects capital and labor demand decisions of all firms equally, credit shocks have idiosyncratic effects on labor and capital depending on the entrepreneur’s ability and wealth. Thus, while in the former the flexibility of wages and interest rates offset fully the contractionary effect of productivity on labor, the heterogeneous
response of firm-level decisions when credit conditions tighten prevent the reduction in wages from achieving the same outcome. It is the re-allocative nature of credit shocks that is essential for its implication for unemployment.

The reminder of our quantitative analysis focuses on exploring the implications of a credit crunch for employment dynamics at the level of the firm. A large empirical literature emerged documenting that financial crisis affect firms differently depending on size. The working hypothesis in these studies is that small business are more heavily reliant on credit to finance their productive activities and capital expenditures, and hence should be more cyclically responsive during recessions that are driven by credit contractions. Gertler and Gilchrist (1994) found evidence supporting this claim, and more recently Fort, Haltiwanger, Jarmin and Miranda (2012) extended the analysis to highlight the role of age, as well as size, in assessing the cyclical behavior of firms: during a credit crunch, employment growth in young/small business declines relative to that of old/large establishments. Our goal is to provide a theoretical underpinning to the working hypothesis in the empirical literature, and understand how the aggregate behavior of the economy is shaped by the responses at the level of the firm.

Our results are in line with the findings in empirical studies. We show quantitatively that net employment growth rates fall for the group of young and small entrepreneurs relative to the old and large, in reflection of the reallocation of factors that occurs in equilibrium from constrained to unconstrained entrepreneurs. By exploring the steady state properties of the distribution of firms over ages and sizes, we uncover that this is explained by the fact that about 90% of the firms are financially constrained in the young and small group, compared to just 10% in the old and large one. This information manifests itself in the distribution of the rates of return to capital across groups, which shows an excess return of 8% in the former group relative to the latter, deviating from the equalization of rates of returns across firms that is prescribed by the frictionless allocation.

**Related Literature** To be written.

**2 Model**

We model an economy populated by a continuum of individuals, who are heterogeneous with respect to their wealth \( a \), entrepreneurial productivity \( z \), and access to employment opportunity. In each period, an individual who has an employment opportunity chooses whether to work for a wage or to operate an individual-specific technology (entrepreneurship). One that does not have an employment opportunity can choose between searching for a job and operating his individual-specific technology.

Access to capital is limited by entrepreneurs’ wealth through a simple collateral constraint, motivated by the imperfect enforceability of capital rental contracts. One entrepreneur can
operate only one production unit (establishment) in a given period. Entrepreneurial ideas are inalienable, and there is no market for managers or entrepreneurial talent.

We assume that there is a centralized labor market where hiring entrepreneurs compete for available unemployed workers. The arrival of unemployed workers to the centralized hiring market is modeled with a simple matching function, whose inputs are the number of the unemployed and the recruiting investments of entrepreneurs. We restrict wage contracts to be the same across workers and entrepreneurs. Workers are paid in each period the wage that clears the current hiring market, and entrepreneurs may terminate the employment relationship at any time. We also consider the case where wages have downward rigidity.

**Heterogeneity and Demographics** Individuals live indefinitely, and are heterogeneous in their wealth $a$, entrepreneurial productivity $z \in Z$, and employment opportunity. Their wealth is chosen endogenously by forward-looking saving decisions, and their entrepreneurial ability follows a stochastic process. In particular, an individual retains his ability from one period to the next with probability $\psi$. With probability $1 - \psi$, he loses the current ability and has to draw a new entrepreneurial ability. The new draw is from a time-invariant ability distribution, whose cumulative density is $\mu(z)$, and is independent of his previous ability level. One can think of the ability shock as an arrival of a new technology making existing production processes obsolete or less profitable.

In the following analysis, we maintain the assumptions that unemployed workers receive unemployment benefits that are equal to the market wage in each period, and that leisure does not enter the utility function. As a result, individuals are indifferent between being employed as a worker and being unemployed, and we will abstract from this dimension of ex-post heterogeneity in writing down the individual problems. However, the number of the unemployed is an important variable for the equilibrium definition and the aggregate dynamics of the model.

The population size of the economy is normalized to 1, and there is no population growth.

**Preferences** Individual preferences are described by the following expected utility function over sequences of consumption, $c_t$:

$$U(c) = \mathbb{E}\left[\sum_{t=0}^{\infty} \beta^t u(c_t)\right], \quad u(c_t) = \frac{c_t^{1-\sigma}}{1-\sigma}$$

where $\beta$ is the discount factor, and $\sigma$ is the coefficient of relative risk aversion. The expectation is over the realizations of the entrepreneurial productivity $z$. 

Technologies and Occupational Choice  At the beginning of each period, an individual chooses whether to operate his own business or not. If not, he either works for the market wage \( w_t \), if he has an employment opportunity, or searches for a job, if unemployed. An entrepreneur with talent \( z \) produces using capital \( k \) and labor \( l \) according to:

\[
zf(k, l) = zk^\alpha l^\theta,
\]

where \( \alpha \) and \( \theta \) are the elasticities of output with respect to capital and labor, and \( \alpha + \theta < 1 \), implying diminishing returns to scale in variable factors at the establishment level.

Taxes and Unemployment Subsidies  We assume that unemployed individuals receive a transfer equal to the period wage, which is financed with a lump-sum tax \( \tau_t \) on all individuals. Given this assumption, from an individual’s point of view, there is no difference between being a wage earner and being unemployed. This allows us to think of individuals as belonging to one of two mutually exclusive states: a (employed/unemployed) worker or an entrepreneur.

Financial Markets  Productive capital is the only asset in the economy. There is a perfectly-competitive financial intermediary that receives deposits, and rents out capital to entrepreneurs. The return on deposited assets—i.e. the interest rate in the economy—is \( r_t \). The zero-profit condition of the intermediary implies that the rental price of capital is \( r_t + \delta \), where \( \delta \) is the depreciation rate.

We assume that entrepreneurs’ capital rental \( k \) is limited by a collateral constraint \( k \leq \lambda a \), where \( a \geq 0 \) is individual financial wealth and \( \lambda \) measures the degree of credit frictions, with \( \lambda = +\infty \) corresponding to perfect credit markets and \( \lambda = 1 \) to financial autarky where all capital has to be self-financed by entrepreneurs. The same \( \lambda \) applies to everyone in a given economy.

Our specification captures the common prediction from models of limited contract enforcement: The amount of credit is limited by individuals’ wealth. At the same time, its parsimoniousness—the fact that financial frictions are captured by one single parameter, \( \lambda \) enables us to analyze the quantitative effects of financial frictions on aggregate transitional dynamics without losing tractability.\(^1\)

\(^1\)Our collateral constraint can be derived from the following limited enforcement problem. Consider an individual with financial wealth \( a \geq 0 \) deposited in the financial intermediary at the beginning of a period. Assume that he rents \( k \) units of capital. Then he can abscond with fraction \( 1/\lambda \) of the rented capital. The only punishment is that he will lose his financial wealth \( a \) deposited in the intermediary. In particular, he will not be excluded from any economic activity in the future. In fact, he is allowed to instantaneously deposit the stolen capital \( k/\lambda \) and continue on as a worker or an entrepreneur. Note that \( \lambda \) in this context measures the degree of capital rental contract enforcement, with \( \lambda = +\infty \) corresponding to perfect enforcement and \( \lambda = 1 \) to no enforcement. In the equilibrium, the financial intermediary will rent capital only to the extent that no individual will renege on the rental contract, which implies a collateral constraint \( k/\lambda \leq a \) or \( k \leq \lambda a \).
**Labor Market** Entrepreneurs hire workers in a centralized and competitive labor market. We restrict labor contracts that entrepreneurs can offer to have the following properties: (1) they pay the wage that clears the hiring market in each period, and (2) the employer may terminate the employment relationship at any time. Laid-off workers become unemployed. In particular, all entrepreneurs, irrespective of their current state, are restricted to offer the same labor contract. In addition, to hire additional workers, entrepreneurs must pay a constant cost $v$, that can be interpreted as a training cost.\(^2\)

We assume that there are frictions in bringing unemployed workers into the centralized hiring market. For those who reach the centralized hiring market, there is no further friction. To be more specific, we assume that the number of unemployed workers that reach the hiring market and hence get matched with hiring firms in a period is a constant-returns-to-scale function of the stock of unemployed workers $U_t$ and the aggregate hiring investments, $V_t$,

$$M_t = \gamma U_t^\phi V_t^{1-\phi}$$

where

$$V_t = v \int \max \{l_t(a_t,l_{t-1},z_t) - l_{t-1}, 0\} G_t(da_t,dl_{t-1},dz_t).$$  \(1\)

Giving the matching function and the firing decision of entrepreneurs, the evolution of unemployment is governed by

$$U_{t+1} = U_t - \gamma U_t^\phi V_t^{1-\phi} + \int \max \{l_{t-1} - l_t(a_t,l_{t-1},z_t), 0\} G_t(da_t,dl_{t-1},dz_t).$$  \(2\)

Here $l_t$ denotes the number of employees an entrepreneur hires in period $t$. For an individual choosing to be a (employed/unemployed) worker, we let $l_t = -1$.

### 2.1 Individual’s Problem

At the beginning of a period, an individual’s state is summarized by his financial wealth $a$, the number of employees he carries over from the previous period $l_{t-1}$ (a positive number if and only if previously an entrepreneur), and entrepreneurial productivity $z$. The value for him at this stage, $v_t(a,l_{t-1},z)$, is the maximum over the value of being a wage earner, $v_t^W(a,z)$, and the value of being an entrepreneur, $v_t^E(a,l_{t-1},z)$:\(^3\)

\(^2\)Our modeling of the labor market follows closely, without incriminating them, Alvarez and Veracierto (2001). Our model can also be interpreted as a simplified version of the Walrasian equilibrium theory of establishment dynamics and matching frictions in Veracierto (2009).

\(^3\)The state of an individual is also described by his access to an employment opportunity $e \in \{0,1\}$. However, by assuming that unemployed individuals receive a transfer equal to the period’s wage, we make this information irrelevant for an individual’s problem.
\[ v_t(a, l_{-1}, z) = \max \{ v^W_t(a, z), v^E_t(a, l_{-1}, z) \} \]  

Note that the value of being a worker depends on his wealth and entrepreneurial idea, which might be implemented in a latter date, but it does not depend on the number of the employees he may have at the beginning of the period.

As a worker, an individual chooses consumption \( c \) and the next period’s assets \( a' \) to maximize his continuation value, subject to the period budget constraint

\[ v^W_t(a, z) = \max_{c,a'} u(c) + \beta E[v_{t+1}(a', -1, z')] \]  

s.t.

\[ c + a' = w_t + (1 + r_t) a - \tau_t \]

Alternatively, individuals can choose to be entrepreneurs. The value function of being an entrepreneur is as follows:

\[ v^E_t(a, l_{-1}, z) = \max_{c,k,l,a'} u(c) + \beta E[v_{t+1}(a', l, z')] \]  

s.t.

\[ a' + c = zk^\alpha \lambda^\theta - w_t l - v \max \{ l - l_{-1}, 0 \} - (r_t + \delta) k + (1 + r_t) a - \tau_t \]

and

\[ k \leq \lambda_t a \]

The occupation choice of an individual is denoted by \( a_t(a, l_{-1}, z) \in \{ W, E \} \).

### 2.2 Competitive Equilibrium

Given an initial distribution of individual wealth, the number of employees carried over from the previous period, and entrepreneurial productivity \( G_0(a, l_{-1}, z) \) and a sequence of collateral constraints \( \{ \lambda_t \}_{t=0}^\infty \), a competitive equilibrium is given by sequences of distributions \( \{ G_t(a, l_{-1}, z) \}_{t=0}^\infty \), allocations \( \{ c_t(a, l_{-1}, z), a_{t+1}(a, l_{-1}, z), k_t(a, l_{-1}, z), l_t(a, l_{-1}, z), o_t(a, l_{-1}, z) \}_{t=0}^\infty \), aggregate hiring investment and unemployment \( \{ V_t, U_t \}_{t=0}^\infty \), and prices \( \{ w_t, r_t \}_{t=0}^\infty \) such that:

1. Given prices \( \{ w_t, r_t \}_{t=0}^\infty \) individual decisions solve (3), (4), and (5) for all \( t \geq 0 \);
2. Aggregate hiring investment and unemployment are given by (1) and (2);
3. The government budget is balanced for all $t \geq 0$

$$\tau_t = w_t U_t;$$

4. Capital market clears at all $t \geq 0$:

$$\int k_t (a, l_{-1}, z) G_t (da, dl_{-1}, dz) = \int a G (da, dl_{-1}, dz), \quad (6)$$

5. Hiring market clears at all $t \geq 0$:

$$\int \max \{l_t (a, l_{-1}, z) - l_{-1}, 0\} G (da, dl_{-1}, dz) = \gamma U^0 V^{1 - \phi}; \quad (7)$$

6. The number of the unemployed follows the equilibrium law of motion given by (2);

7. The joint distribution of wealth, the number of employees, and entrepreneurial productivity $\{G_t (a, l_{-1}, z)\}_{t=0}^\infty$ evolves according to the equilibrium mapping:

$$G_{t+1} (a, l_{-1}, z) = \psi \int_{a_{t+1}(\tilde{a}, l_{-1}, \tilde{z}) \leq a_t (\tilde{a}, l_{-1}, \tilde{z}) \leq l_{-1} G_t (d\tilde{a}, dl_{-1}, d\tilde{z}) + (1 - \psi) \mu (z) \int_{a_{t+1}(\tilde{a}, l_{-1}, \tilde{z}) \leq a_t (\tilde{a}, l_{-1}, \tilde{z}) \leq l_{-1} G_t (d\tilde{a}, dl_{-1}, d\tilde{z}).$$

The definition of a competitive equilibrium is standard with the exception of the labor market clearing condition. Combining the hiring market clearing condition (7) and the law of motion for the number of the unemployed, we obtain:

$$U_t - U_{t+1} = \int [l_t (a, l_{-1}, z) - l_{-1}] G_t (da, dl_{-1}, dz).$$

That is, the hiring market clearing condition and the law of motion for unemployment together imply that the overall labor market clears over time, once we start out with

$$\int l_0 (a, l_{-1}, z) G_0 (da, dl_{-1}, dz) = -U_0.$$
3 (Preliminary) Quantitative Exploration

We next use a quantitative version of our framework to investigate the interaction between a credit contraction, modeled as a tightening of the collateral constraint, and labor market frictions. In particular, we are interested in exploring the aggregate and micro implications, including the effect on unemployment, of a credit contraction. To quantify a plausible credit shock, we calibrated the tightening of the collateral constraint to match the contraction in aggregate business credit observed during the 2008 financial crisis.

3.1 Calibration

Our model is parameterized so that the stationary equilibrium matches a series of aggregate and establishment-level moments in the US economy. We assume a time period in the model is equal to a year.

Following the standard practice, we set the coefficient of relative risk aversion $\sigma$ equal to 1.5, choose the ratio $\alpha \left( \alpha + \theta \right) = 0.33$ to match the aggregate income share of capital, and let the annual depreciation rate be $\delta = 0.06$. In terms of the parameters governing the matching function, we set $\phi = 0.7$, the same choice as Shimer (2005) and close to the upper bound of values reported in Petrongolo and Pissarides (2001), who estimate the elasticity of the matching function with respect to the number of the unemployed. The efficiency parameter $\gamma$, in turn, is determined to achieve a steady state unemployment rate of 4 percent.

Entrepreneurial ability is assumed to follow a Pareto distribution, with cumulative density given by $\mu(z) = 1 - z^{-\eta}$ for $z \geq 1$. Each period, an individual retains his ability with probability $\psi$, while a new ability level from the distribution is drawn with probability $1 - \psi$.

The remaining parameters to be calibrated are $(\alpha + \theta), \eta, \psi, \beta$ and the degree of credit market imperfection $\lambda$. To do so, we target the following moments in the US data: employment share of the top decile of establishments, the share of earnings generated by the top twentieth of the population, the exit rate of establishments, the real interest rate and the ratio of external finance to total non-financial assets of the non-financial business sector.

Table 1 shows the moments in the US data and their counterparts in the model. The decile of the largest firms (in terms of employment) accounts for 69 percent of aggregate employment in 2000. The earnings share of the top 5 percentiles amounts to 30 percent in 1998. The annual establishment exit rate is 10 percent and the annual interest rate 4%. Lastly, we target the

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4The results in this section are preliminary. In particular, we present results for a model with no hiring costs, $v = 0$, and a matching function where unemployed workers are the only input, $\phi = 1$. In addition, to guarantee the stability of unemployment dynamics, we assume that a fraction $\gamma$ of the jobs destroyed in a period are matched with the hiring market in the same period.

5For the quantitative experiments that refer to the model with costless hiring, the elasticity parameter $\phi$ is by construction equal to 1. In this case, achieving an unemployment rate of 4 percent requires picking an efficiency parameter value of $\gamma = 0.697$. 
<table>
<thead>
<tr>
<th>Parameter</th>
<th>US data</th>
<th>Model</th>
<th>Parameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Top 10% Employment</td>
<td>0.69</td>
<td>0.69</td>
<td>$\eta = 4.84$</td>
</tr>
<tr>
<td>Top 5% Earnings Share</td>
<td>0.30</td>
<td>0.30</td>
<td>$\alpha + \theta = 0.79$</td>
</tr>
<tr>
<td>Establishment Exit Rate</td>
<td>0.10</td>
<td>0.10</td>
<td>$\psi = 0.89$</td>
</tr>
<tr>
<td>Real Interest Rate</td>
<td>0.04</td>
<td>0.04</td>
<td>$\beta = 0.9262$</td>
</tr>
<tr>
<td>Credit Market Instruments to Non-Financial Assets</td>
<td>0.70</td>
<td>0.70</td>
<td>$\lambda = 7.5$</td>
</tr>
</tbody>
</table>

ratio of credit market instruments to total non-financial assets in the non-financial business sector of 0.8, a level attained one year before the 2008 financial crisis.

Although all parameters are jointly pinned down from the equilibrium simulation of the model, we can identify which objects in the data are mostly related to which parameter. For instance, the tail parameter of the Pareto distribution of ability, holding other values constant, controls the the share of employment accounted for by the decile of the largest firms. Similarly, $\alpha + \theta$ can be mapped into the earnings share of the top five percent of the population who, as in the data, are mostly entrepreneurs in the model. There is also a direct link between the persistence of the ability process $\psi$ and the probability that an entrepreneur exits production, which points to the annual establishment exit rate in the data. The discount factor, in turn, is closely linked to the target interest rate, while the degree of financial frictions $\lambda$ allows the model to attain a given ratio of credit market instruments to total non-financial assets in the non-financial business sector in the Flow of Funds database.

### 3.2 Aggregate Dynamics of a Credit Crunch

We simulate the aggregate dynamics of the model following a tightening in the collateral constraint $\lambda_t$ that is calibrated to generate a decline in the ratio of external finance to the capital stock,

$$
\int \frac{\max \{ k_t(a, l_{-1}, z) - a, 0 \} G_t(da, dl_{-1}, dz)}{K_t},
$$

that matches the observed decline in the stock of credit market liabilities to nonfinancial assets of the nonfinancial business sector in the US economy from the fourth quarter of 2008 to the
first quarter of 2010. We assume that $\lambda_t$ then gradually converges to its pre-crisis level.$^6$ $^7$

Figure 1: Ratio of External Finance to the Capital Stock

Figure 1 shows the evolution of the ratio of external finance to the capital stock in the data (dashed line) and the model (solid line). For the US data we report the percentage deviations from the trend of the HP filtered series, with a smoothing parameter of 1600. For the model we report the percentage deviation from its steady state value. Following the fourth quarter of 2008, there is a sharp decline in the ratio of credit market liabilities to nonfinancial assets, of the order of 10 percentage points relative to its previous peak, with the lowest point attained in early 2010. In the model we generate a similar contraction, and a smooth recovery to its original steady state.

In the model, the tightening in the collateral constraint leads to a sharp decline in output, explained by a sharp drop in TFP, a smaller decline in investment, and a protracted increase in unemployment. The dynamic of these series in the model (solid line), together with the corresponding series around the 2008 financial crisis (dashed line), are illustrated in Figure 2. Again, we report percentage deviations from the steady state for the model, and from a HP trend for the US data.

The credit contractions results in a reallocation of capital from entrepreneurs with low collateral, relative to their unconstrained level of capital, towards unconstrained entrepreneurs.

$^6$The stock of credit market instruments corresponds to line 18 in the L.101 table of the Flow of Funds. It includes the stock of bank loans of the corporate and the noncorporate sector, and the stock of commercial papers, municipal securities and corporate bonds of the corporate sector. The stock of nonfinancial assets is measured in historical prices to avoid valuation effects, which we abstract from in our theory. For the corporate sector the Flow of Funds reports the stock of nonfinancial assets at historical cost. For the noncorporate sector we impute the stock of nonfinancial assets at historical cost as the sum of the stock of real estate of the noncorporate sector at market value multiplied by the ratio of the stock of real estate of the corporate sector at historical value divided by its market value, plus the stock of equipment and software and inventories at current cost. These are obtained from tables B.102 and B103 of the flow of funds.

$^7$The sequence of collateral constraints that we calibrate is $\{\lambda_1, \lambda_2, \lambda_3, \lambda_4\} = \{7.5, 4.5, 3.0, 3.5\}$ and $\lambda_t = 0.75\lambda_{t-1} + 0.25 \times 7.5$ for $t \geq 5$. 
The reallocation of credit and capital is accompanied by the reallocation of labor across entrepreneurs, a process that is gradually mediated by the matching function. In this process, resources tend to be reallocated from productive but constrained entrepreneurs towards those who are unconstrained and relatively unproductive, which results in a decline in aggregated TFP, as described in the top right panel of Figure 2. The associated reallocation of labor, mediated by a frictional labor market, results in a protracted rise in unemployment, as illustrated in the bottom right panel of this figure.

In the left panel of Figure 3 we illustrate the reallocation of credit across entrepreneurs with different levels of collateral. In particular, we plot the evolution of the external finance to capital ratio of entrepreneurs with wealth below (solid line) and above (dashed line) the median entrepreneurial wealth. Entrepreneurs with low wealth finance a larger fraction of their capital externally, and are hit harder by the credit contraction. Both their capital stock and, more prominently, their external finance are sharply reduced following the tightening of the collateral constraint. On the contrary, during the credit crunch, wealthy entrepreneurs employ more capital and use more external finance, although the former expands at a higher rate leading to a small decline in their ratio.

How does the effect of a credit contraction in our quantitative framework compare with the data from the 2007–8 recession and financial crisis? The dashed lines in Figure 2 and

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8The capital used by wealthy entrepreneurs, whom in a steady state employ around 90 percent of the aggregate capital, increases by up to 7.4 percent, while their external finance increases by up to 6 percent.
the right panel in Figure 3 show the corresponding data, or closely related data, for the US economy around these events.

The model generates a decline in output of 5 percentage points, a substantial fraction of the 7 percentage point decline in output relative to trend observed in the US economy during the contraction that started at the end of 2007. The decline in aggregate TFP in the model is comparable to that experienced by the US economy, while the contraction in investment and the surge in unemployment in the model economy are slightly less than half of the ones observed in the US. Overall, the contraction of aggregate variables tends to be more protracted in the model vis-a-vis the US data.

In the right panel in Figure 3 we report the evolution of the ratio of the stock of credit market liabilities to nonfinancial assets for the noncorporate and corporate sectors, together with disaggregated data for the corporate sector for bank and bond liabilities. Starting in the fourth quarter of 2008, there is a sharp contraction in the stock of credit market liabilities of the noncorporate sector, together with a milder contraction in the credit market liabilities of the corporate sector. Furthermore, when analyzed at a more disaggregated level, the corporate sector suffered a sharp contraction in their bank-related liabilities, which were partially substituted by a surge in the issuance of corporate bonds, at least for those corporations that have access to the corporate bond market. To the extent that we interpret corporations, and in particular, those corporations that have access to corporate bond markets as relatively more unconstrained, the dynamics of external finance in the data is consistent with its dynamics in the model economy.
3.2.1 Implication of Rigid Wages

While the model is successful to account for a large part of the decline in output and TFP, it underpredicts the rise in unemployment following the 2007 recession. A simple extension of the model, in line with arguments in Shimer (2012), is to introduce wage rigidities to the model. The effect of a credit crunch in the model with fixed wages is illustrated by the dash-dot lines in Figure 2.

A tightening of the collateral constraint in an environment with rigid wages leads to an even larger decline in output, accounted by a sharp rise in unemployment, and a deeper by shorter lived drop in TFP. The rise in unemployment is explained by the higher flow of workers into unemployment, and by a relatively more protracted reallocation of these workers into employment. The dynamics of the flow of workers in and out of employment, as a fraction of employment at the beginning of the period, is illustrated in Figure 4.9

![Figure 4: Flows In and Out of Employment, as a Fraction of Beginning of the Period Employment.](image)

3.2.2 Comparing a Credit Crunch with an Exogenous TFP Shock

The analysis of the previous section revealed how burdensome a credit crunch could be for the adjustment of the labor market. Our goal here is to contrast the response of the economy to a more standard source of business cycle fluctuations, a negative shock to the aggregate productivity. To implement the experiment, we start the economy at its stationary equilib-

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9The data series correspond to yearly aggregated flow rates using the monthly flows data from the BLS research series, see http://www.bls.gov/cps/cps_flows.htm. We construct yearly flow rates by multiplying the monthly transition matrices. We report the resulting series minus their overall average.
rium and subject it to an unanticipated drop in aggregate productivity that follows closely the endogenous TFP dynamics displayed by the economy in response to a credit shock (top right panel, Figure 2).

Figure 5 depicts the behavior of aggregate quantities in response to the two shocks. Despite the resemblance of TFP dynamics between the two experiments, the credit-shock model exhibits a sharper and more protracted contraction in aggregate production. The bottom right panel in the figure shows that the bulk of the differential response in output can be attributed to the dynamics of unemployment: It remains irresponsive to a TFP shock but increased by 50 percent at the peak in the credit-crunch case. Investment, on the other hand, plays a less significant role.

The essential characteristic of a credit shock that differentiates it from a decline in TFP is its reallocative nature. Even though all entrepreneurs face a tighter collateral constraint during a crunch, only a subset of those are or become constrained by their individual wealth in their choices of labor and capital demands. In contrast, TFP is a shock that induces a contraction in the employment of all firms equally. The real wage, which is depicted in the right panel of Figure 6, absorbs the pressures from the two shocks differently as well. In the case of the TFP shock, the aggregate reduction in labor demand is fully compensated by a reduction in the wage rate, which ultimately keeps labor demand unchanged. In the credit crunch, the wage rate tends to go down too, due to the firing incentives of the more heavily and newly constrained entrepreneurs. However, it does so only partially, as entrepreneurs
that stay unconstrained take advantage of lower factor prices to increase hiring. With a labor market friction that produces insufficient matches to absorb the unemployed and recently-fired workers, and with wages that do not fully adjust to complete the reallocation, unemployment goes up in the transition.

The response of the interest rate is also markedly different between the two shocks, although in this case it is less relevant for understanding the dynamics of unemployment than it is for explaining the behavior of investment. A credit crunch has a direct negative effect over entrepreneurs’ capital demand decisions, forcing more firms to restrict their scale of operation to the level allowed by the collateral constraint. Furthermore, since capital is being misallocated towards the wealthy but untalented entrepreneurs, the aggregate demand for capital falls even further. To bring the rental market back to equilibrium, the interest rate has to fall sharply. This stronger response of the interest rate during a credit crunch is critical for the overall dynamics of investment, which is virtually indistinguishable from that of the TFP shock. Buera and Moll (2012) show that the isomorphism between a credit crunch and a TFP shock is not only a quantitative result, but a more general implication of a class of models with heterogeneously productive entrepreneurs.

3.3 Micro-implications of a Credit Crunch

The focus of our analysis is switched now to exploring the firm level implications of a credit crunch. A large empirical literature emerged documenting that financial crisis affect firms differently depending on size. The working hypothesis in these studies is that small business are more heavily reliant on credit to finance their productive activities and capital expenditures, and hence should be more cyclically responsive during recessions that are driven by credit contractions. Girlchrist and Gertler (1994) found evidence supporting this claim, and more
recently Fort, Haltiwanger, Jarmin and Miranda (2012) extended the analysis to highlight the role of age, as well as size, in assessing the cyclical behavior of firms: during a credit crunch, employment growth in young/small business declines relative to that of old/large establishments. The goal of this section is to provide a theoretical underpinning to the working hypothesis in the empirical literature, and understand how the aggregate behavior of the economy is shaped by the responses at the level of the firm.

3.3.1 Implementation and Definitions

The distinguishing characteristics of firms in the model, that ultimately determine their employment and capital demands, wealth accumulations, and the extent to which collateral constraints bind, are the entrepreneurial talent and the wealth of the entrepreneur. The model’s equilibrium not only provides optimal rules for these decisions, but also yields a distribution of entrepreneurs over these two idiosyncratic characteristics, which we must transform into a distribution of firms over age and size in order to perform the analysis.

To accomplish this goal, we create a sample of 500,000 agents that we simulate forward according to equilibrium prices and optimal policy rules. We first do so for the stationary equilibrium, which delivers a stationary distribution over age and size; and then continue the simulation for a number of periods that cover the credit crunch and its recovery.10

Our classification of firms into small, large, young and old is done as follows. For the size categorization, we compute the median employment level in the employment-based size distribution and classify a firm as small if its employment at the beginning of the period is below the median, and large if it is above.11 With respect to age, we follow Fort, Haltiwanger, Jarmin and Miranda (2012) and consider young all firms whose age is less than or equal to 5, and old all those producers whose age exceeds 5.

Lastly, our methodology for the aggregation of job flows for establishments within each age/size category follows closely that of Davis, Haltiwanger, and Shuh (1996). That is, we define the aggregate job creation and destruction rates for a given age/size category $s$ as:

$$JC_{s,t} = \sum_{i \in s} \frac{\max \{L_{t+1}(i) - L_t(i), 0\}}{0.5[L_{t+1}(s) + L(s)]}$$

10It is important to clarify that the simulation procedure does not take part at all in the solution of the equilibrium. For this purpose, we kept track of the theoretical joint distribution of firms over ability and wealth. As will be seen below, the disadvantage of the simulation method will show in creating “noise” in the dynamics of job flows in the pictures below, as the sample size of groups of firms keeps shrinking while we make the categorization finer. It was important that such noise did not affect the computation of the equilibrium, but it is less important for the creation of the pictures of interest, which depict a clear pattern in spite of it.

11That is, we bin firms into employment levels according to the fraction of total employment accounted for by each bin. We also worked with the distribution of the number for firms across employment levels, yielding similar patterns.
\[ JD_{s,t} = \sum_{i \in s} \max \left\{ \left[ L_t(i) - L_{t+1}(i) \right], 0 \right\} \cdot \frac{0.5 \left[ L_{t+1}(s) + L(s) \right]}{0.5 \left[ L_{t+1}(s) + L(s) \right]} \]

\[ Net_{s,t} = JC_{s,t} - JD_{s,t} \]

Importantly, these methodology aggregates gross and net flows keeping constant the set of firms that belong to each category between periods \( t \) and \( t + 1 \), exempting the measure from the so called “re-classification bias” discussed in Davis, Haltiwanger and Shuh (1998).

### 3.3.2 Results

We start by exploring the properties of the distribution of firms over ages and sizes in the stationary equilibrium. Table 2 reports the fraction of unconstrained entrepreneurs in each group, as well as the share of aggregate employment, the fraction of firms and the average rate of return to capital. Some features of the table are a direct consequence of our calibration strategy, which targeted properties of the size distribution of firms in the US. For instance, it should not surprise that a small number of large firms account for a significantly larger share of aggregate employment, in consistence with the skewness of the empirical size distribution in the US.

<table>
<thead>
<tr>
<th>Group</th>
<th>Fraction Unconstr. Entrepreneur</th>
<th>Fraction of Total Employment</th>
<th>Fraction of Firms</th>
<th>Av. Productivity</th>
<th>Av. Wealth</th>
<th>Av Rate of Return</th>
</tr>
</thead>
<tbody>
<tr>
<td>YS</td>
<td>0.10</td>
<td>0.14</td>
<td>0.39</td>
<td>0.5</td>
<td>1.5</td>
<td>0.11</td>
</tr>
<tr>
<td>YL</td>
<td>0.11</td>
<td>0.07</td>
<td>0.01</td>
<td>0.82</td>
<td>17.5</td>
<td>0.08</td>
</tr>
<tr>
<td>OS</td>
<td>0.45</td>
<td>0.37</td>
<td>0.56</td>
<td>0.49</td>
<td>3.3</td>
<td>0.04</td>
</tr>
<tr>
<td>OL</td>
<td>0.89</td>
<td>0.42</td>
<td>0.04</td>
<td>0.82</td>
<td>73.2</td>
<td>0.03</td>
</tr>
</tbody>
</table>

However, other statistics in the table are more a virtue of the model than a consequence of the calibration. Consider the first column in the table, referring to the fraction of unconstrained firms by category. The model predicts that the likelihood of becoming financially constrained is a function of the underlying state variables of the firm: productivity and wealth. The table shows that age and size are indeed good predictors of such likelihood: the fraction of unconstrained entrepreneurs is lowest for the young/small group and largest for the old and large group. There exists, then, a mapping from the ability/wealth space onto the age/size one that provides justification for the conjecture that young and small entrepreneurs should be more cyclically responsive than large and old ones during an episode of credit crunch.

The distribution of average productivity and average wealth across groups help clarify why such mapping exists. Notice, from column 4, that average productivity is correlated.
with size, but is independent from age: productivity is higher for the large than the small, but conditional on size, they are identical across ages. Thus, if firms decisions and credit conditions were entirely dependent on productivity, age would be irrelevant. However, wealth does matter for those two, and is indeed correlated with age conditional on size: older entrepreneur are wealthier on average than younger ones.

The last column in the table illustrates the tight connection that exists between credit conditions for a particular type firm, and its rate of return to capital. In a frictionless economy where credit conditions allow firms to operate at the efficient scale, rates of return to capital\(^{12}\) are equalized across production units and are equal to the real interest rate. A binding collateral constraint, on the other hand, drives a wedge between these two, increasing the rates of return to capital for constrained entrepreneurs relative to the equilibrium interest rate in the economy. This is why the last column of table 2 shows an excess return of 8% between the young/small class and old/large one, which is consistent with the lower fraction of unconstrained entrepreneurs in the former compared to the latter.

We now explore the dynamics of net employment growth along the credit crunch for the four age-size groups under consideration. These are depicted in figure 7. The units in the vertical axis represent absolute differences in net employment growth rates with respect to steady state levels\(^{13}\).

\(^{12}\)That is, the marginal product of capital net of depreciation

\(^{13}\)The raw series from the simulation were HP filtered with a smoothing parameter equal to 3. This mild smoothing of the series allowed us to convey the overall pattern of the simulated variables isolated from “small sample noise”.
The behavior of employment growth rates is in accordance with the information conveyed in the steady state table. Young/small and young/large entrepreneurs, whose average rates of return are the highest and whose fraction of unconstrained firms are the lowest, display the sharpest contraction in net employment growth rates relative to their steady state levels. This finding suggests that the direction of re-allocation flows, from constrained to unconstrained entrepreneurs, is accurately captured by the age and the size of the production unit. Recall that being financially constrained or not is a condition that depends on firms characteristics that are presumably difficult to observe in the data, at least for the entire population of producers in the economy: productivity and wealth (or net worth). Hence, once again, the fact that there is a successful mapping from the productivity-wealth space onto the age-size allows us to interpret the dynamics of employment growth rates in the data through the lens of the mechanisms in our model.

4 Conclusions

We proposed a model of heterogeneous agents that integrated credit and labor market frictions to study macro and micro implications of a credit crunch. We discovered that a salient feature of a collapse in credit availability is its re-allocative nature: firms that become financially constrained contract their labor and capital demands, and factors are reallocated towards
unconstrained producers. However, frictions in the labor market interfere with the reallocation process making the absorption of idle resources take time, along which a larger number of workers remain unemployed. Moreover, the reallocation of resources implied by the shock delivers an endogenous reduction in aggregate productivity, as high productivity-low wealth entrepreneurs shed workers and capital into low ability-high wealth ones. Together with a contraction in investment, these three effects create a decline in aggregate economic activity.

Another finding of the paper is to demonstrate that credit and aggregate productivity shocks carry different implications for both micro and macro variables. Even in presence of matching frictions, the unemployment rate remains unchanged in the case of a TFP shock, as the adjustment in wages and interest rates fully offset the decline in productivity. They key is that an aggregate TFP shock affect all firms’ incentives to reduce labor demand equally, which is not the case when the shock is credit driven.

Another contribution of our work is to have validated with theory the finding in the data that firms of different age and size have asymmetric responses to credit-driven business cycle fluctuations. We show that the combination of age and size are a good proxy for the combination of entrepreneurial abilities and wealth that determine the likelihood of being constrained and, hence, the dynamics of employment growth during a credit collapse.
References


