

# Firm Entry and Employment Dynamics in the Great Recession

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## Abstract

The recession of 2007-2009 has been characterized by: (1) a large drop in employment concentrated in small firms, (2) an unprecedented decline in the number of firms, and (3) a slow recovery. This paper develops a heterogeneous firm model with labor adjustment cost, endogenous firm entry, and financial constraints that generates these key facts. The model predicts that a large financial shock results in a long-lasting recession due to limited firm entry. Using confidential firm-level employment data from the Bureau of Labor Statistics, I find support for the model mechanism. In the period of 2007-2009, small and young firms in sectors with high external finance dependence exhibited lower employment growth than those in low external finance dependent sectors. The effect of external finance dependence on employment growth in small and young firms is primarily driven by firm entry and exit.

**Keywords:** employment, firm entry, financial crisis, small business, financial friction, business cycles, slow recovery

**JEL:** E24, E32, E44, G01, L25, J2

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# 1 Introduction

The 2007-2009 recession and the subsequent economic recovery in the United States differed from most historical recessionary periods. Employment in small firms (less than 50 employees) fell relative to employment in large firms (more than 500 employees). The Great Recession also exhibited an unprecedented 5% decline in the number of firms and it is one of only two recessions of the last 35 years during which aggregate lending declined. Finally, the financial crisis was followed by a slow recovery in macroeconomic aggregates while deep recessions post World War II typically featured rapid recoveries with strong increases in output and employment.

This paper investigates both theoretically and empirically the relationship between the financial constraints of small and large firms, firm entry, and a slow economic recovery following the financial crisis.

First, this paper proposes a novel explanation for slow recoveries in the aftermath of a financial crisis. I argue that such recoveries are the result of a credit crunch: a reduction in bank lending affects most directly small, bank-dependent firms. The lack of external funds leads to increased firm exit and prevents the formation of new businesses, which creates a persistent reduction in labor demand. A slow recovery then follows as the reduced number of firms in the economy is only gradually reversed.

Second, this paper uses a confidential dataset on firm-level employment from the Bureau of Labor Statistics. Unlike the existing empirical literature, which typically ignores the 95% of firms with less than 50 employees, this study examines employment growth of the ‘universe’ of firms during the 2007-2009 recession in the United States. The empirical results imply that external financial constraints account for a 4.5 percentage point reduction of employment growth in small firms relative to large firms during 2007-2009. I show that this result is driven by young firms. Finally, this study documents the importance of entry and exit margins to account for the differential effect of external finance dependence on small and large firms.

I develop a quantitative model that generates the aforementioned characteristics of the Great Recession. The model relies on the following key assumptions: Firms are heterogenous in productivity and are subject to labor adjustment costs. They have access to defaultable debt, which generates endogenous borrowing constraints. Entry is endogenous; potential entrants that decide to enter incur set-up costs and have to finance a fraction of these costs externally. The model is calibrated to match the firm size distribution to investigate the effect of financial shocks on small and large firms. Small firms with less than 50 employees account for 30% of aggregate employment in the data.

A temporary financial shock, a six-quarter reduction in the recovery rate in default, increases the cost of external finance and leads to a large reduction in firm entry in the model as potential entrants cannot obtain sufficient funds to enter. This generates a ‘missing generation’ of entrants. The financial shock also leads to an increase in default of small and young firms, which carry debt taken on at entry and from expanding employment. Larger and older firms have accumulated assets and are less constrained. Upon impact, a financial shock reduces employment in small firms relative to large firms. Subsequently some larger firms reach the end of their life cycle and exit the economy. The ‘missing generation’ of entrants implies that there are too few young firms to replace the exiting large firms. A prolonged recession follows, with employment in large firms declining long after the end of the financial shock. The number of small firms starts to recover immediately after the end of the financial shock but it takes 40 quarters for aggregate employment to start to recover as the number of firms only gradually returns to the stationary distribution.

This calibration of the model differs from some of the existing literature by targeting the firm size distribution in the data. Matching the firm size distribution is important for two reasons: a financial shock directly only affects small firms upon impact as large, high productivity firms are essentially unconstrained. Matching the firm size distribution is key to generating a long recession and slow recovery: the lagged decline in the number of large firms has a large impact on aggregate employment as they account for a large fraction of

total employment. If instead the establishment distribution was targeted, as in some other studies, then the model would imply a shallower recession and earlier recovery as large establishments account for a smaller share of employment.

Historically, deep recessions have been followed by rapid recoveries and the data show no large decline in the number of firms over the last 30 years prior to the Great Recession. In the model, a negative temporary shock to aggregate technology leads to a deep but short recession followed by a rapid recovery. It is not accompanied by a significant change in the number of entrants, similar to what we see in the data for past recessions.

I test the model mechanism using firm-level employment data for the financial crisis of 2007-2009. The paper contributes to the broader empirical literature on determining the key factors influencing employment during the Great Recession. This paper uses confidential firm-level employment data from the Quarterly Census of Employment and Wages (QCEW) Longitudinal Database (LDB) from the Bureau of Labor Statistics (BLS). An external financial dependence measure on the sectoral level is constructed from Compustat data based on work by Rajan and Zingales (1998), Kaplan and Zingales (2000), and Cetorelli and Strahan (2006). This measure captures the external financing needs in a given sector by comparing firm cash flows with capital expenditures over multiple years and allows me to construct sectors of high and low external financial dependence.

This paper employs a differences-in-differences methodology that exploits variation across external finance dependence and firm size. Small firms could have been affected differently from large firms during the Great Recession through other channels (e.g. the aggregate demand channel). By comparing the employment change in small and large firms in sectors with different degrees of external financial dependence, I difference out this potential demand effect.

I find that high external finance dependence reduced employment growth in small firms by 4.5 percentage points relative to large firms during the 2007-2009 recession. This confirms the notion that small firms are more affected through credit constraints. I further show that

in particular young firms in sectors of high external finance dependence reduced employment growth relative to those firms in low external finance dependent sectors. The conditional expected growth rate for young, small firms in high external financial dependent sectors is reduced by 8 percentage points relative to low external financial dependent sectors. Finally, firm entry and exit are important factors that explain this observation. The conditional expected growth rate of small, young firms is reduced by only 2 percentage points through external financial dependence in the sample without entering and exiting firms.

The empirical results and the quantitative model show that financial constraints most directly affected small firm employment through entry and exit during 2007-2009. The financial crisis then propagated itself through the financial constraints of small firms leading to a reduced number of firms in the economy and a slow recovery.

## 1.1 Related Literature

This paper is at the intersection of several strands of literature. Recent contributions to the heterogeneous firm and financial constraint literature include, Khan and Thomas (2010), Gilchrist, Sim and Zakrajšek (2010), and Arellano, Bai and Kehoe (2012). These contributions succeed at generating the initial large decline in output during the Great Recession. They do not match the distribution of firms, have a fixed number of firms in the economy, and imply a fast recovery following a financial crisis.

Moreover, the current paper is related to the literature on firm entry and exit and in particular to Clementi and Palazzo (2010), Samaniego (2008), and Lee and Mukoyama (2012). The setup in these papers differs from this paper in that debt has no role in the entry decision of firms. In the model developed in this paper, external finance is a key factor for entry dynamics.

In addition, the quantitative model shares the focus on the employment evolution after recessions with the literature on jobless recoveries including work by Bachmann (2012) and Berger (2012). The framework in Bachmann (2012) generates jobless recoveries in response

to shallow recessions but predicts a rapid recovery in response to a deep recession. Berger (2012) develops a heterogeneous firm model of selective firing. The addition of selective firing can generate a substantial jobless recovery even in response to a severe recession. Both papers lack any role for credit.

The empirical literature related to this paper examines the determinants of the employment decline during 2007-2009. Mian and Sufi (forthcoming) provide evidence that a drop in aggregate demand is the main driver of employment losses during the Great Recession. The authors argue that a stronger negative correlation between the county leverage ratio and employment growth in non-tradable industries in larger *establishments* implies that financial constraints were not important during the recession.<sup>1</sup> Intuitively one would expect small firms to be affected more by external financial constraints than large firms. This paper uses firm-level data as financial constraints are present at the firm rather than the establishment-level.

The most closely related paper in terms of empirical methodology is Duygan-Bump, Levkov and Montoriol-Garriga (2010). These authors use Compustat data to derive financial constraint measures as in the present paper. They also use annual Current Population Survey data on unemployment with less than 100.000 observations per year and find that workers in small firms in sectors of high external finance dependence are more likely to become unemployed. The current paper uses administrative employment data with millions of observations. Since Duygan-Bump et al. (2010) use unemployment rather than firm employment data, they cannot explore the importance of firm entry and exit. Finally, Benmelech, Bergman and Seru (2011) examine the impact of financing constraints on employment using financial and employment measures from Compustat. They limit the analysis to large firms with more than 500 employees.

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<sup>1</sup>The Appendix provides details on the differences between firm size and establishment size distribution.

## 2 Employment, Entry, and Exit During 2007-2009

This section reviews stylized facts on employment, firm entry/exit, and the distribution of firms during and after the financial crisis of 2007-2009.<sup>2</sup> The Appendix provides additional facts on small business lending, home mortgages, spreads of financial variables, and explains the differences between firm size and establishment size distribution.<sup>3</sup>

### 2.1 Employment

The first distinct observation regarding the most recent recession is that small firms contracted employment more than large firms. I use annual Business Dynamics Statistics (BDS) data that are available from 1978 to 2010. Small firms are important for the macroeconomy because Ninety-five percent of firms are small and they account for 30% of aggregate employment. Large firms with more than 500 employees account for 48% of aggregate employment in the data. Figure 1 displays the aggregate employment evolution in small and large firms during historical recessions in figure Panel (a) and during the 2007-2009 financial crisis in figure Panel (b). Year 0 marks the beginning of the recession (i.e., 2007 for the financial crisis; 1980, 1990, and 2001 for historical recession). Employment in year 0 is normalized to 100 for both small and large firms.<sup>4</sup> I then average over historical recessions to construct Panel (a).

During historical recessions, large firms tend to reduce employment relative to small

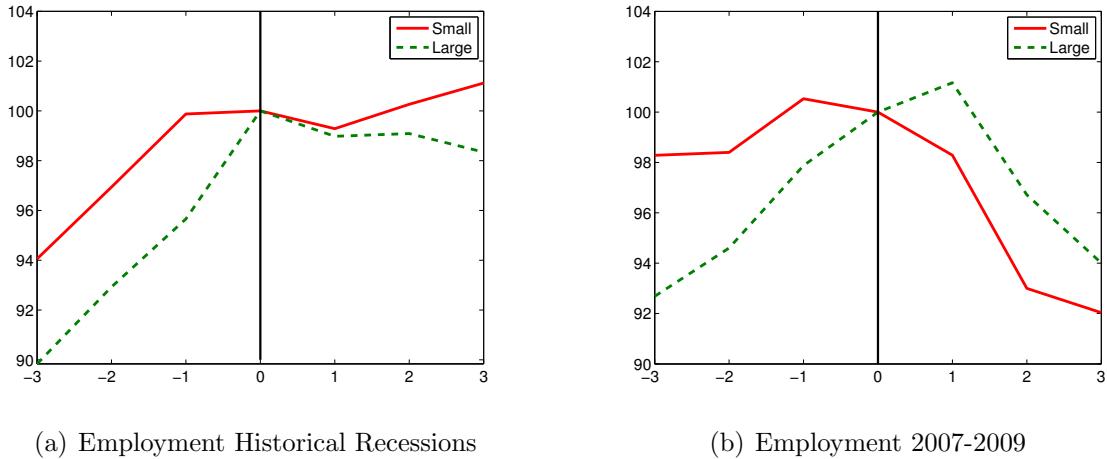
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<sup>2</sup>Some related facts have been documented in existing work: See Gabaix (1999), Gabaix (2011), Hellerstein and Koren (2006), Gilchrist et al. (2010), Duygan-Bump et al. (2010), and Moscarini and Postel-Vinay (forthcoming) among others.

<sup>3</sup>The Appendix is available online at [http://www.michael-siemer.org/Research\\_files/JMP\\_Michael\\_Siemer\\_Appendix.pdf](http://www.michael-siemer.org/Research_files/JMP_Michael_Siemer_Appendix.pdf)

<sup>4</sup>I do not filter the data as any filtering would produce inaccurate results for the last observations. I treat the recessions of 1980 and 1982 as one recession. Changing the year 0 definition for this recession from 1980 to 1982 does not qualitatively alter the results. The continued decline in large firm employment in the historic recession graph is driven by large firm employment not recovering until 1985 in the earliest recession in the data. The employment decline in large firms relative to small firms would be larger if I would drop the 1991 recession. The 1991 recession is somewhat atypical as it was following the Savings & Loan crisis, which shares similarities with the financial crisis.

Figure 1: Aggregate employment in historical recessions vs. 2007-2009 recession



Notes: Employment normalized at the year of NBER recession start to 100, in order to not lose the last observations in the sample the time series are unfiltered. Small captures all firms with less than 50 employees while large contain all firms with more than 500 employees. Historical recessions are the downturns starting in 1980, 1991, and 2001. Source: Business Dynamic Statistics (BDS).

firms and most of the relative decline is explained by small firm employment leading the recovery. The decline in small firm employment relative to large firm employment during 2007-2009 is primarily driven by a decline in small firm employment during 2007 while large firm employment increased.<sup>5</sup> The employment behavior in small and large firms during the Great Recession is thus clearly distinct from historic recessions.

A major contributing factor in the 2007-2009 recession was the housing bust starting in 2006 and the subsequent deep recession in the construction sector. One might expect that the differential impact on small relative to large firms is driven by only one sector (e.g., construction) or a small number of sectors. Figure A-1 in Appendix A follows the same structure as the Figure 1 but provides the corresponding graphs for all eight available SIC classification non-farm sectors . It shows that the small versus large pattern documented

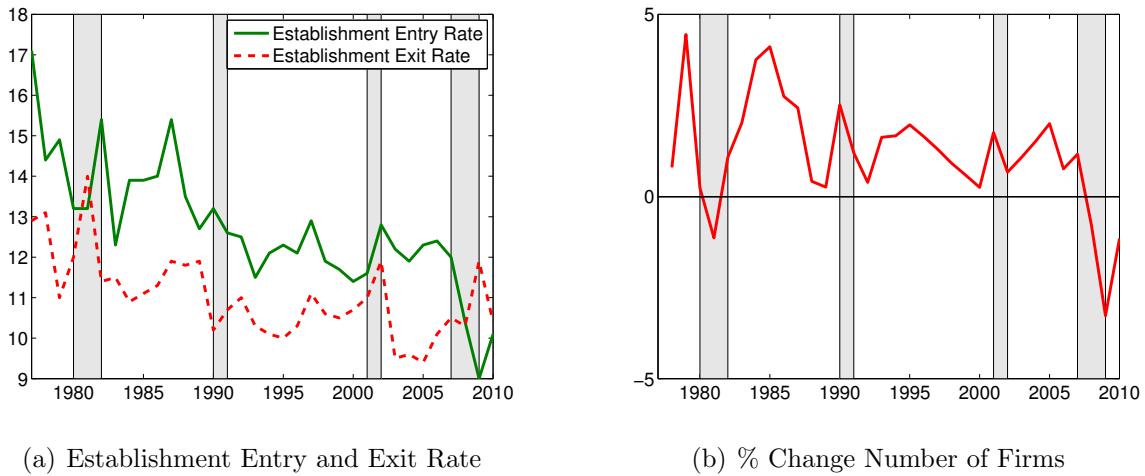
<sup>5</sup>A paper providing related evidence on the employment evolution during recessions in small and large firms is Moscarini and Postel-Vinay (2008). Moscarini and Postel-Vinay (2008) find that employment in large firms is more cyclical historically. Moscarini and Postel-Vinay (forthcoming) note that the even in 2008-2009 employment growth in large firms fell more than in small firms. It is a statement about changes in growth rates, rather than levels as emphasized by this paper.

above is consistent across sectors for the 2007-2009 period, albeit with varying magnitudes. The pattern also remains unchanged if small firms are defined as firms with less than 500 employees instead of 50 employees.

## 2.2 Entry and Exit

Firm entry and exit is an important margin of adjustment during the 2007-2009 recession. Figure 2 shows annual entry and exit rate of establishments between 1978 and 2010. Over the long run, there is a downward trend in both entry and exit rate of establishments.<sup>6</sup> More relevant for the context of this paper are the last years of the sample: During the 2007-2009 recession, the entry rate fell by more than 30% while the exit rate increased by about 15%. In fact, the most recent recession marks the first time that establishment exit exceeded establishment entry for more than one year.

Figure 2: Entry and Exit, 1978-2010



Notes: Figure (a) plots establishment entry and exit rate. Figure (b) plots the percentage change in the number of firms in the economy. Gray shaded areas indicate NBER recession episodes. Source: Business Dynamic Statistics (BDS).

Figure 2(b) shows the net change in the number of firms from 1978-2009. The figure also

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<sup>6</sup>This is an important observation that has been discussed in existing work by Haltiwanger, Jarmin and Miranda (2011) and Reedy and Litan (2011)

shows that the net change in the number of firm in the economy is highly volatile. The 2007-2010 recession is distinct from prior recessions as it is the only recession during which the number of firms declined over multiple years for an aggregate decline of more than 5%.<sup>7</sup>

Table 1 provides details on the decline in the number of firms in 2007-2009 by firm size class. The first column shows that more than 95% of firms are small. The second column

**Table 1: Number of Firms: 2007-2009**

| Size   | Number of Firms | % Change Number of Firms |
|--------|-----------------|--------------------------|
|        | 2007            | 2007-2009                |
| 1-49   | 5,059,512       | -3.96                    |
| 50-499 | 219,845         | -4.98                    |
| 500+   | 20,658          | -1.95                    |

Notes: Number of firms by size class. The first column provides the total number of firms in each firm size class in 2007. The second column provides the percent change in the number of firms between 2007 and 2009 by size class. Source: Business Dynamic Statistics (BDS).

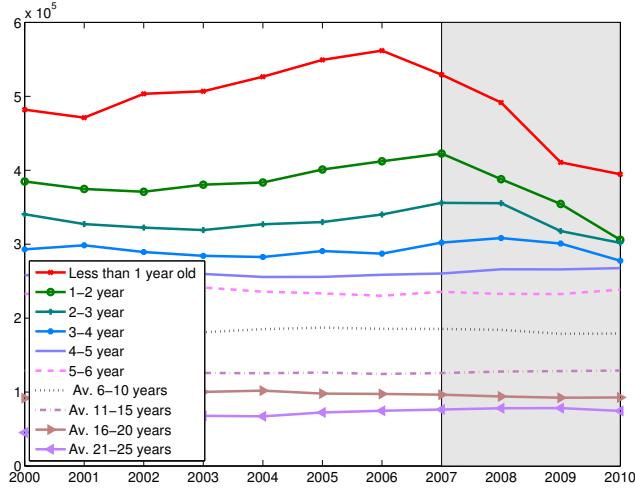
shows that the number of small- and medium-sized firms falls significantly more than the number of large firms between 2007-2009. This is true despite the fact that this table does not take into account the composition bias (i.e., large firms that reduce employment in 2007 might be classified as small firms in 2009, which leads the data to underestimate the true effect on the number of small firms).

Haltiwanger, Jarmin and Miranda (2010) show that it is important to consider firm age for understanding employment growth. Figure 3 displays the number of firms by age group since 2000. There are fewer firms in the older age group than in the younger groups as over time some firms leave the economy. Moreover, the figure shows a decline in startups (firms less than one year old) starting in 2007. Subsequently this decline moves through the age distribution as the number of two, three and four year old firms starts to decline in subsequent years. Finally, for the number of firms older than 5 years there is no substantial decline since 2007.

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<sup>7</sup>The decline in the number of firms during the early 1980s is limited to a single year.

Figure 3: Number of Firms by Age



### 3 Model

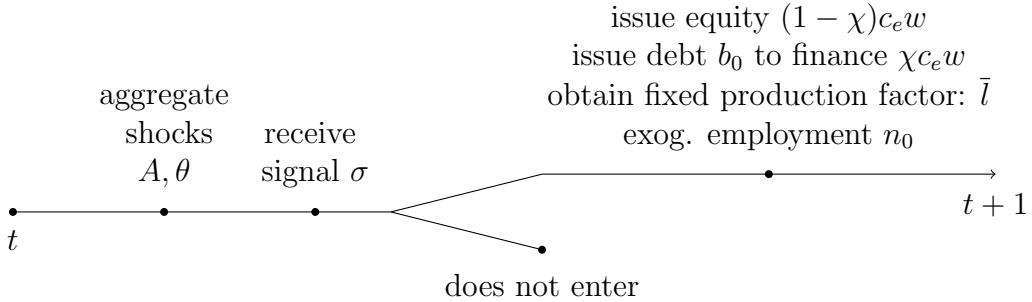
Time is discrete and indexed by  $t = 1, 2, \dots$ . The model economy has two types of agents. A continuum of households and a continuum of heterogeneous firms. The households provide labor services to firms and loans to the firms through financial intermediaries. The households own all firms. Firms are heterogeneous in total factor productivity, use a decreasing returns to scale production function in employment and have access to non-contingent one-period debt through the financial intermediaries. Firms incur adjustment costs when hiring or firing employees and are subject to an endogenous borrowing constraint. The optimal lending contract between financial intermediaries and firms takes into account the likelihood of the firm defaulting by employing a net worth-based default rule.

#### 3.1 Setup

This section describes the firms in the model. The model economy consists of a mass of potential entrants and a mass of incumbent firms. I first describe the decision framework for potential entrants and then the optimization problem for incumbent firms.

### 3.1.1 Potential Entrants

Figure 4: Timing Potential Entrants



The timing of decisions for potential entrants is illustrated in Figure 4: At the beginning of each period there is a fixed number of potential entrants  $M$ . One can think of the constant mass of potential entrants in the following way: At each point in time there exists a given number of (business) ideas that do not depend on the state of the economy. Depending on the quality of the idea and the state of the economy, a fraction of the ideas translates into new businesses. Potential entrants first observe aggregate shocks to technology  $A_t$  and recovery rate parameter  $\theta$ . Then they receive a signal  $\sigma_t$  about their productivity draw  $z_t$ . The transition between signal and future productivity is assumed to follow:

$$\log z_t = \mu_s + \rho_s \log \sigma_t + \sigma_s \epsilon_t^s. \quad (1)$$

A large  $\sigma_t$  suggests that their productivity is likely to be high.

Upon entry new firms have to finance a fraction  $\chi$  of the entry cost  $c_e w(h = h^*)$ , where  $h^*$  denotes steady state average hours worked, externally while the remaining fraction  $1 - \chi$  is financed through equity issuance to the household.<sup>8</sup> I assume that entry is the only occasion that a firm can issue equity. One way to interpret this assumption is that at birth firms rely on a venture capitalist to finance start-up costs but thereafter have to rely on external

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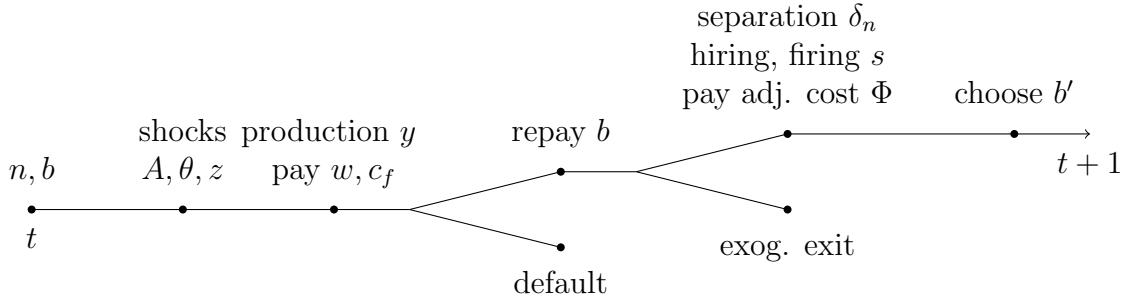
<sup>8</sup>For the remainder of this paper I refer to  $c_e w(h = h^*)$  as  $c_e w$ .

finance. Firms then are endowed with a fixed collateral/ factor in production  $\bar{l}$ . One can view  $\bar{l}$  to be the garage of the entrepreneur's house, which serves both for business purposes but can also be used as collateral. To keep the model tractable, I assume that all entrants start up with initial employment  $n_0$ . The setup of this paper differs from existing work such as Clementi and Palazzo (2010) and Lee and Mukoyama (2012) in an important way: I assume that firms need to externally finance a fraction of the entry cost. The model also differs from existing work on entrepreneurship (cf. Buera and Shin (2010) and Bassetto, Cagetti and De Nardi (2010)) in an important way: entrepreneurs in these models are risk averse. The implicit assumption underlying the entry framework described in this paper is that entrepreneurs are risk neutral. Consequently, entrepreneurs in the the model only maximize the present discounted value of profits.

### 3.1.2 Incumbent Firms

There is a continuum of incumbent firms with a production function that has decreasing returns to scale in employment. Furthermore, firms are heterogeneous in their individual productivity levels.

Figure 5: **Timing Incumbant Firms**



The timing of decisions for incumbent firms is illustrated in Figure 5: Incumbant firms enter period  $t$  with employment stock  $n_t$  and debt  $b_t$ . Employment  $n_t$  is determined a period in advance. At the beginning of the period all shocks are realized, aggregate technology  $A_t$ ,

idiosyncratic technology  $z_t$ , recovery rate parameter  $\theta$ . Subsequently firms choose current period hours  $h_t$  and produce output  $y_t$ . The production technology of firm  $j$  is given by:

$$y_{j,t} = A_t z_{j,t} (n_{j,t} h_{j,t})^\alpha \bar{l}^{1-\alpha}. \quad (2)$$

The firm has two margins of labor adjustment: the intensive margin, hours per employee, that can be adjusted at no cost and the extensive margin, the number of employees, which is subject to adjustment cost. The choice of hours is determined using the wage function obtained from the consumer optimization problem. Firms compensate workers for their labor service by paying wages  $w_t$  and pay the fixed cost of operation  $c_f$ . Production setups that distinguish between hours and number of employees can be found throughout the literature (cf. Burnside, Eichenbaum and Rebelo (1993) and Cooper, Haltiwanger and Willis (2007)). The processes for idiosyncratic technology  $z$  and aggregate technology  $A$  follow AR(1) in logs:

$$\log z_{t+1} = \mu_z + \rho_z \log z_t + \sigma_z \epsilon_{t+1}^z \quad (3)$$

$$\log A_{t+1} = \rho_A \log A_t + \sigma_A \epsilon_{t+1}^A, \quad (4)$$

where  $\mu_z$  is a constant and  $\epsilon_{t+1}^A$  and  $\epsilon_{t+1}^z$  are iid standard normal random variables.

Firms that entered the period with debt meet with the financial intermediary who then decides if the firm has to go into bankruptcy/default using an exogenous default rule based on current cash flows. Finally, firms that are not forced into default pay back their debt  $b_t$ .

To capture the realistic pattern that firms grow slowly because of the lack of internal funds, I impose an exogenous exit rule: Firms reach the end of their life cycle and exogenously exit the economy after production and debt payment with probability  $\pi_d$  (cf Khan and Thomas (2010)). Firms that receive this exit signal leave the economy immediately after paying back their debt and pay any remaining profits as dividends to the households. This assumption prevents that in the model all firms become financially unconstrained and also

allows the model to exhibit a life cycle for firms.

Employment for continuing firms depreciates exogenously – a certain fraction of workers quit every period – by a fraction  $\delta_n$ . Continuing firms then choose the number of workers to hire/fire  $s_t$ . Hiring/firing then determines next period's employment  $n_{t+1}$ . Employment evolution thus follows:

$$n_{j,t+1} = (1 - \delta_n)n_{j,t} + s_{j,t}. \quad (5)$$

Firms that adjust their employment pay the associated labor adjustment cost  $AC_{jt}$ . Costly labor adjustment is a common assumption and its importance has been documented in empirical work (e.g., Cooper et al. (2007) and Bloom (2009)). Adjusting employment not only requires paying search costs for a new worker (or paying severance fees when firing) and disrupts production as well since resources have to be used to train new employees.

The adjustment cost function  $AC$  takes a form similar to related work in Bloom (2009), Bachmann (2012), and Berger (2012),

$$\begin{aligned} AC_{j,t} &= \lambda y_{j,t} + \phi^- \underbrace{(n_{j,t+1} - (1 - \delta)n_{j,t})}_{\equiv s_{j,t}} && \text{if } s_{j,t} < 0 \\ AC_{j,t} &= \lambda y_{j,t} + \phi^+ \underbrace{(n_{j,t+1} - (1 - \delta)n_{j,t})}_{\equiv s_{j,t}} && \text{if } s_{j,t} > 0. \end{aligned} \quad (6)$$

$\lambda y_{j,t}$  is the fraction of current period output that is lost due to labor adjustment and reflects the disruption effect of labor adjustment.  $\phi s_{j,t}$  reflects partial irreversibility of labor adjustment. One can think of training and disruption (severance payments) in the case of hiring (firing).  $\phi$  is the adjustment cost that depends on the size of adjustment. It can differ for upward  $\phi^+$  and downward adjustment  $\phi^-$  of employment.

Finally, incumbent firms choose how much debt  $b_{t+1}$  at price  $q_t$  they want to take into next period. The price  $q_t$  depends on individual firm characteristics. The details of the price

$q_t$  are discussed in the next section. The dividend expression takes the form:

$$D_{j,t} = -c_f + A_t z_{j,t} (h_{j,t} n_{j,t})^\alpha \bar{l}^{1-\alpha} - w(h_{j,t}) n_{j,t} - b_{j,t} + q_{j,t} b_{j,t+1} - AC_{j,t} \geq 0. \quad (7)$$

I impose a non-negativity constraint on dividends that firms have to satisfy. As there is no tax advantage to debt. Firms only take on debt  $b_{t+1} > 0$  to satisfy the non-negativity constraint on dividends  $D_{j,t} \geq 0$ . I assume that firms can not issue equity. There are various reasons under which incumbent firms can be required to issue debt. Firms can have negative profits as employment  $n$  is predetermined, because they incur operational fixed costs  $c_f$  that are larger than their profits or because they adjust employment and have to pay adjustment cost  $AC$ . Finally, firms that enter the period with debt might have to rollover some debt if profits are not sufficient to fully repay. Firms entering the period without debt that cannot obtain a sufficient amount of debt  $b_{t+1}$  to satisfy the zero dividend constraint have to exit the economy. Finally, the economy moves to period  $t + 1$ .

An alternative approach to induce firms to be exposed to debt is a working capital requirement. Introducing this requirement to this model with only inter temporal debt does not significantly alter the implications of the model. Similar to the present setup, a working capital requirement only affects the constrained firms that tend to be small. In a framework with intra-temporal and inter-temporal debt, a working capital requirements can have more significant effects on the economy (e.g., Jermann and Quadrini (2012))

## 3.2 Optimization

This section describes the optimization problem of households, potential entrants and incumbent firms.

### 3.2.1 Households

There is a continuum of households of measure one. Households work, consume, and pool their income. Each agent  $i$  has per period preferences:

$$U(c_{it}, H_{it}) = \frac{c_{it}^{1-\gamma}}{1-\gamma} - \mathcal{I}_{it} \left( \zeta_1 + \zeta_2 \frac{H_{it}^{1+\vartheta}}{1+\vartheta} \right), \quad (8)$$

where  $\mathcal{I}_{it} = 1$  if the household member is employed and zero otherwise. Each household member is endowed with one unit of time. A household member can work zero hours or the household can work  $H_{it} \in [0, 1]$  hours. A fraction  $1 - n$  of households is unemployed and consumes  $c_u$ ; the remaining fraction  $n$  is employed and works total hours  $H_i$  and achieves a consumption level  $c_{n,i}$ , where both hours and consumption are allowed to differ across working households.

The family of households maximizes total utility

$$U(c_u, c_n, H, n) = (1 - n_t) \frac{c_{u,t}^{1-\gamma}}{1-\gamma} + \int_0^{n_t} \frac{c_{n,i,t}^{1-\gamma}}{1-\gamma} - \left( \zeta_1 + \zeta_2 \frac{H_{i,t}^{1+\vartheta}}{1+\vartheta} \right) di, \quad (9)$$

subject to the budget constraint:

$$(1 - n_t)c_{u,t} + \int_0^{n_t} c_{n,i,t} di + \int q_{jt} b_{jt+1} dj \leq \int_0^{n_t} w_t(H_{i,t}) di + \int \varrho_{jt} b_{jt} dj + D_t, \quad (10)$$

where  $b_{jt}$  is the amount of debt issued by firm  $j$  in period  $t-1$  at price  $q_{jt-1}$ . Each unit of debt is redeemed in period  $t$  for  $\varrho_{jt}$ .  $\varrho_{jt}$  captures the loss potentially arising from firm default. The households inter-temporal decisions are determined by the stochastic discount factor (SDF),  $m(S_{t+1}, S_t) = \beta \frac{\lambda(S_{t+1})}{\lambda(S_t)}$ .  $\lambda$  is the marginal utility of consumption.  $S_t = (A_t, \mu_t)$  denotes the aggregate productivity shock and the distribution of firms  $\mu_t$ . The household SDF prices all assets. Section 3.2.2 derives the price of debt  $b_{t+1}$  implied by household preferences. This setup implies that the wage has the following functional form (see derivation in Appendix

B):

$$w_t(H_{it}) = \frac{1}{\lambda_t} \left( \zeta_1 + \zeta_2 \frac{H_{it}^{1+\vartheta}}{1+\vartheta} \right). \quad (11)$$

At this wage the household member is willing to supply any number of hours  $H_{it}$  desired by the firm. Hours can differ across individuals.<sup>9</sup> In other words, every worker receives a fixed compensation plus an hourly (overtime) premium that depends on the number of total hours. Firms take this functional form for the wage as given in their optimization problem.

### 3.2.2 Price of Debt

Define the net worth of a firm as:

$$nw_t \equiv -c_f + A_t z_t (h_t n_t)^\alpha \bar{l}^{1-\alpha} - w_t(h_t) n_t - b_t + \bar{l}. \quad (12)$$

where  $\bar{l}$  is the fixed factor of production received upon firm entry. It also serves as collateral. Firms are forced by the financial intermediary into default if  $nw_t < 0$ . Following default, the firm is shut down and exits. This defines a threshold for technology  $\underline{z}$  such that a firm defaults in the next period if  $z_{t+1} < \underline{z}$ .  $\underline{z}$  is determined by the following condition:

$$\underline{nw} = -c_f + A_{t+1} \underline{z}(n_{t+1}, b_{t+1}, S_{t+1}) (h_{t+1} n_{t+1})^\alpha \bar{l}^{1-\alpha} - w_{t+1}(h_{t+1}) n_{t+1} - b_{t+1} + \bar{l}. \quad (13)$$

This implies that there is a threshold for the technology shock  $\underline{\epsilon}$  in period  $t+1$ ,

$$\underline{\epsilon} \equiv \underline{\epsilon}(n_{t+1}, b_{t+1}, z_t, S_{t+1}) = \log \underline{z}(n_{t+1}, b_{t+1}, S_{t+1}) - \mu_z - \rho_z \log z_t. \quad (14)$$

---

<sup>9</sup>A similar functional form for the wage has previously been used by Cooper, Haltiwanger and Willis (2004) and Cooper et al. (2007) to match the various facts about the relationship of hours and wages in the data.

I assume that a firm that defaults has to exit and the lender recovers a fraction  $\theta$  of the current period profit and the collateral.

$$R_t = \max \{ \theta (-c_f + y_t - w_t(h_t)n_t + \bar{l}) , 0 \} , \quad (15)$$

where  $\theta$  is the recovery rate in default. A financial shock is modeled as an (unexpected) change in the recovery rate parameter  $\theta$ . A decrease in  $\theta$  can be interpreted as increased monitoring cost. Chen (2010) documents that recovery rates for corporate bonds fell during the financial crisis. The immediate impact of a decrease in the recovery rate parameter  $\theta$  is that borrowing on average becomes more expensive and implies a tighter endogenous borrowing constraint for firms. In the model this affects primarily entrants and small businesses, a fact that is also present in the data (e.g., Montoriol-Garriga and Wang (2010)).

The above net worth default rule only applies to firms that hold debt,  $b_{t+1} > 0$ . That is, a firm can only default if it has issued debt. Firms that choose negative debt (assets),  $b_{t+1} < 0$ , have to satisfy the non-negativity constraint on dividends. Firms with assets,  $b_{t+1} < 0$ , save at the risk-free rate. Using this, the price of debt  $q$  is determined as:

$$q(n_{t+1}, b_{t+1}, z_t, A_t, \mu_t) = \begin{cases} E \left[ m(S_t, S_{t+1}) \left( \int_{\epsilon}^{\infty} 1 dF(\epsilon_{t+1}) + \int_{-\infty}^{\epsilon} \frac{R_{t+1}}{b_{t+1}} dF(\epsilon_{t+1}) \right) \right] & \text{if } b_{t+1} > 0 \\ E [m(S_t, S_{t+1})] & \text{if } b_{t+1} \leq 0 \end{cases} \quad (16)$$

I use  $q^+$  and  $q^-$  to refer to the price of holding positive debt and negative debt (assets), respectively.

The integral above can be computed analytically as documented in the Appendix. The underlying assumption for computing the price of debt above is that the financial intermediary is owned by the household and uses the household's discount factor. A similar default rule is employed in Gilchrist et al. (2010). The difference is that in Gilchrist et al. (2010),

debt is renegotiated and firms continue to operate at the newly negotiated level of debt.

### 3.2.3 Potential Entrants

Each potential entrant compares the value of entering  $V^e$  with the cost of entering  $c_e w$  after receiving signal  $\sigma_t$  about its future productivity. The value of an entrant can be written as:

$$V^e(n_0, b_0, \sigma_t, A_t) = E(M(S_{t+1}, S_t)V(n_0, b_0, z_{t+1}) | \sigma_t). \quad (17)$$

A fraction  $1 - \chi$  of the entry cost is financed through equity issuance to the households. The remaining fraction  $\chi$  of the entry cost has to be financed with debt. Each entrant is endowed with employment  $n_0$ . All entrants have to take on debt  $b_0$  from the financial intermediary such that  $q(n_0, b_0, z_t, A_t, \mu_t)b_0 = \chi c_e w_t$ . Finally, each entrant obtains a fixed production factor  $\bar{l}$  upon entry that can be interpreted as either land or a plant required for production and serves as a collateral. In the subsequent period, the problem of the entrants is identical to the problem of an incumbent firm. Note that  $V$  is weakly increasing in the idiosyncratic level of productivity  $z_t$ . A higher signal  $\sigma_t$  means that the productivity realization  $z_t$  is likely to be high. This in turn implies that the conditional distribution of  $z_{t+1}$  is decreasing in  $\sigma_t$ . Thus there exists a threshold  $\sigma^*$  such that:

$$V^e(n_0, b_0, \sigma^*, A_t) = c_e w_t. \quad (18)$$

If  $\sigma_t \geq \sigma^*$ , the potential entrant is going to enter but will not enter otherwise. The entry framework adds a selection effect that is novel in the literature: When the costs of borrowing are high, the required threshold signal  $\sigma_t$  to enter and not default subsequently is going to be high and the number of entrants will thus be low. The average productivity of an entrant in this scenario is thus high.

### 3.2.4 Incumbent Firms

Let  $V^0$  denote the value function of a firm that is not defaulting today. The firm's problem can be divided into subproblems. The firm knows that with probability  $\pi_d$  it is not going to survive until next period. Thus, we can write today's value of the firm as:

$$V^0(n_t, b_t, z_t; S_t) = \pi_d \max_h \left( -c_f + A_t z_t (h_t n_t)^\alpha \bar{l}^{1-\alpha} - w_t(h_t) n_t - b_t + \bar{l} \right) + (1 - \pi_d) V^1(n_{t+1}, b_{t+1}, z_{t+1}; S_{t+1}). \quad (19)$$

The first term is the value of a firm that exogenously has to exit today and maximizes its profits. The second element is for the case that the firm survives until next period. I assume that firms can only return the fixed factor of production to households upon exit.

Firms that do not default in period  $t$  can choose between adjusting and not adjusting their employment. Thus I can use two different value functions for (1) Firms that do not adjust employment  $V^{1,n}$  and (2) Firms that do adjust employment  $V^{1,a}$ :

$$V^1(n_t, b_t, z_t; S_t) = \max \{ V^{1,n}(n_t, b_t, z_t; S_t), V^{1,a}(n_t, b_t, z_t; S_t) \}. \quad (20)$$

I then distinguish between firms that choose positive debt  $b' > 0$  and firms that choose negative debt  $b' < 0$ . The above asset price and default boundary only applies to firms with positive debt holding,  $b' > 0$ . Firms with negative debt (positive asset) save at the risk-free rate  $q^-$  and face zero probability of default.

First, consider the firms not adjusting employment today:

$$V^{1,n}(n_t, b_t, z_t; S_t) = \max \{ V_{b-}^{1,n}(n_t, b_t, z_t; S_t), V_{b+}^{1,n}(n_t, b_t, z_t; S_t) \}. \quad (21)$$

The optimization problem for the firm that does not adjust employment and chooses  $b' > 0$

takes the following form:

$$V_{b+}^{1,n}(n_t, b_t, z_t; S_t) = \max_{h_t, b_{t+1} > 0} \left\{ -c_f + A_t z_t (h_t n_t)^\alpha \bar{l}^{1-\alpha} - w_t(h_t) n_t + q_t^+ b_{t+1} - b_t + E_{A_{t+1}, z_{t+1}} \left( m(S_t, S_{t+1}) \int_{\underline{\epsilon}}^{\infty} V^0(n_t(1-\delta), b_{t+1}, z_{t+1}; S_{t+1}) dF(\epsilon') \right) \right\} \quad (22)$$

subject to the non-negativity constraint in dividends, equation (7), and the price of debt, equation (16). I assume that firms and households share the same discount factor  $m(S_t, S_{t+1})$ . Borrowing is costly as soon as firms face a non-negative probability of default and in the absence of a tax advantage of debt, firms have no incentive to take on debt. Thus firms take on debt only to satisfy the non-negativity dividend constraint. For a firm that chooses  $b' < 0$ , the Bellmann equation becomes:

$$V_{b-}^{1,n}(n_t, b_t, z_t; S_t) = \max_{h_t, b_{t+1} \leq 0} \left\{ -c_f + A_t z_t (h_t n_t)^\alpha \bar{l}^{1-\alpha} - w_t(h_t) n_t + q_t^- b_{t+1} - b_t + E_{A_{t+1}, z_{t+1}} (m(S_t, S_{t+1}) V^0(n_t(1-\delta), b_{t+1}, z_{t+1}; S_{t+1})) \right\} \quad (23)$$

subject to equations (7) and (16).

The problem of a firm that decides to adjustment employment today can also be separated into two cases:

$$V^{1,a}(n_t, b_t, z_t; S_t) = \max \{ V_{b-}^{1,a}(n_t, b_t, z_t; S_t), V_{b+}^{1,a}(n_t, b_t, z_t; S_t) \}. \quad (24)$$

The firm that does choose to adjust its employment and chooses  $b' > 0$  faces the following problem:

$$V_+^{1,a}(n_t, b_t, z_t; S_t) = \max_{s_t, h_t, b_{t+1} > 0} \left\{ -c_f + A_t z_t (h_t n_t)^\alpha - w_t(h_t) n_t + q^+ b_{t+1} - b_t - AC_t + E_{A_{t+1}, z_{t+1}} \left( m(S_t, S_{t+1}) \int_{\underline{\epsilon}}^{\infty} V^0(n_t(1-\delta) + s_t, b_{t+1}, z_{t+1}; S_{t+1}) dF(\epsilon) \right) \right\}, \quad (25)$$

subject to equations (7) and (16), and the labor adjustment costs as defined in equation (6).

An adjusting firm that chooses  $b' < 0$  faces the following Bellman equation:

$$V_-^{1,a}(n_t, b_t, z_t; S_t) = \max_{s_t, h_t, b_{t+1} \leq 0} \left\{ -c_f + A_t z_t (h_t n_t)^\alpha \bar{l}^{1-\alpha} - w_t(h_t) n_t + q_t^- b_{t+1} - b_t - AC_t + E_{A_{t+1}, z_{t+1}} (m(S_t, S_{t+1}) V^0(n_t(1-\delta) + s_t, b_{t+1}, z_{t+1}; S_{t+1})) \right\} \quad (26)$$

subject to equations (7) and (16), and the labor adjustment costs as defined in equation (6).

### 3.3 Recursive Equilibrium

A recursive equilibrium is a set of functions:

$$\{w, p, V^1, \Gamma, C, q, n^h, h^h, N, H\} \quad (27)$$

that solves household, firms and financial intermediary problems as well as clear the good, labor, and bond markets. In particular, it satisfies the following set of conditions:

1. *Household* Taking  $w(h)$  as given, the households labor supply  $h^h$  and  $n^h$ , consumption  $C^h$  satisfy the households optimality conditions their budget constraint.
2. *Incumbants* Taking  $w, p, q, \Gamma$  as given,  $V^1(n, b, z, \varepsilon; A, \mu)$  solves (20). The implied policy functions are  $H(n, b, z, \varepsilon; A, \mu)$ ,  $N(n, b, z, \varepsilon; A, \mu)$  and  $B(n, b, z, \varepsilon; A, \mu)$ .
3. *Financial Intermediary* The financial intermediary determines the optimal bond price  $q(n, b, z; A, \theta, \mu)$  using (16), taking the household stochastic discount factor as given.
4. *Goods Market Clearing* Aggregate consumption plus adjustment cost and bankruptcy

cost equal aggregate output.

$$\begin{aligned}
C(n, b, z; A, \mu) = & \int Az(H(n, b, z; A, \mu) N(n, b, z; A, \mu))^{\alpha} d\mu - \\
& \int AC(n, b, z; A, \mu) \mathcal{J}(N(n, b, z; A, \mu) - n(1 - q))(1 - \pi_d) d\mu - \\
& \int \mathcal{J}(nw(n, b, z; A, \mu) \leq \bar{nw}) \varrho d\mu - \int c_e w d\mu^e,
\end{aligned} \tag{28}$$

where  $\mathcal{J}(x) = 0$  if  $x = 0$  and 1, otherwise. The second to the last term captures the loss of default, while the last term captures the cost of firm entry.

## 5. Labor Market Clearing

$$\begin{aligned}
\int_0^1 n_{i,t}^h di &= \int N(n, b, z, \varepsilon; A, \theta, \mu) d\mu \\
\int_0^1 h_{i,t}^h di &= \int H(n, b, z; A, \theta, \mu) d\mu
\end{aligned}$$

## 6. Measure of Entrants

$$\mu_t^e = M \int_S \int_{\mathcal{B}} dQ(s) dH(z'|s), \tag{29}$$

where  $\mathcal{B} = \{r \text{ s.t. } V^e(n_0, b_0, s) \geq c_e w^*\}$

## 7. Model Consistent Dynamics

The evolution of the distribution of firms follows

$$\mu_{t+1} = \Gamma(A_t, \mu_t, \mu_t^e), \tag{30}$$

where  $\mu_t$  is the distribution of firms over employment, debt and idiosyncratic technology.

### 3.4 Theoretical Results on Dividends

This section describes two propositions regarding the dividend payment policy pursued by incumbent firms in the model. The propositions show the dividend payout policy that firms that issue debt,  $b_{t+1} > 0$  and firms that hold assets,  $b_{t+1} \leq 0$  pursue.

**Proposition 1.** *It is optimal that continuing firms with positive debt holdings,  $b_{t+1} > 0$ , do not pay dividends unless they assign a zero probability to a binding dividend constraint in the future.*

*Proof.* See Appendix C. □

This finding is similar to Caggese (2007) and Khan and Thomas (2010). The intuition is simple: Since the price of debt is less (or equal) to the stochastic discount factor of firms, debt is on average costly and thus firms are better off by paying back their debt. That is, a dollar inside the firm is worth more than a dollar outside the firm. Proposition 2 provides a similar statement to Proposition 1 for firms with asset holdings  $b_{t+1} \leq 0$ .

**Proposition 2.** *Continuing firms that choose positive asset holdings,  $b_{t+1} < 0$ , only consider paying dividends if they assign zero probability to having a binding dividend constraint in the future.*

*Proof.* See Appendix C. □

The intuition for this proposition is somewhat less straightforward: Firms want to avoid to be in the situation in the future that their dividend constraint might be binding and thus want to save and pay zero dividends. As firms and households share the same stochastic discount factor, firms are at most indifferent between paying dividends and saving. The results are important for the following reason: It matches the realistic fact that start-ups are financially constrained and over time accumulate assets such they eventually become unconstrained. Firms save for precautionary reasons. In aggregate firms in the model are net lenders, similar to evidence provided by Armenter and Hnatkovska (2011).

### 3.5 Calibration

The standard approach in the literature (e.g. Bachmann, Caballero and Engel (2008), Khan and Thomas (2010), and Khan (2011)) is to match heterogenous firm models to establishment-level data. As I am interested in firm-level financial constraints, the relevant distribution is the firm size distribution. Thus, while most of the calibration of the model is standard, a few parameters are different from the literature to account for firms rather than establishments. The period is one quarter. Table 2 shows the calibration parameters. I set  $\beta = 0.99$  which corresponds to a 4% annual interest rate. The labor share  $\alpha$  is set equal to 0.7. The calibration for  $\vartheta$  follows Caballero and Engel (1993).  $\zeta_1$  and  $\zeta_2$  are set to match the average employment share in the population of 60% and about 30% of total available time for hours worked. Overall there are about 5 million firms in the U.S. that operate about 6.7 million establishments and employ about 114 million employees as of 2009.<sup>10</sup> I use this to map aggregate to individual consumption. The long run average of the employment population ratio is about 60% and is thus the target for the fraction of workers employed in the model.

Estimates for the separation rates,  $\delta$ , vary greatly. JOLTS data from 12/2000- 7/2012 imply a monthly quit rate of 1.9%, which implies a quarterly quit rate of 5.6%. Bloom, Floetotto and Jaimovich (2010) use a value of 8.8% based on findings by Shimer (2005). Abowd and Zellner (1985) find that about 3.4% of workers exit employment during a typical month between 1972 and 1982. This is similar to the total separation rate in JOLTS that averaged 3.6% monthly. Both Abowd and Zellner (1985) and Shimer (2005) use employment separation and not only quit rates. I thus set  $\delta = 0.056$  to capture worker quit rates.

$c_f$ ,  $\pi_d$  and  $\mu_z$  determine firm exit rates and the average employment size. Helfand, Sadeghi and Talan (2007) find that firm closures account for around 1.5% of employment losses in firms with more than 1,000 employees. As the default rate for large firms is essentially zero in the model, the closures of large firms are captured in  $\pi_d$ . It is clear that the default

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<sup>10</sup>This compares to a total employment of about 140 million in the entire U.S. including the public sector.

Table 2: Calibration Parameters

| Parameter                             | Symbol      | Baseline Value |
|---------------------------------------|-------------|----------------|
| Discount factor                       | $\beta$     | 0.99           |
| Labor Share                           | $\alpha$    | 0.70           |
| Employment depreciation rate          | $\delta_n$  | 0.056          |
| Elasticity of disutility of hours     | $\vartheta$ | 2.90           |
| AR(1) coeff. aggregate technology     | $\rho_A$    | 0.958          |
| Std aggregate technology              | $\sigma_A$  | 0.09           |
| AR(1) coeff. idiosyncratic technology | $\rho_z$    | 0.97           |
| Std idiosyncratic technology          | $\sigma_z$  | 0.2            |
| Fixed operating cost                  | $c_f$       | 0.01           |
| Fraction of lost output if adj.       | $\lambda$   | 0.03           |
| Proportional adj. cost                | $\phi$      | 0.01           |
| Exogenous death rate                  | $\pi_d$     | 0.015          |
| Recovery rate parameter               | $\theta$    | 1              |
| External financing fraction at entry  | $\chi$      | 0.3            |

threshold  $\bar{z}$  is increasing in  $c_f$  and decreasing in  $\mu_z$ . Firm exit rates are increasing in  $\pi_d$  by definition. The average size is increasing in  $\mu_z$ . I follow Lee and Mukoyama (2012) and choose  $\nu(\sigma) = B \exp(-\sigma/\bar{\sigma})$ .  $B$  is chosen such that the probability of the discretized distribution sums to one and  $\bar{\sigma}$  is chosen to match the entry rate.  $\bar{\sigma}$ ,  $\pi_d$  and  $\mu_z$  are then pinned down in numerical simulations. The model targets an average firm size of 21.41 employees, which corresponds to the average firm size in the BDS data from 1977 to 2009, and an exit rate of about 6%.

There is a large range of estimates for  $\rho_z$  in the literature. It is the key parameter to determine the firm size distribution. I thus pick  $\rho_z$  to approximately match the share of employment in large firms in the data.  $\sigma_z$  is taken to be in the middle of the range of values in the literature. The persistence coefficient for the transition between signal and productivity,  $\rho(s)$ , is chosen to be slightly smaller than  $\sigma_z$ . This is supposed to capture that very high (low) signals are not as informative about future productivity as present productivity is about future productivity.  $n_0$  is chosen to match the average firm size of

entrants in the data. Aggregate productivity is calibrated to match the cyclical component of HP-filtered Output from 1970:Q1-2011:Q3. Estimating the  $AR(1)$  process for aggregate technology implies  $\rho_A = 0.958$  and  $\sigma_A = 0.009$ . To obtain a discrete approximation of the two  $AR(1)$  processes, I use the method proposed by Rouwenhorst (1995). The quality of approximation remains high even for highly persistent process, as documented in Kopecky and Suen (2010).  $\theta$  is for simplicity assumed to be 1 in the baseline calibration as I am interested in the implication of a change of  $\theta$ .  $\sigma_z$  is chosen based on plant level estimates by Cooper et al. (2004) and is also used in the heterogeneous firm literature by Bachmann (2012). This estimate is similar to values found by Lee and Mukoyama (2012) as used by Berger (2012) in a related study. Labor adjustment cost parameters  $\lambda$  and  $\phi$  are chosen to correspond to values similar to values found in Bloom (2009).  $\lambda$  is slightly higher than Bloom's estimate to match the fraction of adjusters in the economy. For simplicity,  $\phi^+$  and  $\phi^-$  are chosen to be the same (i.e., upward and downward adjustment are equally costly). I set the fraction of external funds needed at entry to 30%. There is only limited information on this value in the data. Data from the U.S. Small Business administration show that about 50% of funds for startups come from credit cards, (personal and business) loans and lines of credits. The choice of 30% for the fraction of external funds needed at entry is therefore a very conservative value.

## 4 Quantitative Results

This section describes the numerical results of the model. I first provide some details on computation, the price of debt, and the stationary distribution.

### 4.1 Computation

The model framework requires tracking the distribution of firms over debt and employment. To compute the solution of the model, it is necessary to track an this infinitely dimensional

object. The full general equilibrium solution requires the solution shown in Krusell and Smith (1998). To simplify the computation, I compute all impulse response functions under the assumption of perfect foresight.<sup>11</sup> The steady states obtained in the model are identical to what they would be in a Krusell-Smith solution.<sup>12</sup> In contrast to the algorithm by Krusell-Smith I track the entire distribution on a discrete grid to compute the impulse response functions. See Appendix D for computational details.

## 4.2 Price of Debt

Figure 6, panel (a) depicts the price of debt/assets for a low productivity firm. It shows how the price of debt depends on the future employment choice as well as the debt choice. The figure shows that a low productivity firm can only obtain a low interest rate for debt at low values of debt and at low levels of employment.<sup>13</sup> Figure 6, panel (b) shows the price of debt for a higher productivity firm. A higher productivity firm has the ability to take on a significant amount of debt with much larger employment stock.

## 4.3 Stationary Distribution - Steady State

Table 3 shows key moments of the data. The model matches the data quite well with the exception of the inaction rate, which is slightly too low in the model. Thirty-seven percent of firms adjust employment in any given year and the adjustment cost paid account for 5% of GDP. The share of adjustment cost is quite large relative to GDP. It is important to note that the fixed cost component of labor adjustment makes up less than 1% of GDP. There are no corresponding numbers for the data but the adjustment cost are lower and the fraction of

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<sup>11</sup>The algorithm is implemented partially in Matlab and Fortran using MEX.

<sup>12</sup> To facilitate computation, I further assume that firms never pay dividends unless they exogenously exit. While this assumption sounds strong at first glance, one has to keep in mind the following: In the present setup, firms never strictly prefer paying dividends over accumulating assets; it either prefers paying no dividends or is at most indifferent. To be clear, this assumption is not key to any of the results below. It is worth pointing out that Armenter and Hnatkovska (2011) document that firms today are in fact net lenders.

<sup>13</sup>The figures display the price of debt for the case of  $\bar{l} = 0$ .

Figure 6: Price of Debt

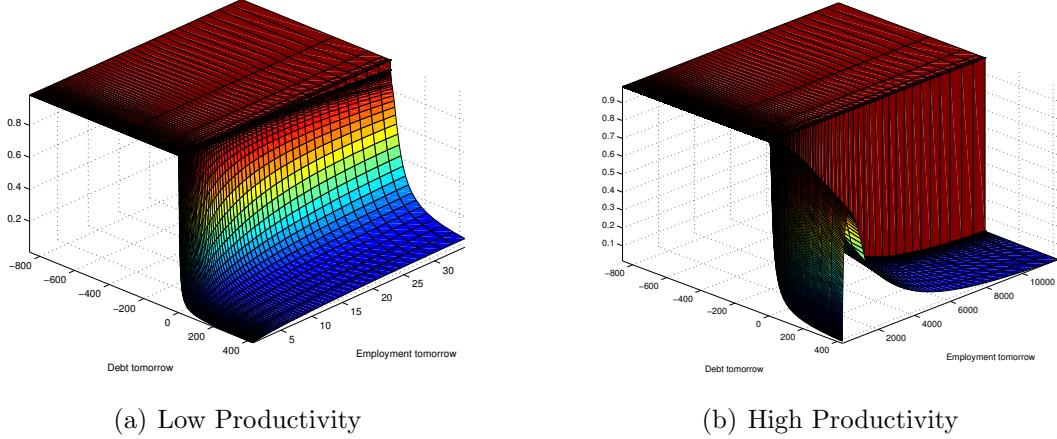


Table 3: Data vs. Model

|  | Data  | Model |
|--|-------|-------|
| Average Employment (firm)              | 21.41 | 21.49 |
| Firm Entry Rate (annual) <sup>14</sup> | 0.08  | 0.068 |
| Fraction of Adjusters (annual)         | 0.37  | 0.38  |
| Adjustment Cost/GDP                    | -     | 4.6%  |
| Entry Cost/GDP                         | -     | 0.2%  |

Notes: Data Source: Business Dynamic Statistic (BDS).

adjusters is larger in my model relative to the model in Bachmann (2012). Endogenous exit in the model is small at only 0.8% of firm annual exit endogenously while the calibration assumed that 6% of firms are assumed to be exiting exogenously. The low rate of endogenous exit can be explained by the high persistence of the idiosyncratic productivity process. Table 4 compares the firm size distribution in the data as discussed in Section 2 with the model implied distribution. The model also matches the employment share (columns 3 and 4) only partially. While the employment share of firms with more than 500 employees is 45% in the model and 48% in the data, the employment is too low for small firms relative to the data.

The employment share of small firms is 30% in the data but only 20% in the model. It

Table 4: Firm Size Distribution

| Firm Size | Firm Share |       | Employment Share |       |
|-----------|------------|-------|------------------|-------|
|           | Data       | Model | Data             | Model |
| 1-49      | 0.956      | 0.94  | 0.306            | 0.21  |
| 50-499    | 0.039      | 0.05  | 0.215            | 0.34  |
| 500+      | 0.004      | 0.001 | 0.479            | 0.45  |

Notes: Firm size distribution in model and Business Dynamic Statistics (BDS) Data.

is very difficult to generate the firm size distribution with the AR(1) process and normal shock. It is significantly easier to match the establishment size distribution. It is generally possible to match either the employment share of small or large firms in the data but the model with only AR(1) technology cannot deliver fat tails that match both small and large firm employment share. It is much easier to match the establishment size distribution with the model. Considering that the model is about external financial constraints, it does not make much sense to do that. Moreover, the model matches well the firm share distribution. About 94% of firms in the model and in the data have less than 49 employees while about 5% have between 50 and 499 employees in both the model and the data (see Table 4, columns 1 and 2).

#### 4.4 The credit shock mechanism: Intuition

The model of the firm is characterized by resembling the life cycle profile of a firm: At birth, firms require external finance. According to their productivity, firms then increase their employment stock to reach their optimal size. Employment growth of young firms depends on the availability of internal or external funds. Finally, when firms reach the end of their life cycle they exit.

Suppose the economy is at the steady state and a financial shock leads to a reduction in the recovery rate parameter  $\theta$ , i.e., the recovery in case of default is lower due to higher monitoring cost. Unconstrained firms are entirely unaffected by the change in  $\theta$ . Thus firms

with zero debt are unaffected by a shock to the recovery rate parameter. Most important is the effect of the financial constraint on entry. As entry requires external finance, a financial shock can substantially reduce entry. This reduces employment in young/small firms on impact while it leaves employment in large firms virtually unchanged. This “missing generation” of young firms is important for the economy as a whole as I discuss in the next section. Furthermore, small/young firms need credit to add employees.

Imagine two firms: one young and one old firm with the same level of productivity. The young firm has a low level of employment, less than the optimal level of employment, while the old firm is at or close to the optimal level of employment. Adjustment costs and borrowing constraints prevent small/young firms from adjusting fast to the optimal employment level. Large firms only need to maintain their employment level and due to decreasing return and resulting positive profits might not need credit to do so. Small firms on the other hand might not be able to finance labor adjustment with their profits alone or have to accumulate profits over several periods before they adjust. Hence, a decrease in the recovery rate parameter  $\theta$  will affect small firms more than larger firms.

## 4.5 Impulse Response

This section examines the effect of a temporary reduction in total factor productivity (TFP) and a drop in the recovery rate parameter in case of default,  $\theta$ . I assume that the economy is at the stationary distribution, computed in general equilibrium, when the shock hits. Shocks are initially unanticipated and the impulse response functions are computed under perfect foresight and currently in partial equilibrium (i.e., wage and interest rates are assumed to remain unchanged).

### 4.5.1 Temporary Shock to the Recovery Rate

This section examines the effect of a temporary reduction in the recovery rate parameter in case of default,  $\theta$ . Figure 7 displays the response of the economy to a temporary decline in

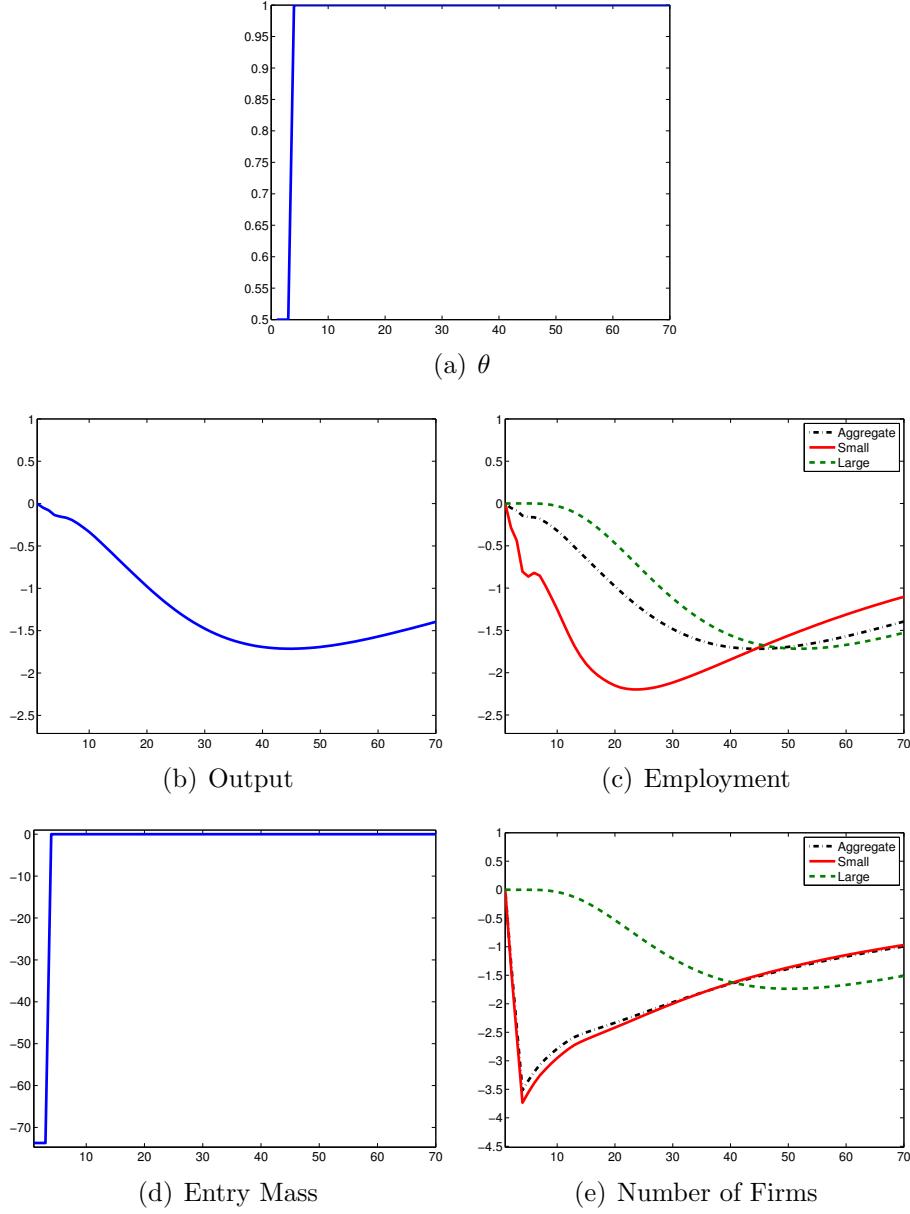
$\theta$ . The recovery rate parameter takes the value  $\theta = 0.5$  for periods 1-4 (i.e., 1 year) and then immediately returns to  $\theta = 1$  thereafter.

Upon impact the financial shock affects directly two types of firms in the economy: (1) young and small firms that are exposed to debt and (2) potential entrants. Young and small firms are exposed to debt as they have to repay the debt taken on upon entry, as well as debt they may have taken on to expand employment and finance the fixed costs of operation. Potential entrants are affected by the financial shock as they are required to externally finance a fraction of the entry cost.

Panel (a) in Figure (7) shows the path of the financial shock. The direct effect of the financial shock then is twofold: First, exit of small and young firms that cannot rollover their debt increases. Second, entry falls by 75% as potential entrants cannot secure enough funding to enter the economy, see Panel (d). Older and larger firms are unaffected by the financial shock upon impact. The reason is that these firms are unconstrained as they have accumulated savings over time. Along with a reduction in the total number of firms in the economy, the number of small firms in the economy falls relative to the number of large firms, see Panel (e). Aggregate employment initially shows only a minor decline as the firms affected by the financial shock do not account for much of aggregate employment. The decline in the number of small firms relative to large firms also implies that employment in small firms falls relative to large firm employment.

Exiting firms have relatively low productivity and the average productivity of entrants is higher during the financial crises than before. The model implies in contrast to many existing models that measured TFP increases similar to the finding in Petrosky-Nadeau (2010). The highest productivity firms in the model are essentially unconstrained and only firms with medium and low productivity are constrained. This implies an increase in measured productivity. In many other models measured TFP declines as high productivity firms are constrained in their investment/hiring (e.g., Khan and Thomas (2010)). Over the six periods of the financial shock, the total number of small firms declines by about 3.5%, which

Figure 7: Impulse Response: Shock to the Recovery Rate Parameter  $\theta$



is somewhat less than the aggregate decline in the data. Aggregate output at the end of the financial shock declines by less than 0.5% (Panel (b) in Figure 7). In 2007-2009, the decline in output was much larger but the economy in the U.S. was also subject to other shocks like an increase in economic uncertainty or a drop in consumer demand, which are not present in the model. Once the financial shock ends, entry returns to its steady level

and the number of small firms in the economy increases. The entry mechanism in the model creates a “missing generation” of entrants. The model results predict that medium and large firms that reach the end of their life cycle are not replaced by young fast-growing entrants. Thus the relatively small reduction in the number of firms leads to a time-lagged decline in the number of medium and large firms.

Even though the immediate effect of a financial shock is small, output continues to decline after the end of the shock as the “missing generation” of entrants shows a significant effect on employment in medium and large firms. While the number of small firms increases immediately after the end of the financial shock, employment in small firms itself takes about 15 quarters until the end of the financial shock to recover. This reflects that the new entrants only slowly grow large enough to reverse the employment decline. Aggregate employment and output only start to slowly recover after 40 quarters, as it takes even longer for the high productivity entrants to grow larger and replace exiting firms, as well as to increase their employment.

The economic response also highlight the importance of matching the firm size distribution. Only when matching the firm size distribution does it become clear that a financial shock primarily affects small firms. The depth of the recession is also affected by the fact that 45% of firms are large and the recovery would start earlier if large firms would contribute less to aggregate employment and output.

The literature generates significant recessions after financial shocks that place financial constraints on highly productive firms and usually predicts a rapid recovery to the steady state. This paper suggests that, unlike the existing literature, matching the firm size distribution and incorporating endogenous entry are key in understanding the long-lasting effects of financial recessions. It further highlights the importance of the life cycle of firms.

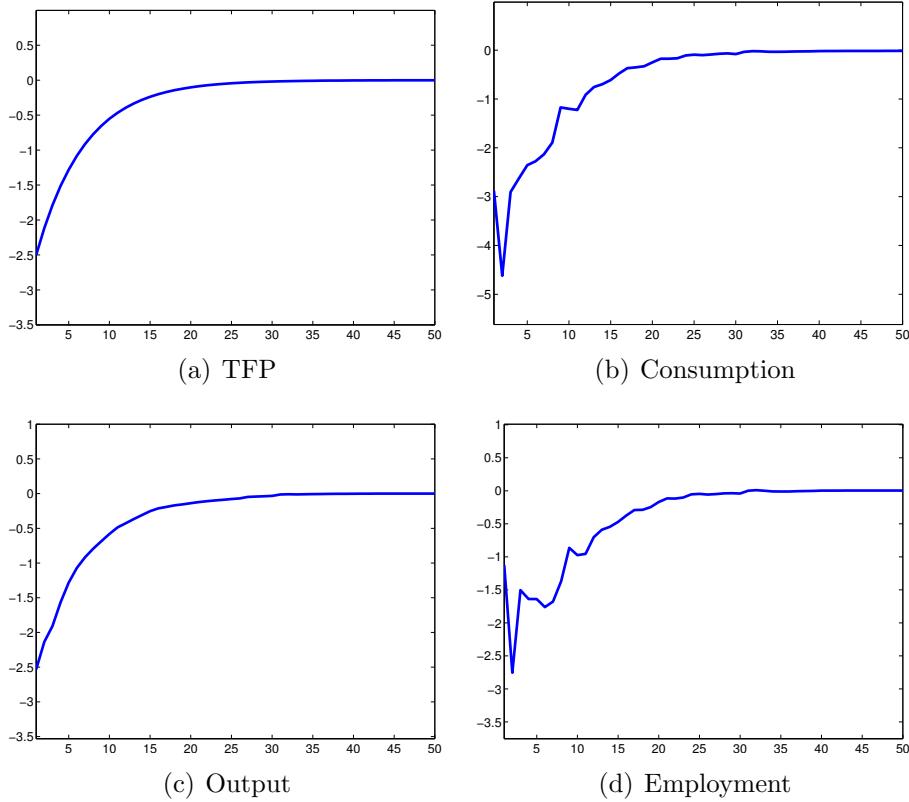
My predictions from the model are similar to the findings in Reinhart and Rogoff (2009b), Reinhart and Rogoff (2009a), and Reinhart and Rogoff (2012). The authors find that it took on average 10 years after Great Depression to return to pre crisis GDP levels. My model

predicts a longer recession but in general equilibrium the recovery is likely to be faster than in the current partial equilibrium analysis.

#### 4.5.2 Temporary Shock to the Aggregate Productivity

Historically deep recessions are followed by rapid recoveries. This is also the prediction of a standard RBC model. This section examines the effects of a temporary TFP shock on the economy. Figure 8 plots the response of the economy to a 2.5% decline in total factor productivity. TFP initially drops by 2.5% and then mean reverts to its steady state, as shown in Panel (a).

Figure 8: Impulse Response: Shock to the TFP



As the number of employees is predetermined one period ahead the biggest decline in employment and output occur in period 2, see Panel (d) in Figure 8. Consumption (Panel

(b)) falls slightly more than output (Panel (c)). This can be explained by the household preferences. The optimality condition imply only that consumption across individuals must be identical but not that consumption volatility is less than output volatility. The reduction in aggregate technology does not change the number of entrants significantly. Most firms in the economy do not hold debt, so there is no large increase in default rates. As entry and exit remain mostly unchanged, the total number of firms in the economy remains virtually constant. The economy returns rapidly to its steady state level closely following the TFP movements. The behavior of the model is thus similar to that of a standard RBC model. The model predictions for the RBC shock are in line with the findings of Samaniego (2008). The author finds that entry and exit are not very sensitive to aggregate TFP shocks. Clementi and Palazzo (2010) find that entry and exit amplify the response of the economy to TFP shock but the amplification is small.

## 4.6 Stationary Distribution: Permanent Shock to the Recovery Rate

In this section I examine the effect of a permanent reduction in the recovery rate in case of default,  $\theta$ . This is a thought experiment in which there is permanent worsening in the efficiency of the financial system. Intuitively one would expect that this should have a detrimental effect on the economy. It is well known that the long-run impact of a shock can be quite different from the short-run impact. When examining uncertainty shocks, one can, for example, see that an increase in economic uncertainty is bad in the short run yet good in the long run (e.g., Bloom (2009)). In this section I show that a similar result can be obtained for a financial shock.

### 4.6.1 Endogenous Entry and Entry Signal

In the entry framework proposed in this paper, entrants have to pay entry cost and further have to externally finance a fraction  $\chi$  of the entry cost. A financial shock in this framework

Table 5: **Effect of (permanent) Financial Shock**

|                     | $\theta$ | $N$   | $Y$   | $C$   | Av. Firm Size | # of Firms |
|---------------------|----------|-------|-------|-------|---------------|------------|
| Partial Equilibrium | 0.5      | -61%  | -61%  | -61%  | +31%          | -70%       |
| General Equilibrium | 0.5      | -0.5% | -1.4% | -1.5% | +5%           | -5%        |

Notes: The table shows the effect of a permanent reduction in the recovery rate  $\theta$  from  $\theta = 1$  to  $\theta = 0.5$ . All changes are relative to the baseline case of  $\theta = 1$ . Partial equilibrium assumes that wages are constant, the general equilibrium allows wages to adjust.

has very different implications from above as it changes the distribution of firms.

A reduction in the recovery rate increases the average cost of borrowing for firms. Suppose hypothetically that both the entrants value function and the wage remain unchanged - in fact the value of the firm is lower and the wage adjusts in general equilibrium. In this scenario, a reduction in the recovery rate implies that the number of firms that are willing to enter remains unchanged. At the same time banks are less willing to extend credit. Some of the firms that are entering - the less productive ones - then are faced with the situation that they cannot rollover their debt after entry. This reduces the number of firms in the economy. The assumption that firms have to take on credit upon entry is thus very important for this result. In a framework where firms do not have to take on credit in order to enter, i.e., a world in which  $\chi = 0$ , the effects of financial constraints are much weaker. The findings here are also in line with Cetorelli (2009), who finds that improved credit conditions lead to the entry of lower productivity firms.

Table 5 displays the long run impact of a permanent reduction in the recovery rate  $\theta$  from  $\theta = 1$  to  $\theta = 0.5$  for two cases: Case 1) Partial Equilibrium and case 2) General Equilibrium.

In partial equilibrium - wages and interest rates are fixed - employment, output, and consumption decrease by about 61% in the long run. The average firm size increases about 5% and the total number of firms falls by 70%.

Allowing wages to adjust in general equilibrium dampens the effect of the financial shock significantly. The reason is that a drop in wages increases firm entry relative to the partial

equilibrium. The increased entry then in turn implies that the total number of firms falls only by about 5%; the average firm size increases by about 5% and output and consumption fall by about 1.5% in the long run. The effect on employment is thus dampened and falls by 1.4%. In order to highlight the importance of the entry framework of the model, I now conduct the following thought experiment: suppose we are in a simpler economy in which the number of firms in the economy is constant.

#### 4.6.2 Constant Mass of Firms

Suppose a hypothetical environment in which exiting firms are replaced at no cost by new firms whose productivity is drawn from the ergodic distribution. Under the assumption that exiting firms are immediately replaced with new firms, the total mass of firms in the economy is constant. I compute a perfect foresight transition path where the recovery rate drops unexpectedly to  $\theta = 0.5$ . In the long run a worsening in the financial conditions, a lower recovery rate, is a positive event for the economy. All macro aggregates are increased relative to the initial situation. The following mechanism explains this effect: Upon impact a number of firms are unable to satisfy the zero dividend constraint. Firms that were previously able to obtain external finance are no longer able to do so as the price of debt increases. Those firms are then forced to exit the economy. As small firms on average have a significantly higher debt/ output ratio than large firms, predominantly the smaller, low productive firms are forced to exit. These firms are then immediately replaced with new firms that draw their productivity from the ergodic distribution of technology, have no debt, and an initial employment endowment of  $n_0$ . In comparison to the initial steady state, the small, low productive firms are less likely to survive. On average, the productivity of surviving firms increases such that aggregate employment in the new steady state is higher.

## 5 Empirical Evidence

In the model, a financial shock upon impact reduces employment in small firms relative to large. The main mechanism implies that a financial shocks leads to an increased number of small firm exits and most importantly a reduced number of entrants. Aggregate data showed that this observation of small firm employment and entry is consistent with the empirical evidence. In this section I examine the importance of financial constraints during the Great Recession using firm-level employment data and sectoral financial constraints measures. This provides a test for the model mechanism and provides evidence on the differential effect of external financial constraints on small and large firms.

I also provide empirical evidence on the effect of financial constraints during 2007-2009 on the entire universe of firms in the U.S. by using confidential micro data from the BLS. Much of the literature excludes the 95% of small firms with less than 50 employees. (e.g., Benmelech et al. (2011)). I construct employment at the firm-level by merging all establishments of each firm in the data since it is well known that financial constraints are present at the firm-level rather than the establishment-level. Using firm-level employment rather than establishment-level data is advantageous relative to Mian and Sufi (forthcoming). This paper combines firm-level employment data with sectoral financial constraint measures from Compustat to examine the role of credit constraints for employment growth during 2007-2009. By constructing sector-level external financial dependence measures, I can use all of the firms in the BLS data.

In contrast to the quantitative model in which by construction the only shock is a financial shock, the identification of the effect of financial constraints in the data is more challenging as the economy faced multiple shocks (e.g., increased economic uncertainty, negative demand shock). It is important to separate the employment-reducing effect coming from the supply of external funds from the employment-reducing effect coming through the demand side and increased economic uncertainty. A stronger reduction in employment in small (young) firms could be due to a reduction in demand that for some reason affected small (young)

firms. To control for this possible endogeneity concern, I separate firms into low and high external finance dependence by sector and employ a differences-in-differences methodology that removes this potential bias. The external financial dependence measure is constructed following Rajan and Zingales (1998), Kaplan and Zingales (2000), and Cetorelli and Strahan (2006). A reduction in demand that primarily affects small firms thus should affect both low and high external finance dependent firms in a similar way. If it is instead the external finance channel that matters, then one would expect that employment losses during the recession are larger in firms in high external finance dependent sectors. The difference-in-difference estimator simply differences out the demand effect.

## 5.1 Data

This project endeavors to merge the following data sources: firm-level financial data from the Compustat database and employment data from the BLS, in particular the Longitudinal Database (LDB) of the Quarterly Census of Employment and Wages (QCEW) data.

### 5.1.1 Employment Data

Employment data are sourced from the QCEW Longitudinal Database (LDB) and are available for all establishments in the U.S.<sup>15</sup> For each establishment, the LDB data provide information on employment, total wage bill, location information (e.g., county and state), sectoral information, first year of non-zero employment, and employer identification number (EIN). The data are available from 1990 to 2011.

In order to aggregate the employment data to the firm-level, there are a number of things that need to be taken into account. See Appendix E for a more detailed description of the dataset construction. The LDB is an establishment-level dataset. It is therefore necessary

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<sup>15</sup>The LDB is based on data maintained for tax purposes. It therefore contains all employers with an employer identification number (EIN) and their establishments legally operating in the United States. Unfortunately not all states make their data available to every external researcher. The states used in the project are: AL, AK, AZ, AR, CA, CO, CT, DE, DC, GA, HI, ID, IL, IN, IA, KS, KY, LA, ME, MD, MN, MO, MT, NEB, NV, NJ, NM, ND, OH, OK, PR, RI, SC, SD, TN, TX, UT, VT, VA, VI, WA, WV, WI.

to merge the establishments to the firm-level since credit constraints are present at the firm rather than the establishment-level. Each firm in the dataset has an employer identification number (EIN). I merge all establishments with the same EIN to construct a firm.

A second concern in the data is that some firms outsource employee management tasks to Professional Employer Organizations (PEO) like ADP or Insperity. In a large number of states these PEO are allowed to submit the employment information to the state under their own EIN rather than their client's EIN. In order to avoid a potential bias, I exclude the NAICS sector that contains the PEO and remove all EIN that report at least one establishment in the PEO NAICS over the sample period.

I follow Haltiwanger et al. (2010) and Moscarini and Postel-Vinay (forthcoming) using the following definition for firm-level employment growth. In particular the growth rate of employment  $n$  at firm  $i$  in sector  $j$  in state  $s$  between year  $t$  and  $t - k$  is:

$$\% \Delta n_{ijst,t-k} = \frac{n_{ijst} - n_{ijst-k}}{n_{ijst-k}^\alpha}, \quad (31)$$

where  $n_{ijst-k}^\alpha = \alpha n_{ijst} + (1 - \alpha)n_{ijst-k}$ . A common choice is  $\alpha = 1/2$ . This definition of the growthrate has several advantages (see Moscarini and Postel-Vinay (forthcoming)). First, the measure is symmetric for positive and negative employment changes. Second, this growth rate is well defined for entrants and exiters. For entrants it takes the value 2, for exiters it takes the value -2. More generally,  $\% \Delta n_{ijst} \in [-2, 2]$ .

Table 6 provides summary statistics for the dataset. The average employment size is 14 in 2007:Q4. This number is substantially lower than the average in the Business Dynamic Statistics (BDS) data. It can be explained by the fact that the dataset is constructed using the definition of a firm by tax liability rather than economic control, does not include all states, and excludes financial firms. These three factors tend to underestimate the size of firms. The average employment growth rate between 2007:Q4 and 2009:Q3 is -19%. We can also see that over the sample period about 450.000 firms entered while about 750.000 firms

Table 6: **Summary Statistics**

|                   | <i>N</i> | Mean  | Std  | Median | 10 Pct | 90 Pct |
|-------------------|----------|-------|------|--------|--------|--------|
| Employment        | 3941388  | 14    | 115  | 4      | 1      | 23     |
| Growth Rate       | 3941388  | -0.19 | 1.14 | 0      | -2     | 2      |
| Employment Small  | 37770836 | 6.5   | 8    | 3      | 1      | 17     |
| Employment Medium | 161379   | 117   | 83   | 85     | 54     | 228    |
| Employment Large  | 9173     | 1387  | 1870 | 840    | 542    | 2580   |
| Exiters           | 745868   | 6.5   | 45   | 2      | 1      | 11     |
| Entrants          | 446108   | 5.8   | 29   | 2      | 1      | 11     |

*Notes:* Growth Rate calculation is based on the symmetric growth rates as discussed above with  $\alpha = 0.5$  for 2007:Q4 to 2009:Q3. Employment Small refers to employment in firms with less than 50 employees, Employment Medium to firms with employment with more than 50 but less than 500 employees. Employment Large refers to firms with more than 500 employees

exited. The statistics for entrants are computed based on their initial firm size.

### 5.1.2 External Finance Dependence Measure

The BLS data do not contain any financial information for the firms. Therefore I use the Compustat dataset to construct credit constraint measures. This study employs sectoral financial dependence measures to exploit employment information of the all firms in the firm universe rather than the smaller subset of firms for which there are financial data available. I construct an external financial dependence measure from financial information following the methodology in Rajan and Zingales (1998), Cetorelli and Strahan (2006), Duygan-Bump et al. (2010), and Shourideh and Zetlin-Jones (2012). I construct for each mature firm  $i$  in sector  $j$  the external finance dependence measure ( $EFD_{ij}$ ):

$$EFD_{ij} = \frac{\sum_t CapEx_{ijt} - \sum_t CF_{ijt}}{\sum_t CapEx_{ijt}}. \quad (32)$$

Mature firms are firms that are in the data for at least 10 years. A value smaller than zero indicates that a firm has higher capital expenditure than free cash flow and has less funds

available. I use the sample period of 1980-1996 following Cetorelli and Strahan (2006) and Duygan-Bump et al. (2010). The credit constraint measure for sector  $j$  is chosen to be the median value across all firms in sector  $j$ . The firm-level credit measure then captures the demand for credit of the firm rather than effects of credit supply. The financial constraint measure is defined on the SIC-2 level as is common in the literature. The high and low external finance dependence are those sectors above and below the median external finance dependence measure. To match financial data with employment data, I need to match NAICS and SIC codes as the employment data only provide NAICS for the entire sample length. I follow the matching of SIC-2 to NAICS-3 in Duygan-Bump et al. (2010).

## 5.2 Empirical Specification

The empirical specification employs employment growth in sector  $j$  in state  $s$  from 2007 to 2009 as the dependent variable and uses combinations of various independent variables. I estimate firm-level employment growth as follows:

$$\begin{aligned} \% \Delta n_{ijs}^{2007-2009} = & \beta_0 + \psi_1 \delta_s + \psi_2 \delta_j + \beta_1 \text{small}_{ijs} + \beta_2 \text{young}_{ijs} + \beta_3 \text{young} * \text{small}_{ijs} \\ & + \beta_5 \text{highEFD}_j * \text{young}_{ijs} + \beta_6 \text{highEFD}_j * \text{small}_{ijs} + \psi_3 X_{ijst} + \epsilon_{ijs}^{2007-2009}, \end{aligned} \quad (33)$$

where  $\text{highEFD}_j$  is an indicator variable that takes the value one for sectors of high external finance dependence as defined above.  $X_{ijst}$  contains additional control variables.  $\delta_s$  are state fixed effects and  $\delta_j$  are industry fixed effects. A firm is classified as small (large) if it has less than 50 (more than 500) employees in 2007 and is classified as young if it is less than five years old. I categorize entrants into the size category based on their employment size in the data at entry. Reducing the sample to only one time period mitigates issues of understating standard errors that were pointed out by Bertrand, Duflo and Mullainathan (2004). A sample with multiple observations per firm over the same period would suffer from strong

positive serial correlation and therefore result in overestimation of significant levels.

### 5.3 Empirical Results

Table 7 shows the expected employment growth rate of small and large firms conditional on state and sector fixed effects in 2007:Q4-2009:Q3 and 2004:Q4-2006:Q3. In both time

**Table 7: Small and large firms in 2004-2006 vs. 2007-2009**

|                 | Employment Growth   |                     |
|-----------------|---------------------|---------------------|
|                 | 2004:Q4-2006:Q3     | 2007:Q4-2009:Q3     |
| small           | 0.183***<br>(0.002) | 0.031***<br>(0.002) |
| large           | 0.013***<br>(0.004) | -0.005<br>(0.006)   |
| 2- digit SIC FE | yes                 | yes                 |
| State FE        | yes                 | yes                 |

Notes: The dependent variable is the firm-level growth rate between 2007:Q4 and 2009:Q3. Standard errors are in parenthesis. Standard errors are heteroskedasticity robust. \*, \*\*, and \*\*\* indicate the significance at the 10%, 5% and 1% levels.

periods the average growth rate in small firms exceeds the growth rate in large firms.<sup>16</sup> The table also shows that over 2007:Q4-2009:Q3 the conditional expected growth rate in small firms was about 3 percentage points larger than in large firms. In the 2004Q4-2006Q3 the difference between small and large was 17 percentage points, more than five times larger than during the financial crisis.

Small firms tend to be more dependent on bank finance than large firms. I thus begin with analyzing the differential effect of external finance conditions on small and large firms. Subsequently, I take a closer look into the data and narrow down which firms are driving the differential impact of external finance dependence on small and large firms.

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<sup>16</sup>This does not contradict the fact that in aggregate small firm employment fell relative to large firm employment during the financial crisis as the average growth rates are not weighted by size. The small young firms are those with the highest growth rates and are smaller than many other small firms.

Table 8: **Effect of High External Finance Dependence: 2007-2009**

|                 | Employment Growth 2007:Q4 - 2009:Q3 |                      |
|-----------------|-------------------------------------|----------------------|
|                 | (1)                                 | (2)                  |
| small           | 0.030***<br>(0.002)                 | 0.054***<br>(0.003)  |
| large           | -0.02**<br>(0.008)                  | -0.001<br>(0.008)    |
| small* high     | -0.038***<br>(0.001)                | -0.038***<br>(0.004) |
| large* high     | 0.090***<br>(0.01)                  | 0.007<br>(0.01)      |
| 2- digit SIC FE | no                                  | yes                  |
| State FE        | no                                  | yes                  |
| Observations    | 3941388                             | 3941388              |

Notes: The dependent variable is the firm-level growth rate between 2007:Q4 and 2009:Q3. Standard errors are in parenthesis. Standard errors are heteroskedasticity robust. \*, \*\*, and \*\*\* indicate the significance at the 10%, 5% and 1% levels.

Column (1) in Table 8 shows the results of a simple OLS regression without fixed effects using firm-level growth rates from 2007:Q4 to 2009:Q3 as described in equation (33). A simple OLS regression suggests that employment in small firms in high external finance dependent sectors (high EFD) grew 4% less than employment in small firms in low external finance dependent sectors (low EFD). On the other hand, large firms in high external finance dependent sector grew 9% faster than large firms in low EFD sectors.

Column (2) shows that conditional on sector and state performance, the central finding remains unchanged: Small firm employment growth in high EFD sectors is on average 3.8% lower than in their low EFD counterparts. For large firms, there is no a significant difference between high and low EFD firm employment growth conditional on sector and state fixed effects. To difference out other effects (e.g. demand effect) that could have affected small firms differently than large firms, I now examine the double difference of firm size and external

finance dependence:

$$(\hat{\beta}^{small,high} - \hat{\beta}^{large,high}) - (\hat{\beta}^{small,low} - \hat{\beta}^{large,low}) \quad (34)$$

$$= (0.016 - 0.006) - (0.054 + 0.001) = -0.045 \quad (35)$$

The estimate of  $-0.045$  means that the effect of the recession on small relative to large firms is about (negative) 4.5 percentage points larger in industries with high external finance dependence. With an average growth rate of firms in the economy of  $-19\%$  (see summary statistics) the differential effect of external finance dependence on small and large firms accounts for an economically significant part of this decline. To alleviate concerns that the finding for the 2007-2009 period might also be relevant in other time periods I estimate the same regression for the 2004-2006 time period. I find that the same double difference is essentially zero.

The literature highlights the importance of young firms for employment growth. Haltiwanger et al. (2010) find that once firm age is taken into account, firm size loses its significance in explaining employment growth. Table 9 examines the relevance of small and young firms and their interaction with external finance dependence measures during the 2007-2009 recession. Column (2) examines the behavior of young firms during the recession. Young firms on average grow much faster than the rest of the economy. This is driven through entering firms. Exit, on the other hand, is somewhat less skewed towards the young and small. At the same time young firms in sectors of high external finance dependence grew more than 6% slower than their counterparts in low EFD sectors. Column (3) combines small and large firms. Small firms in general decreased employment by 1.5 percentage points relative to the average and the previous positive coefficient was driven by young firms. Finally, columns (4) and (5) look at the interaction between small and young, as well as the interaction between small, young, and high external finance dependence. Small and young firms were on average growing much faster than the average from 2007:Q4 to 2009:Q3. Larger young firms were

Table 9: **Effect of High External Finance Dependence: 2007-2009**

|                      | Employment Growth 2007:Q4 to 2009:Q3 |                      |                       |                        |                        |
|----------------------|--------------------------------------|----------------------|-----------------------|------------------------|------------------------|
|                      | (1)                                  | (2)                  | (3)                   | (4)                    | (5)                    |
| small                | 0.054***<br>(0.002)                  |                      | -0.015***<br>(0.002)  | -0.0673***<br>(0.0027) | -0.0759***<br>(0.0025) |
| young                |                                      | 0.301***<br>(0.001)  | 0.301***<br>(0.001)   | 0.0787***<br>(0.0059)  | 0.0419***<br>(0.0095)  |
| small *high          | -0.038***<br>(0.003)                 |                      | -0.0153***<br>(0.003) | -0.0297***<br>(0.0038) | -0.0141***<br>(0.0032) |
| young *high          |                                      | -0.066***<br>(0.002) | -0.066***<br>(0.002)  | -0.0657***<br>(0.0024) | -0.0055<br>(0.0119)    |
| young *small         |                                      |                      |                       | 0.2304***<br>(0.0059)  | 0.2683***<br>(0.0097)  |
| young * small * high |                                      |                      |                       |                        | -0.0622***<br>(0.0122) |
| 2- digit SIC FE      | yes                                  | yes                  | yes                   | yes                    | yes                    |
| State FE             | yes                                  | yes                  | yes                   | yes                    | yes                    |
| Observations         | 3941388                              | 3941388              | 3941388               | 3941388                | 3941388                |

*Notes:* The dependent variable is the firm-level growth rate between 2007:Q4 and 2009:Q3. Standard errors are in parenthesis. Standard errors are heteroskedasticity robust. \*, \*\*, and \*\*\* indicate the significance at the 10%, 5% and 1% levels.

also growing faster than the average but much less so. This highlights that the vast majority of entering firms are small. Most importantly, the estimation results show that high external finance dependence negatively affected small firms (coefficient  $-0.0141$ ) and most strongly small young firms (coefficient  $-0.062$ ). In summary, during the 2007-2009 recession, small and young firms in sectors of high external finance dependence grew significantly slower than small young firms in sectors less dependent on external financing.

### 5.3.1 Growth Rate 2007-2009: Controlling for Entry and Exit

In this section I examine only the firms that are in the panel in both 2007Q3 and 2009Q4 (i.e. firms that entered or exited during this period were removed). I examine if controlling for entry and exit changes the estimation results. Table 10 displays the expected growth rate for young small firms conditional on state and industry fixed effects in the whole sample and in the sample of only continuing firms.

Table 10: **Effect of Entry and Exit during 2007-2009**

|                  | Conditional Expected Growth Rate: 2007:Q4 to 2009:Q3 |                  |
|------------------|--|------------------|
|                  | Whole Sample   | Continuing Firms |
| small young      | 0.37   | 0.14             |
| small young high | 0.29   | 0.12             |
| $\Delta$         | -.08   | -.02             |
| 2- digit SIC FE  | yes  | yes              |
| State FE         | yes  | yes              |

Notes: The conditional expected growth rates are calculated using the estimation results in table 9 for the whole sample and table 11 for the sample of only continuing firms.

The conditional expected growth rate of small and large firms is large and positive in the whole sample as many young and small firms are new entrants that each enter with a growth rate of 2. The sample of only continuing firms has a much lower expected conditional growth rate as all entrants and exiting firms are removed. It shows that entry is the more important margin for small young firms. In the whole sample, small young firms in high external finance

dependent sectors have an expected conditional growth rate that is 8 percentage points lower than the expected conditional growth rate of the small, young firms in low external finance dependent sectors. In the sample of only continuing firms, this difference is only 2 percentage points.

**Table 11: Effect of High External Finance Dependence in 2007-2009: Continuing Firms only**

|                      | Employment Growth 2007:Q4 to 2009:Q3 |                      |                      |                      |                      |
|----------------------|--------------------------------------|----------------------|----------------------|----------------------|----------------------|
|                      | (1)                                  | (2)                  | (3)                  | (4)                  | (5)                  |
| small                | 0.094***<br>(0.002)                  |                      | 0.083***<br>(0.002)  | 0.071***<br>(0.002)  | 0.068***<br>(0.002)  |
| young                |                                      | 0.076***<br>(0.001)  | 0.073***<br>(0.001)  | 0.002<br>(0.002)     | -0.011**<br>(0.004)  |
| small *high          | -0.015***<br>(0.002)                 |                      | -0.011***<br>(0.002) | -0.014***<br>(0.002) | -0.010***<br>(0.002) |
| young *high          |                                      | -0.022***<br>(0.001) | -0.021***<br>(0.001) | -0.020***<br>(0.002) | 0.001<br>(0.005)     |
| young *small         |                                      |                      |                      | 0.073***<br>(0.002)  | 0.087***<br>(0.005)  |
| young * small * high |                                      |                      |                      |                      | -0.022***<br>(0.006) |
| 2 - digit SIC FE     | yes                                  | yes                  | yes                  | yes                  | yes                  |
| State FE             | yes                                  | yes                  | yes                  | yes                  | yes                  |
| Observations         | 2749412                              | 2749412              | 2749412              | 2749412              | 2749412              |

Notes: The dependent variable is the firm-level growth rate between 2007:Q4 and 2009:Q3. Standard errors are in parenthesis. Standard errors are heteroskedasticity robust. \*, \*\*, and \*\*\* indicate the significance at the 10%, 5% and 1% levels.

Table 11 confirms that the results are quite different from the whole sample estimates: The effect of high external finance dependence on employment growth rates is much smaller in absolute value across columns (1)-(5) relative the findings in the entire sample. Comparing Table 11 with Table 9 leads to the following conclusions: Column (1) in both tables shows that for the sample of continuing firms employment growth in high EFD sectors was 1.5 percentage points lower than in low EFD sectors. The same column in the whole sample

implies a reduced growth of 3.9 percentage points, more than double the effect in the sample of continuing firms. If we instead consider column (2), we see that continuing firms in the sector of high EFD on average exhibited a 2.2 percentage point lower employment growth while the same number in Table 9 is about three times larger.

Finally, the same experiment can be made separately for entering and exiting firms. I estimate the same specification but (1) remove all entering firms only and (2) remove all existing firms only. This allows me to separately examine the importance of the entry and the exit margin for the results. The results show that in the sample of only continuing plus exiting firms, small firms in the high external finance dependent sectors grew slower than the conditional average in the sample by 2.1 percentage points. In the sample of continuing firms and entrants, small firms in the high external finance dependent sector grow 3.3 percentage points slower than the conditional average in the sample. The quantitative model implied that the entry margin is more important for the response of the economy to a financial shock. The empirical finding provides support for this mechanism.

## 5.4 Robustness

This section provides two robustness checks. I estimate the same regressions as above but change the time period to 2007:Q4 to 2010:Q4. Subsequently I examine the estimation results when excluding the construction sector. The financial crisis originated in the housing sector which in particular affected the construction sector. Since the construction sector belongs to the high external finance dependent sectors, the estimation results could be sensitive to removing the construction sector.

### 5.4.1 Growth Rate 2007-2010

Using the same model specifications as before, this section provides the regression estimates for the time period of 2007:Q4 to 2010:Q4. Table 12 displays the results. Table (12) generally confirms the previous results. Extending the sample to include part of the recovery period

Table 12: **Effect of High External Finance Dependence in 2007-2010**

|                      | Employment Growth 2007:Q4 to 2010:4 |                      |                      |                      |                      |
|----------------------|-------------------------------------|----------------------|----------------------|----------------------|----------------------|
|                      | (1)                                 | (2)                  | (3)                  | (4)                  | (5)                  |
| small                | 0.113***<br>(0.003)                 |                      | -0.020***<br>(0.003) | -0.099***<br>(0.003) | -0.118***<br>(0.003) |
| young                |                                     | 0.546***<br>(0.002)  | 0.547***<br>(0.002)  | 0.200***<br>(0.007)  | 0.116***<br>(0.011)  |
| small *high          | -0.032***<br>(0.005)                |                      | 0.007<br>(0.004)     | -0.016***<br>(0.004) | 0.018***<br>(0.003)  |
| young *high          |                                     | -0.081***<br>(0.003) | -0.081***<br>(0.003) | -0.079***<br>(0.002) | 0.056***<br>(0.014)  |
| young *small         |                                     |                      |                      | 0.357***<br>(0.007)  | 0.443***<br>(0.011)  |
| young * small * high |                                     |                      |                      |                      | -0.140***<br>(0.014) |
| 2 - digit SIC FE     | yes                                 | yes                  | yes                  | yes                  | yes                  |
| State FE             | yes                                 | yes                  | yes                  | yes                  | yes                  |
| Observations         | 4188410                             | 4188410              | 4188410              | 4188410              | 4188410              |

*Notes:* The dependent variable is the firm-level growth rate between 2007:Q4 and 2010:Q4. Standard errors are in parenthesis. Standard errors are heteroskedasticity robust. \*, \*\*, and \*\*\* indicate the significance at the 10%, 5% and 1% levels.

the estimation results in column (1) and (2) highlight that over the longer sample high external finance dependence has a negative effect on employment growth in small firms as well as young firms. Column (5) is the one that is most different from the results in table (9): the negative effect of high external finance dependence on small (young) firms is exclusively driven by the effect on small and young firms. The coefficients on the interaction of small with high EFD and young with high EFD in column (5) are positive and significant in contrast to the findings in table (9). On the other hand the coefficient on the interaction between young, small and high EFD is even more negative.

#### 5.4.2 Sample Without Construction Sector

This section removes the construction sector. It is otherwise identical to the previous regressions. Table (13) displays the results.

The estimation results roughly confirm the findings from above. All interactions with high external finance dependence are mitigated to some degree but strongly significant. The construction sector is an important factor in the estimation results for high external finance dependent firms but the results are robust if we remove construction from the sample. Overall, the magnitudes are slightly lower.

### 5.5 Extension

In an extension that I am currently pursuing I add MSA level house price data to the analysis: This is similar to the approach in Chaney, Sraer and Thesmar (2010) and Mian and Sufi (forthcoming) and provides a different way in separating financial supply and aggregate demand shock. The advantage of using house price data is that it allows to take advantage of local variation in credit supply, i.e. bank balance sheets in MSAs with large house price declines deteriorated more than balance sheets of banks in areas with small house price declines. Therefore the negative credit supply shock should be larger in those MSA with a larger decline in house prices. Because the local demand effect is also stronger in areas of

Table 13: Effect of High External Finance Dependence in 2007-2009, No Construction

|                      | Employment Growth 2007:Q4 to 2009:Q3 |                      |                      |                      |                      |
|----------------------|--------------------------------------|----------------------|----------------------|----------------------|----------------------|
|                      | (1)                                  | (2)                  | (3)                  | (4)                  | (5)                  |
| small                | 0.054***<br>(0.003)                  |                      | -0.016***<br>(0.003) | -0.069***<br>(0.002) | -0.076***<br>(0.002) |
| young                |                                      | 0.300***<br>(0.001)  | 0.301***<br>(0.002)  | 0.073***<br>(0.006)  | 0.041***<br>(0.009)  |
| small *high          | -0.033***<br>(0.004)                 |                      | -0.009**<br>(0.004)  | -0.028***<br>(0.004) | -0.013***<br>(0.003) |
| young *high          |                                      | -0.044***<br>(0.002) | -0.043***<br>(0.002) | -0.041***<br>(0.002) | 0.012<br>(0.012)     |
| young *small         |                                      |                      |                      | 0.235***<br>(0.006)  | 0.267***<br>(0.009)  |
| young * small * high |                                      |                      |                      |                      | -0.056***<br>(0.012) |
| 2 - digit SIC FE     | yes                                  | yes                  | yes                  | yes                  | yes                  |
| State FE             | yes                                  | yes                  | yes                  | yes                  | yes                  |
| Observations         | 3412590                              | 3412590              | 3412590              | 3412590              | 3412590              |

Notes: The dependent variable is the firm-level growth rate between 2007:Q4 and 2009:Q3. Standard errors are in parenthesis. Standard errors are heteroskedasticity robust. \*, \*\*, and \*\*\* indicate the significance at the 10%, 5% and 1% levels.

stronger house price declines I separate industries into tradable and non-tradable industries following Mian and Sufi (forthcoming) . The intuition is that non-tradable industries are affected by both the local demand and the local credit shock while tradable industries are only affected by local credit conditions. In addition I employ the identification strategy discussed above, using sectoral financial constraint measures.

## 6 Conclusion

This paper presents a heterogenous firm model with financial constraints and firm entry that generates important facts of the 2007-2009 recession. First, firm entry significantly decreases during this period and the total number of firms in the economy falls. Employment in small firms falls more strongly than employment in large firms upon impact of the financial shock. The “missing generation” of entrants implies that over time large firms at the end of their life cycle are not being replaced by young firms. Consequently employment in these firms falls with a delay even after the shock dissipates. A long lasting recession follows along with a slow recovery. Second, this paper empirically examines, using financial data from Compustat and confidential employment data from the BLS, if firm financial constraints negatively affected employment growth in firms. The results reveal that small and young firms in high external finance dependent sectors exhibited lower employment growth than firms in low external finance dependent sectors. The results further suggest that both entry and exit margins are important in understanding the effect of a financial shock. Examining the entry and exit margin separately reveals that the entry margin shows stronger negative effects of external finance dependence on employment growth of young and small firms in 2007-2009 than the exit margin, which is in line with the model predictions.

This paper showed that matching the firm size distribution is important towards understanding the implications of a financial shock. More generally, matching the distribution of firms can be important for examining other mechanisms. Both the model and the empirical

findings imply that it is important for policy makers to consider the business conditions for small firms and start-ups in policy design.

In future collaborative empirical work, confidential employment data from the BLS and bank balance sheet data from the Federal Reserve Bank will be used to construct local measures of bank balance sheet conditions on the county/MSA level by using branch level deposit data. This will provide a direct link between firm employment and bank balance sheets. The methodology will allow examination of the effect of bank balance sheet conditions on firm employment. Furthermore, I am currently developing a tractable DSGE model with a role for a monetary authority that inherits the key characteristics shown in this model. It will allow policy makers to analyze policies that take into account the important role of firm entry in financial recessions.

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