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Firm Exit and Liquidity: Evidence from the Great Recession*

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Abstract

This paper studies the role of credit constraints in accounting for the dynamics of firm exit during the Great Recession. We present novel firm-level evidence on the role of credit constraints on exit behavior during the Great Recession. Firms in financial distress, with tighter access to credit, are more likely to default than firms with more access to credit. This difference widened substantially in the Great Recession while, in contrast, default rates did not vary much by size, age, or productivity. We identify conditions under which standard models of firms subject to financial frictions can be consistent with these facts.

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1 Introduction

The exit of firms is a key channel in the process of creative destruction underlying the functioning of modern economies. When unproductive firms shut down during crises, they free up resources that can be later used by expanding productive firms, resulting in aggregate growth. Yet, firm exit may also amplify crises in the presence of financial market frictions if productive firms with limited cash flows are forced to shut down during times of distress.

In this paper, we investigate the extent to which firm exit may be driven by the amount of liquidity available to firms. To do so, we study the dynamics of firm exit during the Great Recession of 2008/2009 in the U.S. This episode featured an aggregate drought of liquidity along with a deep recession and a sharp increase in firm exit. Figure 1 shows that the exit rate tripled from 2007 to 2008 at the same time as banks reported that they were tightening lending to both small and medium-to-large firms.[1] We ask: To what extent was the increase of firm exit during the Great Recession accounted for by liquidity rather than the natural process through which insolvent firms exit during crises?

We answer this question using a rich firm-level dataset on the universe of U.S. non-financial firms for 2000-2013, with detailed information on firms' active/inactive status, financial position, sales, and employment. We use these data to document salient features of the role of liquidity factors in accounting for firm exit during the Great Recession and to investigate their aggregate implications. We interpret our empirical findings through the lens of a model in which heterogeneous firms endogenously choose whether to exit or remain active as a function of both productivity and the degree of liquidity available. We identify conditions under which the model is consistent with our empirical findings.

Our findings point to the importance of liquidity factors in determining firm exit during the Great Recession. Specifically, we estimate firm-level financial position indicators to be much more important determinants of firm exit than firm-level fundamentals like pro-

[1] Here and throughout the rest of the paper, the exit rate in year t is the share of firms active in January of year t that are not active in January of $t+1$.

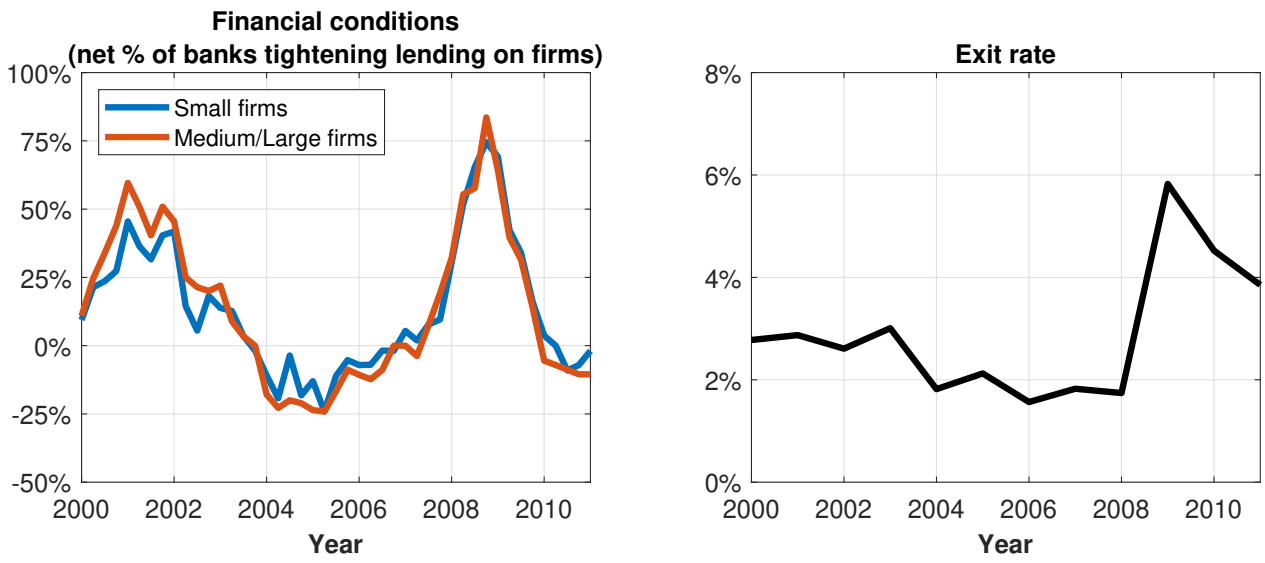

Figure 1: Great Recession, Financial Tightening, and Firm Exit

ductivity, size, or age. In aggregate, we find that firms in financial distress account for 30% of aggregate exit during this episode. These findings point to the importance of policies designed to mitigate liquidity issues during crises, as implemented in the U.S. during COVID-19.

We begin by investigating the empirical relation between firm-level financial position and exit rates. We measure firms' liquidity position based on novel firm-level data on the degree to which firms pay their vendors on time and label firms in financial distress if they pay their vendors late. To ensure the reliability of our dataset, we benchmark key statistics against official sources from the U.S. Census and U.S. Courts, validating the representativeness of our sample. We document three key findings. First, we observe a systematic relationship between firm exit rates and financial distress: Firms that pay their vendors late have much higher exit rates. Second, differences in firm exit rates by financial distress increased substantially during the crisis. Finally, these differences in firm exit rates by financial distress played an important role in accounting for the increase in the aggregate exit rate during this episode.

While these features of the data suggest that there is a tight link between financial factors and firm exit, they could be jointly driven by a common alternative channel. For

instance, unproductive firms or ones that produce low-demand goods might struggle to pay their vendors while also featuring high rates of exit.

To disentangle the role of financial factors in accounting for firm exit from fundamentals such as productivity, we set up an empirical specification with firm exit as a function of both financial factors and these alternative channels. Our main finding is that liquidity factors are a critical determinant of firm exit during the Great Recession relative to alternative factors such as firm-level productivity, size, or age.

We interpret these findings through the lens of a mostly standard, tractable model of firms with endogenous exit decisions and financial constraints. We use this setup to study the determinants of firms' exit decisions. We ask: To what extent are firms' decisions to operate determined by productivity or liquidity? Generically, the model implies that firms' operation decisions are jointly determined by both productivity and the amount of liquidity available. In the model, given a level of productivity, higher liquidity increases firms' operation scale and the likelihood that they will find it profitable to operate. Similarly, given a level of liquidity, higher productivity increases the scale of firms' operations, increasing profitability and the likelihood that they choose to operate.

The generic implication that productivity and liquidity jointly determine exit contrasts to our empirical findings. Thus, we investigate conditions that can reconcile the model's implications for the determinants of firms' operation decisions. We find three conditions such that liquidity factors but not productivity determine exit: (*i*) firms do not need to pay their variable production costs upfront, (*ii*) firms' fixed operation costs are proportional to productivity, and (*iii*) firms' access to finance is increasing in productivity. Condition (*i*) implies that firms operate at their unconstrained production scale. Condition (*ii*) implies that firms' profits are not increasing in productivity: As firms' scale and variable profits increase, so do the fixed costs, offsetting these gains. It is like a zero-profit condition but applying to exit. Condition (*iii*) implies that firm productivity alleviates financial constraints, consistent with the implications of various micro-founded theories of these frictions. Combining these

assumptions, firms' operation decisions are no longer determined by firms' productivity and instead, only liquidity.

Conditions (*i*) and (*ii*) emphasize the importance of costs that scale with size and productivity but which cannot be adjusted faster than debts are due, such as long-term supplier contracts or rent. These conditions are consistent with often-cited previous studies, e.g. Midrigan and Xu (2014), and supported by, e.g. Bergin, Feng, and Lin (2021). The third condition is in line with much of the literature that micro-founds financial constraints with models of imperfectly enforced contracts, which typically imply that productive firms have better access to finance (Albuquerque and Hopenhayn 2004; Clementi and Hopenhayn 2006). Taken together, our model implies that the Great Recession's shock to liquidity reduced firms' ability to finance their fixed operation costs, leading financially vulnerable firms to shut down.

This paper contributes to a large literature investigating the Great Recession to learn about the role of financial factors on firm-level decisions. Closely related to our work are Khan, Senga, and Thomas (2014) and Arellano, Bai, and Kehoe (2019), who study the role of firm-level default on the dynamics of U.S. aggregate dynamics during the Great Recession. We contribute to this literature with a novel dataset with information on firms' financial distress to study the role of credit market frictions on the dynamics of firm exit during crises. Our paper is also closely related to Dinlersoz, Kalemli-Ozcan, Hyatt, and Penciakova (2018), Ebsim, Faria-e Castro, and Kozlowski (2023), and Gourinchas, Kalemli-Özcan, Penciakova, and Sander (2021), who study the role of credit market frictions in the response of U.S. firms during large crises, such as the Great Recession or COVID-19. Our empirical observations are also consistent with models of cyclical credit tightening, such as Farboodi and Kondor (2023) or Gorton and Ordoñez (2014), where financially vulnerable borrowers are most affected.

Our paper is more broadly related to a literature that investigates the role of financial factors during the Great Recession, with a focus on households, firms, and financial insti-

tutions. For instance, see Chodorow-Reich (2013) or Mian and Sufi (2009) for examples of studies focused on households, and Chodorow-Reich and Falato (2022) or Gertler, Kiyotaki, and Queralto (2012) for examples of studies focused on the financial sector. For a more thorough review of this literature, see Gertler and Gilchrist (2018) and Mian and Sufi (2018).

The rest of the paper is structured as follows. In Section 2, we conduct the empirical analysis. In Section 3 we set up the model and study its implications. Section 4 concludes.

2 Access to finance and firm exit during the Great Recession

In this section we investigate the role of access to finance on the dynamics of firm exit during the Great Recession. We exploit a novel dataset with the universe of U.S. establishments and a rich set of variables.

2.1 Data

Our dataset is the National Establishment Time-Series (NETS) database collected by Dun and Bradstreet (D&B), which contains annual longitudinal information on the universe of establishments in the United States. Among other variables, the dataset provides information on establishments' credit ratings and whether they are active, allowing us to identify when firms exit.

Given our focus on exit, financial constraints, and aggregate financial conditions, we aggregate to the firm level rather than at the establishment level because financial constraints likely bind at the firm level if resources can be shared across establishments. The basic unit of observation in the NETS is an establishment, so we aggregate them into firms if they share headquarters.

Throughout the paper, we restrict attention to the period 2000-2013 and focus on firms with at least 10 employees on average over the sample for comparability with other datasets and to avoid firms that are often non-employers.

Credit ratings, delinquency, and financial distress The most important financial variable is the credit rating, Paydex scores, which characterizes the timeliness of an establishment's payments to suppliers. In particular, D&B collects payment histories from the establishment's vendors and assigns a Paydex score to reflect the reported timeliness. This score is used by banks, vendors, and other institutions to assess whether to provide loans and credit to an establishment.

The Paydex score of an establishment is a value between 0 and 100. A score below 50 indicates the establishment has been at least 30 days late with a vendor payment and lower numbers indicate even more late.[2] The NETS database reports each establishment's minimum and maximum Paydex scores each year and we use their minimum. Thus, we consider an establishment to have a low credit rating if it had a low credit rating at any point in a given year. To analyze Paydex scores at the firm level, we aggregate establishments that share a common headquarters and weight establishments' minimum Paydex scores by the number of employees across the different establishments.

We partition firms into two groups, financial distress and good standing, where the former was delinquent at least 30 days that year, as indicated by a minimum Paydex score below 50. Our findings are robust to alternative cutoffs and using three-year prior status, as in Section 5 of the Online Appendix. Summary statistics comparing firms in good financial standing and those in financial distress reveal significant differences in productivity, age, and size, as we describe in Section 2 of the Online Appendix. Firms in good financial standing tend to be larger, older, and more productive. Most importantly, firms in financial distress are more than twice as likely to exit than firms in good financial standing.

Firm-level exit: NETS vs. BDS vs. Bankruptcies Before we study the link between financial distress and firm-level exit, we show that the information on exit in the NETS is

[2]For more information, see `https://docs.dnb.com/static/doc-uploads/supplier/en-US/support/FAQs.pdf`.

consistent with other public data sources.[3] To do so, we focus on (*i*) the Business Dynamics Statistics (BDS) produced by the U.S. Census Bureau from their Longitudinal Business Database and (*ii*) business bankruptcies as reported by U.S. Bankruptcy Courts.

We begin by contrasting NETS with the publicly available firm-level tabulations of the BDS. While the BDS and NETS are both designed to cover the universe of establishments in the US, the entry and exit dynamics may meaningfully differ. As in Haltiwanger, Jarmin, and Miranda (2013) and Ding, Fort, Redding, and Schott (2022), a firm is only counted as exiting if economic activity stops at the physical location of all its establishments. This is a stricter definition than the NETS, for example in the case of reorganizations.[4] Thus, we see more in-and-out churn in the NETS data.[5]

Despite the differences, we can benchmark firm dynamics in NETS to the BDS, focusing on a statistic that can be more comparably measured in both: the number of active firms. Figure 2 compares the growth in the number of firms, normalizing the level to 2007. In both, we restrict the sample similarly to those with at least 10 employees at the firm and to establishments with a known firm linkage. The NETS-based firm dynamics show a slightly larger and more abrupt decline than the BDS. Timing differences between the two surveys partly account for this, as each measures a firm's operation at different points in the year.[6] But overall, the similarities are striking: between 2004 and 2007, the number of firms in both data sets increased by about 2%. Then from this peak, they declined by just under 8%

[3] Crane and Decker (2019) notably compare aggregate dynamics along various dimensions in NETS to other data sources and show that, under certain restrictions, NETS can be made to mimic official employer datasets with reasonable precision.

[4] Specifically, the codebook defines a firm-level exit in the BDS as follows: "Count of firms that have exited in their entirety during the period. All establishments owned by the firm must exit to be considered a firm death. This definition of firm death is narrow and strictly applied so that a firm with 100 establishments would not qualify as a firm death if 99 exited while 1 continued under different ownership. Note firm legal entities that cease to exist because of merger and acquisition activity are not classified as firm deaths in the BDS data." See `https://www.census.gov/content/dam/Census/programs-surveys/business-dynamics-statistics/codebook-glossary.pdf` and `https://www.census.gov/programs-surveys/bds/documentation/methodology.html` for more details.

[5] NETS may also feature higher entry and exit rates because of sample churn, i.e. a continually operating establishment might occasionally cease to be collected by D&B. In discussions with the designers of the NETS database, we confirmed that our subsample should be largely clean of these erroneous exits.

[6] In particular, NETS is measured around the start of each calendar year, while the BDS is measured toward the end of the first quarter of each year.

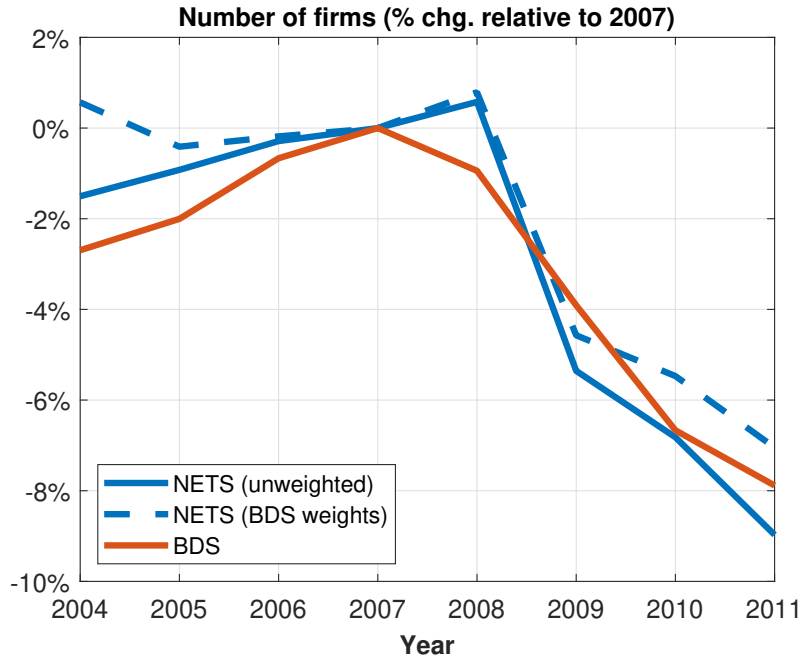

Figure 2: Firms growth: NETS vs. BDS

in BDS and just over 9% in the NETS.

We also re-weighted the NETS firms by size and industry bins to mimic the cross-sectional distribution in the BDS.[7] This is shown in the dotted blue line and is remarkably similar to the unweighted sample. The underlying reason that we do not see particularly different dynamics reflects the economics we explore below, that many of the often-observed factors on which we would weight are not particularly important to exit around this episode.

Business bankruptcy is another imperfect check on the firm-level exit rate observed in NETS. Its measure of outflows is more consistent with the NETS than BDS. However, it is still more restrictive because not every firm closure results in a bankruptcy. But, if the selection into bankruptcy among exiting firms is constant, bankruptcy rate changes will be representative of the firm exit rate.

We use data from U.S. Courts on Chapter 7 bankruptcy filings during the financial crisis and compare it to prior years, from 2001-2007. The long base period smooths over legal changes in the bankruptcy code. Chapter 7 business bankruptcy filings involve the

[7]See Section 1 of the Online Appendix for a detailed comparison of the representativeness of NETS relative to BDS.

liquidation of a debtor's assets, a shutting down that would look like an exit in NETS.[8] Bankruptcy was 179.1% higher in 2008-2010 than in the base period. We compute the analogous statistic in NETS and find the extent of exit over this period relative to the base is strikingly similar: Exits in the NETS were 176.2% higher in 2008-2010 than the 2001-2007 average.

2.2 Financial factors and firm exit

Now, we examine firm-level exit rates and financial distress, measured using Paydex scores.

The left panel of Figure 3 contrasts the dynamics of firm-level exit rates between firms in good financial standing relative to firms in financial distress, which were delinquent for at least 30 days at least once in the year. For context, we also plot the aggregate exit rate. In every year of the sample, firms in good standing have lower exit rates than firms that pay late, at least 2 percentage points higher through most of the sample, and a much larger increase during the recession.

The right panel of Figure 3 disaggregates firm-level exit rates across finer categories of financial status. As in the left panel, firms' exit rates depend systematically on their financial position, monotonically decreasing with Paydex scores. There is a discrete break between those more than or less than 30 days late, our cutoff for financial distress. For instance, firms that were 60 to 90 days late at some point in the year exited at a 5% rate in the years prior to the crisis, while they exited at a nearly 20% rate between 2008 and 2009. In contrast, the exit rates of firms in better financial standing featured a much milder increase.

The substantial increase in exit rates among firms with a weak financial position also affected the dynamics of firm-level exit in the aggregate, as we detail further below. The aggregate exit rate and the exit rate of firms in good financial standing have moved together for most of the sample up to 2008. The two exit rates diverge in 2008 because of the substantial increase in exit among firms in financial distress.

[8] Other common types of bankruptcies, like Chapter 11, are less suitable for our purposes given they involve firm reorganization, with continuing operations.

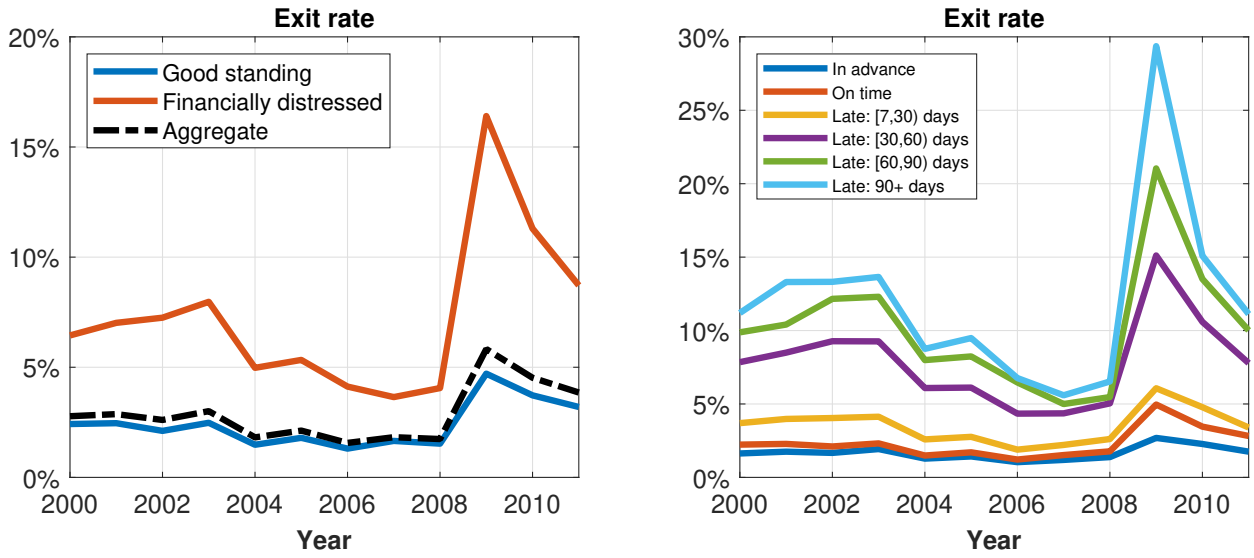

Figure 3: Firm-level financial position and exit rates

2.3 Firm exit: Financial vs. other factors

We now contrast financial distress to other characteristics like firm size, productivity, and age, which are characteristics that previous studies suggested play an important role in accounting for firm-level exit rates. We measure firm size by number of workers and sales, and proxy productivity as sales per worker.

Unconditional Figure 4 plots the exit rates conditional on (*i*) number of workers, (*ii*) sales, (*iii*) sales per worker, and (*iv*) age. These exit rates are "unconditional," examining one channel at a time, without controlling for other variables. Most strikingly, these dimensions generate much smaller differences in exit rates than those reported in Figure 3 based on Paydex scores. While previous studies have shown these dimensions to be important determinants of firm-level decisions, they are less important to the dynamics and cross-sectional differences in exit rates.

Regression analysis We now investigate whether the differences in firm-level exit by financial position documented in Figure 3 are robust when controlling for the observables

Figure 4: Firm-level exit and non-financial factors

examined in Figure 4. To do so, we consider a specification for whether firm i exits in a given period t as a function of its financial position in that period and the other observables shown in Figure 4. We estimate:

$$\text{Exit}_{it} = \sum_{j=2001}^{2011} \beta^j \times \text{Financially distressed}_{it} \times \text{Year}_{it}^j + \sum_{k=1}^{4} \sum_{j=2001}^{2011} \alpha^{jk} \times \text{Age}_{it}^k \times \text{Year}_{it}^j + \sum_{k=1}^{5} \sum_{j=2001}^{2011} \gamma^{jk} \times \text{Sales per worker}_{it}^k \times \text{Year}_{it}^j + \sum_{k=1}^{5} \sum_{j=2001}^{2011} \eta^{jk} \times \text{Workers}_{it}^k \times \text{Year}_{it}^j + \varepsilon_{it},$$

where Exit_{it} is an indicator that is equal to 1 if the firm exists between period t and $t+1$ (that is, its last active period is t). $\text{Financially distressed}_{it}$ is an indicator that is equal to 1 if the firm is financially distressed as defined above. Age_{it}^k is an indicator that is equal to 1 if the firm belongs to age group k. $\text{Sales per worker}_{it}^k$ is an indicator that is equal to 1 if the firm's sales per worker belongs to group k. Workers_{it}^k is an indicator that is equal to 1

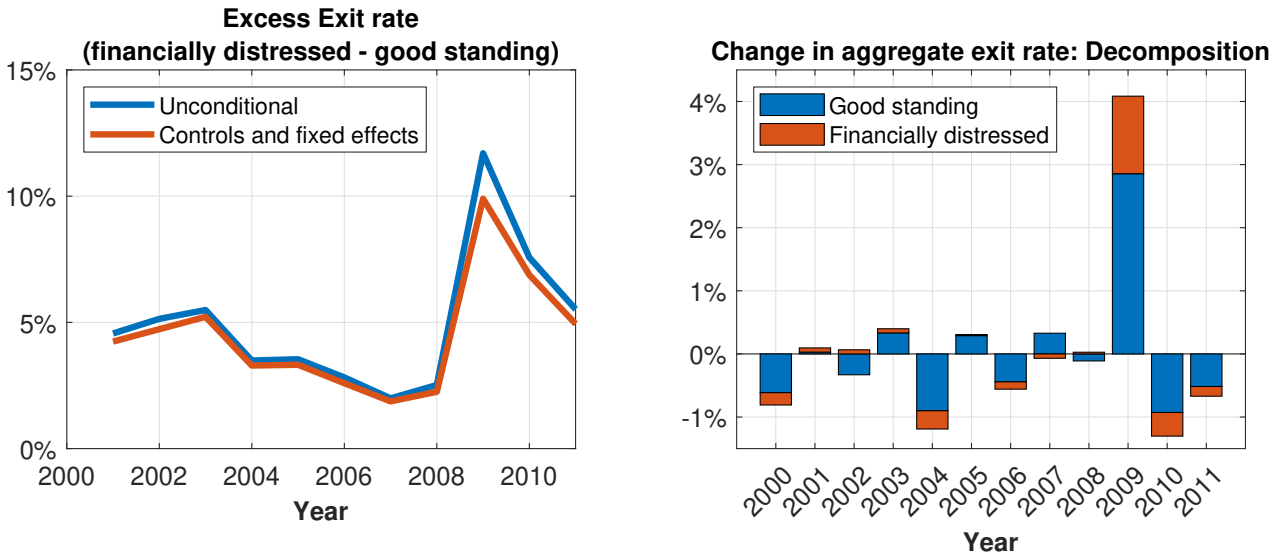

Figure 5: Financial distress and aggregate firm exit

if the firm's number of workers belong to group k. Year_{it}^{j} is an indicator that is equal to 1 if $j = t$. Note that firms' classification into groups based on age, sales per worker, and number of workers is as defined in Figure 4. Finally, $\{\beta^j, \alpha^{jk}, \gamma^{jk}, \eta^{jk}\}$ are coefficients to be estimated and ε is an error term with zero mean.

The key estimates are $\{\beta^j\}$, the coefficients on the interaction between the financially distressed and year indicators. These "excess exit rates" capture the difference in exit rates between financially distressed firms and those in good standing.

The left panel of Figure 5 plots the excess exit rates implied by the specification without any controls and those implied by the model with controls and fixed effects .[9] The figure shows that the estimated excess exit rate declines as we control for other observables because they are correlated with exit and financial distress. But, these controls do not affect excess exit much, financial status is more important.

2.4 Aggregate exit rate decomposition: Role of financial factors

The previous findings show that there are quantitatively and statistically significant differences in exit rates between firms in financial distress and good financial standing during the

[9]See Table 3 of the Online Appendix for the estimated coefficients.

Great Recession. Then, we ask: To what extent does this relatively small set of firms drive the aggregate increase in exit?

In the right panel of Figure 5, we decompose the aggregate exit rate into the contribution of firms in financial distress and firms in good financial standing.[10] For instance, in 2009 the aggregate exit rate increased by approximately 4.1 percentage points, of which financially distressed firms accounted for 1.2 percentage points of the total increase.

These findings show that financially distressed firms contribute disproportionately to the increase of the aggregate exit rate. While financially distressed firms only accounted for 9.5% of all firms in 2008, they account for 30% of the total increase of the aggregate exit rate. These firms also contributed to the subsequent decline of the aggregate exit rate in the crisis' aftermath because of a decline of their exit rates rather than a decline in the share of distressed firms.

3 Theoretical analysis

In this section we set up a model to interpret our empirical findings. We ask: To what extent can a standard model with heterogeneous firms facing credit constraints account for these? To answer, we write a simple, tractable model to clarify the determinants of firms' exit decisions, and what conditions must hold to elevate financial factors over others like productivity or size.

3.1 Setup

We consider an economy with a unit measure of firms heterogeneous in productivity z and net worth a. Firms are indexed by $i \in [0, 1]$, but we omit it for simplicity unless needed. Firms produce a homogeneous good whose price is the numeraire. Production y results from hiring labor at wage rate w to operate a decreasing returns to scale technology with idiosyncratic productivity z: $y = z^{1-\alpha} n^{\alpha}$, where α controls the contribution of labor to

[10] Online Appendix Section 4 shows the linear decomposition of the aggregate exit rate into an expression of the size of each group and their exit rate.

production relative to productivity.

Firms' operations require the payment of fixed operation costs $\phi(z)F > 0 \forall z$ in units of the homogeneous good, where F controls the magnitude of the costs, and $\phi(z)$ controls the dependence of fixed costs on idiosyncratic productivity. This specification captures the extreme case where fixed operation costs are independent of firms' idiosyncratic productivity and the more general case where these depend on firms' productivity but are independent of the effective scale of operation.

Firms operate subject to a working capital requirement, whereby fixed operation costs and a fraction $\nu(z)$ of the wage bill need to be paid before revenues accrue. In the absence of credit market frictions, firms may borrow these costs in full, preventing the timing of payment from distorting firms' production decisions. To study the role of financial factors on firms' decisions, we assume that they operate subject to credit constraints, which we model as a collateral constraint following Kiyotaki and Moore (1997), Midrigan and Xu (2014), and Buera, Kaboski, and Shin (2011), among others. In particular, we assume that firms can post their net worth as collateral, allowing them to borrow $\theta(z)$ units of the good per unit of net worth. These loans are intratemporal, and thus we assume their interest rate is zero for simplicity. Then, firms with net worth a operate subject to the following working capital constraint:

$$\nu(z)wn + \phi(z)F \leq \theta(z)a.$$

Notice that each term of the financial constraint is allowed to generically depend on z since they can often be state-dependent in models of financial constraints.[11]

Firms maximize profits and the timing is as follows: Firms first choose whether to operate and then choose the amount of labor to hire. These choices determine the amount borrowed to pay for the working capital requirements, as well as the firms' profits. Thus,

[11] Another way to think of the constraint is that it models the maximum amount that banks are willing to lend to firms as a multiple of their net worth.

the problem of a firm with idiosyncratic productivity z and net worth a is given by:

$$g(a,z) = \max\{v(a,z), 0\},$$

where we have:

$$\begin{aligned} v(a,z) = & \max_n z^{1-\alpha} n^{\alpha} - wn - \phi(z)F \\ & \text{subject to} \\ & \nu(z)wn + \phi(z)F \leq \theta(z)a. \end{aligned}$$

Given $\phi(z)F > 0$ for all z, there exist firms with productivity z and net worth a such that they cannot afford to finance the fixed operation cost: $\phi(z)F > \theta(z)a$. We assume $v(a,z) = -K$ for these firms, where $K > 0$. Thus, these firms do not choose to operate the firm.

3.2 Analytical approach

In the next subsections, we investigate the role of productivity and financial factors in accounting for firm exit, and we study the extent to which the model can account for the empirical patterns documented in Section 2. We focus on two salient features of the data: (i) the independence of firm-level exit on productivity, and (ii) the importance of financial factors in accounting for firm-level exit.

Given the static nature of the model, we interpret firms' decisions about whether to operate as characterizing the exit decisions of previously active firms. Then, we use the model to study the following two questions: (i) What is the role of productivity on firm-level exit? and (ii) What is the role of financial factors on firm-level exit?

This static analysis represents exit rates by taking a set of firms operating given a set of financial and productivity realizations and then considering their operating decisions. Hence, exit is the difference between firms coming into the period with a particular state and the

ones that chose not to operate.

3.3 Productivity and finance jointly determine exit

We begin by investigating the model's determinants of firm exit. We find that:

Proposition 1. *Firm-level exit is jointly determined by productivity z and net worth a.*

That is, firm exit depends on both productivity z and the extent to which firms have access to finance $\theta(z)a$.

Proof. Firms exit if $v(a, z) < 0$. Then, the proof shows that the firms' value function $v(a, z)$ is jointly determined by z and a. There are two cases to consider depending on whether the borrowing constraint binds or not.

Case 1: Firm is unconstrained The optimal labor choice is given by

$$n_u(z) = \left[\frac{w}{z^{1-\alpha}\alpha}\right]^{\frac{1}{\alpha-1}},$$

which implies that profits are

$$v(a, z) = zw^{\frac{\alpha}{\alpha-1}}(\alpha)^{\frac{\alpha}{1-\alpha}}(1-\alpha) - \phi(z)F.$$

Thus, we observe that productivity z generically affects the value of unconstrained firms, thereby affecting firm exit. Given that the firm is unconstrained, financial factors do not affect exit in this case.

Case 2: Firm is constrained If the constraint binds, we then have that $\nu(z)wn + \phi(z)F = \theta(z)a$. Then, the amount of labor hired by the firm is given by:

$$n_c(a, z) = \frac{\theta(z)a - \phi(z)F}{\nu(z)w},$$

and profits are then given by:

$$v(a,z) = z^{1-\alpha}\left[\frac{\theta(z)a - \phi(z)F}{\nu(z)w}\right]^{\alpha} - \left[\frac{\theta(z)a - \phi(z)F}{\nu(z)}\right] - \phi(z)F.$$

In this case, profits are also a function of both productivity z and net worth a. Conditional on the financial constraint binding, profits are increasing in net worth a and also a function of the productivity level.

Optimal choice The optimal choice ultimately depends on whether the constraint binds. The following equation characterizes the threshold values of productivity z and net worth a at which the constrained choices equal the unconstrained ones:

$$\frac{\theta(z)a - \phi(z)F}{\nu(z)w} = \left[\frac{w}{z^{1-\alpha}\alpha}\right]^{\frac{1}{\alpha-1}}.$$

In particular, given a productivity level z, this equation pins down a net worth level $a^*(z)$ such that the firm is unconstrained for $a > a^*(z)$. □

These findings imply that firms with different levels of productivity and net worth will differ in their participation and exit choices. Therefore, this unrestricted model is generically at odds with our empirical patterns, where financial factors are critical for exit, but exit does not systematically differ by productivity and size.

3.4 Extending model to account for empirical exit patterns

We now reconcile the implications of the model with the patterns in Section 2. Under what conditions does the model imply that firm exit depends on net worth but not firm-level productivity? This is the case if three conditions hold. First, that variable costs are not paid upfront and are not subject to the financial constraint. In the context of our model, this is $\nu = 0$. The next two conditions establish that fixed operation costs and credit constraints are proportional to firm-level productivity, $\phi(z) \propto z$ and $\theta(z) \propto z$.

The following proposition formalizes these statements:

Proposition 2. *If $\nu = 0$, $\theta(z) = \vartheta z$ and $\phi(z) = \varphi z$ for some $\vartheta, \varphi > 0$, then firm exit is determined by net worth a but is independent of productivity z.*

Under these three conditions, firm exit is determined by financial factors but is independent of productivity and scale. The proof is:

Proof. The condition that $\nu = 0$ implies that the labor choice is always unconstrained, regardless of the value of a or z:

$$n = \left[\frac{w}{z^{1-\alpha}\alpha}\right]^{\frac{1}{\alpha-1}},$$

which means that profits are given as described above:

$$v(a, z) = zw^{\frac{\alpha}{\alpha-1}}(\alpha)^{\frac{\alpha}{1-\alpha}}(1-\alpha) - \phi(z)F.$$

Under the second condition, we have that $\phi(z) = \varphi z$, which implies that profits become:

$$v(a, z) = z\left[w^{\frac{\alpha}{\alpha-1}}(\alpha)^{\frac{\alpha}{1-\alpha}}(1-\alpha) - \mu F\right].$$

Having any active firms requires that $w^{\frac{\alpha}{\alpha-1}}(\alpha)^{\frac{\alpha}{1-\alpha}}(1-\alpha) - \mu F > 0$. To the extent that this is the case, we have that firms choose to exit only if their net worth a is not sufficient to pay the fixed operation cost. Here, our final condition comes into play because firms exit if $\theta(z)a < \phi(z)F$, but Assumption 3 holds that $\theta \propto z$ and $\phi \propto z$. Thus, firms only exit if their net worth is sufficiently low, if $\vartheta a < \varphi F$. In this condition, firm-level productivity does not determine whether firms exit. □

We presented three conditions such that firm exit is independent of productivity but is still determined by financial factors, as encoded by the financial constraint and the level of net worth a. In the rest of this section, we argue that these assumptions are reasonable.

Assumption 1: Fixed costs are increasing in productivity Fixed costs do not vary with short-term fluctuations in the level of output, independent of the *current* production scale. But, the level of fixed costs incurred by a firm is often determined by the level of capacity, which is, in turn, a function of productivity. For example, rent, property taxes, insurance, and employee salaries with long-term contracts are all fixed costs likely to vary with firm productivity but not the production level. Further, modeling fixed costs as increasing in productivity is increasingly prevalent (e.g., Midrigan and Xu 2014).

Assumption 2: Variable costs are not finance-intensive Variable costs change in proportion to the level of output or sales, which are generally not as finance-intensive as fixed costs because they can often be paid as they are incurred. The idea is that variable costs are more flexible and easier to adjust in response to changes in demand or market conditions, reducing the need for external financing. Making variable costs entirely independent of finance is a stark way to contrast them with fixed costs. This assumption is also consistent with recent studies, such as Bergin, Feng, and Lin (2021), who show that U.S. firms are more likely to be constrained in their financing of fixed costs than of variable costs.

Assumption 3: Productive firms have better access to finance Assuming that firms' access to credit is a function of their productivity is consistent with both economic theory and empirical evidence. For instance, in standard models with endogenous borrowing constraints (e.g., Albuquerque and Hopenhayn 2004; Clementi and Hopenhayn 2006) lenders can provide productive firms with larger loans while mitigating the incentives to default due to either limited enforcement or asymmetric information. Empirical evidence supports this assumption as well. For instance, Beck and Demirguc-Kunt (2006) and Arellano, Bai, and Zhang (2012) show that access to finance differs systematically by firm size, with smaller firms relatively more distorted by frictions in financial markets than larger firms.

4 Conclusion

In this paper, we investigate the role of financial factors in accounting for the dynamics of firm-level default during the Great Recession. We document a novel set of facts on the relationship between financial distress and exit rates. We interpret this evidence from the lens of a model with heterogeneous firms subject to financial frictions. Our findings suggest that credit constraints played an important role in accounting for the dynamics of firm-level exit during the Great Recession.

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