Financial Shocks and Job Flows*

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Abstract

We provide evidence that disruptions in firm credit due to the decline in house prices played a significant role in the decline in job flows after the Great Recession. Empirically, we find the strongest effects at new and young firms and middle-sized firms. These results are not driven by the construction industry or effects of housing on consumer demand. A heterogeneous firm dynamics model with financial constraints matches our empirical findings across age and size categories. Using our structural model, we estimate that financial shocks account for 25% of the decline in employment in the Great Recession.

Keywords: Job flows, financial frictions.

JEL Classification: E44, J60

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1 Introduction

During the Great Recession, employment decreased 6.5% from its peak in late 2007 to its trough in early 2010.\footnote{Seasonally adjusted total nonfarm employment is taken from the US Bureau of Labor Statistics, the peak is in December 2007 and the trough is in January 2010.} This sharp decline in employment was accompanied by a pronounced and persistent decline in labor market flows. As shown in Figure 1, job creation and destruction during the recovery have fallen relative to the prerecession averages. This decline in job flows experienced in the US during the Great Recession stands in contrast to previous recessions (see Foster, Grim and Haltiwanger (2014)).

![Figure 1: US job flows](image)

The figure shows aggregate US job flows for 2000Q1-2012Q4 from the Business Employment Dynamics.

The sharp decline in US employment and its slow recovery have prompted an extensive debate on the underlying causes of the Great Recession and whether its financial origins make this recession fundamentally different from prior recessions.\footnote{A broad literature has quantified the contribution of various alternative factors to the decline in employment in the US experienced during the Great Recession. Şahin et al. (2014), Lazear and Spletzer (2012), and Mehrotra and Sergeyev (2014) examine the role of labor market mismatch and sectoral shocks. Relatedly, Charles, Hurst and Notowidigdo (2013) investigate the role of the housing bust in reducing employment by unmasking the long decline in manufacturing employment.} In particular, it remains an open question as to whether this financial crisis operated primarily by disrupting credit to households or to firms. Mian and Sufi (2014) argue that declining consumer demand due to household deleveraging accounts for the preponderance of the decline in US employment. Alternatively, Chodorow-Reich (2014) emphasizes the importance of the credit supply channel where disruptions in the US financial
system caused firms to shed workers by raising the cost of external financing.

In this paper, we argue that gross job flows can help separate these margins. First, we establish both empirically and theoretically the link between job flows and financial shocks. Secondly, we use our model to quantify the contribution of firm-side credit disruptions to the overall decline in US employment. As we argue, the movements in job creation and destruction in the Great Recession allow us to disentangle the contribution of credit disruptions to the firm side relative to other factors that would impact both financially constrained and unconstrained firms. Our findings support the view that financial recessions are driven by distinct shocks to firm credit rather than simply amplification of standard business cycle shocks like productivity or monetary policy shocks (financial accelerator view).

Why would job flows be a good indicator of worsening credit conditions for firms? Recent work by Haltiwanger, Jarmin and Miranda (2013) demonstrates that new and young firms account for a disproportionate share of job creation and job destruction due to their “up and out” pattern of expansion. Given the disproportionate contribution of new and young firms to labor market churn, the financial crisis may have had a disproportionate impact on young businesses. A decline in house prices may impair the formation of new firms and the expansion of existing firms by reducing the value of collateral and thereby restricting their access to external finance. Figure 2 provides some suggestive support for this hypothesis, showing a strong correlation between the decline in house prices at the state level and the decline in gross job creation at expanding establishments.

In our empirical work, we provide direct evidence that a decline in collateral values diminishes job creation and job destruction using MSA-level data from the Business Dynamics Statistics (BDS). We exploit MSA-level variation in job flows and housing prices to examine the effects of movements in MSA housing prices on job flows. House prices are taken as a proxy for credit conditions in the banking system but may have a direct effect on firm formation and expansion given the reliance of entrepreneurs on their personal wealth and the value of business real estate to secure lending. We exploit differences between new and existing firms to show that house prices are proxying for firm financing conditions rather than consumer demand.

To address issues of causality, we include MSA and time fixed effects and add direct controls for the business cycle. We also utilize an IV approach based on differences across MSAs in their sensitivity to movements in aggregate US house prices. This land supply elasticity approach - used in the literature to examine the effect of collateral shocks on real variables - is applied here to

\footnote{Cyclical movements in job flows may also be of independent interest given the importance of reallocation for productivity growth (see Davis and Haltiwanger (1999) and Haltiwanger (2012))}

\footnote{Using 2000-2006 averages from the Business Dynamics Statistics, new firms account for about 3% of employment but for nearly 17% of job creation. Similarly, young firms (defined as firms 5 years or younger) account for 12% of employment but 16% of job creation and 21% of job destruction respectively.}

\footnote{Additionally, the effect of a financial crisis on new and young firms may also help explain the observed shift in the US Beveridge curve. Recent work by Gavazza, Mongey and Violante (2014) argues that the effect of a financial crisis on new and young firms may lower the overall rate at which vacancies are converted into hires by shifting hiring away from fast-growing firms.}
The figure shows the change in job creation and the change in house prices across US states. Change in job creation is measured as percent change in job creation at expanding establishments taking the post-recession (2010-2012) average relative to the prerecession average (2004-2006).

examine the effect of housing prices on job flows.

Our empirical results show that a shock to housing prices reduces job creation persistently and reduces job destruction with a lag. These results hold under both the OLS and IV specifications and are robust to alternative controls for the MSA business cycle. Moreover, we document differences across firm age and size categories in the sensitivity of job flows to housing price shocks. In particular, we find that job creation for middle-sized firms (20-99 employees) and new and young firms (1-5 years) exhibit greater sensitivity to housing prices relative to small firms (1-19 employees) and mature firms (6+ years of age) respectively. Similar patterns hold for job destruction with middle-size firms and young firms showing a fall in job destruction when house prices fall.

Furthermore, we show that our results are not driven by the direct effect of house prices on job flows within the construction industry. We use state by industry by age data to create job flows measures ex-construction, and show that the patterns remain unchanged in the ex-construction subsample. Furthermore, we show that within construction, job flows are more sensitive at new and young firms relative to mature firms consistent with the age patterns we find in the all industry data.

Using state level data, we also document systematic differences in the sensitivity of employ-
ment at new firms v. employment at new establishments of existing firms (for example, a local independent coffee shop v. a new Starbucks location) to house price changes. Employment at new firms falls when housing prices decline, while employment at new establishments of existing firms is unchanged. This differential response is consistent with the view that house prices are proxying for credit conditions rather than some component of local demand given that new establishments from existing firms are likely to belong to older and larger firms with better access to external financing.

To examine the theoretical effect of a financial shock (a tightening of collateral constraints) on job flows and employment, we build a firm dynamics model with financial frictions and decreasing returns to scale. Newly born firms and young firms accumulate assets and expand towards their optimal scale. Mature firms are more likely to be financially unconstrained and are free to expand or contract subject to idiosyncratic shocks to firm productivity. Firms differ in productivity levels so that some businesses remain small without any binding financial constraint. We compare financial shocks to aggregate productivity shocks which, we argue, are also a proxy for other types of shocks that would impact both constrained and unconstrained firms. Our model is calibrated to match the size and age distribution of employment in the US. In our calibration, most financially constrained firms are small/medium-sized firms, but most small/medium-sized firms are not constrained.

Using our firm dynamics model, we show that financial shocks diminish aggregate job creation and destruction over the transition path. In marked contrast to productivity shocks, total reallocation (sum of creation and destruction) falls in response to a financial shock consistent with job flows behavior in the Great Recession established in Foster, Grim and Haltiwanger (2014). Our model also generates the job flows age and size patterns documented in our empirical results. In particular, a financial shock reduces job creation more at new and young firms relative to mature firms and reduces job destruction at young firms while leaving mature firms largely unaffected. A negative financial shock results in declines in job creation at middle and large sized firms while creation actually rises at small firms. Destruction falls at middle-sized firms while rising at small firms. These patterns are consistent with our empirical findings and at odds with the age and size patterns generated by a productivity shock.

The fact that financial and productivity shocks reduce employment via different margins allows us to estimate the contribution of each shock to the decline in US employment experienced in the Great Recession. We choose financial and productivity shocks to match the initial movement of job flows at the onset of the Great Recession. We find that $-33.1\%$ financial shock and $-3.8\%$ productivity shock generate at 6% decline in employment. The financial shock accounts for 25% of the decline in employment. Our findings indicate a substantial role for the firm credit channel in the decline in overall employment and in explaining the sharp decline in job creation. Nevertheless, our results suggest that a shock that impacts all firms is still needed to account for most of the decline.

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6 In this dimension, our calibration fits the stylized fact in Hurst and Pugsley (2011) that most small business owners do not wish to grow large.
in employment. The consumer deleveraging channel likely accounts for a substantial fraction of this component of the fall in employment.

1.1 Related Literature

Our paper is related to several strands of literature. Firstly, our work is related to an extensive literature documenting the effect of disruptions to firm credit on real outcomes like investment and employment. Ivashina and Scharfstein (2010) document the decline in bank lending for banks more adversely impacted during the Great Recession, while Becker and Ivashina (2014) identify shocks to credit supply and their effects on investment at small firms. Chodorow-Reich (2014) shows how disruption to firm credit during the Great Recession reduced employment. Greenstone, Mas and Nguyen (2014) use county banking and employment data to examine the effect of firm credit shocks on employment at small establishments. We differ from these papers by examining job flows and showing how the job creation margin can be used to determine the impact of firm credit disruptions on overall employment.

A subset of the literature on shocks to firm credit has emphasized the particular importance of housing prices and real estate collateral values. Papers by Gan (2007) and Chaney, Sraer and Thesmar (2012) examine the effect of collateral shocks on firm investment. The latter authors use firm-level financial data to show that a decline in the value of real estate for a firm’s headquarters has a statistically significant effect of firm investment. Adelino, Schoar and Severino (2013) documents that small business starts and employment levels showed a strong sensitivity to increases in housing prices during the boom years from 2002-2007. Chaney et al. (2015) explores the effect of real estate collateral on employment using firm level data in France. A subset of these papers use the land supply elasticity instruments proposed in Saiz (2010) and our IV strategy follows a similar approach. Our empirical work differs primarily in its focus on job flows data and emphasis on age/size patterns to distinguish shocks.

Our paper draws extensively on a literature that studies the cyclical behavior of job flows and cyclical differences in employment across firm size and age. The influence of startups and young firms on job creation and job destruction is documented in Haltiwanger, Jarmin and Miranda (2013), but we establish facts about the sensitivity of job flows across firm size and age to housing price shocks. Our empirical work is closest to work by Fort et al. (2013) that examines the cyclical role of housing prices on employment and job flows. Our results are consistent with their results and differ primarily in the use of MSA level data and an instrument variables approach to identify exogenous housing price shocks. We also provide novel evidence on the firm credit channel by comparing new firms and new establishments of existing firms.

To our knowledge, this paper is among the first to study the behavior of job flows and their response across age and size categories to different shocks in a quantitative firm dynamics model.
Gomes (2001) and Cooley and Quadrini (2001) build firm dynamics models with various financial frictions to fit facts on the firm age and firm size distribution and stylized facts about the financing of small versus large businesses. However, our model comes closest to Khan and Thomas (2013) who study the effect of a credit shock in a model with collateral constraints and firm-specific capital. They find that credit shock recessions behave differently than productivity driven recessions focusing on the implications for the dynamics of investment.

Also, the mechanism at work in our model is similar to the type of financial frictions emphasized in recent firm dynamics models by Siemer (2013) and Schott (2013) However, we focus on the job flows effect of financial shocks and identifying financial shocks relative to productivity shocks whereas these papers focus primarily on explaining jobless recoveries.

Finally, our paper contributes to a literature that examines whether business cycles can be explained by shocks that originate in the financial sector and efforts to identify recessions that are financially driven versus recessions that are driven by other conventional business cycle shocks. We are perhaps closest in spirit to Chari, Christiano and Kehoe (2013) who examine the impact of recessions by firm size. Recent work by Jermann and Quadrini (2012) and Liu, Wang and Zha (2013) examine the role of financial or collateral shocks in the Great Recession and as a source of business cycles. Buera and Moll (2012) present a model where collateral shocks are isomorphic to technology shocks. An important difference in our model relative to these models is that financial frictions only impact a small subset of firms.

The paper is organized as follows: Section 2 discusses our data and presents empirical results on the link between collateral values and job flows. Section 3 presents a simple continuous time firm dynamics model and characterizes firm behavior. Section 4 outlines the benchmark model while Section 5 describes our calibration strategy and presents our estimation results. Section 6 concludes.

2 Empirical Strategy and Results

2.1 Empirical Strategy

Any test of the hypothesis that an increase in financial frictions diminishes job flows must overcome several challenges of both measurement and causality. Our empirical strategy addresses these issues by using MSA-level variation in job flows and financial conditions to determine the causal effect of increased financial frictions on job flows.

The first issue we confront is finding suitable proxy for financial conditions at the MSA level. Since financial constraints are not typically observable, we use data on the growth rate of MSA house prices as a proxy for financial conditions. To the extent that lending to firms is secured by either the firm’s real estate or the owner’s real estate, movements in housing prices should directly
affect the ability of a firm to obtain financing. For firms with access to corporate debt and equity markets, housing price movements may be a poor proxy for financial conditions. However, the vast majority of firms do not issue debt or equity securities, instead relying upon bank financing or other forms of collateralized finance. Fairlie and Krashinsky (2012) provide direct evidence for changes in housing equity on entrepreneurship using data from the Current Population Survey, while Schmalz, Sraer and Thesmar (2013) show in French data that higher house prices increase the probability of becoming an entrepreneur and, conditional on starting a business, increase the initial scale of the firm. Adelino, Schoar and Severino (2013) also document the importance of the collateral channel in the employment at small establishments.

In addition to finding a suitable proxy for financial frictions, the relative dearth of job flows data in the time series limits any analysis of the effect of financial frictions on job flows in the aggregate data. Instead, we exploit MSA-level variation in job flows and housing prices to improve the power of our estimates and increase useful variation from state and regional housing booms.

The most significant challenge in establishing a causal effect of housing price movements on job flows is ruling out an aggregate demand channel that drives a correlation between job flows and housing prices. We address this concern in several ways. Firstly, we include location and time fixed effects to account for the business cycle and differences across MSAs in job flows. Secondly, to control for MSA-specific demand shocks, we include controls for the business cycle. Our baseline regression takes the following form:

\[ y_{it} = \alpha_i + \delta_t + \gamma (L) \Delta GSP_{it} + \beta (L) \Delta hp_{it} + \epsilon_{it} \]

where \( y_{it} \) is job creation or job destruction for MSA \( i \) at time \( t \). \( \Delta GSP_{it} \) represents the growth rate of the MSA-level business cycle variable, while \( \Delta hp_{it} \) is the growth rate of MSA housing prices. Our coefficient of interest is the sum of the coefficients \( \beta (1) \) on MSA housing prices. A positive coefficient indicates that falling house prices decrease job flows over a three-year period.

Alternatively, we also adopt an IV strategy following the methodology laid out in the empirical literature on the real effect of housing price shocks. In our IV estimates, we use both a Bartik approach and the land supply elasticity approach, using elasticities computed in Saiz (2010). Under the Bartik approach, MSA-level house price growth is instrumented with US house price growth interacted with an MSA dummy. This IV strategy is similar to the methodology used in Nakamura and Steinsson (2014) in their study of government spending multipliers. The authors use movements in national government defense spending as an instrument for state-level government spending by exploiting differences in state sensitivity to government defense expenditures.

Our other IV approach interacts the MSA-level land supply elasticities computed in Saiz (2010) with national house prices. In both cases, the identifying assumption is that whatever causes movements in national house prices is uncorrelated with MSA-specific aggregate demand shocks.
Our IV regression takes the following form:

\[
y_{it} = \alpha_i + \delta_t + \beta (L) \Delta \hat{h}p_{it} + \epsilon_{it} \quad \text{(2nd stage)}
\]
\[
\Delta h_{p_{it}} = \alpha_i + \delta_t + \rho_i (L) \Delta h_{p_{it}} + u_{it} \quad \text{(1st stage)}
\]

where \(\Delta \hat{h}p_{it}\) is the fitted value for MSA house prices obtained from the first-stage regression of MSA house prices on national house prices interacted with an MSA dummy or with the Saiz land supply elasticity. As before, the coefficient of interest is the sum of coefficients \(\beta(1)\) measuring the effect of housing prices on job flows.

To further examine the effect of housing prices on job flows, we decompose the effect of housing prices on job flows by firm size and firm age categories. As before, we utilize both OLS and IV specifications. Our OLS specification is a generalization of the MSA-level job flows regression:

\[
y_{iht} = \alpha_i + \delta_t + \kappa_h + \gamma_h (L) \Delta GSP_{it} + \beta_h (L) \Delta h_{p_{it}} + \epsilon_{iht}
\]

where \(y_{iht}\) is job creation or job destruction for MSA \(i\), in year \(t\) and category \(h\). In addition to MSA and time fixed effects, we include category fixed effects. In these regressions, we allow both the MSA business cycle variable and MSA house prices to have differential effects on job flows across categories, and our coefficient of interest is \(\beta_h(1)\) - the sum of coefficients of MSA house prices by category. The IV specification is analogous to the IV specification for aggregate job flows, where the instrument is now national house price growth interacted with a MSA-category dummy (Bartik approach) or the MSA land supply elasticity (Saiz approach):

\[
y_{iht} = \alpha_i + \delta_t + \kappa_h + \beta_h (L) \Delta \hat{h}p_{it} + \epsilon_{iht} \quad \text{(2nd stage)}
\]

Importantly, it is worth stressing that our empirical strategy cannot rule out effects on job flows through the home-equity channel emphasized by Mian and Sufi (2014). Even if our IV approach successfully identifies exogenous housing price shocks, the effect of these shocks on job creation and job destruction may be driven by a decline in consumer demand due to a decline in household wealth. However, in the last set of regressions, we compare the behavior of employment at new firms versus employment at new establishments of existing firms; we argue that the fact that new establishments of existing firms do not respond to house price shocks provides evidence in favor of the credit supply channel. Furthermore, as we establish, the patterns that we document for job creation and destruction across age and size categories are the same as those generated by a firm dynamics model under a collateral shock that disrupts firm credit. It is not obvious that a reduction in demand due to a decline in housing equity would replicate these patterns along both the creation and destruction margin across age and size categories.\(^7\)

\(^7\)Additionally, we find that our results remain unchanged in the 1982-1990 subsample - a period that largely precedes the growth in home equity and subprime lending that more strongly links consumer demand to housing wealth.
2.2 Data

We draw on several distinct data sources for measures of job flows, house prices, and MSA measures of the business cycle. Data on job flows comes from the Business Dynamics Statistics compiled by the US Census Bureau. The Business Dynamics Statistics is drawn from the Census Bureau’s Longitudinal Database (LBD), a confidential database that tracks employment at the establishment and firm level over time. The Business Dynamics Statistics report job creation and job destruction by firm age and size categories at the state and MSA level; prior to the development of BDS, these data were only available to researchers with access to confidential Census microdata. The job flows data in the BDS is drawn from Census Bureau’s Business Register, which consists of the population of firms and establishments with employees covered by unemployment insurance or filing taxes with the Internal Revenue Service.\(^8\)

Specifically, we use data on gross job creation and job destruction at the MSA level from 1982-2012, where job creation measures the increase in employment at new firms or expanding firms and job destruction measures the decrease in employment at exiting firms or contracting firms. Firm level employment is recorded in March of each year and job flows are measured with respect to employment in the previous year. Our data set includes job flows from 366 MSAs resulting in a panel of 31 x 366 observations.

Our house price data comes from the Federal Housing Finance Agency’s MSA level house price indices. We use the all-transactions indexes which provide a quarterly time series of housing prices from 1975 to present. These data are not seasonally adjusted, but we use year-over-year changes in the log of the house price index as our measure of MSA housing price growth. National housing prices are measured in the same way using the national house price index.\(^9\)

MSA-level business cycle measures come from the Bureau of Economic Analysis (BEA). Our baseline measure for the MSA business cycle is the growth rate of MSA personal income. We use measures of annual personal income and compute the growth rate as the change in the log of MSA personal income. Since job flows are measured as of March in a given year, we use the growth rate of MSA personal income in the previous year. For example, an observation of job creation for a given MSA in 2010 is matched with the growth rate of MSA personal income in 2009. Since housing prices are reported quarterly, no similar lag is required for house price growth. In addition to personal income, we also use real MSA gross product growth and employment growth as alternative proxies for the business cycle from BEA regional data.

\(^8\)A more complete description of the BDS and access to job flows data is available at http://www.census.gov/cesdataproducts/bds/.

\(^9\)Housing price data may be downloaded from: http://www fhfa.gov.
### Table 1: Effect of housing prices on aggregate job flows

<table>
<thead>
<tr>
<th></th>
<th>Job Creation</th>
<th>Job Destruction</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>OLS (1)</td>
<td>IV (Bartik) (2)</td>
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<tr>
<td><strong>Panel A</strong></td>
<td></td>
<td></td>
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<tr>
<td>Current housing price growth</td>
<td>0.34**</td>
<td>0.31**</td>
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<tr>
<td></td>
<td>(0.04)</td>
<td>(0.15)</td>
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<tr>
<td>1 year lagged housing price growth</td>
<td>0.18**</td>
<td>0.06</td>
</tr>
<tr>
<td></td>
<td>(0.03)</td>
<td>(0.21)</td>
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<tr>
<td>2 years lagged housing price growth</td>
<td>0.00</td>
<td>0.20**</td>
</tr>
<tr>
<td></td>
<td>(0.03)</td>
<td>(0.08)</td>
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<tr>
<td>Num. Obs.</td>
<td>9343</td>
<td>2653</td>
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<tr>
<td>First stage F-test</td>
<td>6.0</td>
<td>24.0</td>
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<tr>
<td></td>
<td>3.8</td>
<td>23.0</td>
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<tr>
<td><strong>Panel B</strong></td>
<td></td>
<td></td>
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<tr>
<td>Sum of coefficients</td>
<td>0.53**</td>
<td>0.57**</td>
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<tr>
<td></td>
<td>(0.05)</td>
<td>(0.08)</td>
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Panel A of the table presents coefficient estimates relating job flows to housing price growth at the MSA level. Panel B presents the sum of the coefficient estimates on current, 1 year and 2 years lagged housing price growth. Each column of the table reports results from a different regression. The dependent variable is MSA-level job creation in the first three columns and MSA-level job destruction in the last three columns. ** - coefficient estimate significant at the 5% level. Standard errors are in parentheses.

### 2.3 Empirical Results

#### 2.3.1 Aggregate Job Flows

Table 1 displays the coefficients of MSA housing price growth on job creation and job destruction at the MSA-level. MSA job creation and job destruction are converted to logs and detrended using a linear MSA-specific time trend. As Table 1 shows, both the OLS and IV specifications give statistically significant coefficients for MSA house prices on job creation on impact and with a lag. For job destruction, the impact effect of house prices is negative, but the second lagged coefficient is positive implying that a decline in house prices reduces ob destruction in subsequent years. It is worth noting that since the sample ends in March 2012, our estimates for the effect of house prices on job flows are exploiting variation that does not fully include the weak recovery after the Great Recession.\(^{10}\)

Panel B in Table 1 also displays the sum of the coefficients on housing prices. For job creation, the sum of the coefficients is positive and statistically significant indicating that housing price movements have a persistent effect on job creation. For job destruction, the sum of the coefficients

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\(^{10}\)Figure 1 uses a different data set, the Business Employment Dynamics, maintained by the Bureau of Labor Statistics that is available with a shorter delay and at quarterly frequencies, but is not available at the MSA-level.
under the baseline OLS and IV specifications is not statistically different from zero. However, excluding the impact effect, the sum of the lagged coefficients of housing prices on job destruction is positive and statistically significant across both the OLS and IV specifications. For the IV regressions, current and lagged house prices are instrumented with F-statistics above 10 under the Saiz approach.\textsuperscript{11} The Bartik-type instrument delivers first-stage F statistics below 10, but partial r-squareds around 10%.\textsuperscript{12} Our OLS results are robust to using either real MSA gross product growth or MSA employment growth as cyclical controls and are robust to using first-differenced job flows instead of linearly detrended job flows. Additionally, our results continue to hold in state-level data instead of MSA-level data.

2.3.2 Category-Specific Job Flows

We first consider job flows by firm size, and consider three categories: small firms (1-19 employees), medium-sized firms (20-99 employees), and large firms (100+ employees). Firm size assigns size categories based on an average of employment in the previous year and employment in the current year raising potential issues of reclassification bias (see Moscarini and Postel-Vinay (2012) for a discussion). However, initial firm size data is not available at the MSA level, and our results are unchanged in state level data using size categories based on initial firm size.

Table 2 displays the results from the category-specific regressions of job creation and job destruction on housing prices. The table shows the sum of coefficients on MSA housing prices, $\beta_h(1)$ under the OLS and IV specifications. For job creation, middle and large sized firms exhibit the highest sensitivity to housing prices, followed by small firms. In the case of the IV specification, the coefficient of housing prices on job creation for small firms is negative meaning a decrease in house price growth raises job creation at small firms. Job destruction for middle-sized firms display a positive coefficient on housing prices under all specifications, though the coefficients are not statistically significant under IV specifications. Job destruction also falls for large firms, but the positive job destruction coefficient for large firms is influenced by a positive impact coefficient.

Table 2 also shows that the difference in coefficients between middle-sized firms and small firms is statistically significant across all specifications for both job creation and job destruction. In contrast, the difference for middle and large sized firms for job creation is generally not significant. As with the results for overall job flows, the general pattern of a positive coefficient of job flows on housing prices at middle-sized firms and stronger response relative to small-sized firms is robust to use of state-level data and alternative controls for the MSA business cycle.

\textsuperscript{11}The Saiz land supply elasticities are only available for a subset of our MSAs. Therefore, both the Bartik and Saiz IV regressions are subsamples of the data used for the OLS regressions.

\textsuperscript{12}Similar to the issues discussed in footnote 30 of Nakamura and Steinsson (2014), instrumenting local house prices with national house prices results in a large number of instruments for each endogenous regressor (MSA house price growth has 88 instruments - each MSA dummy interacted with national house price growth) that results in F-statistics below 10. However, like Nakamura and Steinsson (2014), our instruments deliver similar magnitudes in terms of partial r-squareds.
**Table 2:** Effects on housing prices on job flows by firm size

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<tr>
<th></th>
<th>Job Creation</th>
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<td>OLS</td>
<td>IV (Bartik)</td>
<td>IV (Saiz)</td>
<td>OLS</td>
<td>IV (Bartik)</td>
<td>IV (Saiz)</td>
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<td>Panel A</td>
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<tr>
<td>1-19 employees</td>
<td>0.37**</td>
<td>0.25**</td>
<td>-0.13</td>
<td>-0.10**</td>
<td>-0.34**</td>
<td>-0.43**</td>
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<tr>
<td></td>
<td>(0.04)</td>
<td>(0.06)</td>
<td>(0.11)</td>
<td>(0.04)</td>
<td>(0.07)</td>
<td>(0.11)</td>
</tr>
<tr>
<td>20-99 employees</td>
<td>0.75**</td>
<td>0.73**</td>
<td>0.66**</td>
<td>0.28**</td>
<td>0.01</td>
<td>0.18</td>
</tr>
<tr>
<td></td>
<td>(0.06)</td>
<td>(0.06)</td>
<td>(0.09)</td>
<td>(0.06)</td>
<td>(0.07)</td>
<td>(0.11)</td>
</tr>
<tr>
<td>100+ employees</td>
<td>0.58**</td>
<td>0.81**</td>
<td>0.83**</td>
<td>0.13*</td>
<td>0.23**</td>
<td>0.56**</td>
</tr>
<tr>
<td></td>
<td>(0.06)</td>
<td>(0.09)</td>
<td>(0.13)</td>
<td>(0.08)</td>
<td>(0.09)</td>
<td>(0.12)</td>
</tr>
<tr>
<td>Num. Obs.</td>
<td>28029</td>
<td>7959</td>
<td>7959</td>
<td>28029</td>
<td>7959</td>
<td>7959</td>
</tr>
<tr>
<td>Panel B</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>H = (20-99 emp)</td>
<td>0.38**</td>
<td>0.49**</td>
<td>0.79**</td>
<td>0.38**</td>
<td>0.35**</td>
<td>0.60**</td>
</tr>
<tr>
<td></td>
<td>(0.04)</td>
<td>(0.04)</td>
<td>(0.09)</td>
<td>(0.04)</td>
<td>(0.05)</td>
<td>(0.09)</td>
</tr>
</tbody>
</table>

The table presents the effect of housing price growth at the MSA level on job flows by firms size categories (1-19, 20-99 and 100+ employees). Each column in the table reports results from a different regression. The dependent variable is job creation in the first three columns and job destruction in the last three columns. The numbers reported are the sum of the effects of current, 1 year and 2 years lagged changes in house price growth on job flows by firm size. Panel B reports the difference in the effect of housing price changes on job flows between medium (20-99 employees) and small firms (1-19 employees). ** - coefficient estimate significant at the 5% level. Standard errors are in parentheses.

**Table 3:** Effect of housing prices on job flow by firm age

<table>
<thead>
<tr>
<th></th>
<th>Job Creation</th>
<th></th>
<th></th>
<th>Job Destruction</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>OLS</td>
<td>IV (Bartik)</td>
<td>IV (Saiz)</td>
<td>OLS</td>
<td>IV (Bartik)</td>
<td>IV (Saiz)</td>
</tr>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
<td>(4)</td>
<td>(5)</td>
<td>(6)</td>
</tr>
<tr>
<td>Panel A</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Births</td>
<td>0.88**</td>
<td>0.66**</td>
<td>0.68**</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.07)</td>
<td>(0.09)</td>
<td>(0.13)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Young Firms, 1-5 years</td>
<td>0.48**</td>
<td>0.63**</td>
<td>0.55**</td>
<td>0.36**</td>
<td>0.20**</td>
<td>0.47**</td>
</tr>
<tr>
<td></td>
<td>(0.07)</td>
<td>(0.11)</td>
<td>(0.14)</td>
<td>(0.07)</td>
<td>(0.09)</td>
<td>(0.13)</td>
</tr>
<tr>
<td>Mature Firms, 6+ years</td>
<td>0.33**</td>
<td>0.31**</td>
<td>-0.01</td>
<td>-0.06</td>
<td>-0.19**</td>
<td>-0.03</td>
</tr>
<tr>
<td></td>
<td>(0.05)</td>
<td>(0.09)</td>
<td>(0.15)</td>
<td>(0.06)</td>
<td>(0.08)</td>
<td>(0.12)</td>
</tr>
<tr>
<td>Num. Obs.</td>
<td>28029</td>
<td>7959</td>
<td>7959</td>
<td>18686</td>
<td>5306</td>
<td>5306</td>
</tr>
<tr>
<td>Panel B</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>H = Births - Mature or Young - Mature</td>
<td>0.55**</td>
<td>0.36**</td>
<td>0.69**</td>
<td>0.43**</td>
<td>0.40**</td>
<td>0.50**</td>
</tr>
<tr>
<td></td>
<td>(0.08)</td>
<td>(0.08)</td>
<td>(0.14)</td>
<td>(0.07)</td>
<td>(0.07)</td>
<td>(0.13)</td>
</tr>
</tbody>
</table>

The table presents the effect of housing price growth at the MSA level on job flows by firm age categories (births, 1-5 and 6+ years old). Each column in the table reports results from a different regression. The dependent variable is job creation in the first three columns and job destruction in the last three columns. The numbers reported are the sum of the effects of current, 1 year and 2 years lagged changes in house price growth on job flows by firm age. The first three columns of panel B reports the difference in the effect of housing price changes on job flows between new and mature firms. The last three columns of panel B present the difference in the effect of housing price between young and mature firms. ** - coefficient estimate significant at the 5% level, * - coefficient estimate significant at the 10%. Standard errors are in parentheses.
Table 4: Effect of housing prices on job creation within industry

<table>
<thead>
<tr>
<th></th>
<th>All Industries</th>
<th>Construction</th>
<th>All Industries ex-Construction</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>OLS (1)</td>
<td>IV (Bartik)</td>
<td>OLS (3) IV (Bartik)</td>
</tr>
<tr>
<td>Panel A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sum of coefficients</td>
<td>0.24**</td>
<td>0.54**</td>
<td>1.67**</td>
</tr>
<tr>
<td></td>
<td>(0.10)</td>
<td>(0.12)</td>
<td>(0.18)</td>
</tr>
<tr>
<td>Num. Obs.</td>
<td>1479</td>
<td>1479</td>
<td>1479</td>
</tr>
<tr>
<td>Panel B</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>New and young firms</td>
<td>0.51**</td>
<td>0.75**</td>
<td>2.37**</td>
</tr>
<tr>
<td>&lt; 5 years</td>
<td>(0.10)</td>
<td>(0.12)</td>
<td>(0.24)</td>
</tr>
<tr>
<td>Mature firms</td>
<td>0.11</td>
<td>0.41**</td>
<td>1.01**</td>
</tr>
<tr>
<td>&gt; 5 years</td>
<td>(0.10)</td>
<td>(0.13)</td>
<td>(0.21)</td>
</tr>
<tr>
<td>Num. Obs.</td>
<td>2958</td>
<td>2958</td>
<td>2958</td>
</tr>
<tr>
<td>Panel C</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>New and young -mature firms</td>
<td>0.39**</td>
<td>0.34**</td>
<td>1.36**</td>
</tr>
<tr>
<td></td>
<td>(0.09)</td>
<td>(0.08)</td>
<td>(0.28)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Panel A of the table presents the sum of coefficient estimates on current, 1 year, and 2 year lagged state housing price growth. Panel B presents the sum of the coefficient estimates on state house price growth by firm age categories. Panel C reports the difference in the sum of coefficients for new and young versus mature firms. Each column of the table reports results from a different regression. The dependent variable is state-level job creation by industry in all columns. ** - coefficient estimate significant at the 5% level. Standard errors are in parentheses.

We also consider job flows by firm age categories: new firms, young firms (1-5 years of age), and mature firms (6+ years of age). These firm age categories are same categories used in Haltiwanger, Jarmin and Miranda (2013). Table 3 shows that job creation at new firms exhibit the strongest response to housing prices followed by job creation at young firms. Job creation at mature firms exhibits the least sensitivity to house prices and, in the case of column (3), is not statistically different from zero. By definition, new firms have zero job destruction. Job destruction at young firms shows a positive and statistically significant coefficient on housing prices, while job destruction at mature firms moves inversely to housing prices (though statistically significantly negative only in column (5)). The last row of Table 3 shows that the difference in coefficients on job creation for new firms versus mature firms is statistically significant, as is the difference in coefficients on job destruction for young firms versus mature firms. As before, these patterns are preserved in state-level data and with the use of alternative MSA business cycle controls.

2.3.3 Job Flows and Construction

Firms within the construction industry tend to be smaller and younger than firms in the economy overall. To rule out whether the size and age patterns we document are driven by industry compo-
Table 5: Effect of housing prices on job destruction within industry

<table>
<thead>
<tr>
<th></th>
<th>All Industries</th>
<th>Construction</th>
<th>All Industries ex-Construction</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>OLS</td>
<td>IV (Bartik)</td>
<td>OLS</td>
</tr>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
</tr>
<tr>
<td></td>
<td>(5)</td>
<td>(6)</td>
<td>(7)</td>
</tr>
<tr>
<td>2 years lagged housing price growth</td>
<td>0.30**</td>
<td>0.34**</td>
<td>1.11**</td>
</tr>
<tr>
<td></td>
<td>(0.08)</td>
<td>(0.09)</td>
<td>(0.18)</td>
</tr>
<tr>
<td>Num. Obs.</td>
<td>1479</td>
<td>1479</td>
<td>1479</td>
</tr>
<tr>
<td>New and young firms</td>
<td>0.24**</td>
<td>0.49**</td>
<td>1.63**</td>
</tr>
<tr>
<td>&lt; 5 years</td>
<td>(0.11)</td>
<td>(0.11)</td>
<td>(0.25)</td>
</tr>
<tr>
<td></td>
<td>-0.17</td>
<td>-0.30</td>
<td>-0.58**</td>
</tr>
<tr>
<td></td>
<td>(0.13)</td>
<td>(0.10)</td>
<td>(0.20)</td>
</tr>
<tr>
<td>Num. Obs.</td>
<td>2958</td>
<td>2958</td>
<td>2958</td>
</tr>
<tr>
<td>New and young</td>
<td>0.42**</td>
<td>0.79**</td>
<td>2.20**</td>
</tr>
<tr>
<td>-mature firms</td>
<td>(0.10)</td>
<td>(0.10)</td>
<td>(0.26)</td>
</tr>
<tr>
<td></td>
<td>0.23**</td>
<td>0.74**</td>
<td>(0.11)</td>
</tr>
</tbody>
</table>

Panel A of the table presents the sum of coefficient estimates on current, 1 year, and 2 year lagged state housing price growth. Panel B presents the sum of the coefficient estimates on state house price growth by firm age categories. Panel C reports the difference in the sum of coefficients for new and young versus mature firms. Each column of the table reports results from a different regression. The dependent variable is state-level job destruction by industry in all columns. ** - coefficient estimate significant at the 5% level. Standard errors are in parentheses.

We also find similar patterns for the effect of house price growth on job destruction after

---

13 MSA level data disaggregated by industry and age is not publicly available from the Business Dynamics Statistics due to disclosure concerns. Indeed, state x industry x age is not available either. However, we use data from Fort et al. (2013) who obtained from the Census Bureau a customized state x industry x age disaggregation of job flows. Their data ends in 2010, therefore, our industry regressions utilize a panel of 51 states (including DC) from 1982-2010.

14 No state level land supply elasticities are available, but the Bartik coefficients appear similar to the elasticities of major MSAs within a state.

15 The age categories in our industry regressions differ from the age categories in our MSA-level regressions due to the categories chosen by the authors in Fort et al. (2013). In our MSA-level age regressions, firms 5 years of age are included as young firms.
Table 6: Effect of housing prices on new firms and establishments

<table>
<thead>
<tr>
<th></th>
<th>Employment at New Firms</th>
<th>Employment at New Establishments of Existing Firms</th>
<th>Ratio of New Firm Employment to New Establishment Employment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>OLS (1)</td>
<td>IV (Bartik) (2)</td>
<td>OLS (3) IV (Bartik) (4)</td>
</tr>
<tr>
<td>Panel A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sum of coefficients</td>
<td>0.50**</td>
<td>0.46**</td>
<td>-0.12</td>
</tr>
<tr>
<td></td>
<td>(0.16)</td>
<td>(0.15)</td>
<td>(0.16)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0.15**</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(0.05)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0.09</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(0.06)</td>
</tr>
<tr>
<td>Num. Obs.</td>
<td>1479</td>
<td>1479</td>
<td>1479</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1479</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1479</td>
</tr>
</tbody>
</table>

Panel A reports the sum of the coefficient estimates on current, 1 year and 2 years lagged housing price growth. Each column of the table reports results from a different regression. The dependent variable is detrended log employment at new firms in columns (1)-(2), detrended log employment at new establishments of existing firms in columns (3)-(4), and the fraction of employment at new firms to employment at all new establishments in columns (5)-(6). ** - coefficient estimate significant at the 5% level. Standard errors are in parentheses.

controlling for the contribution of construction. Table 5 displays the response of job destruction to state house price growth for all industries, within construction, and all industries excluding construction. Panel A displays the 2-year delayed response of job destruction to house prices. The positive coefficient is consistent with the coefficients reported in Table 1 and shows that a decline in house price growth depresses job destruction in subsequent years. Panel B display differences in the sum of the coefficients between young and mature firms - job destruction falls more at young firms than mature firms after a decline in house prices, consistent with our MSA-level firm age regressions. While the response coefficients are stronger in construction, the differential effect between young and mature firms within construction is consistent with the presence of a firm credit channel in addition to the direct effects of a decline in house prices on demand for construction services. The differential effect of house prices on job destruction by age hold across both OLS and IV specifications. The within industry differences between young and mature firms are also consistent with the findings in Fort et al. (2013) who adopt a slightly different empirical specification.

2.3.4 Employment at New Establishments

The state level data on job flows from the Business Dynamics Statistics also allow us to distinguish the response of new firms versus new establishments of existing firms. If a decline in house prices operates primarily by reducing household demand, new firms and new establishments of existing firms should respond similarly.16 More concretely, if a decline in house prices proxies for a shock to credit conditions, then new independent coffee shops would not open but established chains like Starbucks that are unlikely to face binding credit constraints would still open new locations.

---

16An establishment is a single physical location where work takes place. The vast majority of new firms form a single new establishment. By contrast, large mature firms typically have multiple establishments (consider retailers like Walmart or Starbucks).
By contrast, if a decline in house prices diminishes demand for all goods like coffee, both the independent coffee shop and Starbucks would be impacted.

Table 6 finds evidence consistent with the former, supporting the credit supply channel. Panel A gives the cumulative effect of house price growth on employment at new firms in left two columns, on employment at new establishments of existing firms in middle columns, and on the fraction of employment at new firms relative to employment at all new establishments in the right two columns. As columns (1) and (2) show, a decline in house prices reduce employment at new firms consistent with our findings for job creation at new firms. However, as columns (3) and (4) show, a decline in house prices has no statistically significant effect on employment at new establishments of existing firms. Moreover, a decline in house prices lowers the share of employment at new firms relative to the share of employment at all new establishments, meaning that the differential response to house prices is statistically significant as seen in columns (5) and (6). In each case, employment is measured at the state level from 1982-2010 (MSA level data is not available), and log employment is detrended with state-specific linear trends. Importantly, in the OLS specification, employment at new establishments of existing firms is quite cyclical; existing firms respond strongly to the state business cycle in opening new establishments. In short, it is not the case that new employment at existing establishments is simply less sensitive to both the state business cycle and house price growth.

3 Simple Model

In this section, we present a simple continuous time, firm dynamics model to study effects of a change in financial constraints on asset accumulation, employment, and job flows in a stationary equilibrium. This simple model illustrates the mechanisms at work that causes a financial constraint to diminish job flows at young firms and middle-sized firms. We develop a simple continuous time model that allows us to derive analytical results.

We start with a real business cycle model and add (i) a financial friction that limits the amount of firm borrowing, (ii) firm heterogeneity, (iii) and a decreasing returns to scale production technology. The economy consists of three types of agents: identical households, heterogeneous firms, and identical intermediaries. Each household consumes, supplies labor and trades on asset markets. The household consists of a measure $n$ workers. Workers supply labor to firms and return their wages to the household. Each firm hires workers from households and borrows capital from intermediaries to produce. Intermediaries own the capital stock, issue one-period real risk-free bonds, and rent capital to firms. Every period a fraction $\sigma$ of firms exit and transfer their assets to the household while an equivalent measure of new firms are born; these firms receive an initial transfer of assets from the households. There is a single consumption good in the economy that serves as the numeraire good. There are two types of assets: capital and the risk-free one period real bonds. Capital can
be freely converted to the consumption good and back using a one-to-one technology. There is no aggregate uncertainty in the simple model and the only idiosyncratic uncertainty is the risk of exit for individual firms. We assume that real interest rate on one-period safe bonds $r$ is constant.\textsuperscript{17}

### 3.1 Households

Let $c_t$ be consumption and $n_t$ be labor supply of a typical household in instant $t$. Household preferences are given by:

$$
\int_0^\infty e^{-\rho t} U (c_t - v (n_t)) \, dt. \tag{1}
$$

where $\rho$ is the rate of time preferences. We follow Greenwood, Hercowitz and Huffman (1988) and define instantaneous utility in terms of consumption in excess of disutility of labor, given by increasing and convex function of labor supply. This assumption eliminates any wealth effect on labor supply.

The household faces a flow budget constraint as follows:

$$
\dot{a}_t = w_t n_t + r a_t + \Pi_t - c_t, \tag{2}
$$

where the dot above a variable denotes the derivative with respect to time, $r$ is one-period return on household assets $a_t$, $\Pi_t$ is net payouts to the household from the ownership of firms, $w_t$ is real wage, $w_t n_t$ is household labor income. The return on bonds $r$ is exogenous, while wages $w_t$ are endogenously determined but taken as a given by agents.

Households start with initial holding of risk-free bond $a_0^H$. For the problem to be well-defined we impose the natural debt limit constraint:

$$
a_t \geq - \int_t^\infty \left[ w_s n_s + \Pi_s \right] e^{-r(s-t)} \, ds. \tag{3}
$$

### 3.2 Firms

The economy is composed of a unit measure of firms which produce homogeneous output. Firms behave competitively on output, asset, and labor markets. Each firm faces an exogenous rate of exit $\sigma$ in which case the firm transfers its assets to the household and disappears forever. Between $t$ and $t + \Delta$, with $\Delta$ being sufficiently small, measure $\sigma \Delta$ of firms exit and $\sigma \Delta$ of new firms enter. Every new firm enters with a predetermined level of initial assets $a_F$ that is the same across all firms.

Productivity of every firm $A \cdot z_i$ consists of two components: a common component $A$ (aggregate productivity) and firm-specific productivity $z_i$, where $i$ indexes the firm. Both values are constant

\textsuperscript{17}One reason for this assumption is that we are studying the behavior of small open economy. See, for example, Mendoza (2010) for similar assumption.
over time for a given firm in our simple model. Firm-specific productivity $z_i$ can take on two values \{$z_L, z_H$\} with $z_L < z_H$. The probability of being born with a high firm-specific productivity is $\mu$, i.e., $Pr(z = z_H) = \mu$.

Firms apply $\Lambda_{t,t+\tau} = e^{-\rho \tau} \left[ c_{t+\tau} - v(n_{t+\tau}) \right] / U' \left[ c_t - v(n_t) \right]$ as their discount factor between periods $t$ and $t + \tau$. Each firm maximizes the present discounted value of its terminal wealth. Formally, each firm maximizes:

$$\max_{\{n_{i,t+\tau}, k_{i,t+\tau}\}_{\tau=0}^{\infty}} \int_{0}^{\infty} e^{-\sigma \tau} \Lambda_{t,t+\tau} a_{i,t+\tau} d\tau,$$

(4)

where $a_{i,t+\tau}$ is holdings of risk-free bonds by firm $i$ in period $t + \tau$, $k_{i,t}$ is the amount of capital the firm rents in period $t$.\(^{18}\) Firms face both a wealth accumulation constraint and a financial constraint. Their wealth accumulation constraint is given by:

$$\dot{a}_{i,t} = \pi_{i,t} + ra_{i,t},$$

(5)

where the firms’ profits are given by:

$$\pi_{i,t} = Az_i \left( k_{i,t}^{\alpha} n_{i,t}^{1-\alpha} \right)^{\phi} - r_k k_{i,t} - w_t n_{i,t},$$

(6)

The first term, $Az_i \left( k_{i,t}^{\alpha} n_{i,t}^{1-\alpha} \right)^{\phi}$, represents a decreasing-returns-to-scale production function. The second and the third terms represent the cost of capital and labor inputs respectively.

The firm also faces a financial constraint of the following form:

$$k_{i,t} \leq \chi a_{i,t},$$

(7)

where $\chi \geq 1$ denotes the leverage ratio which is common across firms. This constraint states that the firm cannot rent more capital than the amount of the firm’s holdings of risk-free bonds times $\chi$. Parameter $\chi$ indexes the severity of financial frictions: $\chi = \infty$ corresponds to a frictionless capital rental market and $\chi = 1$ corresponds to self-financing. This specification reflects the prediction of corporate finance models with limited contract enforcement.\(^{19}\)

### 3.3 Intermediaries

Competitive intermediaries issue one-period risk-free real bonds and rent out capital at rate $r_{k,t}$ to firms. Because consumption good can be freely transformed to capital the zero-profit condition of

---

\(^{18}\)The assumption of no dividend payouts before exiting is similar to assuming that firms maximize the discounted stream of positive payouts to the household. In this alternative case, because of the binding financial constraint, firms would prefer to retain earnings until they grow out of the financial constraint. Once firms become unconstrained, the timing of payouts is irrelevant, and we can assume that all payouts occur when firms exit.

\(^{19}\)See Evans and Jovanovic (1989) for an early use of this specification of the financial constraint. Buera and Shin (2011) argue that this type of financial constraint can be derived by assuming limited liability on the side of the firms and one-period punishment for not honoring repayment.
the competitive intermediaries requires:

\[ r_{k,t} = r + \delta, \]  

(8)

where \( \delta \) is the depreciation rate of capital. The zero-profit condition and the absence of capital adjustment costs imply that rental rate of capital is constant and pinned down by return on bonds and depreciation rate in equilibrium.\(^{20}\)

3.4 Competitive Equilibrium

A competitive equilibrium is allocation \( \{c_t, a_t, n_t, \{a_{i,t}, n_{i,t}, k_{i,t}\}_{i \in [0,1]}\}_{t \geq 0} \) and prices \( \{w_t, r_{k,t}\}_{t \geq 0} \), \( r \) such that:

1. Households solve (1)-(3) given initial level of assets \( a_H^0 \) taking prices \( r, r_k, \{w_t\}_{t \geq 0} \) as given;
2. Firms solve (4) - (6) given initial level of assets \( a^F \) taking prices \( r, r_k, \{w_t\}_{t \geq 0} \) as given;
3. Intermediaries optimize so that (8) is true;
4. Firms and representative household choices satisfy \( n_t = \int n_{i,t} \, di \).

3.5 Characterization of the Firm’s Problem

We now consider a stationary equilibrium in which prices are constant over time. Household optimal labor choice leads to the following relation in stationary equilibrium:

\[ w = v'(n). \]  

(9)

The expression equates the real wage with the marginal disutility of working.\(^{21}\)

Firm maximization of its expected terminal wealth is equivalent to static optimization of the profit function conditional on the financial constraint. The profit function is strictly concave so the first order conditions are sufficient. Optimal capital and labor choices imply the following labor and capital demand conditions:

\[ A z_i \alpha \phi k_{i,t}^{\alpha \phi - 1} n_{i,t}^{(1- \alpha) \phi} = r_k + \frac{\eta_{i,t}}{\lambda_{i,t}^F}, \]  

(10)

\[ A z_i (1 - \alpha) \phi k_{i,t}^{\alpha \phi} n_{i,t}^{(1- \alpha) \phi - 1} = w, \]  

(11)

where \( \lambda_{i,t}^F \) is firm’s marginal value of additional unit of safe debt holdings \( a_{i,t} \) and \( \eta_{i,t} \geq 0 \) is the Lagrange multiplier on the financial constraint. Equation (10) states that, at the optimum, a firm

\(^{20}\)The absence of capital adjustment costs is a strong assumption. However, Liu, Wang and Zha (2013) argue that in a model with financial frictions capital adjustment costs are estimated to be close to zero and much smaller than in models without financial frictions, like in Christiano, Eichenbaum and Evans (2005) and Smets and Wouters (2007).

\(^{21}\)There is also a standard Euler equation for households. However, its form does not affect the results that follow.
equates its marginal product of capital to rental rate of capital plus the cost of making the collateral constraint tighter. Equation (11) equates marginal product of labor to the real wage.

When the financial constraint binds it must be that $\eta_{i,t} > 0$ and $k_{i,t} = \chi a_{i,t}$. The labor demand condition - equation (11) - can be rewritten as follows:

$$n_{i,t} = \left[ \frac{z_i A \phi (1 - \alpha)}{w} \right]^{1-\phi(1-\alpha)} \cdot \left( \frac{\alpha \phi}{w} \right)^{\frac{\phi(1-\alpha)}{1-\phi(1-\alpha)}}. \tag{12}$$

Substituting optimal employment (12) and capital $k_{i,t} = \chi a_{i,t}$ into the profit function (6), the law of motion for assets (5) becomes:

$$\dot{a}_{i,t} = D_i a_{i,t}^\psi - B a_{i,t},$$

where $D_i \equiv \left( z_i A \chi^\phi \right)^{1-\phi(1-\alpha)} \cdot \left( \frac{\phi(1-\alpha)}{w} \right)^{\frac{\phi(1-\alpha)}{1-\phi(1-\alpha)}} \cdot [1 - \phi(1 - \alpha)]$, $B \equiv r_k \chi - r > 0$; $\psi \equiv \phi \alpha / (1 - \phi(1 - \alpha)) < 1$. The solution to this first-order differential equation is given by:

$$a_{i,t} = \left\{ \frac{D_i}{B} - \left( \frac{D_i}{B} - (a^F)^{1-\psi} \right) e^{-B(1-\psi)t} \right\}^{1/(1-\psi)}. \tag{13}$$

The path of assets (13) is increasing in $t$ since otherwise profits would be negative implying that firms are not optimizing. The assets path is convex in $t$, increasing with $\chi$ at all $t$ before become unconstrained, and increasing in firm-specific productivity $z_i$.\footnote{The fact that $a_{i,t}$ increases with $\chi$ before the firm becomes unconstrained is nontrivial. There are two competing forces. Firstly, higher values of $\chi$ imply that the firm can rent more capital which acts to increase assets $a_{i,t}$. Secondly, the higher capital and diminishing returns to capital imply that the growth rate of $a_{i,t}$ is lower for a given level of $a_{i,t}$. We show in appendix that the second effect does not reverse the first effect before the firm grows out of its financial constraint.}

We derive the solution shown in equation (13) in Appendix A.2, and Appendix A.3 characterizes the properties of this solution. Labor demand $n_{i,t}$ is increasing in $t$, may be convex or concave in $t$, is increasing in $\chi$, and is increasing in $z_i$ because labor demand (12) is a concave and increasing function of asset holdings $a_{i,t}$.

If the financial constraint does not bind then $\eta_{i,t} = 0$. Optimality with respect to labor (11) and capital (10) allow us to express labor and capital demand in terms of prices:

$$n_i^* = (z_i A \phi)^{1/(1-\phi)} \left( \frac{\alpha}{r_k} \right)^{\alpha/(1-\phi)} \left( \frac{1 - \alpha}{w} \right)^{(1-\alpha)/(1-\phi)},$$

$$k_i^* = (z_i A \phi)^{1/(1-\phi)} \left( \frac{\alpha}{r_k} \right)^{1-(\alpha/(1-\phi))} \left( \frac{1 - \alpha}{w} \right)^{(1-\alpha)/(1-\phi)}.$$

The optimal capital and labor choices are $k_{i,t} = \min \{ k_{i,t}^*, k_{i,t} \}$ and $n_{i,t} = \min \{ n_{i,t}, n_i^* \}$, where $\bar{k}_{i,t}, \bar{n}_{i,t}$ are the constrained optimal choice of capital and labor.
3.6 Comparative statics with fixed wages

In this section, we analyze the effect of changes in aggregate productivity $A$ and the financial constraint $\chi$ while holding wages $w$ fixed. We first examine the life-cycle behaviour of firms with different permanent productivities to demonstrate the differential effect of productivity and financial shocks, and then examine how these shocks aggregate over the age distribution of firms to determine overall employment and job flows.

Figure 3 shows the firm-level employment dynamics conditional on survival for two firms with different levels of firm-specific permanent productivity. The more productive firm cannot achieve its optimal level immediately and has to grow before it reaches its optimal employment level $n^*(z_H)$. In contrast, the low-productivity firm has sufficient capital initially to immediately jump to its optimal level of employment $n^*(z_L)$.

![Figure 3: Firm employment dynamics.](image)

The figure shows the employment dynamics of two firms with different levels of firm-specific permanent productivity $z$ conditional on surviving to certain age. The figure is plotted for fixed prices.

Figure 3 demonstrates the role of age and size in identifying the effect of a financial shock. The financial constraint is irrelevant for the low productivity firms; a tightening of the financial constraint has no impact on employment for these firms. In contrast, for growing high-productivity firms, the financial constraint impacts their rate of growth while leaving the unconstrained optimal level of employment unchanged.

Let $\tilde{t}$ denote the moment in time when a firm grows out of its financial constraint (assuming that the firm was financially constrained at the beginning of its life).\footnote{\tilde{t} solves equation $k_{i,\tilde{t}} = k^*$ which equates optimal unconstrained level of capital to optimal constrained level of capital.} We can now compare two stationary equilibria with different levels of financial constraint parameter $\chi_L < \chi_H$. Based on the discussion in the previous section, we can conclude that $n_{i,t}(\chi_L) \geq n_{i,t}(\chi_H)$, where we explicitly indicate that the employment path is a function of financial parameter $\chi$. The inequality is strict...
when financial constraint binds and becomes an equality when the firm accumulates sufficient assets to become unconstrained. We can show that it takes more time to grow out of financial constraints for a firm in an economy with tighter financial conditions, i.e. $\bar{t}(\chi_H) < \bar{t}(\chi_L)$. These results are presented in Figure 4. Because the optimal unconstrained size of the firm is unchanged, job creation for any given firm is unchanged over its lifecycle conditional on surviving long enough to reach its optimal size.

**Figure 4:** Firm employment dynamics: comparative statics with respect to $\chi$.

The figure shows how the employment paths for two firms with different levels of firm-specific permanent productivity $z$ depend on the level of financial constraint parameter $\chi$.

The individual firms’ behaviour under different $\chi$’s implies a straightforward aggregation across firms. First, employment at the unconstrained firms does not depend on $\chi$. Because it takes more time to reach the optimal employment level with a lower $\chi$, the average constrained firm is smaller. Aggregation across all constrained and unconstrained firms immediately implies $n(\chi_L) < n(\chi_H)$, where $n(\cdot)$ denotes aggregate employment. Second, job destruction in the model only occurs when a firm exits. Job destruction is lower in a stationary equilibrium with a lower $\chi$ because the typical exiting firm is smaller and firms exits are i.i.d. Finally, in a stationary equilibrium, job creation must equal job destruction. So, a lower $\chi$ is associated with lower job creation.

Aggregate productivity $A$ has a qualitatively different effect on employment paths of firms relative to financial constraint parameter $\chi$. While the unconstrained optimal size of firms is independent of financial constraint, productivity directly affects the optimal size. So, lower aggregate productivity depresses employment at all ages. As such, changes in aggregate productivity will affect both high and low-type firms, and constrained and unconstrained firms. However, like Khan and Thomas (2013), changes in productivity $A$ may interact with the financial constraints to generate asymmetric effects on firm employment across age and size categories.

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24The formal details are summarized in Appendix A.4.
3.7 Comparative statics with flexible wages

In the previous section, we showed that aggregate employment and job flows are increasing in $\chi$ when wages are fixed. Now we argue that allowing for wage adjustment to equalize labor demand and supply does not offset these effects completely. Denote $n^d(w, \chi)$ aggregate demand for labor and $n^s(w)$ aggregate supply of labor. Recall that because of the absence of wealth effects the labor supply only depends on the real wage. Labor market clearing requires $n(\chi) = n^d[w(\chi), \chi] = n^s[w(\chi)]$. This relation holds for any value of $\chi$. Taking the full derivative with respect to $\chi$, we obtain:

$$
\frac{dn}{d\chi} = \frac{dn^s(w)}{dw} \cdot \frac{dw}{d\chi} = n^d_2[w(\chi), \chi] \cdot \frac{dn^s(w)}{dw} - n^d_1[w(\chi), \chi] > 0,
$$

where $n^d_1[w(\chi), \chi] < 0$, $n^d_2[w(\chi), \chi] > 0$ are partial derivatives of labor demand with respect to the first and second arguments and $dn^s(w)/dw > 0$. The above formula shows that positive elasticity of labor supply will lead to increase in wage $w$ which will reduce labor demand. However, this effect is not large enough to undo the direct effect of an increase in labor demand when $\chi$ increases.

Because firm exits are exogenous and i.i.d. across firms, aggregate job destruction is proportional to employment: $JD = \sigma n(\chi)$. This implies that tighter financial constraints lower job destruction. In stationary equilibrium job creation equals job destruction and therefore job creation also falls when financial constraints tighten.

4 Benchmark Model

To quantitatively examine the effects of financial and productivity shocks, we move to discrete time and extend our model in several dimensions. Our benchmark model builds on the simple model by adding firm-specific transitory productivity shocks, which allow us to match the level of aggregate job flows in the data. In the benchmark model, aggregate productivity $A_t$ and financial constraint parameter $\chi_t$ are allowed to change over time. By setting the benchmark model in discrete time, we can more easily calibrate our model and directly compare its predictions to the data. We also assume that the exogenous rate of firm exit depends on age to match the declining hazard rate of firm exit.

Time is discrete and is indexed by $t = 1, 2, \ldots$. Firms’ production function is decreasing returns to scale: $y_{i,t} = A z_i \epsilon_{i,t} \left( k_{i,t}^{\alpha} n_{i,t}^{1-\alpha} \right)^{\phi}$. The common component of productivity, $A_t$, and financial tightness, $\chi_t$, can change over time. The common component of productivity $A_t$ follows a Markov process which takes values in a set $A$ with conditional distribution $H(A_{t+1}|A_t)$. Financial shock $\chi_t$ follows another Markov process with values in $K$ and conditional distribution $Q(\chi_{t+1}|\chi_t)$. Finally, the transitory firm-specific component of productivity $\epsilon_{i,t}$ follows a Markov process which takes values in $E$ and has conditional distribution $G(\epsilon_{i,t+1}|\epsilon_{i,t})$ with newly-born firms drawing from productivity distribution $G_0(\epsilon_{i,0})$. 

23
The aggregate state of the economy, denoted $x_t$, is summarized \( \{ A_t, \chi_t, a^H_t, \xi_t \} \), where $\xi_t$ is the distribution of firms over their assets, firm-specific transitory and permanent productivity and age, and $a^H_t$ is the wealth of the representative household. Let $\xi' = \Gamma(A, \chi, a^H, \xi)$ be the law of motion for the firm distribution over the state space. Also let $\Phi(x_{t+1}|x_t)$ be the conditional distribution of the aggregate state. This conditional distribution can be expressed as follows:

\[
d\Phi[A', \chi', (a^H)', \xi'|A, \chi, a^H, \xi] = \mathbb{1}\left[ \xi' = \Gamma(A, \chi, a^H, \xi) \right] \mathbb{1}\left[ (a^H)' = f(A, \chi, a^H, \mu) \right] 
\cdot dH(A'|A)dQ(\chi'|\chi),
\]

where $f(\cdot)$ is a household policy function.

### 4.1 Households

The household problem is a discrete time analogue to (1)-(3) and can be summarized as follows:

\[
V^H(a^H, x) = \max_{c, n, a'} \left\{ u[k - v(n)] + \beta \int V^H (a^H', x') d\Phi(x'|x) \right\}, \\
\text{s.t.} \quad c + (a^H)' = wn + (1 + r)a^H + \Pi.
\]

Households choose consumption $c$, labor supply $n$, and next period assets $(a^H)'$ subject to the natural debt limit constraint and the standard budget constraint taking prices $w, r$ and firm profits $\Pi$ as given.

### 4.2 Firms

The firms problem is the discrete time analogue to (4)-(7). In contrast to the simple model, firms face transitory firm-specific productivity shocks $\epsilon_{i,t}$ and the exit rate $\sigma_\tau$ is now age specific. Formally, firms solve:

\[
V^F(z, \epsilon, a, \tau, x) = \max_{k, n, a'} \left[ \sigma_\tau a' + [1 - \sigma_\tau]V^F(z, \epsilon', a', \tau + 1, x') \right] d\Phi(x'|x)dG(\epsilon'|\epsilon), \\
\text{s.t.} \quad a' = Az \epsilon (k^\alpha n^{1-\alpha})^{\phi - \tau k} - wn + (1 + r)a, \\
k \leq \chi a.
\]

Firms operate a decreasing returns to scale production technology subject to idiosyncratic and aggregate productivity shocks. Firms maximize a weighted average of next period assets and their continuation value where $\sigma_\tau$ is the exogenous probability of exit of a firm that is $\tau$ years old. Firms choose capital $k$, next period assets $a'$, and employment $n$ subject to a standard accumulation equation for assets and the same financial constraint on renting capital from intermediaries as described in the previous section.

Firms enter and exit exogenously. We assume the number of newly born firms $M_0$ is equal to the number of exiting firms so that the total number of firms is constant.
4.3 Intermediaries

Financial intermediaries are perfectly competitive and operate as described in the previous section. The zero-profit condition for intermediaries requires:

\[ r_k = r + \delta. \]

4.4 Recursive Equilibrium

A recursive equilibrium is a collection of value functions: \( V^H(a^H, x), V^F(z, \epsilon, a, \tau, x) \), allocations: \( c(a^H, x), a^H, n(z, \epsilon, a, \tau, x), k(z, \epsilon, a, \tau, x), a'(z, \epsilon, a, \tau, x) \), prices: \( w(x), r_k(x), r \), and a law of motion for states: \( \Gamma(x) \) such that:

1. Households, firms, intermediaries optimize;
2. Capital, labor and goods markets clear;
3. \( \Gamma: \) for all Borel \( E \times A \in \mathbb{R}^+ \times \mathbb{R}^+ \)
   and \( \tau \geq 1 \)

   \[ \xi'(z, E \times A, \tau) = (1 - \sigma_{\tau-1}) \int_{\epsilon' \in E} \int_{(\epsilon, a) \in B(z, A, x)} d\xi(z, \epsilon, a, \tau - 1) dG(\epsilon' | \epsilon), \]

   and \( \tau = 0 \)

   \[ \xi'(z, E \times A, 0) = \mathbb{1}(a_0 \in A) \mu(z) M_0 \int_{\epsilon \in E} dG_0(\epsilon), \]

where

\[ B(z, A, x) = \{ (\epsilon, a) : \pi(z, \epsilon, a, x) + (1 + r(x)) a \in A \}, \]

given \( \xi_0 \).

5 Calibration and Quantitative Predictions of the Model

To explore the quantitative implications of our model, we calibrate a version of our benchmark model. We examine the effect of one-time unanticipated and permanent financial and aggregate productivity shocks in our model on overall job flows and the distribution of job creation and job destruction across firm size and firm age categories along the transition path.
5.1 Calibration Strategy and Targets

Our calibration strategy chooses several common parameters from the literature. Given that our empirical evidence on job flows is observed in annual data, we use annual values for several common parameters. As shown in Table 7, the household’s discount rate $\beta$ and the capital share $\alpha$ are standard. The depreciation rate of capital $\delta$ is set to match the depreciation rate for equipment. The parameter $\phi$ governing the degree of decreasing returns to scale is set at 0.95, comparable to values chosen in Cooley and Quadrini (2001) and Khan and Thomas (2013). We experiment with several different values for the Frisch elasticity $\nu$ to gauge the importance of labor supply response in our quantitative experiment. A Frisch elasticity of zero conforms to the case of a vertical labor supply curve, while an infinite Frisch elasticity conforms to the case of a horizontal labor supply curve. In the former case, wages adjust so that total employment is unaffected by the collateral shock. In the latter case, wages are unchanged so employment is demand determined. In effect, this case conforms to the partial equilibrium effect of the collateral shock or, equivalently, the effect of a collateral shock with perfect real wage rigidity. In our preferred calibration, we choose a Frisch elasticity of $\nu = 1$ - within the range of typical Frisch elasticities in the macro literature.

<table>
<thead>
<tr>
<th>Aggregate Parameters</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Discount rate $\beta$</td>
<td>0.99</td>
</tr>
<tr>
<td>Depreciation rate $\delta$</td>
<td>0.07</td>
</tr>
<tr>
<td>Capital share $\alpha$</td>
<td>0.3</td>
</tr>
<tr>
<td>Decreasing returns $\phi$</td>
<td>0.95</td>
</tr>
<tr>
<td>Frisch elasticity $\nu$</td>
<td>0;1;\infty</td>
</tr>
<tr>
<td>Initial assets $a_0$</td>
<td>8</td>
</tr>
<tr>
<td>Collateral constraint $\chi$</td>
<td>8</td>
</tr>
<tr>
<td>Transitory shock (size) $\epsilon$</td>
<td>0.025</td>
</tr>
<tr>
<td>Transitory shock (persistence) $\rho_\epsilon$</td>
<td>0.6</td>
</tr>
</tbody>
</table>

This table describes the model parameters and the values chosen in our calibration. The calibration strategy and targets are described in the text.

It remains to choose an initial level of assets $a_0$, the collateral constraint parameter $\chi$, firm exit rate $\sigma$, and a support and distribution of idiosyncratic productivity levels $\epsilon$. We select the distribution of the idiosyncratic productivity levels to target the distribution of employment by mature firms in the data. In our model, firms that survive sufficiently long converge towards their optimal level of employment. We take averages of employment share by firm size categories for firms over 21 years of age in the Business Dynamics Statistics from 2000-2006, and we back out the implied level of idiosyncratic productivity so that the optimal employment size of the firm is at the midpoint of the employment bin range. We choose the distribution of firms over idiosyncratic productivity levels to target the share of employment by firm size in the data. Table 8 shows the
Table 8: Idiosyncratic shock calibration

<table>
<thead>
<tr>
<th>Size Bins (# empl.)</th>
<th>Employment distribution in % (Data)</th>
<th>Firm distribution in % (Model)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-4</td>
<td>2.5</td>
<td>44.0</td>
</tr>
<tr>
<td>5-9</td>
<td>3.6</td>
<td>22.5</td>
</tr>
<tr>
<td>10-19</td>
<td>5.1</td>
<td>15.3</td>
</tr>
<tr>
<td>20-49</td>
<td>8.5</td>
<td>9.8</td>
</tr>
<tr>
<td>50-99</td>
<td>7.1</td>
<td>4.1</td>
</tr>
<tr>
<td>100-249</td>
<td>9.8</td>
<td>2.5</td>
</tr>
<tr>
<td>250-499</td>
<td>7.0</td>
<td>0.8</td>
</tr>
<tr>
<td>500-999</td>
<td>6.4</td>
<td>0.4</td>
</tr>
<tr>
<td>1000-2499</td>
<td>8.6</td>
<td>0.2</td>
</tr>
<tr>
<td>&gt;2499</td>
<td>41.4</td>
<td>0.5</td>
</tr>
</tbody>
</table>

The middle column of this table presents the distribution of employment across firm size bins for firms between 21-25 years of age in the BDS (2000-2006 averages). This distribution of the permanent component of productivity required to match this distribution of employment is given in the right-hand column.

size bins used and the employment shares that our calibration targets. The last column shows the implied distribution of firms that matches the employment shares we are targeting, showing that most firms are small, low-productivity firms.

Instead of choosing a single constant exit rate for firms, we choose time-dependent exit rates for the first five years before a constant exit rate for firms older than five years. We do this to capture the declining hazard of firm exit - with an endogenous firm exit margin, selection effects would generate this declining hazard for young firms without the need for exogenous differences in exit rates. In the absence of endogenous entry and exit, the firm’s policy functions and the steady state are unaffected by the assumption of time-dependent exit rates. We choose entry and exit rates to match the empirical age distribution of firms using 2000-2006 averages from the BDS. Table 9 provides the age distribution of firms and the distribution implied by our calibration. By construction, the empirical distribution and model distribution match for firms aged 0-5, but differs for older ages when a constant exit rate is assumed. The exit rate for firms older than age 5 is \( \sigma = 0.069 \) and implies a model age distribution that closely matches the empirical distribution.

The final parameters that we choose are the initial level of assets \( a_0 \) and the collateral constraint parameter \( \chi \). We jointly choose these parameters shown in Table 7 to best match the distribution of employment by firm age and size. The empirical and model distributions are shown in Table 10. Our calibration closely matches the age distribution of employment and does a reasonable job matching the size distribution of employment. Our calibration has a somewhat lower distribution of employment among new and younger middle-sized and larger firms and consequently a too large employment share for small firms. The size distribution for new and young firms is determined in
Table 9: Exit rate calibration

<table>
<thead>
<tr>
<th>Firm Age (years)</th>
<th>Firm distribution in % (Data)</th>
<th>Firm distribution in % (Model)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>10.2</td>
<td>10.2</td>
</tr>
<tr>
<td>1</td>
<td>7.7</td>
<td>7.7</td>
</tr>
<tr>
<td>2</td>
<td>6.6</td>
<td>6.6</td>
</tr>
<tr>
<td>3</td>
<td>5.8</td>
<td>5.8</td>
</tr>
<tr>
<td>4</td>
<td>5.2</td>
<td>5.2</td>
</tr>
<tr>
<td>5</td>
<td>4.7</td>
<td>4.7</td>
</tr>
<tr>
<td>6-10</td>
<td>18.0</td>
<td>18.0</td>
</tr>
<tr>
<td>11-15</td>
<td>12.6</td>
<td>12.6</td>
</tr>
<tr>
<td>16-20</td>
<td>8.8</td>
<td>8.8</td>
</tr>
<tr>
<td>21-25</td>
<td>6.2</td>
<td>6.2</td>
</tr>
<tr>
<td>&gt;25</td>
<td>14.4</td>
<td>14.3</td>
</tr>
</tbody>
</table>

This table displays the distribution of firms in the data and the model. Age-specific exit rates are chosen to exactly match exit rates in the data for firms 5 years old or younger. A constant exit rate is assumed for firms older than five years. The implied distribution of employment for firms older than 5 years is given in the right-hand column of the table.

part by the initial level of assets $a_0$. Heterogeneity in initial asset levels would likely allow us to match exactly the size distribution for new and young firms. In our baseline calibration, 97% of firms have less than 100 employees and 12% of firms are credit-constrained. Most constrained firms are small/medium-sized firms (91%), but the vast majority of small and medium-sized firms are financially unconstrained (89%).

For tractability and simplicity, we assume that firms face transitory shocks around their permanent level of idiosyncratic productivity. That is, firms are born with a permanent productivity level that determines the firm’s optimal size and experience small shocks around this permanent productivity level. Transitory shocks evolve according to a symmetric three state Markov chain: transitory productivity can be high, neutral, or low. This specification ensures that adding transitory shocks only results in two additional parameters: the size of the shock and the persistence of the shock.

The size of the transitory shock is set at 2.5% to target job flows of about 15% of employment, matching averages in the Business Dynamics Statistics from 2000-2006. The persistence of the idiosyncratic shock is set at 0.6 (the diagonal elements of the matrix of transition probabilities); this value is in line with estimates for the annual persistence of idiosyncratic productivity shocks used in Khan and Thomas (2013) and Clementi and Palazzo (2013). For example, if current productivity is at its neutral level, the firm remains at the same level of productivity with probability 0.6 and transitions to either high or low productivity with probability 0.2 respectively.

Table 10 summarizes the fit of our model with data in terms of the distribution of employment.
Table 10: Distribution of employment by firm size and age

<table>
<thead>
<tr>
<th>Panel A: data</th>
<th></th>
<th></th>
<th></th>
<th>Panel B: model</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Births</td>
<td>2.8</td>
<td>18.5</td>
<td>0.0</td>
<td>1.9%</td>
<td>33.8</td>
<td>23.4</td>
<td>1.9%</td>
</tr>
<tr>
<td>1-5 years</td>
<td>15.2</td>
<td>16.5</td>
<td>15.7</td>
<td>17.8</td>
<td>17.5</td>
<td>18.1</td>
<td>17.8</td>
</tr>
<tr>
<td>6+ years</td>
<td>84.0</td>
<td>65.0</td>
<td>84.3</td>
<td>62.9</td>
<td>54.4</td>
<td>58.9</td>
<td>62.9</td>
</tr>
</tbody>
</table>

Panel A of the table presents the distribution of employment and job flows over firm size and age categories in % in Business Dynamics Statistics database over 2000-2006. Panel B shows the distribution of employment and job flows over firms size and age categories in % in steady state of the baseline calibration of our model.

and job flows. The left panel compares the fit across firm age categories while the right panel compares the fit across firm size categories. The model does a good job of matching the distribution of employment and job creation across firm age categories. Job destruction at young firms is somewhat low in our model compared to the data (consequently, job destruction at mature firms is too high). Our calibration also performs well in matching the distribution of employment and job flows across firm size categories. Job creation and destruction is a bit too high for middle-sized firms and employment is a bit too low at small firms. However, this calibration shows that only a few parameters are needed to generate a decent fit for employment and job flows across age and size categories.

5.2 Effect of Collateral and Productivity Shocks

We consider the transition path for a permanent 20% tightening of the collateral constraint parameter from $\chi = 8$ to $\chi = 6.4$. This tightening conforms to the magnitude of the drop experienced in US housing prices during the Great Recession. The collateral shock is modeled as a permanent shock given the persistence of the drop in nominal US housing prices, with prices five years since the start of the recession still 20-25% below their peak. The results we present are unchanged for persistent shocks that last five years or longer and then gradually normalize.

The left panel of Figure 5 displays the transition paths for employment under a financial shock, while the right panel illustrates the same path for a productivity shock that generates a similar long-run decline in employment. We display both transition paths with an infinite Frisch elasticity and with a Frisch elasticity of $\nu = 1$. In both cases, the rental rate is held constant (i.e. small open economy assumption).\(^{25}\)

\(^{25}\)We think the constant interest rate assumption better captures the effect of the zero lower bound.
The figure displays the transition paths for employment under financial and productivity shocks. The size of productivity shock is chosen to deliver a similar decline in employment as under the financial shock for the case of Frisch elasticity of 5.

As the transition paths illustrate, both permanent financial and productivity shock generate similar effects on employment on impact. The firm dynamics model generates little endogenous propagation in subsequent periods, but the financial shock does reduce employment in subsequent periods as effects filter through the age distribution of firms. Due to the tightened collateral constraint, large firms that exit are replaced by smaller firms reducing overall employment over the transition. With wage adjustment, this effect is somewhat offset.

Figure 6 displays the transition paths for gross job creation and job destruction under the financial and productivity shocks. The financial shock, shown in panels (a) and (b), reduces employment by sharply reducing job creation, while the productivity shock, shown in panels (c) and (d) reduces employment through a sharp increase in job destruction. The partial equilibrium effect of the financial shock on job creation in panel (a) is particularly stark with job creation dropping some 80% relative to steady state while job destruction increases only slightly. Wage adjustment in panel (b) reduces the large effect of a financial shock on job creation to a plausible magnitude but preserves the relatively larger effect of financial shocks relative to productivity shock on gross job creation. In Appendix B, we also consider the transition path for job flows for a real interest rate shock to proxy for the effect of various types of demand shocks.

A financial shock reduces employment by reducing job creation as both new firms are smaller and existing firms grow less in the next period. Job destruction also increases because a tighter financial constraint leads some growing firms to reduce employment in the next period. A productivity shock reduces employment by increasing job destruction since all unconstrained firms contract in size.

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26In a model with sticky prices, a monetary policy shock or other demand shock would affect firm markups and the real interest rate. Our productivity shock is isomorphic to a markup shock if retailers costless differentiate a homogenous intermediate good and sell to consumers. Therefore, we consider the productivity shock and interest rate shock as good proxies for demand shocks in our setting.
The figure displays the transition paths for gross job creation and job destruction under the financial and productivity shocks. The numbers plotted display changes relative to the initial (steady state) levels. For example, job creation declines by 45% on impact after the financial shock in case of infinite Frisch elasticity. The effects of the financial shock are shown in panels (a) and (b), while the productivity shock effects are shown in panels (c) and (d).

while exerting a smaller effect on the path of employment growth of those firms still growing out of their financial constraint. As we show in Appendix B, a real interest rate shock has similar effects on job flows to a productivity shock reducing employment primarily by operating via the job destruction margin.

Interestingly, this pattern fits the response of job flows in the last two recessions as seen in Figure 1 - the 2001 recession was characterized by a relatively sharp response of job destruction, while the 2008 recession was characterized by a strong response of job creation. Indeed, in 2008, job destruction did not exceed the levels reached in 2001 in a much milder recession. These findings are also consistent with the conclusions reached by Foster, Grim and Haltiwanger (2014) who use state level data to show that total reallocation (sum of job creation and job destruction) fell in the Great Recession while rising in the three other recessions since 1980. As Figure 1 illustrates, TFP shocks raise total reallocation while financial shocks display outright decline. This decline in total reallocation reduces aggregate productivity growth as employment is reallocated to smaller, low-productivity firms who are financially unconstrained.

After the impact period, job creation from a financial shock falls below its steady state level and
converges towards a lower level. Job destruction behaves similarly converging towards the lower level of job creation. While permanent productivity shocks also reduce job flows in the long-run, financial shocks result in a larger reduction in job flows; in the case of constant wages, job flows fall by 11% of steady state levels under a permanent financial shock while job flows fall by 9% of steady state levels - somewhat less - under a productivity shock.

Table 11: Effect of shocks on job flows

<table>
<thead>
<tr>
<th></th>
<th>Permanent Financial Shock</th>
<th></th>
<th>Permanent Productivity Shock</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Frisch = ∞ Frisch = 0 Frisch = 1</td>
<td>Frisch = ∞ Frisch = 0 Frisch = 1</td>
<td></td>
</tr>
<tr>
<td>Panel A: Job Creation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aggregate</td>
<td>-0.24 -0.04 -0.05</td>
<td>-0.15 0.00 -0.01</td>
<td></td>
</tr>
<tr>
<td>Births</td>
<td>-0.12 -0.07 -0.07</td>
<td>-0.07 0.00 0.00</td>
<td></td>
</tr>
<tr>
<td>1-5 years</td>
<td>-0.47 -0.31 -0.32</td>
<td>-0.12 0.01 0.00</td>
<td></td>
</tr>
<tr>
<td>6+ years</td>
<td>-0.23 0.02 0.00</td>
<td>-0.18 0.00 -0.01</td>
<td></td>
</tr>
<tr>
<td>Size</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1-19 emps</td>
<td>-0.07 0.05 0.04</td>
<td>-0.06 -0.01 -0.01</td>
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</tr>
<tr>
<td>20-99 emps</td>
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<td>-0.17 0.02 0.00</td>
<td></td>
</tr>
<tr>
<td>100+ emps</td>
<td>-0.35 -0.08 -0.10</td>
<td>-0.21 0.01 -0.01</td>
<td></td>
</tr>
<tr>
<td>Panel B: Job Destruction</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aggregate</td>
<td>-0.04 -0.04 -0.04</td>
<td>0.06 0.00 0.01</td>
<td></td>
</tr>
<tr>
<td>1-5 years</td>
<td>-0.07 -0.06 -0.07</td>
<td>0.02 0.00 0.01</td>
<td></td>
</tr>
<tr>
<td>6+ years</td>
<td>-0.04 -0.03 -0.03</td>
<td>0.07 -0.01 0.01</td>
<td></td>
</tr>
<tr>
<td>1-19 emps</td>
<td>0.00 0.02 0.02</td>
<td>0.07 -0.01 0.01</td>
<td></td>
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<tr>
<td>20-99 emps</td>
<td>-0.07 -0.07 -0.07</td>
<td>0.06 0.00 0.01</td>
<td></td>
</tr>
<tr>
<td>100+ emps</td>
<td>-0.05 -0.05 -0.05</td>
<td>0.07 -0.01 0.01</td>
<td></td>
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</tbody>
</table>

The table displays the effect of permanent negative financial shock (a 20% decline in collateral constraint parameter) and permanent negative productivity shocks (the size of the shock produces the same long-run decline in aggregate employment level) on the distribution of job creation and job destruction by firm age and size categories. The table shows the average effect over the first three years after the shock where job flows expressed as changes relative to the initial (steady state) level. For example, the aggregate job creation declines by 24% on average over the first three years after the shock. The first three columns display the job flows effects of a permanent financial shock, while the last three columns display the job flows effects of a permanent productivity shock. Each column conforms to different values for the Frisch elasticity: an infinite Frisch elasticity (rigid wages), zero Frisch elasticity (vertical labor supply), and the last column is our preferred specification.

Table 11 displays the effect of financial and productivity shocks on the distribution of job creation and job destruction by firm age and size categories. The table shows the average effect over the first three years after the shock where job flows are expressed as percentage changes from their initial (steady state) level to match our empirical specification. The left-hand side displays the job flows effects of a permanent financial shock, while the right-hand side displays the job flows effects of a permanent productivity shock. The three columns in each panel conform to different values for the Frisch elasticity: first column is the case of a infinite Frisch elasticity (rigid wages), the second column is the case of a zero Frisch elasticity (vertical labor supply), and the last column
is our preferred specification.

As the first and eighth rows show, the collateral shock depresses job creation and job destruction both relative to productivity shocks and relative to steady state so long wages do not fall to maintain the same level of employment. The fall in job creation under a financial shock is particularly stark in the PE case with rigid wages with job creation falling 47%. Consistent with our aggregate job flows regressions, job destruction shows little response to a collateral shock over a three year period - an increase on impact is offset by subsequent declines in job destruction in the following periods. By contrast, job destruction rises above steady state levels under a negative productivity shock.

5.2.1 Age Effects

The effect of the collateral shock on job creation by age largely mirrors the empirical patterns we document. For firm age categories, younger firms exhibit the strongest response to a collateral shock followed by new firms and mature firms. In our empirical results, new and young firms exhibited a similar long-run decline in job creation in response to a decline in housing prices. Our model exhibits a more muted response of job creation at new firms. However, the absence of an active entry margin in our calibration likely accounts for this discrepancy. An active entry margin should increase the sensitivity of job creation among new firms. In the absence of wage adjustment, mature firms also exhibit a large decrease in job creation in response to a collateral shock. However, the general equilibrium response of wages offsets the effect of the financial shock on mature firms by lowering wages and raising employment at unconstrained firms. For a high Frisch elasticity, the drop in wages is insufficient to raise employment at mature firms above their steady state level, consistent with the positive sign on the coefficient estimated in our firm age regressions.

Our model also does a good job of matching the empirical patterns of housing price growth on job destruction by firm age. Job destruction falls for young firms relative to mature firms under a financial shock, consistent with the empirical ordering we document where job destruction falls for young firms while remaining largely unchanged for mature firms. On impact, job destruction rises at both young and mature firms since tighter financial constraints lower capital and labor demand. After impact, destruction falls at young firms because they become smaller after the collateral shock. Therefore, the jobs destroyed by these firms when they exit also fall. In contrast, for mature firms, there are two competing effects in periods after impact: given exogenous exit rates, fewer firms survive to their optimal size reducing job destruction, however, as wages fall, optimal size increases for unconstrained firms leading to greater job destruction when these firms exit.

By contrast, productivity shocks generate a more uniform effect across firm age categories. As the last column shows, productivity shocks generate largely uniform declines in job creation across firm age categories. Mature firms rather than young firms exhibit the sharpest declines to a negative productivity shock. Additionally, a productivity shock raises job destruction at both
young and mature firms, though the shock does have a larger relative effect on mature firms similar to a financial shock.

5.2.2 Size Effects

For firm size categories, our model matches the ordering of sensitivity across size categories with large and middle-sized firms experiencing the biggest decline in job creation followed by small firms. In the case of small firms, a negative collateral shock generates an increase in job creation consistent with the sign of the coefficient on housing prices in some of our IV specifications. A collateral shock has a stronger effect on medium-sized and large firms because the collateral constraint is more likely to bind for high productivity, growing firms. Low productivity (small) firms need not accumulate sizable assets to achieve their optimal size, while high productivity firms must wait to accumulate capital to achieve optimal size. These higher productivity firms transit through the middle-sized employment category and are most sensitive to the effects of a tighter collateral constraint on their growth rates. With wage adjustment, the effect on large firms is partially offset by increased job creation among unconstrained firms - lower wages raise their optimal size and increases job creation at these high productivity unconstrained firms.

In terms of job destruction, we find declines in job destruction for middle-sized and large firms while an increase in job destruction for small firms. This ordering is consistent with our empirical evidence for small and middle-sized firms and consistent with the finding that collateral shocks raise job destruction for small firms. While our empirical estimates for large firms find larger declines in job destruction for large firms in comparison to middle-sized firms, this anomaly is driven entirely by the impact response of job destruction in our regressions. For large firms, job destruction decreases with a negative housing price shock in the MSA-level regressions. However, if we restrict our attention to the lagged response of job destruction, the empirical pattern across firm size categories is consistent with our model.\footnote{Importantly, large firms are more likely to operate across multiple MSAs somewhat complicating comparison of model and data for large firms. Our state level regressions (not shown) find a coefficient of housing price shocks on job destruction at large firms that is lower than middle-sized firms consistent with the predictions of our model.}

In the PE case, job destruction falls for middle-sized and larger firms because constrained firms become smaller after a collateral shock, while unconstrained firms do not become bigger. As a result, higher productivity firms spend a longer period of time as smaller firms. When these firms exit, job destruction falls among middle-sized firms but increases for small firms. In general equilibrium, lower wages offset this effect for the highest productivity firms mitigating the effect of the collateral shock on job destruction for large firms relative to middle-sized firms.

As with firm age categories, the response of job flows to a productivity shock is more uniform across size categories than the response to a collateral shock. Across all specifications, job creation falls most for large firms in response to a negative productivity as opposed to middle-sized firms.
Similarly, job destruction at large firms is most sensitive to a negative productivity shock and job destruction increases across all size categories. These patterns and signs are at odds with the empirical patterns we document further supporting the view that our empirical strategy successfully identifies shocks to firm credit as opposed to productivity shocks or other business cycle shocks.

5.2.3 Net Employment Effect

Financial and productivity shocks also generate disparate effects across age and size on employment. As Table 12 shows, a financial shock generates differential effects on employment across firm age. Employment falls most at new and young firms relative to mature firms after a financial shock. By contrast, a TFP shock has the strongest effect on mature firms with relatively weaker effects on new and young firms. In the extreme case of a zero Frisch elasticity, TFP shocks generate nearly uniform effects across age categories. The employment effects of a financial shock by firm age are consistent with the findings of Siemer (2013) who documents a decline in employment growth at young firms during the Great Recession.

<table>
<thead>
<tr>
<th>Age</th>
<th>Employment</th>
<th>Financial Shock</th>
<th>Productivity Shock</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Frisch = ∞</td>
<td>Frisch = 0</td>
<td>Frisch = 1</td>
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<tr>
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<tr>
<td>1-5 years</td>
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<tr>
<td>6+ years</td>
<td>-0.06</td>
<td>0.02</td>
<td>0.01</td>
</tr>
<tr>
<td>1-19 emps</td>
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<td>0.09</td>
<td>0.09</td>
</tr>
<tr>
<td>20-99 emps</td>
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<td>-0.03</td>
<td>-0.03</td>
</tr>
<tr>
<td>100+ emps</td>
<td>-0.09</td>
<td>-0.02</td>
<td>-0.03</td>
</tr>
</tbody>
</table>

The table displays the effect of permanent negative financial shock (a 20% decline in collateral constraint parameter) and permanent negative productivity shocks (the size of the shock produces the same long-run decline in aggregate employment level) on the distribution of employment by firm age and size categories. The table shows the average effect over the first three years after the shock with employment expressed as changes relative to the initial (steady state) level. For example, the aggregate employment declines by 7% on average over the first three years after the shock. The first three columns display the employment effects of a permanent financial shock, while the last three columns display the employment effects of a permanent productivity shock. Each column conforms to different values for the Frisch elasticity: an infinite Frisch elasticity (rigid wages), zero Frisch elasticity (vertical labor supply), and the last column is our preferred specification.

The differences between financial shocks and TFP shocks across firm size categories are harder to discern. As Table 12 shows, both types of shocks reduce employment the most at relatively large firms. In the case of a financial shock, employment rises slightly at the smallest firms while falling at middle-sized and large firms. A productivity shocks results in a similar ordering of employment responses across firm size categories suggesting that firm size is a less robust indicator of financial constraints than firm age and highlighting the importance of decomposing employment into the
The figure displays the paths for gross job creation and job destruction after the financial and productivity shocks in the model and in the data. The numbers plotted display changes relative to the initial (steady state) levels. The two shocks that drive model dynamics are chosen to match the initial changes (between 2008 and 2009) in job flows in the data.

creation and destruction margins to distinguish disruptions in credit supply from other types of recessionary shocks. It is worth noting that our employment effects by firm size in response to a TFP shocks are consistent with the findings of Moscarini and Postel-Vinay (2012) who find that employment responds more strongly at large versus small firms in recessions.

5.3 Shocks Decomposition

Given that financial shocks and productivity shocks (a stand-in for other types of aggregate demand shocks) operate on distinct margins of employment, we can use job flows to decompose the effect of each of those factors on the decline in employment experience in the US during the Great Recession. As we saw in Figure 6, financial and productivity shocks that bring about the same long-run decline in employment have dramatically different effects on aggregate job flows. This differential behavior of the two shocks on job flows allows us to identify their magnitudes.

We choose permanent financial and productivity shocks to match initial changes in job flows in the Great Recession in the US. It is clear from Figure 1 that a sharp decline in aggregate job creation and sharp increase in job destruction occurred between 2007Q4 and 2009Q1. In the annualized data coming from BDS database similar magnitudes of changes in job flows are observed between March 2008 and March 2009. We focus on the initial difference between these two years because we also wish to compare the job flows behavior by firm categories for which we only have annual data.

Figure 7 compares the behavior of job flows in the model and the data. To match the initial changes in job flows we estimate a negative productivity shock of 3.8% and a negative financial
Job flows in the model match the behavior of job flows in the data on impact. Our model captures the initial dynamics of aggregate job flows but underestimates more recent job creation given the assumption of a permanent shock. US job creation recovers somewhat by 2012 (the last data point) as financial conditions have normalized and employment growth accelerated.

Figure 8 compares employment and job flows in our model across different firm age categories to their counterparts in the data. Our model matches the behavior of employment and job flows fairly well, particularly for new firms and mature firms. Our model overpredicts the fall in job creation at young firms, but this discrepancy may be related to the particularly stark nature of the financial shock that impacts all young firms at the same time instead of more slowly impacting these firms over time as they seek to secure fresh financing for expansion.

The figure displays the paths for gross job creation and job destruction after the financial and productivity shocks in the model and in the data across new, young and mature firms. The numbers plotted display changes relative to the initial (steady state) levels.

Figure 9 shows the model predictions about employment and job flows dynamics across firm size categories. The model matches the data for employment and job flows dynamics for medium and large firms in the wake of the Great Recession. However it misses the employment and job creation dynamics for small firms. Here, the impact of wage adjustment on small firms is particularly important. As wages fall, small unconstrained firm increase their optimal size. To the extent that these firms face any fixed cost in hiring, our model likely overpredicts the increase in employment and job flows at these firms.

Finally, because we use both financial and productivity shocks in the model to match the initial
The figure displays the paths for gross job creation and job destruction after the financial and productivity shocks in the model and in the data across small, medium and large firms. The numbers plotted display changes relative to the initial (steady state) levels.

changes in the job flows in the recent US recession, we can study the relative importance of the two shocks for explaining the employment decline. The ratio of the long-run decline in employment driven only by financial shock to the decline driven by both shocks is 0.25 while the same ratio for productivity shock is 0.75.²⁸ Our decomposition indicates that the financial shock that worsens firm credit conditions can explain a quarter of the decline in employment in the Great Recession. This firm credit margin is distinct from the any effects of the financial crises on aggregate demand or complications due to the zero lower bound and may account for the more persistent impacts of the financial crisis on employment and productivity growth.

6 Conclusion

The US housing crisis has raised concerns that depressed real estate values may inhibit firm formation and expansion, disrupting the process of innovation and labor market turnover essential for a healthy economy. An extensive literature has documented the importance of real estate collateral for new firms to obtain lending and for businesses to obtain financing for expansion. Recent work also documents the disproportionate contribution of new and young firms to overall labor market

²⁸Similar ratios for the on-impact effect is 0.20 and 0.82. Observe that the two numbers may not sum to one because of the nonlinear interaction effects.
turnover. Given these facts, it stands to reason that job flows may be particularly sensitive to a decline in collateral values.

In this paper, we provide support for this hypothesis illustrating the empirical and theoretical link between job flows and housing prices. Using MSA-level variation in job flows and housing prices, we show that both job creation and lagged job destruction decline in response to a fall in housing prices. We control for aggregate demand effects by introducing direct controls for the business cycle and by using a land supply elasticity approach common in the empirical literature on the real effects of collateral shocks. We also document size and age patterns in the sensitivity of job flows to housing prices, showing that job flows for new and young firms (0-5 years of age) are most sensitive to housing prices shocks as are job flows for medium-sized firms (20-99 employees). The differential effects of house price shocks across firm age continues to hold after excluding job flows from the construction industry. Further, we argue that movements in house prices proxy for firm credit disruptions given that new firm employment responds to house price shocks while employment at new establishments of existing firms remains unaffected.

We build a firm dynamics model with collateral constraints and examine the effect of a collateral shock on overall job flows and job flows by firm size and age category. We show analytically in a simple version of our model that a collateral shock must reduce employment, job creation and job destruction, and demonstrate why a collateral shock should have stronger effects for young firms and medium-sized firms. Our benchmark model is calibrated to match the distribution of employment by firm size and age observed in the data and replicates the empirical pattern of job flow sensitivity to house prices by firm size and age categories. Given the observed movements in US job flows in the Great Recession, we estimate the contribution of financial and productivity shocks to the decline in overall employment. We find evidence for a substantial disruption to firm credit that accounts for a quarter of the decline in employment. Importantly, our results leave room for other factors, including household deleveraging (as in Mian and Sufi (2014)) and a binding zero lower bound, to explain the remaining 75% of the decline in employment.

Future work may explicitly model the housing market to further disentangle the effects of a housing crisis on household consumption versus the effect of a housing crisis on the banking system and firm collateral. An explicit model of the housing sector can also measure the direct effect of a housing crisis on construction employment while allowing for the evaluation of monetary and credit policies pursued in the Great Recession.
References


Chaney, Thomas, Zongbo Huang, David Sraer, and David Thesmar. 2015. “Real Estate Collateral and Labor Demand.” Mimeo. Toulouse School of Economics.


A Simple Model: Characterization

A.1 Firms Optimality

To describe the solution to the firm’s problem, we specify the Hamiltonian:

$$H = e^{-\sigma t}\Lambda_{0,t}a + \lambda_F \left[ \varepsilon (k^\alpha n^{1-\alpha})^\phi - r_k k - wn + ra \right] - \eta[k - \chi a].$$

The maximum principle leads to

$$H_k = \lambda_F [z\varepsilon\phi k^{\alpha-1}n^{(1-\alpha)\phi} - r_k] - \eta = 0,$$

$$H_n = \lambda_F [z\varepsilon (1 - \alpha)\phi k^{\alpha\phi}n^{(1-\alpha)\phi-1} - w] = 0,$$

$$\dot{\lambda}_F = - \left\{ e^{-\sigma t}A_{0,t} + \lambda_F r + \eta \chi \right\},$$

$$k \leq \chi a, \quad \eta \geq 0, \quad \eta[k - \chi a] = 0.$$

A.2 Constrained Firm Assets Solution

To solve equation

$$\dot{a} = Da^\psi - Ba,$$

where we omitted time and firm subscripts, introduce the following change of variables $y = \log a$. Hence,

$$\dot{y} = D e^{(\psi-1)y} - B.$$

We can rewrite this equation as follows

$$\frac{dy}{D e^{(\psi-1)y} - B} = dt.$$

Rearranging we get

$$\frac{1}{B(\psi - 1)} \left( \frac{d (D e^{(\psi-1)y} - B)}{D e^{(\psi-1)y} - B} - d((\psi - 1)y) \right) = dt.$$

Integrating this equation leads to

$$\log \left[ D e^{(\psi-1)y} - B \right] - (\psi - 1)y = B(\psi - 1)t + \text{const}.$$

Transforming back to original variable

$$\log[D - B a^{1-\psi}] = B(\psi - 1)t + \text{const}.$$

Since initial level of assets is $a^F$ we have

$$\log \left[ \frac{D - B a^{1-\psi}}{D - B(a^F)^{1-\psi}} \right] = B(\psi - 1)t.$$

This can be expressed as

$$a = \left\{ \frac{D - (D - B(a^F)^{1-\psi})e^{-B(1-\psi)t}}{B} \right\}^{1/(1-\psi)}.$$
A.3 Properties of asset path for financially constrained firms

Monotonicity in $t$. For an asset path of the firm facing the financial constraint to be increasing over time it must be that $a_{i,t}^{1-\psi} < D_i/B$. We show that this inequality is satisfied for a financially constrained firm. If the financial constraint binds then $\eta_{i,t} > 0$ and hence the optimality with respect to capital implies $Az_i\alpha\phi k_i^{\alpha\phi-1}n^{(1-\alpha)\phi}_{i,t} > r_k$. Taking into account $k_{i,t} = \chi a_{i,t}$ and optimal labor choice (12) the previous inequality can be rewritten as

$$a_{i,t}^{1-\psi} < \frac{\psi D_i}{\chi \eta_k} < \psi \frac{D_i}{\chi \eta_k - r} = \psi \frac{D_i}{B} < \frac{D_i}{B}. \quad (A.1)$$

This verifies that asset path is increasing over time for financially constrained firm.

Convexity in $t$. $\dot{a}_{i,t} = D_i a_{i,t}^{\psi} - Ba_{i,t}$ implies $\ddot{a}_{i,t} = (\psi D_i a_{i,t}^{\psi-1} - B) \dot{a}_{i,t} = (\psi D_i a_{i,t}^{\psi-1} - B) (D_i a_{i,t}^{\psi} - Ba_{i,t})$. From (A.1) we know that $\psi D_i a_{i,t}^{\psi-1} > B$ implying that the path is convex.

Monotonicity in $\chi$.

$$\frac{d a_{i,t}^{1-\psi}}{d \chi} = \frac{\partial a_{i,t}^{1-\psi}}{\partial D_i} \frac{d D_i}{d \chi} + \frac{\partial a_{i,t}^{1-\psi}}{\partial B} \frac{d B}{d \chi}$$

$$= \frac{D_i}{B} \left(1 - e^{-B(1-\psi)t}\right) \left[\frac{D_i}{D_i} - \frac{B_X}{B}\right] + \left[\frac{D_i}{B} - (a^F)^{1-\psi}\right] e^{-B(1-\psi)t}(1-\psi)\omega t B_X \quad (A.2)$$

where we used notation $D_{i,\chi} = dD_i/d\chi$, $B_X = dB/d\chi$. The second term of this expression is positive while the first one is negative because

$$\frac{D_i}{D_i} - \frac{B_X}{B} = \frac{\alpha\phi}{1 - \phi(1-\alpha)} \frac{1}{\chi} - \frac{r_k}{r_k \chi - r} < 0.$$

We now show that the second term dominates. Let’s denote $g(t) \equiv da_{i,t}^{1-\psi}/d\chi$ and write (A.2) in more concise form as

$$g(t) = -C_1(1 - e^{-\omega t}) + C_2 e^{-\omega t} \omega t,$$

where $C_1 = -[D_{i,\chi}/D_i - B_X/B] D_i/B > 0$, $C_2 = [D_i/B - (a^F)^{1-\psi}] B_X/B > 0$ and $\omega = B(1-\psi)$. It is easy to check that $C_2 > C_1$. Observe that $g(0) = 0$ and $g'(t) = \omega e^{-\omega t}(C_2 - C_1 - C_2 \omega t)$. This implies that there exists $0 < T_1 < \infty$ such that $g'(t) > 0$ for $t \in [0, T_1)$ and $g'(t) \leq 0$ for $t \geq T_1$.

If function $g(t)$ is positive in instant $T_2$ when the firm grows out of its financial constraint then function $g(t)$ is positive in every instant before this happens. We now show that $g(T_2) > 0$. $T_2$ is defined by the following two equations

$$Az_i\alpha\phi k_{i,T_2}^{\alpha\phi-1}n_{i,T_2}^{(1-\alpha)\phi} = r_k,$$

$$k_{i,T_2} = \chi a_{i,T_2}.$$

The first relation says that there is no longer a wedge in optimal capital choice due to financial constraint. The second equation states that optimal capital choice is still equal to assets times financial parameter. Combining these two equations leads to

$$a_{i,T_2}^{1-\psi} = \frac{\psi D_i}{r_k \chi} = \frac{D_{i,\chi}}{B_X}.$$
Next, taking into account the last expression and (13) we can write
\[ e^{-B(1-\psi)T_2} = \frac{D_i}{B} - \frac{D_{i,x}}{B_x} - (a^F)^{1-\psi} \]

From this we get
\[ g(T_2) = \frac{D_i}{B} \frac{D_{i,x}}{B_x} - \frac{(a^F)^{1-\psi}}{B} \left[ \frac{D_{i,x}}{D_i} - \frac{B_x}{B} \right] \]
\[ + \frac{D_i}{B} \left[ \frac{D_i}{B} - \frac{(a^F)^{1-\psi}}{B} \right] \frac{D_{i,x}}{B_x} - \frac{B_x}{B} \log \frac{D_i}{B} - \frac{D_{i,x}}{B_x} - (a^F)^{1-\psi} \]
\[ = \frac{D_i}{B} \left[ \frac{D_{i,x}}{D_i} - \frac{B_x}{B} \right] \frac{D_{i,x}}{B_x} - \frac{(a^F)^{1-\psi}}{B} \log \left[ 1 - \frac{D_{i,x}}{B_x} - (a^F)^{1-\psi} \right] \}

Note that \( x \equiv \frac{D_{i,x}}{B_x} - (a^F)^{1-\psi} \) \in (0, 1) and function \( p(x) \equiv x + \log(1 - x) < 0 \) for \( x \in [0, 1) \) because \( p(0) = 0 \) and \( p'(x) < 0 \) for \( x \in (0, 1) \). This implies that \( g(T_2) > 0 \) and hence the derivative of assets path \( a_{i,t} \) with respect to financial constraint parameter \( \chi \) is positive at any time before the financial constrained firm becomes unconstrained.

**Monotonicity in \( z_t \).**
\[ da_{i,t}^{1-\psi} = \frac{\partial a_{i,t}^{1-\psi}}{\partial D_i} \frac{dD_i}{dz_i} = \frac{D_i}{B} \left( 1 - e^{-B(1-\psi)t} \right) \frac{\psi}{z_i} > 0. \]

**A.4 Aggregation across firms when wage is fixed**

Total labor demand is given by
\[ n(\chi) = \mu \left[ \sigma \int_0^{\chi} n_{zh,i,t}(\chi) e^{-\sigma t} dt + \sigma \int_0^{\chi} n_{zh,i,t}^* e^{-\sigma t} dt ight] + (1 - \mu) n_{zh}^* \]

where we assumed that the low-productivity firms are not constrained. Next, the high-productivity firms labor demand under \( \chi_L \) and \( \chi_H \) satisfies
\[ \int_0^{\chi_L} n_{zh,i,t}(\chi_L) e^{-\sigma t} dt + \int_0^{\chi_L} n_{zh,i,t}^* e^{-\sigma t} dt < \int_0^{\chi_L} n_{zh,i,t}(\chi_L) e^{-\sigma t} dt + \int_0^{\chi_L} n_{zh,i,t}^* e^{-\sigma t} dt \]
\[ < \int_0^{\chi_L} n_{zh,i,t}(\chi_L) e^{-\sigma t} dt + \int_0^{\chi_L} n_{zh}^* e^{-\sigma t} dt. \]

This leads to \( n(\chi_L) < n(\chi_H) \).

Because firms exits are i.i.d. it must be that \( JD(\chi) = \sigma n(\chi) \). So, \( JD(\chi_L) < JD(\chi_H) \). Because in stationary equilibrium \( JC(\chi) = JD(\chi) \), aggregate job creation also increase with \( \chi \).
B Real Interest Rate Shocks

In this section, we consider the effect of real interest rate shocks on aggregate job flows and the distribution of job flows across age and size categories. We consider this shock a proxy for a variety of demand shocks such as monetary policy shocks or government spending shocks that could generate business cycles. A shock to the interest rate could also proxy for a wealth or deleveraging shock emphasized in Mian and Sufi (2014) and Eggertsson and Krugman (2012). Like the productivity shock, the real interest rate shock impacts all firms, raising the rental rate on capital. For unconstrained firms, this shock lowers capital and labor demand, while for financially constrained firms, this shock raises payments to capital, lowers firm profitability, and reduces the growth rate of assets.

Figure 10: Job flows transition paths

As Figure 10 shows, a real interest rate shock delivers similar effects to a productivity shock on job creation and job destruction. We choose an interest rate shock (roughly 2.5%) that delivers the same decrease in employment as the financial and productivity shocks. Like a productivity shock, an interest rate shock lowers employment by operating on the job destruction margin. Job creation is nearly unchanged or even slightly increasing after an interest rate shock. The interest rate shock, by reducing employment at unconstrained firms and lowering wages, increases the rate
of job creation at new and young firms since a decrease in wages raises labor demand at constrained firms. Thus, like productivity shocks, interest rate shocks are not a good candidate for explaining the sharp decline in job creation seen in the Great Recession.

A real interest rate shock has similar effects on job flows across age and size categories as a productivity shock and therefore cannot account for the empirical patterns across age and size that we document. Interest rate shocks raise job creation at young and middle-sized firms in sharp contrast to a financial shock. The interest rate shock also raises job destruction across all firm age categories like a productivity shock. These patterns stand in contrast to the effects of a financial shock on job destruction.