Collateral Damage: Housing, Entrepreneurship, and Job Creation*

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Abstract

Entrepreneurial activity in the U.S. collapsed prior to and during the Great Recession. This collapse was significant in terms of both new firm formation and job creation from entrepreneurs, and it coincided with a historic decline in home values that preceded the onset of broad recession by at least nine months. I construct a heterogeneous agent DSGE model with both housing and entrepreneurship. The model is characterized by financial frictions that affect both credit supply and credit demand. I consider the consequences of shocks to house prices and financial frictions by comparing model steady states and studying transition paths. The model produces a negative relationship between entrepreneurial activity and both house prices and loan-to-value ratios; the consequences of economywide credit spreads are more nuanced, with high spreads causing economic disruption that entices new low-productivity entrepreneurs into production. The results suggest that recessions associated with housing market collapse may necessarily be “different” in terms of the crucial contribution of entrepreneurs to job creation.

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The Great Recession was preceded by a simultaneous decline in house prices and startup activity, both of which were largely unprecedented in scale. Given the crucial job market role played by young firms (see Haltiwanger, Jarmin and Miranda (2013) and Haltiwanger (2012)), understanding the cause of the startup collapse is important. Fort et al. (2012) suggest that young firms account for about 22 percent of the decline of net job growth associated with the Great Recession, so the causes of the collapse of young firm activity may be significant contributors to U.S. labor market stress. I describe evidence that house prices and startup activity were positively related during the last decade and that startup credit access often depends on household finances. I suggest that the pre-recession decline in startup and entrepreneurial activity may be partially attributed to the decline in the value of housing collateral and provide some stylized facts that are consistent with this theory. I then construct a model that is capable not only of producing a decline in startup and entrepreneurial activity in response to a decline in house prices but also of nesting the house price mechanism with other channels through which housing and financial frictions can affect the real economy. The model’s results suggest that recessions associated with large house price declines are “different”. That is, they are naturally accompanied by slower job growth as a result of distressed cohorts of young firms.

The effects of house prices on bank balance sheets and consumer spending have been studied extensively, and there is a large literature on the effect of financial constraints on job flows, the firm age (and size) distribution, and entrepreneurship. However, the relationship between housing and entrepreneurship has received less attention. I construct a heterogeneous agent DSGE model, based on the macroeconomic literature studying entrepreneurship, in which housing plays a collateral role for potential entrepreneurs and in which the distributional implications of financial constraints can be examined. I describe several steady state experiments; the most important of which involves a shock to housing preferences that induces a large decline in the value of housing. I compare this experiment with experiments based on changes in the permissible loan-to-value ratio associated with household borrowing
and changes in the credit spread affecting all firms. I then calculate equilibrium transition paths from the baseline to the experimental steady states. In these exercises, the model produces a reduction in entrepreneurial activity generally and startup activity in particular, including labor demand from entrepreneurs, in response to declines in house prices or loan-to-value ratios. A heightened credit spread—an indicator of credit conditions faced by all types of firms—does not necessarily reduce entrepreneurial activity disproportionately, suggesting that the housing collateral mechanism is more important for explaining Great Recession data.

The model includes a corporate sector that is not subject to collateral constraints; as a result, collateral constraint experiments need not affect aggregate production. Corporate firms can raise output in response to reduced entrepreneurial activity, leaving the aggregate economy healthy. In this respect, the quantitative results I describe may be thought of as a lower bound on the effects of collateral values on entrepreneurial job creation. In the absence of a healthy non-entrepreneurial sector, aggregate demand effects could result in further reductions in entrepreneurial activity.

The present study does not attempt to explain the path of house prices in recent decades, preferring to take the large post-2005 decline as exogenous to aggregate entrepreneurial activity. I implement the price decline with a shock to housing preferences amidst constant, exogenous housing supply.

Section 1 describes evidence and literature relevant to housing, entrepreneurship, and the model. Section 2 describes the model in detail. Section 3 describes the model calibration. Section 4 describes results from steady state comparisons; in future drafts this section will report results from transition path experiments as well. Section 5 describes areas for improvement. All figures can be found in Appendix A.
1 Evidence and literature

1.1 Data on housing and young firms

As documented by Haltiwanger, Jarmin and Miranda (2011) and Haltiwanger, Jarmin and Miranda (2012), the Great Recession was preceded by a sharp decline in the number of new firms and the number of jobs created by startups; this fact holds even when the construction industry is ignored (see Figure 1).\(^1\) While the figure does show that startup activity tends to be a leading indicator, the most recent startup collapse was exceptionally large. Figure 2 (again omitting construction) shows that startup activity declined not just in absolute terms, but also relative to the overall number of firms and to total job creation.\(^3\) Both figures use annual data; startup data are recorded in March of each year.\(^4\)

At least at the annual frequency, the timing of the decline in startup activity coincides broadly with the peak and deterioration of house prices and home equity. Figure 3 plots measures of startup activity (omitting construction) against the S&P/Case-Shiller national house price index,\(^5\) all normalized by their 2000 levels. The top panel of Figure 3 shows quantities of startup firms and startup jobs, and the bottom panel shows startup firms and startup job creation as shares of overall firm totals.\(^6\) Annual house price indices are reported as of the first quarter of the noted year, but note that these indicies tend to measure prices

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\(^1\)The construction industry is defined as two-digit SIC codes 15, 16, and 17.

\(^2\)All data on startups are from Business Dynamics Statistics, a publicly available dataset starting in the late 1970s that aggregates administrative data on the universe of private nonfarm establishments; establishments are observed in March of each year. My absolute employment measures are “dynamic” in the sense that the reported measure for year t is the average of the observations of March t and March t-1.

\(^3\)Many startups are small, and the decline in small firm job creation in the mid-2000s expansion has been documented before (see Moscarini and Postel-Vinay (2009), Moscarini and Postel-Vinay (2012)). These explanations fail to distinguish between young and small firms, however, and given the specific role of young firms in job creation, additional focus on young firms is warranted.

\(^4\)Recession bars in the figures are also based on annual data, where the following years count as recessions: 1981-1982, 1990, 2001, and 2008-2009. According to the NBER, the most recent recession began in December 2007 and ended in July 2009.

\(^5\)FHFA home prices or the Federal Reserve’s measure of home equity (from Flow of Funds) would show similar timing (with home equity showing an even sharper relationship but FHFA peaking somewhat later).

\(^6\)The job creation measure is actually the startup component of the overall job creation rate, where the job creation rate is constructed as in Davis, Haltiwanger and Schuh (1998).
Table 1: Correlations: State-level house price declines and startup activity

<table>
<thead>
<tr>
<th></th>
<th>house prices</th>
</tr>
</thead>
<tbody>
<tr>
<td>startup firms (level)</td>
<td>0.3381</td>
</tr>
<tr>
<td>startup job creation (level)</td>
<td>0.4192</td>
</tr>
<tr>
<td>startup firms (share of total)</td>
<td>0.3400</td>
</tr>
<tr>
<td>startup job creation (share of total)</td>
<td>0.4192</td>
</tr>
</tbody>
</table>

Decline from peak to trough as percent of peak

at a lag. Startup firm and jobs data are reported annually in March.

Readers should evaluate timing as follows: in the top panel of Figure 3, the number of startup firms peaks in March 2006, and the graph shows this occurring at the same time as the 2006:Q1 house price index observation. In March 2007, the number of startup firms was 5 percent lower than the number observed in March 2006, and most house price indices also reported lower price levels in 2007:Q1 than in 2006:Q1. In the bottom panel of Figure 3, the component of the aggregate job creation rate that is accounted for by startups peaks in March 2006.\(^8\) In short, both panels of the figure show that by March 2007, startup activity had fallen from its March 2006 level, while the NBER defines the recession as not beginning until December 2007. Hence, \textit{the decline in startup activity led the recession by between nine and twenty-one months.}

The timing indicates that demand-side factors or broad financial sector explanations for the link between startups and house prices may be inapplicable. For example, Figure 4 plots fixed nonresidential investment, investment in equipment and software, and fixed residential investment. It appears that the slowdown in startup activity which began between March 2006 and March 2007 was coincident with the decline in residential investment but prior to developments in other measures of investment. More evidence for a housing explanation comes from regional heterogeneity. Figure 5 plots peak-to-trough declines (as percent of peak) in house prices and startups’ share of job creation rates at the state level, where

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\(^8\)Recall that this measure is constructed using data reported in both March 2006 and March 2005; it is the number of jobs accounted for by startups as of March 2006 divided by the average of the number of economywide jobs reported in March 2006 and 2005.
Table 2: Descriptive regressions: Declines in startup activity on declines house prices

<table>
<thead>
<tr>
<th></th>
<th>firms (level)</th>
<th>job creation (level)</th>
<th>firms (share)</th>
<th>job creation (share)</th>
</tr>
</thead>
<tbody>
<tr>
<td>house prices</td>
<td>0.178</td>
<td>0.241</td>
<td>0.186</td>
<td>0.241</td>
</tr>
<tr>
<td>$P &gt;</td>
<td>t</td>
<td>$</td>
<td>0.015</td>
<td>0.002</td>
</tr>
</tbody>
</table>

Decline from peak to trough as percent of peak

“peak” and “trough” are defined for each state individually (so peak and trough dates may be different across states). Table 1 reports correlations between these declines as well as declines in the level of startup job creation, the number of startup firms, and the startup share of firms. Table 2 reports coefficients from descriptive regressions of declines in startup activity against house price declines, again at the state level. These data indicate that states with larger house price declines on average experienced larger declines in startup activity.

Temporal coincidence does not imply causality, but these data are suggestive of a relationship between house prices and startup creation.

The empirical relationship between house prices and young firm activity is documented and explored more formally by Fort et al. (2012). The authors employ vector autoregression to isolate the effect of exogenous variation in house prices on young firm activity at the state level, concluding that “the collapse in housing prices play[ed] a critical role” in the dramatic decline in new firm formation and young firm job flows prior to and during the Great Recession. While this study is silent on the specific mechanism linking house prices and startups, it demonstrates a clear relationship between them and provides evidence that is not inconsistent with a role for home equity in startup financing. This relationship is particularly strong for young firms in Construction, Retail Trade, FIRE, and Services, suggesting avenues for future empirical research. More evidence is provided by Adelino, Schoar and Severino (2013). Using estimates of housing supply elasticities from Saiz (2010) as an instrument for house price changes at the level of metropolitan areas, Adelino et al. find that between 2002 and 2007, exogenous increases in house prices (where “exogenous” is defined in terms of the elasticity instrument) were associated with increased employment in small businesses relative to large businesses. This effect is particularly strong for businesses in industries
that typically rely heavily on external financing, and the effect is strong even in tradeable industries, implying that the effect of house prices is not solely due to the impact of house prices on local consumption demand.

1.2 Young and small business credit

Firm size has a large role impact on credit access (Cole and Wolken (1995), 629). Multiple surveys have found that small businesses borrow primarily from commercial banks rather than directly from broader credit markets. Small firms also frequently use credit cards and other “nontraditional” finance sources (Mishkin (2008)). While these reports fail to distinguish between young and small firms, many young firms are small and may therefore be subject to such financial constraints. Additionally, according to the 2010 Kauffman Firm Survey, young firms obtain “about three-quarters of their funds from banks via loans, credit cards, and lines of credit” (Frequently asked questions about small business finance (2011), 2). Adrian, Colla and Shin (2012) report that large firms were largely able to replace bank financing with bond financing in the wake of the financial crisis, but this is not an option available to most young and small firms.

Studying entrepreneurial credit poses some challenges. One difficulty is that entrepreneurial credit often lies at the intersection of household and business lending, resisting clean categorization (Cole and Wolken (1995), 633). The Federal Reserve Board conducts a quarterly survey of senior loan officers\(^9\) at approximately sixty domestic banks (and some foreign banks operating domestically), but the questions are divided, without nuance, between commercial and household lending. Further, the survey rarely asks direct questions about collateral. That said, the surveys from the 2007-2008 period provide some suggestive evidence. The 2007 surveys indicate a gradual but steady move to tighter mortgage lending standards, although they have no direct questions about collateral. The January 2008 survey\(^{10}\) includes a special question about the outlook for loan quality in the coming year. “Between about 70

\(^9\)Past surveys are described at http://www.federalreserve.gov/boarddocs/snloansurvey/.
\(^{10}\)http://www.federalreserve.gov/boarddocs/snloansurvey/200801/default.htm
percent and 80 percent of domestic respondents expect the quality of their prime, non-traditional, and subprime residential mortgage loans, as well as of their revolving home equity loans, to deteriorate in 2008.” The April 2008 survey\textsuperscript{11} includes a special question about home equity lines of credit (HELOCs): “Nearly all respondents pointed to declines in the value of the collateral significantly below the appraised value for the purposes of the HELOCs as reasons for tightening terms on those lines.” Subsequent surveys indicated ongoing tightening of HELOC standards. Overall, the surveys do not provide conclusive evidence for the entrepreneurship channel as they give insufficient attention to collateral and fail to obtain information about home equity lending for business purposes. However, they do at least indicate steadily stricter loan-to-value ratios and other standards starting in late 2006 as lenders began to notice that lending against housing was becoming riskier.\textsuperscript{12}

Some evidence suggests that the relationship between house prices and entrepreneurship has changed over the last few decades. Few small businesses reported reliance on mortgage credit in 1993\textsuperscript{13} (Cole and Wolken (1995)), but this number increased during the 1990s (Bitler, Robb and Wolken (2001)). Growth in entrepreneurs’ reliance on credit lines and bank loans during this period is also evident (Mach and Wolken (2006)), but the nature of the collateral backing these lines is difficult to determine in the data. I take these changes in entrepreneurial finance as exogenous; that is, I do not investigate why home equity-related business borrowing grew in recent decades. This omission is nontrivial since it could affect the applicability of my hypothesis to earlier time periods; if legal or other exogenous changes

\textsuperscript{11}http://www.federalreserve.gov/boarddocs/snloansurvey/200805/

\textsuperscript{12}In December 2012 I collected some limited anecdotal evidence by interviewing several community bankers. Each of them reported that collateral was the key criterion used to evaluate loan applications from prospective business creators. The bankers gave some weight to earnings history for older firms, but new firms lack such history. The dominant (and almost sole) sources of collateral for new firms were structures, with personal homes being very common. One banker reported that when house prices began declining, his bank virtually ceased making loans to new firms. All bankers reported having watched local housing conditions carefully during the house price decline, even in the context of non-construction business lending decisions. The bankers also reported sharp declines in loan-to-value ratios. One banker reported that, prior to 2006, small businesses often received loans in excess of 100 percent of collateral value, and all bankers reported that loan-to-value ratios were typically below 80 percent during and after the collapse in housing.

\textsuperscript{13}These data raise questions about the nature of entrepreneurial finance prior to the expansion of home equity finance, but I leave these for future study.
in recent decades created more opportunities for housing-related borrowing, I would not necessarily expect the relationship between housing and startups to be strong in former times even if house prices help explain startup activity during the last decade. I leave this “upstream” investigation to future research.

While it is difficult to investigate the role of housing collateral for startup credit directly, it is clear that (a) new (and small) firms are largely lacking in access to the types of credit facilities enjoyed by large firms, and (b) young and small firms rely heavily on external credit for operation (Robb and Robinson (2010)). Lacking any earnings history, new firms’ access to credit may therefore depend heavily on collateral. These facts and implications are consistent with an important role for the decline of housing collateral value in the recent decline of startup activity, though other channels may be relevant as well.

### 1.3 Financial constraints and entrepreneurship

How much do financial constraints matter for the firm age distribution, job flows, and entrepreneurship? Several empirical studies have found evidence of financially constrained behavior among young firms or at least dependence of growth paths on initial assets. These include Angelini and Generale (2008) (using Italian data), Huynh and Petrunia (2010) (using Canadian data), Chaney, Sraer and Thesmar (2012), and Kleiner (2013). From these studies, there is evidence that the conditional size distribution of financially constrained firms is different from the distribution of unconstrained firms and that the number of firms facing financial constraints is nontrivial. Firms with more initial assets grow faster, and real estate holdings in particular seem to serve as collateral and therefore can constrain growth and investment.

Theoretical research using heterogeneous agent models following Hopenhayn (1992) has found that including financial constraints can improve the models’ ability to match U.S. data. Cooley and Quadrini (2001) find that the introduction of financial frictions in the form of costly default allows the model to replicate the mutually conditional size and age
distributions of firms in terms of growth, growth volatility, gross job flows, and exit.\textsuperscript{14} Khan and Thomas (2011) study a model with endogenous entry, partially irreversible investment, and collateralized borrowing constraints. In their model, financial shocks result in persistent drops in total factor productivity and large recessions. The Khan and Thomas model also assumes a predetermined capital stock and entry measure, perhaps hindering its ability to study the startup extensive margin or the full implications of collateral for household and firm behavior. Though not dealing with financial constraints, Lee and Mukoyama (2012) is also relevant to the present study; the authors study a heterogeneous firm model with entry and exit over the business cycle and find that entry costs affect the cyclical dynamics of entry.

Entrepreneurship in particular has been studied with a variety of structural models. Quadrini (2009) reviews the macroeconomic entrepreneurship literature, noting that many studies have found consequences of borrowing constraints and that, in particular, such constraints help explain the observed degree of wealth concentration. What distinguishes models with entrepreneurship from other heterogeneous agent models (even those with firm entry) is the close link in such models between firm entry and household assets. A important paper in this literature is Quadrini (2000). By dividing production between corporate and non-corporate sectors, Quadrini’s model allows for the familiar separation between firm and household decisions for continuing firms while giving household characteristics strong relevance for startup activity. Models with entrepreneurship typically find significant consequences of borrowing constraints for households. Buera (2009) estimates the welfare costs of borrowing constraints to be about 6 percent of lifetime consumption. Cagetti and De Nardi (2006) can replicate the empirical wealth distribution endogenously, arguing that “the tightness of borrowing constraints and voluntary bequests are the main forces in determining the number of entrepreneurs, the size of their firms, the overall wealth concentration in the population, and the aggregate capital accumulation” (866).

\textsuperscript{14}Note, however, that the nature of investment costs may also carry explanatory power for these outcomes; see D’Erasmo (2011).
While these studies suggest the relevance of financial constraints for entrepreneurs, Hurst and Lusardi (2004) raised some controversy by finding no empirical evidence of a strong relationship between household wealth and entrepreneurship among PSID households. However, Fairlie and Krashinsky (2012) argue that the Hurst and Lasardi (2004) results are weakened when one distinguishes between entrepreneurial entry decisions driven by job loss and other reasons for entry. They also find a strong relationship between home equity and entrepreneurship, although Fairlie (2012) finds that the impact of declining home equity on entrepreneurship was partially offset by increased job loss in the Great Recession: bad labor markets may drive some people into self employment. In general, though, there are strong empirical reasons to believe that financial constraints have a large effect on entrepreneurship at least along some margins.

A number of empirical studies have considered the implications of the collateral and balance sheet roles of housing. That housing matters for consumer decisions has been well documented (see, e.g., Cooper (2012)). Mian and Sufi (2011) show that home equity borrowing was likely responsible for a significant portion of household borrowing in the early 2000s, noting also that the new borrowing does not appear to have been used for paying down other consumer debt or buying other houses. Mian, Rao and Sufi (2012) and Mian, Sufi and Trebbi (2012) find that the collapse of home prices and consequent tightening of the home equity credit supply led to nontrivial declines not only of residential investment but also of general consumption, focusing on nontradeables. This mechanism could potentially explain the observed decline in startups, though the different timing of declines in startups and overall activity suggests other mechanisms are more likely. Fort et al. (2012) note that, given the tendency of young firm finances to be linked to household finances, the Mian et al. results are not inconsistent with a firm credit channel of house prices, with the link depending on firm age. Both Fort et al. (2012) and Adelino, Schoar and Severino (2013) find effects of house price declines in sectors other than nontradeables, suggesting that the Mian et al. demand channel is only a partial explanation for the link between house prices
and overall activity.

A number of studies give structural underpinnings to a housing collateral channel as well as a bank balance sheet channel of overall home price shocks (see, e.g., Iacoviello (2010), Iacoviello and Neri (2010), Iacoviello (2011), Midrigan and Philippon (2011), Guerrieri and Lorenzoni (2011), and Iacoviello and Pavan (2013)). None of these studies allows for a direct channel between housing collateral and entrepreneurship, instead allowing only for effects on consumption and indirect effects on investment in the housing sector.

Corradin and Popov (2012) provide a simple model in which housing collateral matters for entrepreneurial decisions; this model does not allow for a broader examination of the firm age distribution and job flows. The authors also conduct an empirical exercise, finding that rising home equity increases the likelihood of entering entrepreneurship. However, these results are found on the Survey of Income and Program Participation, which is unlikely to be sufficiently representative of potential entrepreneurs (the authors note that this survey “over-samples from areas with high poverty concentrations”).

Siemer (2012) provides an in-depth study of financial frictions and firm dynamics in the recent recession. The author constructs a heterogeneous firm model with default and endogenous borrowing constraints, and calibrates it carefully to the firm distribution, based on the notion that credit constraints are likely to act at the firm level rather than the establishment level. Following a shock to the default recovery rate, the model produces a prolonged recession with a “jobless recovery.” The key mechanism driving the slow recovery of the labor market is a “missing generation” of new firms due to the tightened credit constraint—a key element of my own hypothesis. In a strictly empirical exercise, the author concludes that “external financial constraints account for a 4.5 percentage point reduction of employment growth in small firms relative to large firms during 2007-2009 . . . driven by young firms” (2).

Siemer (2012) is a significant contribution to the literature on credit constraints, firm dynamics, and the Great Recession. It is relevant, though, that Siemer’s model essentially
takes collateral value as entirely exogenous: new firms are given a capital endowment that
serves as both collateral and the productive asset (rather than firms being able to make
decisions to change their collateral asset holdings). This renders the model incapable of
studying perhaps the largest source of collateral for new businesses, home equity, which
differs from the collateral in Siemer’s model both because its value was subject to dramatic
to and during the Great Recession and because housing serves not only as
collateral but also as durable consumption. The financial shock in Siemer’s model does not
affect the value of collateral but rather the default recovery parameter, which results in a
tightening of endogenous borrowing constraints. In this sense his model is almost like a
special case of mine, since I can also tighten borrowing constraints through the loan-to-value
ratio parameter. Additionally, Siemer’s empirical exercises are performed on BLS data that
cannot identify firms operating in more than one state. In any case, the empirical results
are not inconsistent with a housing collateral hypothesis.

The conclusion to be drawn from existing research, then, is the following. There are
strong theoretical and empirical reasons to believe that borrowing constraints are highly
relevant for new businesses, and there is evidence that such constraints were among the
key drivers of the real economy before and during the Great Recession. There are also
strong reasons to believe that home equity plays a significant economic role as a primary
element of household balance sheets. But less research has studied the potential role of
housing as business collateral and the consequences of the decline in house prices for the
firm age distribution, job flows, and entrepreneurship in the Great Recession. A structural
theoretical investigation of precisely these issues is the primary marginal contribution of the
present study.
2 Model

Consider a model of entrepreneurship based on Buera, Kaboski and Shin (2011) and augmented with housing as in Iacoviello and Pavan (2013). Heterogeneous households choose whether to be workers or entrepreneurs. Housing can be owned or rented; owned housing can be used as collateral for consumer loans or capital rental. Housing supply is exogenous and constant. Households are distributed over a four-dimensional state space based on financial assets, owned housing, previous occupational status (so that new entrepreneurs may be different from incumbents), and entrepreneurial productivity (which is responsible for generating a wealth distribution).

Output is produced by both a representative corporate firm and entrepreneurs (as in Quadrini (2000)). Entrepreneurs are households that choose to operate their production technology, hiring labor and renting capital. All households face idiosyncratic shocks to their entrepreneurial productivity; this shock is the driver of heterogeneity in the model.

A zero-profit financial sector borrows from households with positive savings to supply loanable funds, rental housing, and productive capital for entrepreneurs and the corporate firm. Loanable funds and rental capital are produced at an exogenously determined cost; in equilibrium this cost is manifested as a credit spread paid by borrowers and firms.

2.1 Production

Entrepreneurs and the representative firm produce the same consumption good which can be saved or used as productive capital. All firms rent capital from the financial intermediary at rate \( r^k \), which includes compensation for depreciation (as described below), and hire labor from a common labor market at wage \( w \). Capital is rented, utilized, and returned to the financial intermediary within the period, so it is not an intertemporal decision. Corporate output is produced with the following constant returns to scale technology:
\[ Y_c = Z_c K_c^\xi N^{1-\xi} \]  

(1)

where \( \xi \in (0, 1) \). Corporate production does not involve fixed costs, so profits are given by \( Z_c K_c^\xi N^{1-\xi} - r^k K_c - w N_c \). Note that the CRS nature of corporate technology implies a fixed relationship between wages and the capital rental rate; the corporate firm’s first-order conditions imply

\[ w = (1 - \xi) Z_c \left( \frac{r^k}{\xi Z_c} \right)^{\frac{\xi}{\xi - 1}} \]  

(2)

Since \( \xi < 1 \), this implies an inverse relationship between \( r^k \) and \( w \).

All households can receive an idiosyncratic entrepreneurial productivity draw \( z \) from a Pareto\((x_m, \eta)\) distribution. Household productivity is persistent: each period, there is probability \((1 - \gamma)\) that the household receives a new \( z \) draw. Households that do not receive a new draw can produce with the same productivity as in the previous period. Households observe their entrepreneurial productivity before making their occupational decision. Entrepreneurial output is produced with the following decreasing returns to scale technology:

\[ y_c = z k^{\alpha} n^{\theta} \]  

(3)

where \( \alpha \in (0, 1), \theta \in (0, 1), \) and \( \alpha + \theta < 1 \). Startups (entrepreneurs that were workers in the previous period) pay an entry cost \( v \), but incumbent entrepreneurs pay no fixed costs and have profits \( z k^{\alpha} n^{\theta} - r^k k - w n \). Since labor and capital demand are not intertemporal decisions, the entrepreneur’s profit maximization problem is independent of all other household decisions; when borrowing constraints do not bind, profit maximization is also independent of the households financial and housing wealth. Unconstrained labor and capital demands
can be easily derived from the entrepreneur’s first-order conditions:

\[ k^u(z; r^k, w) = \left[ \frac{r^k}{\alpha z} \left( \frac{\theta z}{w} \right)^{\frac{\theta}{\theta - 1}} \right]^{\frac{\theta - 1}{1 - \alpha - \theta}} \]

\[ n^u(z; r^k, w) = \left( \frac{w}{z^\theta k^u(z; r, w)^\alpha} \right)^{\frac{1}{\theta - 1}} \]

Observe the unconstrained factor demand functions depend only on the wage \( w \), the capital rental rate \( r^k \), and productivity \( z \). The borrowing constraint and factor demand functions that hold when it binds are described below.

### 2.2 Financial sector

A representative financial intermediary borrows from savers at interest rate \( r \) and converts savings into loans, capital, and rental housing using linear technology. The financial intermediary owns capital and rental housing and, therefore, suffers depreciation losses. Additionally, conversion of deposits into capital and loanable funds is subject to exogenous marginal intermediation cost \( \tau \). Consider the following definitions:

\[
\begin{align*}
K_c & \quad \text{Corporate capital demand} \\
K_e & \quad \text{Total capital demand from entrepreneurs} \\
A_s & \quad \text{Total savings among households with positive financial wealth} \\
A_b & \quad \text{Loan demand among borrower households} \\
M_r & \quad \text{Total demand for rental housing} \\
r & \quad \text{Interest rate on household savings}
\end{align*}
\]

Taking the interest rate \( r \) as given, the financial intermediary solves the following profit maximization problem:
\[ \max_{K_c, K_e, A_b, M_r} r^k(K_c + K_e) + r^a_{\text{borrow}} A_b + r^h q M_r - \delta_k(K_c + K_e) - \delta_h M_r - \tau(K_c + K_e + A_b) - r A_s \]

subject to

\[ K_c + K_e + A_b + q M_r = A_s \]

that is, the financial intermediary lends out the total amount of household savings, dividing it between physical capital, loanable funds, and rental housing. The first-order conditions corresponding to the intermediary’s choice variables are:

\[ K_c, K_e : \quad r^k = \delta_k + \tau + r \quad (6) \]

\[ A_b : \quad r^a_{\text{borrow}} = \tau + r \quad (7) \]

\[ M_r : \quad r^h = \delta_h + r^h \quad (8) \]

Thus, the intermediation cost manifests itself as a credit spread with respect to the interest rate paid to savers. Agents that borrow from the bank must pay the basic interest rate along with extra payment to cover relevant depreciation and intermediation costs. For notation purposes, the first-order condition on loanable funds allows me to concisely define the interest rate associated with the asset \( a \) generally as

\[ r^a = \begin{cases} r & \text{if } a \geq 0 \\ r + \tau & \text{if } a < 0 \end{cases} \quad (9) \]
It is simple to show that the financial intermediary, while owned by the households, has zero profits (see Appendix B).

### 2.3 Households

Households have preferences given by

$$u(c, h') = \frac{c^{1-\sigma_c}}{1-\sigma_c} + \varepsilon \frac{(\kappa m)^{1-\sigma_h}}{1-\sigma_h}$$

(10)

where $c$ is nondurable consumption, $m$ is housing consumption (either rented or owned), and $\kappa \in [0, 1]$ governs the utility penalty for renting, with $\kappa = 1$ for home owners. Housing is durable with depreciation rate $\delta_h$. Nondurable consumption is the numeraire; housing can be purchased at price $q$ or rented at rate $r^h$; both prices are determined by market equilibrium. Households can be entrepreneurs ($e = 1$) or workers ($e = 0$); entrepreneurs have profits from decreasing returns to scale production, and workers receive wage $w$ (set by labor market clearing). The household has access to asset $a$ for saving or borrowing at rate $r^a$ given by (9).

The household’s owned housing stock is given by state variable $h$, where

$$h = \begin{cases} 
    m & \text{if owner} \\
    0 & \text{if renter} 
\end{cases}$$

(11)

Note that, in a given period, the household derives utility from the housing decision made in the previous period. This reflects time costs associated with home purchases and is consistent with the timing of the borrowing constraint described below. Note that this implies that the binary tenure decision is also made one period in advance, but the rental housing quantity decision is made in the same period in which it is consumed. Owned housing
adjustment is costly as in Iacoviello and Pavan (2013); adjustment beyond replacement of depreciation results in cost $\psi qh$. This cost may be thought of as including realtor fees, renovation inconveniences, and/or moving costs. Note that a household changing from owning to renting pays this fee, as does an owning household that simply adds a room to its house. A household changing from renting to owning does not pay this cost as $h = 0$ in this case. Rental housing contracts last only one period and are opened and closed without friction, so renting households can change their housing consumption freely. This setup is an attempt to capture the notion that household consumption is much more flexible for renters than for owners.

All household borrowing—both loanable funds and capital rental—is subject to a borrowing constraint:

$$k \leq a + \phi qh$$

with $k = 0$ for workers. Positive $a$ indicates positive savings while negative $a$ reflects borrowing; any household may borrow up to the collateral value of their owned housing given by $\phi qh$ (so renters may not borrow at all and must have positive savings to engage in entrepreneurial production). When $k = 0$, the borrowing constraint may be thought of as a simple mortgage technology with loan-to-value ratio $\phi$. As I will describe below, the borrowing constraint is the model’s mechanism for making entrepreneurial decisions and profits dependent on household balance sheets.

The borrowing constraint given by (12) may be thought of as a reduced-form simplification of borrowing conditions motivated by agency problems. For example, Buera, Kaboski and Shin (2011) derive a borrowing constraint from an exogenous default recovery parameter faced by banks along with a no-default condition. In the event of default, banks can recover a fixed portion of entrepreneurial profits along with wealth deposited with the financial in-
termediary; the bank derives the borrowing constraint by choosing the maximum amount of loaned capital at which the household prefers repayment to default. The resulting level of permissible capital rental is increasing in household wealth and entrepreneurial productivity. My simplified borrowing constraint has similar properties except that it discards the role of profits in the constraint for tractability purposes. Further, I apply the loan-to-value parameter to housing (and not liquid wealth) based on the notion that liquid wealth is relatively easy for the bank to seize and use while foreclosed housing is characterized by costs and risks that render it less valuable as loan security (from the bank’s perspective). In my specification, the borrowing constraint works like a technology allowing households to extract cash from their home.

Capital is not owned by firms, as if entrepreneurs face a requirement that working capital be financed through borrowing. However, consider a special case in which \( h = 0, a > 0, \) and the rental rate on capital is not subject to a credit spread. This is equivalent to a model in which part (or all) of a household’s financial wealth is held as physical capital, as if capital is not rented but owned by the entrepreneurial household. Therefore, the working capital constraint setup differs from firm ownership of capital when there is an intermediation cost (credit spread) and when the household owns housing. Housing is a versatile asset in that borrowing against it to rent capital is almost as if the house itself is productive capital.

Households maximize the value of lifetime utility, which is given by

\[
v(s, a, h, z) = \max_{e \in \{0, 1\}} \{ v^{e=0}(a, h, z), v^{e=1}(s, a, h, z) \}
\]

where \( v^{e=0}(a, h, z) \) is the value of being a worker, \( v^{e=1}(s, a, h, z) \) is the value of being an entrepreneur, and \( s \) is a state variable tracking entrepreneurial entry with
\[ s = \begin{cases} 0 & \text{if the household was an entrepreneur in the previous period} \\ 1 & \text{if the household was a worker in the previous period} \end{cases} \]

Households that choose to be workers \((e = 0)\) solve the following problem:

\[
v^{e=0}(a, h, z) = \max_{c \geq 0, a', h' \geq 0, m \geq 0} \{ u(c, m) + \beta [\gamma v(1, a', h', z) + (1 - \gamma) \mathbb{E} v(1, a', h', z')] \}
\]

subject to

\[
c + a' + q (h' - (1 - \delta_h)h) + \mathbb{I}_{rent} r^h qm + \mathbb{I}_{h' \neq h} \psiqh \leq w + (1 + r^a)a
\]

\[
0 \leq a + \phiqh
\]

where \(\mathbb{I}_{rent}\) indicates housing tenure\(^{15}\) with

\[
\mathbb{I}_{rent} = \begin{cases} 1 & \text{if } h = 0 \text{ (renter)} \\ 0 & \text{if } h = m \text{ (owner)} \end{cases}
\]

and \(\mathbb{I}_{h' \neq h}\) indicates housing adjustment with

\[
\mathbb{I}_{h' \neq h} = \begin{cases} 1 & \text{if } h' \neq h \\ 0 & \text{if } h' = h \end{cases}
\]

\(^{15}\)If the housing utility term satisfies the Inada condition (as in my specification), \(m > 0\) so the definition of \(\mathbb{I}_{rent}\) given here describes mutually exclusive possible values.
Note that for households that own housing \((h > 0)\), the term \(m\) in the utility function is predetermined. Note also that households that purchase enough housing to replace depreciation do not pay an adjustment cost; equivalently, households are required to perform maintenance on their home to avoid adjustment cost.

Households that choose to be entrepreneurs \((e = 1)\) solve the following problem:

\[
v^{e=1}(s, a, h, z) = \max_{c \geq 0, a', h' \geq 0, m \geq 0, k \geq 0, n \geq 0} \left\{ u(c, m) + \beta \left[ \gamma v(0, a', h', z) + (1 - \gamma) \mathbb{E}_{z'} v(0, a', h', z') \right] \right\}
\]

subject to

\[
c + a' + q (h' - (1 - \delta_h)h) + I_{\text{rent}} r^h q m + I_{h' \neq h} \psi q h \leq z k^\alpha n^\theta - r^h k - wn - sv + (1 + r^a) a
\]

\[
k \leq a + \phi q h
\]

where \(I_{\text{rent}}\) and \(I_{h' \neq h}\) are defined in (14) and (15), respectively, and \(v\) is the fixed entry cost paid by new entrepreneurs \((s = 1)\). Again, \(m\) is predetermined for home owners \((h > 0)\).

It is important to note that the borrowing constraint, when binding, makes the entrepreneur’s optimal labor and capital demand functions dependent on the state of household wealth as of the beginning of the period; but the factor demand decisions can still be made independently of other household choices made during the same period. This is due to the intratemporal nature of the capital decision, which prevents marginal utility terms from affecting the capital and labor first-order conditions.\(^{16}\) Based on the unconstrained factor demands given by (4) and (5), and using Kuhn-Tucker conditions, actual capital and labor demand are given by

\(^{16}\)Separating consumption and production decisions in this way simplifies computation considerably.
\[ k(z, a, h; r_k, w, q) = \begin{cases} 
\left[ \frac{s^h}{\alpha z} \left( \frac{\theta z}{w} \right)^{\frac{\theta - 1}{\sigma - 1}} \right] \frac{1}{\sigma - 1} & \text{if } k^u(z; r_k, q) \leq a + \phi qh \\
 a + \phi qh & \text{otherwise} 
\end{cases} \]  
\tag{17}

\[ n(z, a, h; r_k, w, q) = \left( \frac{w}{z \theta k(z, a, h; r_k, w, q)^{\alpha}} \right)^{\frac{1}{\sigma - 1}} \]  
\tag{18}

That is, capital demand equals its unconstrained level if that level is consistent with the borrowing constraint. Labor demand depends on the borrowing constraint because it is a function of capital demand. Both factor demand functions are therefore functions of household wealth (financial and housing) and, as a result, the house price and the loan-to-value ratio. With decreasing returns to scale technology, the constraint on capital and labor demand implies a constraint on both entrepreneurial output and profits. This is the key mechanism for this model: a household with little financial and housing wealth can receive a large productivity draw but operate at a scale that is well below the unconstrained optimal level or may even choose to be a worker instead.

### 2.4 Equilibrium

Define \( \mu(s, a, h, z) \) as the distribution of households over the state space, with

\[ \sum_{s=0}^{1} \int_{a} \int_{h} \int_{z} \mu(s, a, h, z) dh da = 1 \]

Define aggregate variables as
where $I_{a'≥0}(s,a,h,z)$ is 1 for households with positive financial assets and 0 for borrowers, and $I_{rent}(s,a,h,z)$ is defined by (14). Descriptions of these variables follow:
Define $H_s$ as the exogenously set supply of housing. Equilibrium requires the following:

The financial market clears:

$$K_e + K_c + q M_r = A_s + A_b$$  \hfill (30)

The labor market clears:

$$N_e + N_c = N_s$$  \hfill (31)

The housing market clears:

$$H + M_r = H_s$$
The aggregate resource constraint holds\textsuperscript{17}:

\[
Y_e + Y_c + A_s + A_b = C + A_s' + A_b' - \tau A_b' + q(H' - (1 - \delta_h)H) + \delta_h q M_r + S_e v + (\delta_k + \tau)(K_e + K_c)
\]  

(32)

where $S_e$ is the number of startups. The resource constraint simply requires that total consumption; net new savings; housing investment and rental; and the costs of depreciation, entry, and financial intermediation are equal to total output plus the net stock of financial assets (recall that $A_b$ and $A_b'$ are negative by definition). While it is uncommon for prices to appear in aggregate resource constraints, observe that the house price $q$ enters here. Since housing supply is fixed and exogenous, $q$ acts as a key multiplier governing the rate at which output (or the consumption good) can be converted into housing. A reduction in $q$ is like a positive technology shock, allowing the economy to support the housing stock with lower output. Lower $q$ leaves more resources available for consumption and investment. Recall, though, that $q$ is determined endogenously.

The distribution of households over the state space follows the law of motion

\[
\mu'(s, a, h, z) = \Psi(\mu(s, a, h, z))
\]

where $\Psi$ depends on optimal policy rules $a'$ and $h'$, the law of motion for $z$ given by

\[
z' = \begin{cases} 
z & \text{with probability } \gamma \\
z' \sim P(z) & \text{with probability } 1 - \gamma \end{cases}
\]

\textsuperscript{17}I show the derivation of the resource constraint in the Appendix B.
and the law of motion for $s$ given by

$$s' = \begin{cases} 
1 & \text{if } e(s, a, h, z) = 0 \\
0 & \text{if } e(s, a, h, z) = 1 
\end{cases}$$

The steady state is characterized by equilibrium prices and allocations with the distribution law of motion at a fixed point:

$$\mu = \Psi(\mu(s, a, h, z))$$

A transition path is characterized by distributions associated with an initial and a terminal steady state, $\mu_0$ and $\mu_T$ respectively, along with intermediate distributions such that

$$\mu_t = \Psi(\mu_{t-1}(s, a, h, z)) \quad \forall t \in \{1, 2, ..., T\}$$

$$\mu_T = \mu_{T-1}$$

and price vectors

$$\{r_t\}_{t=0}^T$$

$$\{w_t\}_{t=0}^T$$

such that all markets clear in every period on the transition path.
## Table 3: Literature-based calibration

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Discount factor</td>
<td>$\beta$ 0.92</td>
</tr>
<tr>
<td>Relative risk aversion, nondurables</td>
<td>$\sigma_c$ 1.5</td>
</tr>
<tr>
<td>Housing supply</td>
<td>$H_s$ 2.5</td>
</tr>
<tr>
<td>Housing adjustment cost</td>
<td>$\psi$ 0.05</td>
</tr>
<tr>
<td>Entrepreneurial productivity persistence</td>
<td>$\gamma$ 0.89</td>
</tr>
<tr>
<td>Rate of capital depreciation</td>
<td>$\delta_k$ 0.06</td>
</tr>
<tr>
<td>Rate of housing depreciation</td>
<td>$\delta_h$ 0.03</td>
</tr>
<tr>
<td>Entrepreneurial output capital parameter</td>
<td>$\alpha$ 0.299</td>
</tr>
<tr>
<td>Entrepreneurial output labor parameter</td>
<td>$\theta$ 0.491</td>
</tr>
<tr>
<td>Corporate output capital parameter</td>
<td>$\xi$ 0.33</td>
</tr>
</tbody>
</table>


BEA: Bureau of Economic Analysis; average rate for residential structures

## Table 4: Moment-based calibration

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Moment</th>
<th>Model</th>
<th>Data</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Housing utility, initial</td>
<td>$\varepsilon$ 0.52</td>
<td>Housing/GDP, 2006</td>
<td>1.8</td>
<td>1.8</td>
</tr>
<tr>
<td>Housing utility, terminal</td>
<td>$\varepsilon$ 0.36</td>
<td>Housing/GDP, 2011</td>
<td>1.2</td>
<td>1.2</td>
</tr>
<tr>
<td>Rental utility parameter</td>
<td>$\kappa$ 0.99</td>
<td>Renter share of population</td>
<td>0.33</td>
<td>0.32</td>
</tr>
<tr>
<td>RRA, housing</td>
<td>$\sigma_h$ 1.56</td>
<td>Share of pop., &gt;4,000 sq ft</td>
<td>0.09</td>
<td>0.05</td>
</tr>
<tr>
<td>Entrep. TFP (scale)</td>
<td>$x_m$ 1.28</td>
<td>Entrep. employment share</td>
<td>0.176</td>
<td>0.176</td>
</tr>
<tr>
<td>Entrep. TFP (scale)</td>
<td>$\eta$ 10.44</td>
<td>min/max entrep. size</td>
<td>0.06</td>
<td>0.04</td>
</tr>
<tr>
<td>Entry cost</td>
<td>$\upsilon$ 0.68</td>
<td>Startup employment share</td>
<td>0.01</td>
<td>0.03</td>
</tr>
</tbody>
</table>


BDS: Business Dynamics Statistics.

### 3 Calibration

I take several parameter values from existing literature; these are reported on Table 3.

I calibrate other parameters to match key moments from U.S. data. These are reported on Table 4.

Observe that I calibrate the housing utility parameter twice. The initial value corresponds with the baseline steady state. The terminal value corresponds with the primary experimental steady state in which house prices have fallen. I calibrate these two steady states to match the value of housing as a percent of output to the U.S. in 2006 and 2011, respectively. As shown on Table 5, the terminal steady state features a house price that is about 31 percent lower than the initial steady state.
Data moments describing entrepreneurial activity are taken from the Longitudinal Business Database (LBD). While there is no agreed upon definition of entrepreneurship, I use a characterization that combines age and legal form of organization: I define entrepreneurs as including all firms younger than 5 years and sole proprietorships (of all ages). A definition based only on age produces similar model results. The ratio of smallest to largest entrepreneurs is based on a sample in which the smallest and largest 5 percent of qualifying firms are omitted.

The American Housing Survey (AHS) provides housing occupancy data based on size bins of 500 square feet. The largest category consists of housing units of 4,000 square feet or more. While the model allows for housing to be a continuous variable, I discretize it into nine possible values representing increments of 500 square feet to correspond with the AHS calibration. It is reasonable to treat housing as a discrete variable; housing is bought (or rented) as numbers of rooms, and continuous adjustments to house size are unrealistic.\footnote{Further, computational limitations render housing continuity impractical; the savings asset variable $a$ is already continuous, so adding another continuous choice and state variable to the model ensures “curse of dimensionality” complications in the form of a costly tradeoff between model accuracy and computation time.}

The solution method is described in Appendix D.

4 Results

4.1 Steady state comparisons

I consider five steady state scenarios based on different values of the house preference parameter $\varepsilon$, the loan-to-value ratio $\phi$, and the intermediation cost (credit spread) $\tau$. Table 5 labels and describes the five steady state scenarios. Table 6 describes selected model outcomes for the five scenarios.

Observe that both the decline in the house price and the tightening of the loan-to-value ratio result in a lower share of activity from entrepreneurs and startups in the steady state.
Table 5: Steady state scenarios

<table>
<thead>
<tr>
<th>Preference</th>
<th>House price</th>
<th>LTV Ratio</th>
<th>Spread</th>
</tr>
</thead>
<tbody>
<tr>
<td>“Baseline”</td>
<td>0.517</td>
<td>1.395</td>
<td>0.92</td>
</tr>
<tr>
<td>“Price”</td>
<td>0.362</td>
<td>0.957</td>
<td>0.92</td>
</tr>
<tr>
<td>“LTV”</td>
<td>0.517</td>
<td>1.350</td>
<td>0.78</td>
</tr>
<tr>
<td>“Spread”</td>
<td>0.517</td>
<td>1.200</td>
<td>0.92</td>
</tr>
<tr>
<td>“All”</td>
<td>0.362</td>
<td>0.850</td>
<td>0.78</td>
</tr>
</tbody>
</table>

Table 6: Steady state results

<table>
<thead>
<tr>
<th></th>
<th>Baseline</th>
<th>Price</th>
<th>LTV</th>
<th>Spread</th>
<th>All</th>
</tr>
</thead>
<tbody>
<tr>
<td>$r$</td>
<td>8.099</td>
<td>8.102</td>
<td>8.109</td>
<td>8.000</td>
<td>8.013</td>
</tr>
<tr>
<td>$w$</td>
<td>0.9880</td>
<td>0.9879</td>
<td>0.9876</td>
<td>0.9106</td>
<td>0.9103</td>
</tr>
<tr>
<td>Entrepreneur output</td>
<td>0.336</td>
<td>0.282</td>
<td>0.320</td>
<td>0.352</td>
<td>0.288</td>
</tr>
<tr>
<td>Total output</td>
<td>1.486</td>
<td>1.483</td>
<td>1.484</td>
<td>1.374</td>
<td>1.371</td>
</tr>
<tr>
<td>Entrepreneurs’ own. rate</td>
<td>0.83</td>
<td>0.85</td>
<td>0.60</td>
<td>0.82</td>
<td>0.61</td>
</tr>
<tr>
<td>Entrepreneurial employment</td>
<td>0.167</td>
<td>0.140</td>
<td>0.159</td>
<td>0.189</td>
<td>0.155</td>
</tr>
<tr>
<td>Entrep. share of employment</td>
<td>0.176</td>
<td>0.147</td>
<td>0.168</td>
<td>0.201</td>
<td>0.163</td>
</tr>
<tr>
<td>Startup employment</td>
<td>0.013</td>
<td>0.010</td>
<td>0.012</td>
<td>0.014</td>
<td>0.011</td>
</tr>
<tr>
<td>Startup share of employment</td>
<td>0.013</td>
<td>0.011</td>
<td>0.013</td>
<td>0.015</td>
<td>0.011</td>
</tr>
<tr>
<td>Aggregate savings</td>
<td>3.99</td>
<td>3.79</td>
<td>4.21</td>
<td>3.21</td>
<td>3.08</td>
</tr>
<tr>
<td>Housing/GDP ratio</td>
<td>1.78</td>
<td>1.19</td>
<td>1.52</td>
<td>1.65</td>
<td>1.06</td>
</tr>
<tr>
<td>Constrained entrepreneurs</td>
<td>0.845</td>
<td>0.852</td>
<td>0.852</td>
<td>0.797</td>
<td>0.801</td>
</tr>
<tr>
<td>Renters</td>
<td>0.33</td>
<td>0.36</td>
<td>0.43</td>
<td>0.33</td>
<td>0.41</td>
</tr>
</tbody>
</table>

The magnitude of the decline is plausible compared with levels of entrepreneurial activity observed in U.S. data during 2009-2011. Tightening these constraints on credit demand increases the share of entrepreneurs that are constrained (in addition to tightening the constraint for those already constrained). Interestingly, the shock to housing preferences does not induce substitution into saving, while the shock to the loan-to-value ratio significantly expands the precautionary saving motive. This is a complicated question, since the change in housing preferences affects intertemporal conditions that drive the interest rate.

Consistent with the data, high home ownership rates prevail among entrepreneurs. The ownership rate falls, however, when loan-to-value ratios tighten, as the marginal value of housing as collateral falls. The decline in house prices induces a decline in the general home ownership rate, another result that is consistent with data for the Great Recession period.
Total output falls only slightly in the low-price scenario and does not fall at all in the low loan-to-value ratio scenario, reflecting the ability of the corporate sector to raise output in response to reduced entrepreneurship. Wages are also little affected by these experiments. The lack of change in aggregate outcomes supports the notion that the collateral constraint is the key mechanism driving the decline in entrepreneurship.

The high credit spread scenario is associated with markedly lower total output and wages but higher entrepreneurial activity. The key reason for this is the wage, which falls in the high-spread case. Wages affect the entrepreneurial decision directly; a lower wage reduces the opportunity cost of producing as opposed to providing labor. Further, due to the corporate technology a lower wage is necessarily associated with a higher interest rate that offsets the benefit of the lower wage bill faced by entrepreneurs.19 This result has relevance for the Great Recession: it is not clear ex ante what effect broad financial stress affecting all firms may have on entrepreneurship, since weak labor markets create incentives to become self employed. Bad economic conditions generally can create “entrepreneurs of necessity.” As such, the frictions that affect entrepreneurs and households specifically, as opposed to those that affect all firms, are key to understanding the decline of entrepreneurial activity.

The scenario in which the house price and loan-to-value ratio decline and the credit spread increases may be the most relevant for the Great Recession. Lower wages resulting from broad distress among firms are not sufficient for offsetting the contraction in credit access among entrepreneurs and startups, so entrepreneurial labor demand is depressed more than labor demand in the corporate sector.

Figure 6 plots the minimum productivity that is necessary to nudge a household into choosing entrepreneurship. The figure is based on the actual policy functions of households. The points described above are illustrated by the productivity thresholds: In the “price” and “loan-to-value” scenarios, households must receive relatively high productivity draws to

19While the “marginal” entrepreneurs induced into production necessarily have low productivity, the model likely overstates their productivity relative to reality. These are likely to be “entrepreneurs of necessity,” whose labor market prospects are extremely grim. As such, the model likely overstates the amount of job creation that results from such entrepreneurs.
Table 7: Transition path parameters

<table>
<thead>
<tr>
<th></th>
<th>Price</th>
<th></th>
<th>LTV</th>
<th></th>
<th>Spread</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(t)</td>
<td>(\varepsilon)</td>
<td>(\phi)</td>
<td>(\tau)</td>
<td>(\varepsilon)</td>
<td>(\phi)</td>
</tr>
<tr>
<td>1</td>
<td>0.517</td>
<td>0.92</td>
<td>0.009</td>
<td>0.517</td>
<td>0.92</td>
<td>0.009</td>
</tr>
<tr>
<td>2</td>
<td>0.362</td>
<td>0.92</td>
<td>0.009</td>
<td>0.517</td>
<td>0.78</td>
<td>0.009</td>
</tr>
<tr>
<td>3</td>
<td>0.362</td>
<td>0.92</td>
<td>0.009</td>
<td>0.517</td>
<td>0.78</td>
<td>0.009</td>
</tr>
</tbody>
</table>
| ... | ... | ... | ... | ... | ... | ... | ... | ... | ...
| T | 0.362 | 0.92 | 0.009 | 0.517 | 0.78 | 0.009 | 0.517 | 0.92 | 0.037 |

choose entrepreneurship. The baseline scenario and the scenario with a high credit spread have much lower thresholds; as mentioned above, the low wage is the reason for the low threshold in the “spread” scenario. More generally, the figure illustrates that entrepreneurship is more likely for wealthier (or less-indebted) households, a direct consequence of the borrowing constraint.

Figure 7 plots the distribution of several variables for each steady state scenario. Observe that the idiosyncratic productivity shock is sufficient to generate a wide distribution of households over wealth.

### 4.2 Transition paths

I consider transition paths from the initial baseline steady state to the low-price, low-loan-to-value ratio, and high-spread steady states. In each case, the economy begins in the baseline steady state at time \(t = 0\). At time \(t = 1\), agents are informed that at time \(t = 2\) parameters will take on new values corresponding with the terminal steady state, where the experimental parameters are \(\Phi \in \{\varepsilon, \phi, \tau\}\). Figures 8 and 9 document transition paths for several variables.

The results make clear the relationship between the house price and entrepreneurial activity, with the house price mattering even more than the loan-to-value ratio. Figure 9 shows that the house price decline drives an increase in the number of constrained entrepreneurs. Aggregate output and savings also fall considerably in response to the drop in the house price, requiring many periods before convergence to the terminal steady state. Home ownership gradually falls (consistent with Great Recession data). In general, the transition path data
suggest that lower house prices reduce entrepreneurship, with the collateral constraint as the key mechanism. Steady state comparisons show that the terminal steady state is characterized by lower entrepreneurial activity, but transition paths show even more entrepreneurial stress and even declining aggregate output following the initial shock.

5 Conclusion

I provide evidence consistent with the existence of a relationship between home values and entrepreneurship, with a key mechanism being the dependance of entrepreneurial decisions on housing collateral. I construct a model characterized by rich financial frictions, a housing sector, and entrepreneurship. The model suggests that entrepreneurship may indeed be tied to house values and that recessions associated with large house price declines are likely to be “different” in the sense that low house prices can constrain entrepreneurs generally and startups in particular, with quantitatively significant consequences for job creation. This is a plausible mechanism for which there is growing evidence in the literature. Moreover, the model suggests that broader supply-side financial frictions cannot explain a steady-state decline in the relative share of entrepreneurial activity in the economy.

The model results may be thought of as a lower bound on the effects of housing collateral shocks on entrepreneurial job creation and on the effects of distressed entrepreneurs on the broader economy. One reason for this is that, in the model, the house price acts as a technology for converting output to housing, and a decline in the house price leaves more output available for other uses. This can boost consumer demand, offsetting the pressures on entrepreneurial firms. Additionally, the model has a corporate sector that is not distressed by household collateral shocks. This corporate sector can compensate for low entrepreneurial output and labor demand, allowing households to continue to consume at high levels. The Great Recession was characterized by stress on large firms associated with, for example, credit supply restrictions and low aggregate demand. In reality and in my model, these
effects can indirectly boost entrepreneurship through a labor market channel, but in reality the resulting increase in entrepreneurship is not likely to be characterized by the kind of high-growth entrants that drive job creation. Overall the model suggests that recessions that are characterized by significant declines in home values are likely to be accompanied by lower entrepreneurial activity.
References


Appendix A: Figures

Figure 1: Startup activity in levels

![Startup Firms Graph]

Startups firms, linear trend, NBER recession

Source: Business Dynamics Statistics and NBER (annual data)

![Startup Jobs Graph]

Startup jobs, linear trend, NBER recession

Source: Business Dynamics Statistics and NBER (annual data)
Figure 2: Startup activity (shares)

Startup Share of Firms
Excluding construction

Source: Business Dynamics Statistics and NBER (annual data)

Startup Component of Job creation Rate
Excluding construction

Source: Business Dynamics Statistics and NBER (annual data)
Figure 3: Startup activity and house prices

Source: Business Dynamics Statistics, S&P

Figure 4: National investment

Investment
Billions of chained 2005 dollars, seasonally adjusted

Source: BEA and NBER
Figure 5: State declines

Startup Component of Job Creation & House Prices
Percent decline, peak to trough

Source: Business Dynamics Statistics and FHFA

Figure 6: Productivity thresholds for entrepreneurship

Minimum productivity

Baseline
Price
LTV
Spread
All
Figure 7: Distribution outcomes
Figure 8: Transition dynamics
Figure 9: Distribution outcomes
Appendix B: Derivations

Financial intermediary profits

The financial intermediary’s profit maximization problem is given by:

\[
\max_{K_c, K_e, A_b, M_r} r^k (K_c + K_e) + r^a_{\text{borrow}} A_b + r^h q M_r - \delta_k (K_c + K_e) - \delta_h M_r - \tau (K_c + K_e + A_b) - r A_s
\]

subject to

\[
K_c + K_e + A_b + q M_r = A_s
\]

The first-order conditions follow:

\[
\begin{align*}
K_c, K_e : & \quad r^k = \delta_k + \tau + r \\
A_b : & \quad r^a_{\text{borrow}} = \tau + r \\
M_r : & \quad r^h = \delta_h + r^h
\end{align*}
\]

Substituting the first-order conditions into the profit function yields

\[
\text{Profits} = r (K_c + K_e) + r A_b + r q M_r - r A_s
\]

Substituting the financial market clearing condition given by (30) yields the result of zero profits.
Aggregate resource constraint

The workers’ budget constraint is given by (13), and the entrepreneurs’ budget constraint is given by (16). These can be collapsed into a general budget constraint applying to all households:\(^{20}\)

\[
c + a' + q (h' - (1 - \delta_h)h) + I_{\text{rent}}^h qm + \mathbb{I}_{h' \neq h} \psi qh \leq zk^\alpha n^\theta - r^k k - wn - esv + (1 - e)w + (1 + r^a)a
\]

Recall that \(k = n = 0\) and \(e = 0\) for workers, and \(e = 1\) for entrepreneurs. Since utility is increasing in consumption, the budget constraint holds with equality for all households. Integrating both sides of (33) across the entire state space yields the aggregate resource constraint:

\[
\sum_s \int_{a,h,s} \left( c + a' + q (h' - (1 - \delta_h)h) + I_{\text{rent}}^h qm + \mathbb{I}_{h' \neq h} \psi qh \right)
= \sum_s \int_{a,h,s} \left( zk^\alpha n^\theta - r^k k - wn - esv + (1 - e)w + (1 + r^a)a \right)
\]

Rearranging and using the notation for aggregate quantities given by (19)-(29) and substituting the financial sector’s first-order conditions given by (6)-(8) simplifies the equation:

\[
C + A'_b + A'_a + q (H' - (1 - \delta_h)H) + (r + \delta_h)qM_r + \psi qH_{\text{adj}}
= Ye - (r + \delta_h + \tau)Ke + w(N_s - N_e) - S_e v + (1 + r)A_s + (1 + r + \tau)A_b
\]

\(^{20}\)Optimal choice variables are functions of the state (i.e., \(a' = a'(s, a, h, z)\)); for notational simplicity, I omit the parenthetical state list in this derivation.
Transforming (35) using market clearing conditions (described by (30) and (31), respectively) yields

\[
C + A_b' + A_s' + q (H' - (1 - \delta_h)H) + \delta_h q M_r + \psi q H_{adj} = Y_e - (r + \delta_h + \tau) K_e + w N_c - S_e v + A_s + A_b + \tau A_b + r (K_e + K_c)
\]

The CRS technology of corporate production implies that \( Y_c = (r + \tau + \delta_h) K_c + w N_c \); substituting this identity into the aggregated budget constraint yields

\[
C + A_b' + A_s' + q (H' - (1 - \delta_h)H) + \delta_h q M_r + \psi q H_{adj} = Y_e + Y_c + A_s + A_b + (\delta_h + \tau) (K_e + K_c) - S_e v + \tau A_b
\]

Rearranging yields the intuitive resource constraint given by (32).

**Appendix C: Computational approach**

**Tauchen Method implementation**

Consider a pareto \( \text{pareto}(x_m, \eta) \) process \( \epsilon(t) \). Let \( z \) be an AR(1) process with \( z(t) = \gamma z(t-1) + \epsilon(t) \).

Then discretize the \( z \) space into \( N_z \) equally spaced points, with \( z_1 = x_m \) and

\[
z_{N_z} = \frac{x_m}{0.001^\frac{1}{\eta}}
\]

This is the value of \( z \) for which the CDF is equal to 0.999 (this value is necessarily arbitrary, since the domain of the random variable is unbounded). Using Tauchen’s method, the
probability of transitioning from \( z_i \) to \( z_j \) is given by

\[
\pi_{i,j} = \left( \frac{x_m}{z_j - \frac{z_i - z_j - 1}{2} - \gamma z_i} \right)^\eta - \left( \frac{x_m}{z_j + \frac{z_j + 1 - z_i}{2} - \gamma z_i} \right)^\eta, \quad i \in \{1, \ldots, N_z\}, \ j \in \{2, \ldots, N_z - 1\}
\]

\[
\pi_{i,1} = 1 - \left( \frac{x_m}{z_1 + \frac{z_2 - z_1}{2} - \gamma z_i} \right)^\eta
\]

\[
\pi_{i,N_z} = \left( \frac{x_m}{z_{N_z} - \frac{z_{N_z - 2N_z - 1}}{2} - \gamma z_i} \right)^\eta
\]

For model tractability, reset transition probabilities to zero when \( \pi_{i,j} < 0.00025 \) and scale up all remaining positive probabilities accordingly. I set \( N_z = 50 \), with values for \( x_m \) and \( \eta \) given on Table 4.

**Computational algorithm: Steady states**

Solving for the model steady state (for a given parameter calibration) requires the following steps:

1. Make an initial guess for \( q \), the house price.

2. Make an initial guess for \( r \), the interest rate paid to savers.

3. Based on the corporate firm’s optimality condition given by (2), use \( w = (1-\xi)Z_c \left( \frac{r+\delta_k+\tau}{\xi Z_c} \right) \frac{\xi}{1+\xi} \) to obtain the wage. The optimality condition also provides the corporate capital/labor ratio implied by the interest rate guess: \( \frac{K_c}{N_c} = \left( \frac{Z_c^\xi}{r+\delta_k+\tau} \right) \frac{1}{1-\xi} \). Define this capital/labor ratio as \( X_{KN} \).

4. Given the price vector \( (r, w, q) \) and using value function iteration, solve for the entrepreneur value function \( v^{e=1}(s, a, h, z) \) and associated policy functions \( x_{e=1}(s, a, h, z) \) for \( x \in \{a', h', m, k, n\} \). Solve for the worker value function \( v^{e=0}(a, h, z) \) and associated policy functions \( x_{e=0}(a, h, z) \) for \( x \in \{a', h', m\} \). For all points on the (discretized)
state space, define \( v(s, a, h, z) = \max(v^{e=0}(a, h, z), v^{e=1}(s, a, h, z)) \), and define optimal policy functions as follows:

\[
x(s, a, h, z) = \begin{cases} 
ex^{e=1}(s, a, h, z) & \text{if } v^{e=1}(s, a, h, z) > v^{e=0}(a, h, z) \\
ex^{e=0}(a, h, z) & \text{if } v^{e=0}(a, h, z) \geq v^{e=1}(s, a, h, z)
\end{cases}
\]

5. Make an initial guess \( \mu_0 \) for the distribution of households, obtain \( \mu' = \Psi(\mu_0) \), then iterate until convergence (according to desired tolerance) to fixed point \( \mu^* \).

6. Clear the labor market by defining

\[
N_c = N_s - N_e
\]

Then compute \( K_c = X_K N_c \). Define

\[
K_c^* = A_s + A_b - K_e - qM_r
\]

7. If \( K_c = K_c^* \) (within chosen tolerance), then the financial market clears. If not, update the guess for \( r \) and return to step 3.

8. Compare aggregate housing demand \( M_r + H' \) to housing supply \( H_s \). If \( M_r + H' = H_s \) (within chosen tolerance), all markets clear and the stationary state equilibrium has been obtained. Otherwise, update the guess for \( q \) and return to step 2.

**Computational algorithm: Transition path**

The process for solving transition paths is as follows:

1. For a T-period transition path, define \( v_T(s, a, h, z) \) as the equilibrium value function found in step 3 of the steady state solution algorithm for the final steady state, and
define $\mu_0(s,a,h,z)$ as the equilibrium household distribution found in step 4 of the steady state algorithm for the initial steady state.

2. Define $\Theta$ to represent the parameter being used in the transition path experiment; that is, $\Theta \in \{\varepsilon, \phi, \tau\}$. Specify a path of the experiment parameter, $\{\Theta_t\}_{t=0}^T$, with $\Theta_0$ and $\Theta_T$ matching the parameter value used in the initial and final steady states, respectively.

3. Specify a guess for the path of interest rates, $\{r_t\}_{t=0}^T$, with $r_0$ and $r_T$ matching the equilibrium interest rates obtained from the initial and final steady states, respectively. Specify a guess for the path of house prices, $\{q_t\}_{t=0}^T$, with $q_0$ and $q_T$ matching the equilibrium house prices obtained from the initial and final steady states, respectively.

4. Define $v_t(s,a,h,z)$ as the value function at time $t$ in the transition path. Define $x_t(s,a,h,z)$ as a policy function associated with $v_t(s,a,h,z)$, with $x_t \in \{a', h', m, e, k, n\}$. Obtain the path of policy functions $\{x_t\}_{t=1}^{T-1}$ by solving value functions using backward iteration from $v_T(s,a,h,z)$, taking the path of interest rates as given and obtaining the path of wages using the corporate firm’s optimality conditions.

5. Using the obtained path of policy functions and the initial household distribution $\mu_0(s,a,h,z)$, iterate forward to obtain a path of distributions $\{\mu_t\}_{t=1}^{T-1}$. Using the distribution path, for each period check market clearing conditions for labor and capital by comparing implied corporate capital/labor ratios to the ratio consistent with the initial guess of $r_t$, and check housing market clearing by comparing aggregate housing demand with the exogenous housing supply.

6. If all markets clear in every period, an equilibrium transition path has been obtained. If not, make new guesses for $\{r_t\}_{t=0}^T$ and $\{q_t\}_{t=1}^{T-1}$ and return to step 4.\footnote{A new guess for the interest rate path can be conveniently obtained from the capital/labor ratios that would clear labor markets in each period. Unfortunately there is no technological condition that implies a good guess for house prices.}

7. Ensure that the final steady state is obtained before the end of the transition path;
that is, the household distribution should become stationary at some \( t < T \). If this condition fails, lengthen the transition path (increase \( T \)) and return to step 1.

Note that there are no mathematical properties of the model that provide a method for updating price path guesses which guarantees convergence to an equilibrium path. In practice, the method of guess updating matters a great deal, and there is not a single updating algorithm that works best in all applications. For the three transition path experiments I describe above, I used three different guess-updating methods. In one case, I began from the last period of the transition and worked backwards, clearing markets in each period before moving on to the previous period, then returning to late periods when markets move out of equilibrium. In another case, I did the opposite, starting from the first period and moving forward. In the final case, I used an algorithm that switched between the methods.