Understanding the Secular Decline in New Business Creation*

Shijun Gu
University of Minnesota

Lichen Zhang
University of Minnesota and FRB Minneapolis

Preliminary and incomplete

Abstract

The U.S. economy has experienced a significant decline in the formation of new businesses since the early 1980s. There is no consensus, however, regarding the main driving force behind it. Although both changes in entry costs and the persistence of shocks to productivity are potential candidates, neither of them can be directly observed from the data. Furthermore, their implications on aggregate productivity and welfare could differ widely. This paper develops a quantitative general equilibrium model of entrepreneurship to identify and quantify their relative importance in explaining the observed declines in new business creation. We find that the relative contribution of higher entry cost is 1.5 to 2 times larger than that of higher persistence of shocks. Moreover, the increases in entry cost have led entrepreneurs to pay 15% more in terms of their first year's profit to start a business.

JEL Classifications: D21, D25, E13, E20, E23

Keywords: Entrepreneurship, business dynamism, firm entry

*We are deeply indebted to our advisors Manuel Amador, Ellen McGrattan, and Tim Kehoe for their invaluable guidance and continuous support. Part of the thoughts and results of the paper is based on an early version (September 2017) of our paper. The views expressed herein are those of the authors and not necessarily those of the Federal Reserve Bank of Minneapolis or the Federal Reserve System. All errors are our own. Contact: Shijun Gu (email: guxxx385@umn.edu); Lichen Zhang (email: zhan1542@umn.edu)

1 Introduction

A growing body of research documents a significant drop in the formation of new businesses in the United States since the early 1980s. This decline in the creation of new businesses is at the center of the decline in the overall dynamism experienced by the U.S. economy in the last last three decades, because startups and young firms contribute to job creation, productivity, and economic growth (Decker et al. (2014)).

Recent papers have sparked heated debate regarding reasons for the secular decline in new business creation. A possible explanation is that the cost of starting a firm is increasing as a result, for example, of the growth of occupational licensing (Kleiner and Krueger (2013)) or weaker anti-trust enforcement, which would otherwise erect entry barriers (Gutierrez and Philippon (2018)). Another possible reason is that shocks to firms' productivity have become more serially correlated over time than before, in the sense that it is less likely that an unproductive firm will become a productive one. This stems, for example, from better intellectual property protection (Akcigit and Ates (2019b)), which makes it harder for less productive firms to use ideas from highly productive, successful firms. Consequently, potential startups may not choose to enter the market, since they believe it is less likely that they will succeed. These two forces cannot be observed directly from the data; this requires for a framework, assisted by a set of relevant moments, in order to infer them indirectly. Moreover, the implications of these two forces can be vastly different. If the decline in new business creation is mainly due to higher entry cost, it essentially reduces overall welfare and total factor productivity (TFP). If, on the other hand, it is the fact that shocks to firms' productivity become more persistent over time accounts for the largest part of the decline, overall welfare and TFP can be even higher than before. The intuition is that more persistent shocks to productivity help undo the misallocation of production factors in the presence of financial friction through entrepreneurs' stronger self-financing motives, as emphasized by Buera and Shin (2011) and Moll (2014).

The goal of this paper is to identify and quantify the relative contributions of higher entry cost and higher persistence of shocks to the observed declines in new business creation, relying on a set of moments regarding business dynamism. More specifically, the two key moments we use are the dispersion of employment growth rate and the relative size of entrants. Our intuition is that if the decline in firm entry is due to a higher entry cost, entrants should become larger relative to incumbents. Likewise, if the decline in firm entry is due to higher persistence of productivity shocks, we should observe a lower dispersion of the employment growth rate; this is because higher persistence means that large firms continue to be large and small firms continue to be small. In the data, dispersion of the employment growth rate at both firm level and establishment level has dropped dramatically over the last three decades (Decker et al. (2016)), while the relative size of entrants remains fairly stable and has even increased slightly since the early 2000s (Hopenhayn et al. (2019)). This suggests that the decline in firm entry is likely to be driven by the two forces jointly.

To further test and examine these insights, we first develop a quantitative general equilibrium model of entrepreneurship that features occupational choices. In the model, an individual must decide in each period whether to be a worker or an entrepreneur conditional on their assets, productivity in running a business (i.e., entrepreneurial productivity), and productivity in working for someone else. A new business is created if an individual who was previously a worker chooses to become an entrepreneur. If a worker becomes an entrepreneur, she must pay a fixed entry cost. Each agent's entrepreneurial productivity and working productivity are two independent Markov processes disciplined by the data.

The two forces that contribute to the decline in new business creation we focus on in this paper manifest as an increase in the fixed entry cost and an increase in the persistence of entrepreneurial productivity shocks respectively. While it is straightforward that a higher fixed entry cost causes fewer workers to choose to become entrepreneurs, it is not self-evident that the higher persistence of entrepreneurial productivity shocks also leads to less entry. The reason is as follows. Given the level of assets and working productivity, only agents with relatively high entrepreneurial productivity choose to become an entrepreneur, so potential entrepreneurs, i.e., workers, are those with low entrepreneurial productivity. With more persistent entrepreneurial productivity shocks, potential entrants know that once they become entrepreneurs, they are more likely to remain in a state of low productivity; therefore, they are reluctant to enter the market.

We calibrate the model to the U.S. business sector under the assumption that it was at the steady state in the early 1980s to match several key moments, especially the entry rate, the employment share of entrants, dispersion of the employment growth rate, and the relative size of entrants. Based on our baseline calibration, entrants must pay an entry cost equal to their first year's average profit. The entry cost is also equal to around 79% of the average entrepreneurial income and six times that of the average labor income.

We then use this calibrated model to quantitatively infer which force—higher persistence of productivity shocks or higher entry cost—plays a more important role in driving the observed declines in new business creation. To achieve this goal, we perform our quantitative analysis in two steps. First, we increase the persistence of entrepreneurial productivity shocks and the entry cost in the model to match the decline in the employment share of entrants,

[1] then check the movement of the other key moments (e.g., the dispersion of employment growth rate) we use to discipline model parameters. If one or more movements of the moments are not consistent with their empirical counterpart, we can at least say that the factor that drives the movement may not solely account for the decline in new business creation. Our finding is that after increasing the persistence of entrepreneurial productivity shocks while holding all other parameters fixed, dispersion of the employment growth rate declines (consistent with the data) and the relative size of entrants also declines (inconsistent with the data). If we increase the entry cost to match decline in the employment share of entrants while holding all other parameters fixed, dispersion of the employment growth rate increases (inconsistent with the data) and the relative size of entrants also increases (inconsistent with the data). This implies that the rising persistence of shocks or rising entry cost cannot account for all of the entire decline in the new business creation.

Second, we recalibrate the persistence of the entrepreneurial productivity process and the entry cost to match five moments during the 2010s simultaneously: the annual entry rate of entrepreneurs, the employment share of entrants, the entrepreneurial employment share, dispersion of the employment growth rate, and the relative size of entrants. While increasing the persistence of entrepreneurial productivity shocks and increasing the entry cost both contribute to the decline in entry rate as well as the employment share of startups, they yield opposite predictions regarding the other three moments. For example, higher persistence leads to a lower dispersion of the employment growth rate, but higher entry cost generates higher dispersion. Therefore, these five moments are balanced with each other, providing us with a new estimation on the persistence of shocks and entry cost in the 2010s.

We find that the persistence of productivity shocks and the entry cost both increase substantially. After decomposing the changes, we find that the relative contribution of higher entry cost is more than 1.5 times that of the higher persistence of idiosyncratic entrepreneurial productivity shocks to the decline in the entry rate of entrepreneurs, and around twice the decline in the employment share of startups. Moreover, the entry cost paid by start-ups in the 2010s becomes 1.15 times the average profit of entrants, 96.3% of the average entrepreneurial income, and 8.8 times the average labor income. This means that increases in the entry cost cause entrepreneurs to pay 15% more in terms of their first year's profit, 22% more in terms of the average entrepreneurial income, and 33% more in terms of the average labor income to start a business.

[1] Alternatively, we can increase the persistence of entrepreneurial productivity shocks and the entry cost in the model to match the decline in entry rate of entrepreneurs, which makes no difference. We choose to match the decline in the employment share of entrants due to technical reasons, which will be explained in Section 5.

In terms of welfare and TFP, our quantitative results show that the increased entry cost and persistence of shocks calibrated to the 2010s jointly lead to a 2.8% decline in entrepreneurial TFP and a 2.0% decline in consumption-equivalent welfare. Moreover, higher entry cost alone reduces both entrepreneurial TFP and consumption-equivalent welfare, while higher persistence of productivity shocks alone generates a higher level of entrepreneurial TFP and consumption-equivalent welfare. These results are consistent with those of Buera and Shin (2011) and Moll (2014), who consider a model similar to ours (their model also features heterogeneous entrepreneurs and an imperfect capital rental market). That is, sufficiently persistent shocks imply that steady-state productivity losses and the welfare cost of market incompleteness are relatively small.

Our results do not mean—and are far from implying—that the increased entry barriers and higher persistence of idiosyncratic productivity shocks are the only two possible drivers of the observed decline in the creation of new businesses. However, our analysis, however, sheds light on the relative importance of the two factors in contributing to the declining firm entry and employment share of entrants. Identifying their relative importance is important, since although both higher entry cost and higher persistence of shocks lead to observed declines in new business creation, they have divergent impacts on TFP and welfare. Because our work suggests a more important role played by higher entry cost—which reduces TFP and welfare—this should be a concern for policy makers.

Finally, we study the implications of higher entry cost and higher persistence of shocks on how firms respond to a negative credit shock that mimics a financial crisis in transitional dynamics, based on our calibration results. Suppose there is a credit shock that suddenly tightens the collateral constraints of entrepreneurs and then recovers to the pre-crisis state. Our key finding is that given the path of credit shocks, the set of parameters with higher entry cost and higher persistence of shocks that are calibrated to the data from the 2010s generates a slower transition of the stock of entrepreneurs to the pre-crisis level. This result provides insights on the slow recovery from the Great Recession compared with the previous recessions. It is well-known that both the Great Recession and the 1980-1982 recession (or "Double Dip Recession") were accompanied by large drops in the number of firms, but the recovery in the number of firms has been much more sluggish since the Great Recession. The insights based on our results are that the entry barrier in the late 2000s is much larger than that in the early 1980s, which makes it harder for an entrepreneur who previously exited the market due to a credit crunch to re-enter the market.

Related Literature. This paper is related to a growing literature on the causes and consequences of the secular decline in firm creation and entrepreneurship observed in the United States since the early 1980s. Several papers have documented a decrease in the share of economic activity accounted for by small and new businesses in the United States (see, for example, Haltiwanger et al. (2012); Decker et al. (2014); and Pugsley and Sahin (2019), among others).

There is not a definitive explanation for the decline in new business creation, but the literature has proposed several potential candidates. For example, Hopenhayn et al. (2019) argue that the decline in the growth rate of the labor force participation observed in the data is at the heart of the decline in the formation of new businesses. Engbom (2019) examines how the aging of the U.S. population reduces individuals' incentives to start new firms. Salgado (2018) shows that skill-biased technical changes and the decrease in the cost of capital goods can account for a significant fraction of the decline in entrepreneurship. Akcigit and Ates (2019a) quantitatively investigate which force plays a dominant role in a group of candidates (i.e., lower effective corporate tax, higher R&D subsidy, higher entry cost, and lower knowledge diffusion from frontier firms and lagged ones) in explaining the decline in firm entry and the slowdown in the overall dynamism (e.g. increased concentration) of the U.S. economy. They conclude that the decline in knowledge diffusion is the most important driver, which may explain the higher persistence of productivity shocks we emphasized in our paper.

Our work is complementary to two papers, by Buera and Shin (2011) and Moll (2014), that feature models (i.e., a Bewley-Aiyagari-styled heterogeneous agent model with production and an imperfect capital rental market) quite similar to the one we study; they also focus on the persistence of idiosyncratic productivity shocks. Buera and Shin (2011) show that the overall welfare cost of market incompleteness can be increasing, decreasing, or even nonmonotone in shock persistence, depending on the relative strengths of its two components: the cost of a lack of insurance and the cost of imperfect capital markets. The reason is that more persistent shocks are harder to self-insure but simultaneously lead to better allocation of production factors through entrepreneurs' self-financing. Based on similar logic, Moll (2014) argues that the persistence of idiosyncratic productivity shocks determines the size of steady-state productivity losses and shows that more persistent shocks lead to smaller steady-state losses but slower transitions. In our paper, we show that higher persistence of shocks hinders new business creation in the steady state, and leads to a quicker transition of firm entry and the employment share of entrants.

Finally, we join the literature that examines the reasons for lack of firm entry and the slow recovery of the number of firms after the Great Recession. Clementi et al. (2014); Khan and Thomas (2013); and Siemer (2014) develop a quantitative heterogeneous firm model that features borrowing constraints and showing that lack of entry is a consequence of credit crunches, since credit tightening directly affects small and young firms the most. The results of our work indicate that the slow recovery of the number of firms after the Great Recession may be due to a higher entry cost compared with the level in the early 1980s.

The paper is organized as follows. Section 2 briefly discusses the data we use in this paper. Section 3 describes the model set-up and defines a recursive competitive equilibrium. Section 4 discusses the calibration. In Section 5, we report the main results of this paper. Section 6 discusses the implications of the main results reported in Section 5 on firms' response to a credit shock that mimics a financial crisis. Section 7 concludes the paper.

2 Data

As emphasized in Decker et al. (2014), measuring entrepreneurship and its economic effects is difficult. There are two major strands of literature to follow. The first strand of literature (e.g. Decker et al. (2014), Haltiwanger et al. (2012)) uses firm-level data or establishment data to measure it and define entrepreneurs as a particular type of firms based on their age and size (in terms of number of employees). Since available government datasets on the U.S. firms do not have a specific entry for "entrepreneurs." but have traditionally contained information about the size and age of firms, some observers have written or spoken as if small and young businesses are synonymous with entrepreneurs. We also notice that there are several recent papers defining entrepreneurship based on the legal form of the business organizations (e.g. Bhandari and McGrattan (2019), Dyrda and Pugsley (2019)). For example, Dyrda and Pugsley (2019) defines entrepreneurial income as the income from pass-through entities (i.e. sole proprietorships, partnerships, and S corporate firms). The second strand of literature (e.g. Quadrini (2000), Cagetti and DeNardi (2006)) uses household-level data such as PSID and SCF and define entrepreneurs as a type of households based on whether they own a business or are self-employed. [2]

[2]Even among papers which use household-level data to define entrepreneurs, there is little consensus about which households or individuals should be classified as such. For example, Evans and Leighton (1989) considers as entrepreneurs those that are self-employed, Hurst and Lusardi (2004) all those households that own a business, whereas Gentry and Hubbard (2004) defines as entrepreneurs all those business owners with businesses with a total market value of $5,000 or more. Quadrini (2000) considers both, business owners and self-employed as entrepreneurs. Cagetti and DeNardi (2006) define entrepreneurs as those self-employed business owners that have an active management in the firm. Salgado (2018) thus refer to four classifications of entrepreneurs that encompass the different alternatives considered in the literature.

In this paper, we follow the first strand of literature on measuring entrepreneurship. We define entrepreneurs as establishments with less than 20 employees using data from the Business Dynamic Statistics (BDS). Our reasoning is as follows. Establishments with less than 20 employees are relatively small businesses. The reason for choosing 20 employees as a cutoff is that based on Dyrda and Pugsley (2019), the average size of establishment with legal form of sole proprietorship and partnership is around 6 employees, and by choosing 20 employees as a cutoff for defining entrepreneurship, we get the average size of entrepreneurs closer to 6.

The following are the definitions of the moments that we are going to use in this paper. We compute the annual entry rate of entrepreneurs as the number of establishment with age 0 and size smaller than 20 employees divided by the number of establishments with size smaller than 20 employees. We compute the employment share of startups as the total employment of establishments with age 0 and size smaller than 20 employees divided by the total employment of all the employer establishments in BDS for a specific year. We compute the entrepreneurial employment share as the total employment of establishments with size smaller than 20 employees divided by the total employment of all the employer establishments in BDS for a specific year. The average size of entrant entrepreneurs relative to the incumbent entrepreneurs is computed as the average size of establishments with age 0 and size smaller than 20 employees divided by the average size of establishments with size smaller than 20 employees for a specific year. Finally, the dispersion of employment growth rate is computed as the standard deviation of the employment growth rate for all the continuing firms (i.e. $(l_{i,t} - l_{i,t-1})/[0.5 \times (l_{i,t} + l_{i,t-1})]$ where lit denotes the employment of firm i in year t). Since we do not have firm-level or establishment-level census data, we draw this moment from Decker et al. (2016) that uses Longitudinal Business Dynamics (LBD) data to compute the standard deviation of employment growth rate for all the employer establishments for the years 1980-2014. [3]

3 Model

We consider a model of entrepreneurship based on Buera et al. (2011) and Buera and Shin (2013) but augmented with an entry cost and a corporate production sector as in Quadrini (2000).

[3] We admit that there is discrepancy between this moment and the other moments used in this paper. The ideal moment should be the standard deviation of employment growth rate for all the continuing employer establishments with size smaller than 20 employees. However, since we do not have LBD data at hand, this is the best moment on dispersion of employment growth rate that we can use for now.

We model an economy populated by a continuum of individuals, who are heterogenous with respect to their wealth (or assets), previous occupational status (so that new entrepreneurs are different from incumbents), entrepreneurial productivity, and working productivity. In each period, an individual chooses whether to work for a wage or to operate an individual-specific technology (entrepreneurship). One entrepreneur can operate only one production unit (establishment) in a given period. Entrepreneurial ideas are inalienable, and there is no market for managers or entrepreneurial talent to be traded. If a previously worker becomes an entrepreneur, she needs to pay a fixed entry cost.

Output is produced by both entrepreneurs and a representative corporate firm. A zero-profit financial intermediary borrows from households with positive savings to supply productive capital for entrepreneurs and the corporate sector.

3.1 Environment

Heterogeneity and Demographics. Consider an economy with a continuum of individuals of measure one. Individuals live infinitely and are heterogenous in their asset a_t, previous occupational status d_{t-1}, worker ability ϵ_t, and entrepreneurial productivity z_t. Both the worker ability and the entrepreneurial productivity follows a Markov process, and the two processes are independent to each other. There is no population growth and no aggregate uncertainty either.

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

$$U(C) = \mathbb{E}_0 \left[\sum_{t=0}^{\infty} \beta^t u(c_t) \right] \tag{1}$$

where β is the discount factor, which is smaller than one. The expectation is taken over the realizations of the worker ability ϵ_t and the entrepreneurial productivity z_t. We choose a period utility function that has a constant relative risk aversion. That is, $u(c_t) = \frac{c_t^{1-\sigma}-1}{1-\sigma}$.

Occupational Choice and Production Technology. At the beginning of each period, after the realization of shocks, an individual chooses whether to operate his own business or work for a wage (labor is indivisible). If the individual decides to be a worker, she receives an income of $w_t\epsilon_t$ where ϵ_t is an idiosyncratic, positively autocorrelated shock, and w_t is the market wage rate in period t. A worker cannot borrow but can save in a risk-free asset, at, with return r_t. If the individual chooses to be an entrepreneur, she gains access to a productive technology that uses her own entrepreneurial ability z_t, capital k_t, and labor l_t, based on a decreasing-return-to-scale technology:

$$z_t f(k_t, l_t) = z_t (k_t^{\alpha} l_t^{1-\alpha})^{\gamma} \tag{2}$$

where $\gamma < 1$ is the span-of-control parameter. A share γ of output goes to factor of inputs. Out of this, a fraction of α is going to capital and $1 - \alpha$ going to labor.

In reality, a large fraction of firms are not managed by households weighing the cost and benefit of running their own business or working in someone else's company. Therefore, as in Quadrini (2000) and Cagetti and DeNardi (2006), we model a second sector of production populated by a large number of homogeneous firms which we refer to as the non-entrepreneurial, or corporate sector. Firms in this sector are operating a constant returns to scale production technology given by

$$AF(K_{C,t}, L_{C,t}) = AK_{C,t}^{\theta} L_{C,t}^{1-\theta} \tag{3}$$

where A is the time-invariant corporate productivity, which will be normalized to 1, while $K_{C,t}$, $L_{C,t}$ are corporate capital and labor demand respectively. Corporate production does not involve fixed costs. Both sectors produce the same good, and in both sectors capital depreciates at the same rate.

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

3.2 Stationary Equilibrium

Recursive Problem of Individuals. At the beginning of the period, each individual is characterized by her asset a, working productivity ϵ, and entrepreneurial productivity z, previous occupational status d_-, where $d_- = 0$ identifies a worker and $d_- = 1$ an entrepreneur. Then, an individual solves the occupation choice problem given by

$$v(a, \epsilon, z, d_-) = \max_{d \in \{0,1\}} \left\{ (1-d) v^W(a, \epsilon, z, d_-) + d v^E(a, \epsilon, z, d_-) \right\}, \tag{4}$$

where v^W is the value of being a worker, v^E is the value of being an entrepreneur, and d denotes an individual's current-period occupation.

The problem solved by current-period workers is given by

$$v^W(a,\epsilon,z,d_-) = \max_{c,a'\geq 0}\left\{u(c) + \beta\sum_{\epsilon',z'} P(\epsilon',z'|\epsilon,z)v(a',\epsilon',z',d=0)\right\}, \tag{5}$$

subject to

$$c + a' = (1+r)a + w\epsilon,$$

and also to the laws of motion of ϵ and z, and the law of motion of the distribution of individuals over idiosyncratic states. Additionally, $P(\cdot|\cdot)$ is transition probabilities, v is continuation value, and $d = 0$ indicates that the individual will enter next period as a worker before choosing a new occupation.

The problem solved by current-period entrepreneurs is given by

$$v^E(a,\epsilon,z,d_-) = \max_{c,a'\geq 0}\left\{u(c) + \beta\sum_{\epsilon',z'} P(\epsilon',z'|\epsilon,z)v(a',\epsilon',z',d=1)\right\}, \tag{6}$$

subject to

$$c + a' + \mathbb{I}(d_- = 0)\kappa = (1+r)a + \pi(a,z),$$

and also to the laws of motion of ϵ and z, and the law of motion of the distribution of individuals over idiosyncratic states. Additionally, $P(\cdot|\cdot)$ is transition probabilities, and v is continuation value, and $d = 1$ indicates that the individual will enter next period as an entrepreneur before choosing a new occupation. The profit function is given by

$$\pi(a,z) = \max_{0\leq k\leq \lambda a, l\geq 0}\left\{zf(k,l) - wl - (r+\delta)k\right\}.$$

Here, $\mathbb{I}(d_- = 0)$ is an indicator function which is equal to 1 if the individual was a worker in the previous period, i.e. $d_- = 0$, and is equal to zero otherwise. This function captures the assumption that the fixed cost of creating a firm is paid only by those individuals transitioning from a worker to an entrepreneur.

Note that we focus on within-period borrowing, or capital rental for production purposes. We do not allow borrowing for inter-temporal consumption smoothing, which translates into $a' \geq 0$. Several papers have documented the importance of borrowing constraints to the decision to become an entrepreneur.[4]. Here, we assume that entrepreneurs' capital rental k is limited by a multiple of the collateral, i.e. $k \leq \lambda a$.[5]

Problem of Corporate Sector. The problem of the corporate (non-entrepreneurial) sector is simple and is given by

$$\pi_C = \max_{K_C, L_C \geq 0} \left\{ AF(K_C, L_c) - wL_C - (r + \delta)K_C \right\}. \tag{7}$$

Definition of Equilibrium. A stationary recursive competitive equilibrium is value functions v, v^E , and v^W; individual's policy functions c, a', and d; entrepreneur's factor demand k and l; corporate sector's factor demand K_C and L_C; prices r and w; and a distribution (μ) over individual wealth (a), working ability (ϵ), entrepreneurial ability (z), previous occupation status (d_-) such that

1. given prices, the policy functions—namely, c, a', d, k, l—solve dynamic programming problems associated with value functions v, v^E, v^W;

2. given prices, corporate sector's factor demand—namely, K_c and L_c—solve corporate firm's optimization problem;

3. the asset market clears

$$\int a'(a, \epsilon, z, d_-) d\mu = K_C + \int_{d(a,\epsilon,z,d_-)=1} k(a, \epsilon, z, d_-) d\mu; \tag{8}$$

4. the labor market clears

$$\int_{d(a,\epsilon,z,d_-)=0} \epsilon d\mu = L_C + \int_{d(a,\epsilon,z,d_-)=1} l(a, \epsilon, z, d_-) d\mu; \tag{9}$$

5. the distribution of individuals over states (a, ϵ, z, d_-) are invariant, i.e.,

$$\mu(a, \epsilon, z, d_-) = \Psi(\mu(a, \epsilon, z, d_-)), \tag{10}$$

[4] See, for instance, Evans and Jovanovic (1989), Quadrini (2000), Hurst and Lusardi (2004), or Cagetti and DeNardi (2006).

[5] Alternatively, we can have entrepreneurs own capital k and face a constraint on borrowing leverage, i.e. $b' \leq \frac{\lambda - 1}{\lambda} k'$. Defining $b = k - a$, with the understanding that $b < 0$ denotes savings, and assuming that λ capital and debt (k, b) are chosen after the realizations of idiosyncratic shocks (ϵ, z) give us an equivalent problem to the one specified in our paper. This assumption that producer profits are a function solely of its net worth or wealth at, not of capital k and debt b in isolation, helps to reduce the dimension of the problem and simplifies the computation, which is widely used in the literature (e.g. Gavazza et al. (2018); Midrigan and Xu (2014)).

where Ψ depends on optimal policy of a' and d as well as the law of motion of ϵ and z.

4 Calibration

We numerically solve the model by using non-linear methods, and find a stationary equilibrium where individual decisions are consistent with market clearing prices.[6] We begin with the subset of parameters calibrated externally, and then consider those estimated within the model. Calibrated parameters are chosen such that the model resembles the U.S. economy around early 1980s when the U.S. business dynamism starts to decline. Thus, data moments are averages over 1980-1985 unless otherwise specified.

4.1 Externally Calibrated Parameters

To maintain the tractability of the calibration, we take some parameters directly from the literature. The time period in this model is equal to a year. We take a standard value of 1.5 for the coefficient of risk aversion of the households' utility function and the span of control parameter of 0.79 following Buera et al. (2011). The capital share parameter of corporate firms' production function is set to be 0.35 matching the labor income share of corporate sector in early 1980s. For simplicity, we make the value of the capital share parameter of entrepreneurs equal to that of the corporate sector. Taking the scale of production γ into consideration leads to a capital share $\alpha\gamma = 0.28$, which is close to the value used in the literature (e.g. Buera et al. (2011), Cagetti and DeNardi (2006)). The capital depreciation rate is set to be 6% based on the BEA fixed asset tables taking both physical capital and BEA-measured intangible capital (or IPP capital) into consideration.

The working productivity ϵ is assumed to follow an autoregressive process with normal innovations, $log\epsilon' = \rho_\epsilon log\epsilon + e_\epsilon$ with $e_\epsilon \sim N(0, \sigma_\epsilon)$. Since the main focus of this paper is on the producers' side, we take the parameters that govern the process of working productivity, i.e. $(\rho_\epsilon, \sigma_\epsilon)$ from Bhandari and McGrattan (2019), which is also consistent with the estimated wage processes of Low et al. (2010) for U.S. households in U.S. Census and the Survey of Income and Program Participation (SIPP). Table 1 summarizes these parameter values.

[6] See Appendix for computation details.

Parameter		Value	Source/Target
Curvature of utility function	σ	1.50	BKS 2011
Entrepreneur capital share	α	0.35	-
Entrepreneur scale of production	γ	0.79	BKS 2011
Corporate capital share	θ	0.35	Corp. labor income share
Persistence of ϵ shocks	ρ_ϵ	0.70	Bhandari and McGrattan 2019
SD of ϵ shocks	σ_ϵ	0.16	Bhandari and McGrattan 2019
Capital depreciation rate	δ	0.06	BEA fixed asset tables

Table 1: Parameter values set externally

4.2 Internally Calibrated Parameters

The entrepreneurial productivity z is assumed to follow a discretized version of an autoregressive process with normal innovations, $logz' = \rho_z logz + e_z$ with $e_z \sim N(0, \sigma_z)$. In particular, we approximate this autoregressive process with a 9-state Markov chain following the procedure of Rouwenhorst (1995).[7] We have six parameters $(\beta, A, \rho_z, \sigma_z, \kappa, \lambda)$ left to be calibrated within the model. Table 2 lists the results. Even though every targeted moment is determined simultaneously by all parameters, in what follows we discuss each of them in relation to the parameter for which, intuitively, that moment yields the most identification power.

Discount factor β is chosen such that the annual real interest rate is 4%. The productivity of the representative corporate firm A is calibrated to match the aggregate employment of all the entrepreneurs as a share of total employment (i.e. the sum of employment of both corporate sector and entrepreneurial sector).[8] We calibrate the collateral parameter λ to match the aggregate debt-to-value-added ratio for the non-corporate sector in the data.[9]

The rest three parameters $(\rho_z, \sigma_z, \kappa)$ are calibrated jointly to match three important moments that regards the dynamism of the U.S. economy in the early 1980s. The first one is the annual entry rate of entrepreneurs. In the model, the moment in period t is calculated as the number of entrants (i.e. entrepreneurs in period t who are workers in period $t-1$) as a share of total number of entrepreneurs in period t. Increasing the persistence of entrepreneurial productivity process ρ_z and increasing the fixed entry cost κ respectively both leads to a reduction in the entry rate of entrepreneurs. While it is straightforward

[7]We choose the Rouwenhorst's method over the Tauchen's method (see Tauchen (1986)) since Rouwenhorst method has better performance in the case of highly persistent shocks.

[8]We calibrate A to match the entrepreneurial employment share since we assume the mean of log of entrepreneurial productivity shocks z is zero. Alternatively, we can normalize A to one and calibrate the mean of log z to target the entrepreneurial employment share, which makes no difference.

[9]The data on debt is liability level of loans for non-financial noncorporate business sector, obtained from Z.1 Financial Accounts of the U.S. of the Board of Governors of the Federal Reserve System, retrieved from FRED, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/series/NNBLL.

that a higher κ renders less workers choose to become entrepreneurs, it is not self-evident that a higher ρ_z also leads to less entry. The reason is as follows. Given the level of assets and working productivity, only agents with relatively high entrepreneurial productivity choose to become an entrepreneur, so potential entrepreneurs, i.e. workers, are those with low entrepreneurial productivity. With more persistent entrepreneurial productivity shocks, potential entrants know that once they become entrepreneurs they are more likely to remain low productivity, so they choose not to enter the market. [10]

The second moment is the standard deviation of employment growth rate for continuing establishments (excluding entrants and exiters). We draw this moment from Decker et al. (2016). Decker et al. (2016) uses LBD data and calculates an establishment i's employment growth rate in year t as $(l_{i,t} - l_{i,t-1}) / [0.5 \times (l_{i,t} + l_{i,t-1})]$. In the model, we are consistent with this definition to compute the moment of the standard deviation of employment growth rate for all the entrepreneurs. The third moment is the average size of entrants relative to the average size of all the entrepreneurs in the economy. Note that although we are not directly targeting the employment share of entrants, which is another important moment regarding business dynamism and features a secular decline in recent decades, since we are matching the entry rate, the employment share of entrepreneurs, and the relative size of entrants, then the employment share of entrants are automatically matched.[11] The employment share of entrants in the model is equal to 0.021 which is very closer to its empirical counterpart 0.022.

Increasing ρ_z while fixing the unconditional distribution of the idiosyncratic productivity shocks reduces the standard deviation of employment growth rate as well as the relative size of entrants. Increasing κ raises both the relative size of entrants and also the standard deviation of employment growth rate. Thus, although an increase in the persistence of

[10]Due the general equilibrium (GE) effect, an increase in ρ_z leads to a higher equilibrium wage (since with more persistent shocks, entrepreneurs have stronger motivation to do self-financing to get rid of the collateral constraint so that they can choose capital and labor optimally, which increases labor demand), and a higher wage means being a worker becomes more attractive, so one may wonder whether it is mainly due to the GE effect or the reason specified above. Based on our computation, we find that the reason specified above is the dominant one. The GE effect only slightly strengthen the results on the decline. Suppose we increase ρ_z from 0.915 to 0.940. With GE, the entry rate declines from 12.5% to 10.76%, while without GE, i.e. fixing the wage, the entry rate declines from 12.5% to 10.89%.

[11]More specifically, the equation {entry rate} $\times$ {startups relative size} = {employment share of startups} $\times$ {employment share of entrepreneurs} always holds. The reasons are as follows. The $LHS \equiv \frac{N_s}{N_e} \times \frac{l_s}{l_e} = \frac{L_s}{L_e} = \frac{L_s}{L} / \frac{L_e}{L} \equiv RHS$ where N_s denotes the number of startups, N_e denotes the number of entrepreneurs (so $\frac{N_s}{N_e}$ means the entry rate of entrepreneurs), l_s denotes the average size of startups, l_e denotes the average size of entrepreneurs (so $\frac{l_s}{l_e}$ means the relative size of entrants), L_s denotes the employment of startups, and L_s denotes the employment of entrepreneurs (so $\frac{L_s}{L}$ and $\frac{L_e}{L}$ mean the employment share of startups and the employment share of entrepreneurs respectively). This equation thus implies that if any three of the four moments are matched to the data perfectly, the rest one will be automatically matched.

Parameter		Value	Moment	Data	Model
Discount factor	β	0.943	Annual risk-free rate	0.040	0.040
Corporate productivity	A	1.326	Entrep. employment share	0.272	0.272
Persistence of z shocks	ρ_z	0.915	Annual entry rate	0.125	0.125
SD of z shocks	σ_z	0.236	SD of employment growth	0.634	0.633
Entry cost	κ	12.17	Relative size of entrants	0.630	0.630
Collateral parameter	λ	5.431	Debt to value added (entrep.)	1.355	1.357

Table 2: Parameter values calibrated internally

entrepreneurial productivity process ρ_z and the entry cost κ both contribute to a decline in entry rate, the other two moments, i.e. the dispersion of employment growth rate and the relative size of startups, can help us identify the parameters governing the productivity process and the entry cost parameter separately. Based on our baseline calibration, we obtain a ρ_z of 0.915. [12] Moreover, we find that the entry cost in early 1980s faced by firms equals the average income of entrants, 78.9% of the average entrepreneurial income, and six times of the average labor income.

5 Main Results

This section consists of three parts. In Subsection 5.1, we show that higher entry cost and more persistent productivity shocks cannot solely account for the decline in new business creation. In Subsection 5.2, we use the calibrated model from Section 4 to measure changes in entry cost and the persistence of shocks from the 1980s to 2010s. We then identify and quantify how changes in entry cost and the persistence of idiosyncratic productivity shocks contribute to the observed declines. Moreover, we check the implications of changes in these two factors on the aggregate productivity and welfare in Subsection 5.3 in terms of the creation of new businesses. In Subsection 5.4, we analyze the robustness of our main results.

5.1 Understanding the Factors in Isolation

We first change the entry cost κ and the persistence of productivity shocks ρ_z (while fixing the unconditional distribution of shocks—i.e., fixing $\sigma_z/\sqrt{1-\rho_z^2}$ by adjusting the standard

[12] Although the persistence of idiosyncratic productivity shocks is considered an important parameter, there is no consensus on the estimated value of it. The calibrated value obtained in this paper is not far away from the existing literature that uses establishment-level or firm-level data to estimate ρ_z. For example, Cooper and Haltiwanger (2006) estimate it to be 0.981. Lee and Mukoyama (2015) estimate it be 0.843 or 0.956 depending on the specification used for estimation.

	Data (1)		$\rho_z = 0.976$ (2)		$\kappa = 26.1$ (3)	
	Start	End	Start	End	Start	End
Entry rate	0.125	0.077	0.125	0.063	0.125	0.091
Empl. share of startups	0.022	**0.013**	0.022	**0.013**	0.022	**0.013**
Entrep. empl. share	0.272	0.250	0.272	0.532	0.272	0.159
SD of empl. growth rate	0.634	0.535	0.634	0.330	0.634	0.666
Relative size of entrants	0.630	0.635	0.630	0.386	0.630	0.905

Table 3: Qualitative experiment results

deviation σ_z, as in Buera and Buera and Shin (2011) and Moll (2014)) to match the decreased employment share of startups in the data for the 2010s respectively.[13] We increase ρ_z from the baseline value 0.915 to 0.976 and κ from 12.17 to 26.10 in order to match the overall decline in the employment share of startups. Table 3 summarizes the key results. It shows the observed change in each variable and compares them with their model counterparts in each experiment.

A few observations stand out. First, despite the fact that an increase in the persistence of shocks leads to a lower entry rate of entrepreneurs and a lower standard deviation of the employment growth rate, both of which are consistent with the data qualitatively, changes in the entrepreneurial employment share and the relative size of entrants are not consistent with the data. Second, the directions of change in the entry rate and entrepreneurial employment share resulting from higher entry cost κ are consistent with the data. However, the higher entry cost generates an increase in the dispersion of the employment growth rate, which decreases in the data, and an increase in the relative size of entrants which is relatively stable in the data.

5.2 Identification and Decomposition

The results from the previous section imply that higher entry cost κ and higher persistence of shocks ρ_z should jointly account for the decline in new business creation (in terms of both the entry rate and employment share of entrants). Since we can observe neither κ nor ρ_z

[13] Alternatively, we can increase κ and ρ_z to match the decreased entry rate of entrepreneurs respectively, but in that case, we find that we are not able to the increase in entry cost (column 3) to match the entire decline in firm entry. Even though we increase κ to a very large number, e.g. ten times of the value of κ in the initial steady state, the entry rate is stable around 0.082. In that case, only financially unconstrained agents with highest entrepreneurial productivity choose to become or keep being an entrepreneur. However, if we keep increasing κ, the entry rate will jump to zero from 0.082. We thus increase κ to match the decline in the employment share of startups in the data, making it comparable for the case of increased persistence of shocks.

	Model (1980s)	Model (2010s)	Data (2010s)
Parameter			
ρ_z	0.915	0.940	–
κ	12.17	17.79	–
Moment			
(1) Entry rate	0.125	0.079	0.077
(2) Entrants empl. share	0.021	0.012	0.013
(3) Entrants relative size	0.630	0.610	0.630
(4) SD empl. growth rate	0.634	0.592	0.535
(5) Entrep. empl. share	0.272	0.250	0.250

Table 4: Entry Cost and Persistence of Shocks

directly from the data, we can only infer the changes in the two factors from the relevant moments that may be the consequences of them. The moments we use for calibration give us some clue to separately identify and quantify how changes in these two factors contribute to the observed declines in the creation of new businesses. We thus conduct the following numerical exercise. We jointly recalibrate the persistence of idiosyncratic entrepreneurial productivity shocks ρ_z while fixing the unconditional distribution of shocks and fixed entry cost κ to match a set of moments in the data for the 2010s, including the (1) entry rate of entrepreneurs, (2) employment share of entrants, (3) relative size of entrants, (4) dispersion of the employment growth rate, and (5) entrepreneurial employment share. That is, we estimate two parameters to target five moments to exploit the power of "over-identification."

Next, we discuss how we choose these moments strategically. The first two moments—i.e., entry rate and entrants' employment share—are main indicators of the creation of new businesses. Given the goal of this paper, we must include these two moments into the set for re-calibration. However, since higher persistence of shocks ρ_z and higher entry cost κ both lead to a lower employment share of entrants and a lower entry rate, these two moments provide no information on the relative contribution of higher κ and higher ρ_z to the decline in new business creation. Therefore, we add (3) relative size of entrants and (4) dispersion of the employment growth rate, which are informative moments in identifying κ and ρ_z in the baseline. To further discipline the change of κ and ρ_z, we add (5) entrepreneurial employment share, because higher ρ_z and higher κ have opposite impacts on this moment.[14] More specifically, a higher ρ_z leads to a higher entrepreneurial employment share, since it favors large, highly productive entrepreneurs—but higher κ leads to a lower entrepreneurial

[14]Note that in the baseline calibration, we discipline the corporate productivity parameter A to match the entrepreneurial employment share, but in the case of re-calibration, we fix A at the baseline level.

Entry cost to	Model (1980s)	Model (2010s)	Change
Entrants avg. profit	1.00	1.15	15%
Avg. entrep. profit	0.79	0.96	22%
Avg. labor income	6.00	8.80	47%

Table 5: Entry Cost in Real Terms

employment share, since it makes it harder for potential entrants to become entrepreneurs. After jointly recalibrating ρ_z and σ_z to match the chosen moments, we get $\rho_z = 0.940$ and $\kappa = 17.79$. The results are summarized in Table 4.

With the newly estimated persistence of shocks ρ_z and fixed entry cost κ, we find that the entry cost now becomes around 1.15 times the average income of entrants, 96.3% of the average entrepreneurial income, and around 8.8 times the average labor income. In contrast, for ρ_z and κ calibrated to the economy in the early 1980s, the entry cost is only 1 times the average income of entrants, 78.9% of the entrepreneurial income and 6 times the average labor income. We summarize the results in Table 5. This means that the entry cost not only increases in nominal value, but also causes potential entrants in the 2010s pay more, in real terms, to start a business than in the 1980s.

We then use the recalibrated parameters $\rho_z = 0.940$ and $\kappa = 17.79$ to perform the following decomposition in order to ascertain which force plays a relatively more important role in generating the decline in new business creation in terms of entry rate and the employment share of startups. We first fix the entry cost $\kappa = 12.17$, which is the calibration value in the initial steady state that captures the economy in the early 1980s. We then let the parameter for the persistence of shocks ρ_z equal 0.940, which is the newly calibrated value and captures the economy in the 2010s. This gives us results that can be used to compute the relative contribution of higher ρ_z to the decline in new business creation. Likewise, we follow the same procedure to compute the relative contribution of higher κ. More specifically, denoting a variable of interest by X, its value at time t when both channels move by X_t^2, and its hypothetical value when channel i is shut down by X_t^{2-i}, we can express the contribution of the channel i to the total deviation over the three decades as follows:

$$contribution_i = \frac{X_{2010s}^2 - X_{2010s}^{2-i}}{X_{2010s}^2 - X_{1980s}^2}$$

We summarize the paper's main results in Table 6. We find that the relative contribution of higher κ is more than 1.5 times that of higher ρ_z to the decline in the entry rate of entrepreneurs, and around twice the decline of the employment share of startups.

	Higher κ		Higher ρ		Both
Entry rate	$-2.85p.p$	(62.6%)	$-1.72p.p$	(38.0%)	$-4.60p.p$
Entrants empl. share	$-0.57p.p$	(70.2%)	$-0.28p.p$	(39.4%)	$-0.94p.p$

Note: Percentage values in parentheses measure the share of the contribution from the specific channel to the total model-generated deviation between 1980s and 2010s.

Table 6: Relative Contributions

5.3 TFP and Welfare

In this section, we examine the changes in entrepreneurial total factor productivity (TFP) and consumption-equivalent welfare induced by higher entry cost and more persistent entrepreneurial productivity shocks[15] and summarize the results in Table 7. Overall, compared with our baseline estimation, the increased entry cost and more persistent shocks faced by entrepreneurs in the 2010s lead to a 2.80% decline in entrepreneurial TFP and a 1.97% reduction in consumption-equivalent welfare. After decomposing the two factors that contribute to the decline in new business creation, we can see that higher entry cost alone reduces both entrepreneurial TFP and consumption-equivalent welfare, while higher persistence of productivity shocks alone generates a higher level of entrepreneurial TFP and consumption-equivalent welfare. This is because entrepreneurs can undo capital misallocation via self-financing: With persistent shocks, self-financing is an effective substitute for well-functioning capital rental markets in terms of allocating production factors, as emphasized by Buera and Shin (2011) and Moll (2014).

	Higher κ	Higher ρ	Both
Entrep. TFP	-5.04%	3.45%	-2.80%
Welfare	-1.76%	0.44%	-1.97%

Table 7: TFP and Welfare

Our results, whereby a higher entry cost and higher persistence of productivity shocks impact welfare and TFP differently, have important implications. If the decline in new business creation is mainly driven by higher persistence of shocks, this decline can be good in terms of welfare and TFP. If, on the other hand, the higher entry cost is a more dominant reason for the decline in new business creation, this should be a concern, since an increase in

[15]The TFP of the entrepreneurial sector is computed as the Solow residual:

$$TFP = \frac{\int_{d(a,\epsilon,z,d_-)=1} y\left(a,\epsilon,z,d_-\right) d\mu}{\left[\left(\int_{d(a,\epsilon,z,d_-)=1} l_t\left(a,\epsilon,z,d_-\right) d\mu\right)^{\alpha}\left(\int_{d_t(a,\epsilon,z,d_-)=1} k_t\left(a,\epsilon,z,d_-\right) d\mu\right)^{1-\alpha}\right]^{\gamma}}$$

entry cost worsens aggregate productivity and overall welfare. Since our key finding of this paper suggests that higher entry cost plays a more important role in explaining the decline in new business creation, policymakers should take action to effectively reduce the entry barriers faced by potential startups.

5.4 Robustness

In this section, we analyze the robustness of our main finding regarding how we obtain the new estimation on entry cost κ and persistence of shocks ρ_z reported in subsection 5.2. Generally speaking, we obtain new estimation on κ and ρ_z to target five moments specified in Table 4 by searching an optimizer to minimize the distance between the moments generated from the model and their empirical counterparts given a specified weight matrix. Specifically, the vector of parameters Ψ is chosen to minimize the minimum-distance-estimator criterion function

$$f(\Psi) = (m_{data} - m_{model}(\Psi))' W (m_{data} - m_{model}(\Psi)), \tag{11}$$

where m_{data}, m_{model} are the vectors of moments in the data and model, and W is a diagonal weighting matrix.[16] We give each moment an equal weight so that these moments are balanced to each other to give us new estimation on entry cost κ and persistence of shocks ρ_z jointly.

Next, we re-do this procedure by assuming alternative weighting matrices and objective functions for minimization. The first case we consider is to give entry rate and employment share of entrants a weight of five and give the rest three moments a weight of one.[17] The second case we consider is to use an alternative objective function that has been used by the existing literature (e.g. Acemoglu et al. (2018); Akcigit and Ates (2019b)) for calibration,[18] which is defined as

$$\sum_{k=1}^{N} \frac{|m_{data} - m_{model}(k)|}{\frac{1}{2}|m_{data}| + \frac{1}{2}|m_{model}(k)|} \tag{12}$$

where k denotes each moments and N is the number of targets. In this case, we give each

[16] Since we only have a relatively small number of parameters calibrated within the model, we use a local search method rather than a combination of global stage and local search used in quantitative labor literature when the number of parameters calibrated within the model is large.

[17] We would always keep the weight equal for the two moments (1) dispersion of employment growth rate, and (2) entrants relative size. Since these two moments are major governors' of persistence of shocks and entry cost respectively, we do not want to give either of them more weight. Otherwise, the leading result on the relative contribution in the decline of new business creation will be biased towards either higher persistent of shocks or higher entry cost.

[18] Compared to the one used in our paper, i.e. equation (11), the objection function specified in equation (12) prioritizes the moments that are easier to match but sacrifices moments harder to match.

	Data (2010s)	Baseline	Case I	Case II	Case III
Parameter					
ρ_z	–	0.940	0.939	0.938	0.938
κ	–	17.79	17.81	17.42	17.24
Moment					
(1) Entry rate	0.077	0.079	0.079	0.081	0.082
(2) Entrants empl. share	0.013	0.012	0.012	0.012	0.013
(3) Entrants relative size	0.630	0.610	0.614	0.613	0.611
(4) SD empl. growth rate	0.535	0.592	0.594	0.597	0.597
(5) Entrep. empl. share	0.250	0.250	0.249	0.250	0.251

Table 8: Robustness Check

moment an equal weight. The third case we consider is to still use the objection function defined in equation (12) but give entry rate and employment share of entrants a weight of five and give the rest three moments a weight of one.

We report the results on the estimation of κ and ρ_z in alternative ways in Table 8. The case that gives moment (1) and (2) more weight is labelled as "Case I", the case that uses the objective function in (12) and give each moments an equal weight is labelled as "Case II", and the case that uses the objective function in (12) and give moment (1) and (2) more weight is labelled as "Case III". We can see that the new estimation on ρ_z and κ in both cases are very close to the one used in this paper, labelled as "Main" in Table 8. In any case, our conclusion that the relative contribution of higher entry cost is roughly 1.5 to 2 times as large as that of higher persistence of shocks in explaining the observed declines in new business creation will not be changed.

6 Impact of Credit Shocks

Our results in Section 5 implies that higher entry cost plays a relatively more important role in explaining the decline in firm entry as well as the employment share of entrants in the recent three decades. In this section, we want to use the two sets of parameters --- persistence of entrepreneurial productivity shocks ρ_z and fixed entry cost κ --- to study how changes in persistence of shocks and entry cost affect the entry and the stock of entrepreneurs in response to a credit shock that mimics a financial crisis.

We simulate the aggregate dynamics of the model tightening the collateral constraint λ_t

that is calibrated to generate a decline in the ratio of debt to the value-added,

$$\frac{\int max\left\{k_t\left(a,\epsilon,z,d_-\right)-a,0\right\}d\mu_t}{\int y_t\left(a,\epsilon,z,d_-\right)d\mu_t}.$$

We reduce the value of λ_t for the first three periods such that the largest decline in the debt-to-value-added ratio the model is able to generate is around 25 percentage points. This is consistent with the magnitude of the largest decline in the debt-to-value-added ratio for the non-corporate business sector in the U.S. economy during the Great Recession. After the three periods of negative credit shocks, we assume that λ_t goes back to its pre-crisis level immediately.[19] To be clear, the initial contraction in λ_t is a completely unexpected event, but its deterministic path after the initial drop is perfectly known. The first two panels of Figure 1 shows the path of the credit shocks fed into the model and the resulting evolution of the ratio of debt to value-added for different sets of persistence of shocks and entry cost (ρ_z, κ) The first set ($\rho_z = 0.915$, $\kappa = 12.2$) is our baseline calibration that targets moments in the early 1980s. The second set ($\rho_z = 0.940$, $\kappa = 17.8$) is our re-calibration results that targets moments in 2010s.

Since the results from previous section suggest that (1) entrepreneurs in 2010s face higher entry cost than firms in 1980s, and (2) entrepreneurs' productivity shocks become more persistent in 2010s than 1980s, we would like to know if these changes are going to lead to different results on the aggregate dynamics of firms in response to the credit shocks defined above. Thus, we compare the results on transitional dynamics of entry rate of entrepreneurs, the stock of entrepreneurs, and several important macro variables for the two sets of parameters on persistence of shocks ρ_z and entry cost κ. The one that captures 1980s is represented by the blue solid line, and the one that captures 2010s is represented by the green dashed line. Our key finding is reported in the third panel of Figure 1. When entrepreneurs in the economy face higher persistence of shocks and higher entry cost that captures the conditions in 2010s, the number of entrepreneurs declines less but recovers slower. The behavior of entry rate is less volatile in the case of 2010s, meaning it declines less but also overshoots less.

To explain these patterns more clearly, we check how changes in ρ_z and κ separately affect the transitional dynamics of entry and the stock of entrepreneurs. We find that when only κ increases to the level of 2010s, both the entry rate and the number of entrepreneurs

[19]We define the path of credit shocks in this way to simulate a financial crisis because we want to show that the recovery speed of firm entry and the stock of firms depend on the values of ρ_z and κ. Alternatively, we can let λ_t gradually recover and eventually converge to its pre-crisis level as in Buera et al. (2015). In that case, the slow recovery of firm entry and the stock of firms will be mostly driven by the slow recovery of λ_t.

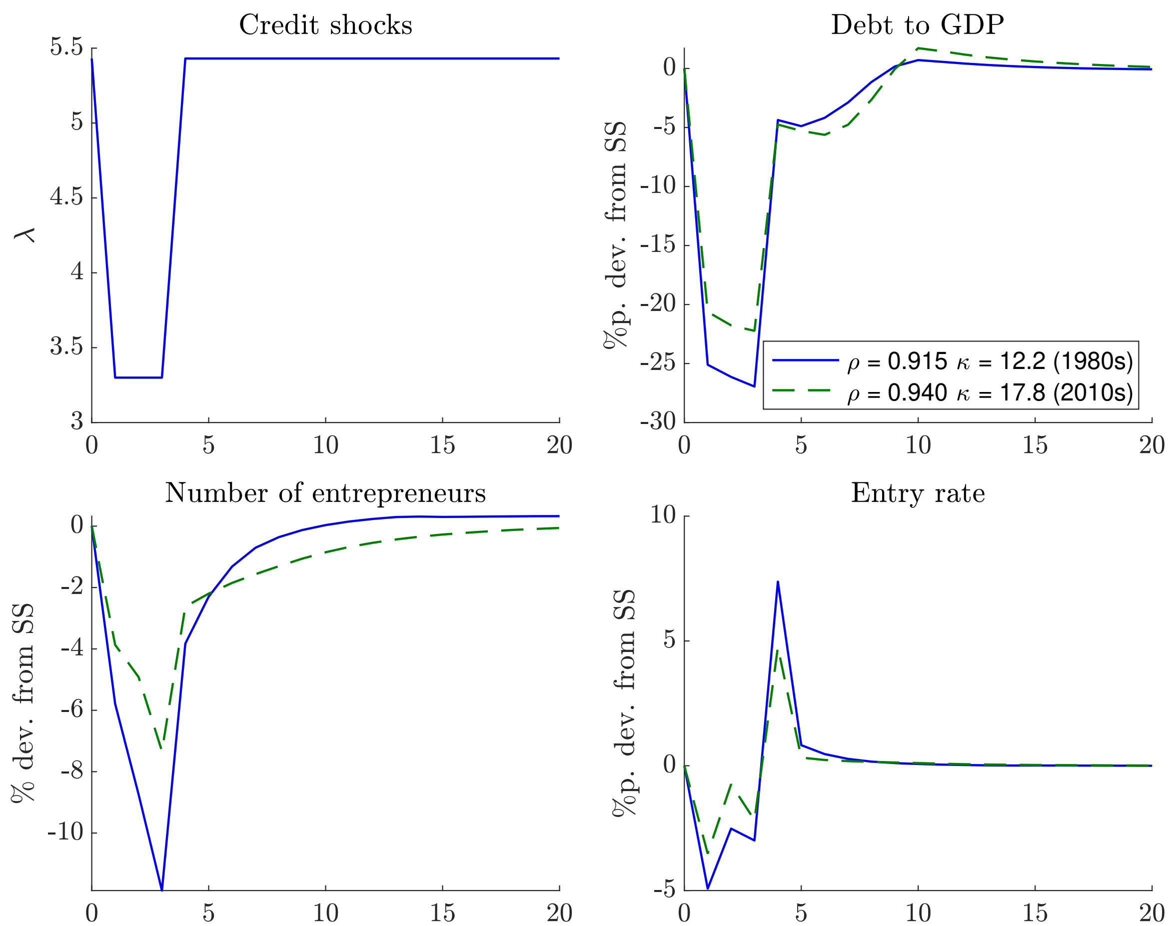

Figure 1: Transition Dynamics: Entrepreneurs' Dynamics

decline less but recover slower. The reason is that when entry cost is very high, it is harder for incumbent entrepreneurs to exit the market since they know if they exit, they are harder to re-enter the market. When only ρ_z increases to the level of 2010s, both the entry rate and the number of entrepreneurs decline more but recover faster. With more persistent shocks, entrepreneurs have a stronger motivation to do self-financing thus saving more. This makes interest rate decline less in response to the negative credit shock. Consequently, entrepreneurs' profits drop a lot, while the decline in equilibrium wage due to negative credit shocks is relatively modest. Therefore, the decline in the entry and the stock of entrepreneurs is larger when persistence of shocks is higher. Likewise, when shocks are more persistent, agents with high productivity shocks that are previously exit the market due to the negative credit shock will enter the market immediately as credit condition goes back to the pre-crisis level. This renders a quicker recovery. When both ρ_z and κ increase to our estimated level that captures the condition faced by firms in 2010s, the pattern is more similar to the one when only κ rises. This implies that the increase in the fixed entry cost is the dominant force to explain the different patterns of transitional dynamics of entry rate and the stock of entrepreneurs in response to a negative credit shock that mimics a financial crisis.

The results above provide some insights on the comparison of 1980-1982 recession ("Double-Dip Recession") and the Great recession in terms of the number of firms. We know that both the Double-Dip Recession and the Great Recession experience a dramatic drop in the number of firms, but the recovery in the stock of firms from the Great Recession is slower. Our results indicate that higher entry cost faced by potential startups may be an important reason for the phenomena.

We also check the aggregate dynamics (under perfect foresight) of several important macro variables including output, total wealth (capital stock), and total factor productivity (TFP) driven by credit shocks given different values of persistence shocks ρ_z and entry cost κ. We report the results in Figure 2. We can see that changes in ρ_z and κ do not make a significant difference on the transitional dynamics of these macro variables. The output produced by entrepreneurs declines less and recovers slightly slower in the case of higher persistence of shocks and higher entry cost. So do the aggregate output, total wealth, and TFP of the entrepreneurial sector. Our results on the decline in aggregate output resulting from credit crunch are consistent with Shourideh and Zetlin-Jones (2017) that casts doubts on the ability of credit shocks to generate significant economic fluctuations.[20] Since our model

[20] Shourideh and Zetlin-Jones (2017) develops a general equilibrium model of heterogeneous firms with borrowing collateral constraints, which are the same as the ones in our paper. The authors find that when the model is calibrated to match the observed financing patterns that roughly 80\% of investment by private firms is financed externally compared to 20% for public firms, a large negative credit shock which generates

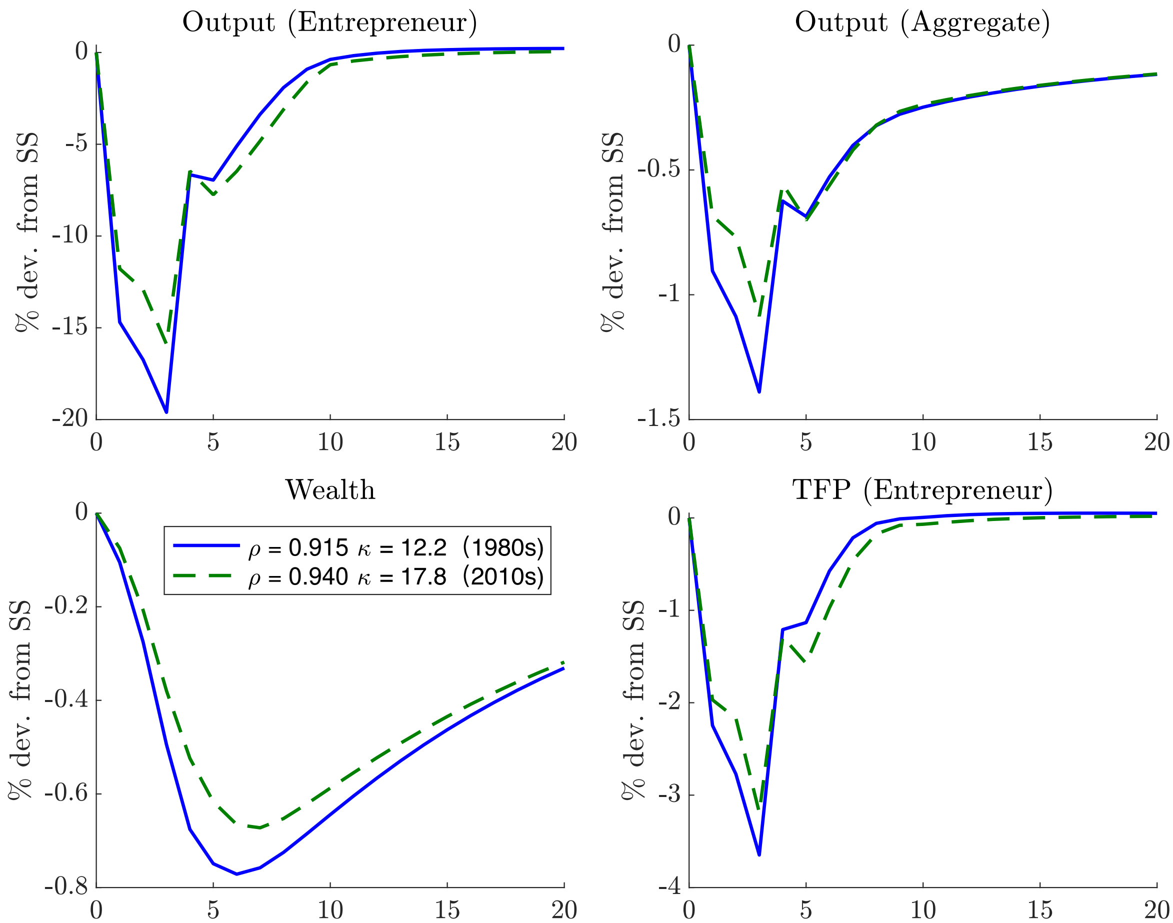

Figure 2: Transition Dynamics: Macro Variables

features a corporate sector which is not subject to a credit constraint,[21] after calibrating our model to match the employment share of entrepreneurs and corporates as well as the debt-to-value-added ratio for non-corporate sector, our model also generates a modest decline in total output, as the second panel of Figure 2 shows.

7 Conclusion

In this paper, we propose a general equilibrium model of entrepreneurship to separately identify and quantify how changes in entry cost and persistence of idiosyncratic productivity shocks contribute to the observed declines in the creation of new businesses. We show that entrepreneurs face more persistent productivity shocks and higher entry cost to start up a business in the 2010s than in the 1980s. We find that the relative contribution of higher entry cost is 1.5 times larger than that of higher persistence of entrepreneurial productivity shocks in accounting for the decline in the entry rate of entrepreneurs, and twice as large in accounting for the decline in the employment share of new entrants. Our results suggest that higher entry barriers potentially play a more important role in explaining the secular decline in the new business creation experienced by the U.S. economy since the early 1980s. We also find that higher persistence of shocks and higher entry cost have different impacts, respectively, on TFP and welfare, which implies the importance of differentiating the two types of shocks that contribute to the decline in firm creation.

Given the above results, we study the implications of changes in entry cost and persistence of entrepreneurial productivity shocks on the aggregate dynamics of entry and the stock of entrepreneurs following a credit crunch. The key finding is that with higher persistence of entrepreneurial productivity shocks and the higher entry cost that captures the conditions faced by entrepreneurs in the 2010s, the number of entrepreneurs declines less but recovers more slowly. This sheds light on the more sluggish recovery in termns of the number of firms during and after the Great Recession compared with the 1980-1982 recession: The entry barrier in the late 2000s is much larger than that in the early 1980s which makes it harder for an entrepreneur who previously exited the market due to a credit crunch to re-enter it.

The findings of this paper also present a direction for not only future research but also policy design. Our results show that both the entry cost to start a firm and the persistence of

the decline in aggregate debt-to-assets observed following the Great Recession can only lead to roughly a 1% decline in the aggregate GDP.

[21] Our assumption that corporate firms are not borrowing constrained is consistent with the existing literature (see, for example, Dyrda and Pugsley (2019); Shourideh and Zetlin-Jones (2017) .

productivity shocks are higher than before, which are quantitatively powerful in explaining the decline in new business creation. In our framework, we assume the two factors are independent of each other. However, it is likely that higher entry cost and higher persistence of shocks are in fact linked. For example, with more persistent productivity shocks, the highly productive incumbents will gain more market power, which may erect entry barriers for potential startups. Therefore, future research should be devoted to understanding not only the underlying reasons for both higher entry cost and higher persistence of shocks, but also the potential connections between them. In terms of policy, our results suggest that the appropriate response in terms of encouragiing new business creation and reviving business dynamism in the U.S. economy should focus more on reducing entry barriers. We leave for future research the design of policies aimed at effectively reducing entry barriers.

References

Acemoglu, D., U. Akcigit, H. Alp, N. Bloom, and W. Kerr (2018): "Innovation, Reallocation, and Growth," *American Economic Review*, 108, 3450–3491.

Akcigit, U. and S. T. Ates (2019a): "Ten Facts on Declining Business Dynamism and Lessons from Endogenous Growth Theory," Working Paper.

——— (2019b): "What Happened to U.S. Business Dynamism?" Working Paper.

Bhandari, A. and E. R. McGrattan (2019): "Sweat Equity in U.S. Private Business," Working Paper.

Buera, F. J., R. N. Fattal-Jaef, and Y. Shin (2015): "Anatomy of a credit crunch: From capital to labor markets," *Review of Economic Dynamics*, 18, 101–117.

Buera, F. J., J. P. Kaboski, and Y. Shin (2011): "Finance and Development: A Tale of Two Sectors," *The American Economic Review*, 101, 1964–2002.

Buera, F. J. and Y. Shin (2011): "Self-insurance vs. self-financing: A welfare analysis of the persistence of shocks," *Journal of Economic Theory*, 146, 845–862.

——— (2013): "Financial Frictions and the Persistence of History: A Quantitative Exploration," *Journal of Political Economy*, 121, 221–272.

Cagetti, M. and M. DeNardi (2006): "Entrepreneurship, Frictions, and Wealth," *Journal of Political Economy*, 114.

Clementi, G. L., A. Khan, B. Palazzo, and J. K. Thomas (2014): "Entry, Exit and the Shape of Aggregate Fluctuations in a General Equilibrium Model with Capital Heterogeneity," Working Paper.

Decker, R., J. Haltiwanger, R. Jarmin, and J. Miranda (2014): "The Role of Entrepreneurship in US Job Creation and Economic Dynamism," *Journal of Economic Perspectives*, 28, 3–24.

——— (2016): "Where Has All The Skewness Gone? The Decline in High-Growth (Young) Firms in The US," *European Economic Review*, 86, 4–23.

Dyrda, S. and B. Pugsley (2019): "Taxes, Private Equity, and Evolution of Income Inequality in the US," Working Paper.

Engbom, N. (2019): "Firm andWorker Dynamics in an Aging Labor Market," Federal Reserve Bank of Minneapolis Working Paper 756.

Evans, D. S. and B. Jovanovic (1989): "An Estimated Model of Entrepreneurial Choice under Liquidity Constraints," *Journal of Political Economy*, 97, 808–827.

Evans, D. S. and L. S. Leighton (1989): "Some Empirical Aspects of Entrepreneurship," *The American Economic Review*, 79.

Gavazza, A., S. Mongey, and G. Violante (2018): "Aggregate Recruiting Intensity," *American Economic Review*, 108, 2088–2127.

Gentry, W. M. and R. G. Hubbard (2004): "Entrepreneurship and household saving," *Advances in Economic Analysis & Policy*, 4.

Gutierrez, G. and T. Philippon (2018): "How EU markets became more competitive than U.S. markets," NBER Working Paper.

Haltiwanger, J., R. Jarmin, and J. Miranda (2012): "Where Have All the Young Firms Gone?" *Business Dynamics Statistics Briefing.*

Hopenhayn, H., J. Neira, and R. Singhania (2019): "The Rise and Fall of Labor Force Growth: Implications for Firm Demographics and Aggregate Trends," Working Paper.

Hurst, E. and A. Lusardi (2004): "Liquidity Constraints, Household Wealth, and Entrepreneurship," *Journal of Political Economy*, 112.

Judd, K. L., L. Maliar, S. Maliar, and I. Tsener (2017): "How to solve dynamic stochastic models computing expectations just once," *Quantitative Economics*, 3.

Khan, A. and J. K. Thomas (2013): "Credit Shocks and Aggregate Fluctuations in an Economy with Production Heterogeneity," *Journal of Political Economy*, 121, 1055–1107.

Kleiner, M. and A. Krueger (2013): "Analyzing the Extent and Influence of Occupational Licensing on the Labor Market," *Journal of Labor Economics*, 31, 137–202.

Low, H., C. Meghir, and L. Pistaferri (2010): "Wage Risk and Employment Risk over the Life Cycle," *The American Economic Review*, 100, 1432–67.

Midrigan, V. and D. Y. Xu (2014): "Finance and Misallocation: Evidence from Plant-Level Data," *American Economic Review*, 104, 422–581.

Miranda, M. J. and P. L. Fackler (2002): *Applied Computational Economics and Finance*, MIT Press.

Moll, B. (2014): "Productivity Losses from Financial Frictions: Can Self-Financing Undo Capital Misallocation?" *American Economic Review*, 104, 3186–3221.

Mongey, S. (2015): "Lecture notes for Quantitative Macroeconomics," Tech. rep., New York University.

Pugsley, B. and A. Sahin (2019): "Grown-up Business Cycles," *The Review of Financial Studies,*, 32, 1102–1147.

Quadrini, V. (2000): "Entrepreneurship, Saving, and Social Mobility," *Review of Economic Dynamics*, 3, 1–40.

Rouwenhorst, K. (1995): *Asset Pricing Implications of Equilibrium Business Cycle Models. In: Cooley, T.F. (Ed.), Frontiers of Business Cycle Research.*, Princeton University Press.

Salgado, S. (2018): "Technical Change and Entrepreneurship," Working Paper.

Shourideh, A. and Zetlin-Jones (2017): "External Financing and the Role of Financial Frictions over the Business Cycle: Measurement and Theory," *Journal of Monetary Economics*, 92.

Siemer, M. (2014): "Firm Entry and Employment Dynamics During the Great Recession," Working Paper.

Tauchen, G. (1986): "Finite state markov-chain approximations to univariate and vector autoregressions," *Economics Letters*, 20, 177–181.

Young, E. R. (2010): "Solving the Incomplete Markets Model with Aggregate Uncertainty Using the Krusell-Smith Algorithm and Non-stochastic Simulations," *Journal of Economic Dynamics and Control*, 34, 36–41.

A Computational Algorithm

In this computational appendix we first lay out the solution method for the heterogeneous-agent household problem described in Section 3. Then, we discuss the algorithm for computing the transition dynamics.

A.1 Household Problem

In this subsection, we first describe the general solution algorithm for finding steady-state equilibrium. Next, we lay out an efficient method for solving the recursive equilibria.

A.1.1 Computing stationary equilibrium

We have three nested fixed point problems. First, we have to solve market clearing wage ($\overline{w}$) and interest ($\bar{r}$) rate. Second, we have to compute an approximation of the stationary distributions $\overline{\mu}^W$ and $\overline{\mu}^E$ over financial asset a, working productivity ϵ, and entrepreneurial talent z for each occupation. Third, we have to compute a fixed point in (expected) continuation values $\bar{v}^1$ (containing entry option) and $\bar{v}^2$ (containing exit option).[22] The iteration is then as follows:

1. Guess an initial wage rate, w_0, initial distributions, μ_0^W and μ_0^E, and initial (expected) value functions v_0^1 and v_0^2. The initial interest rate can be obtained by the following equation:
$$r_0 = \frac{\theta(A(1-\theta))^{\frac{1}{\theta}}}{1-\theta} w_0^{\frac{\theta-1}{\theta}} - \delta$$

2. In price iteration i, given prices w_i and r_i, the loop as follows

   (a) In iteration k, solving the household problem requires finding the fixed point in value functions. We apply the collocation method to approximate the expected continuation values, and use golden-search approach to solve saving decisions. For each idiosyncratic state, entry decision can be obtained by comparing the value of entry with the value of being a worker and exit decision can be solved by comparing the value of exit with the value of being an entrepreneur.

   (b) We implement both value function iteration and Broyden's algorithm to update a finite set of coefficients that can define the value functions. The root-finding

[22] We provide detailed information on what function to approximate in Appendix A.1.2.

problem stops if the convergence criterion $max\{\| v^1_{k+1} - v^1_k \|, \| v^2_{k+1} - v^2_k \|\} < \zeta$ is satisfied. Otherwise, repeat step $2(a)$ with the updated coefficients.

(c) Solve saving, entry, and exit decision rules on a finer grid. Create big transition matrix[23] using saving policy functions and exogenous transitions matrix $P(z'|z)$ and $P(\epsilon'|\epsilon)$.

(d) Start from the initial distribution μ^W_0 and μ^E_0. In iteration j, updating distributions by applying big transition matrix, entry, and exit decisions on existing ones.

(e) Iteration stops if the convergence criterion $max\{\| \mu^W_{j+1} - \mu^W_j \|, \| \mu^E_{j+1} - \mu^E_j \|\} < \zeta$ is satisfied. Otherwise, repeat step $2(d)$ with the updated distributions.

(f) Aggregate across all households and compute aggregate labor supply, L^W, asset supply, A, entrepreneur's capital demand, K^E. Capital for corporate sector can be obtained by $K^C = A - K^E$. If $K^C < 0$, then go to step 1 and guess a new price. Then, aggregate labor for corporate sector can be calculated as follows:

$$L^C = \frac{1-\theta}{\theta}\frac{r_i + \delta}{w_i}K^C$$

3. Check if the convergence criterion $\| L^W - L^C - L^E \| < \zeta$ is satisfied. If yes, $STOP$. Otherwise, update wage rate $w_{i+1} = w_i - \phi(L^W - L^C - L^E)$, where ϕ controls the adjustment speed, and then go back to step 2.

A.1.2 Computing recursive equilibria

This subsection describes how to use Mongey (2015) algorithm to compute the recursive equilibria. This approach accelerates computation speed by adapting Judd et al. (2017) method on pre-computation of expectation functions to collocation method for approximating value functions. Moreover, Miranda and Fackler (2002) toolbox allows us to efficiently find optimal policies using vectorized golden-section search and solve fixed point problems using Broyden's algorithm.

The continuous and discrete choice problem described in the model section can be solved by approximating two expected continuation values as follows

$$v^1(s) = \sum_{\epsilon', z'} P(\epsilon', z'|\epsilon, z) max\{v^W(s'), v^F(s')\},$$

[23] Here, we use Young (2010) method that is a discrete approximation to the law of motion of the distribution of agents over states.

$$v^2(s) = \sum_{\epsilon',z'} P(\epsilon', z'|\epsilon, z) max\{v^W(s'), v^E(s')\},$$

where $v^1(s)$ nests a worker's entry decision and $v^2(s)$ nests an entrepreneur's exit decision,[24] and the state vector is $s = [a, \epsilon, z]$.[25] Note that we have $N_a = 100$ asset grid points, $N_\epsilon = 9$ working productivity shock grid points, and $N_z = 9$ entrepreneurial productivity shock grid points. In total, there are $N = N_a \times N_\epsilon \times N_z = 8,100$ states.

We now replace the functions we want to approximate with interpolants

$$v^1(s_i) = \sum_{j=1}^{N} \phi(s_i)c_j^1 = \Phi(s)c^1,$$

$$v^2(s_i) = \sum_{j=1}^{N} \phi(s_i)c_j^2 = \Phi(s)c^2,$$

where ϕ is a basis function, c^1 and c^2 are vectors of coefficients, and $s_i \in s$ is a collocation node. If we substitute these interpolants into the original system of functional equations we have N system of equations with N unknowns as follows

$$\Phi(s)c^1 = (P \otimes \mathbf{I}_{N_a})[(1 - I^f(s))\odot\Phi(s)c^W + I^f(s)\odot\Phi(s)c^F],$$

$$\Phi(s)c^2 = (P \otimes \mathbf{I}_{N_a})[I^e(s)\odot\Phi(s)c^W + (1 - I^e(s))\odot\Phi(s)c^F],$$

where $P \otimes \mathbf{I}_{N_a}$ is a pre-computed expectation matrix, $I^f(s)$ and $I^e(s)$ captures the entry and exit decisions at s, respectively, and $\Phi(s)c^W$, $\Phi(s)c^E$, and $\Phi(s)c^F$ are values associated with worker, entrepreneur, and entrant, respectively. Note that they can be rewritten as follows

$$\Phi(s)c^W = max\Big\{u(w\epsilon + (1 + r)a - a'(s)) + \beta\Phi([a'(s), \epsilon, z])c^1\Big\},$$

$$\Phi(s)c^E = max\Big\{u(\pi(s) + (1 + r)a - a'(s)) + \beta\Phi([a'(s), \epsilon, z])c^2\Big\},$$

$$\Phi(s)c^F = max\Big\{u(\pi(s) + (1 + r)a - a'(s) - \kappa) + \beta\Phi([a'(s), \epsilon, z])c^2\Big\}.$$

We can solve for c^1 and c^2 by applying either value function iteration or Broyden's (Quasi-Newton) algorithm. In practice, we start with two sets of initial guess, c_0^1 and c_0^2. Then, we

[24] v^W and v^F in the continuation value v^1 correspond to the options the individuals whose $d_- = 0$ have: staying in the worker sector, or switching to the entrepreneur sector, respectively. v^W and v^E in the continuation value v^2 correspond to the options the indivuduals whose $d_- = 1$ have: switching to the worker sector, or staying in the entrepreneur sector, respectively.

[25] For computational purpose, $s = [\mathbf{i}_{N_z \times N_\epsilon} \otimes a, \mathbf{i}_{N_z} \otimes \epsilon \otimes \mathbf{i}_{N_a}, z \otimes \mathbf{i}_{N_\epsilon \times N_a}]$, where $\otimes$ is a symbol of tensor product and $\mathbf{i}_N$ is a N-by-1 matrix of ones.

iterate on the following system for two times

$$c^1_{k+1} = \Phi(s)^{-1}(P \otimes \mathbf{I}_{N_a})[(1 - I^f(s))\odot\Phi(s)c^W + I^f(s)\odot\Phi(s)c^F],$$

$$c^2_{k+1} = \Phi(s)^{-1}(P \otimes \mathbf{I}_{N_a})[I^e(s)\odot\Phi(s)c^W + (1 - I^e(s))\odot\Phi(s)c^F].$$

Next, we rewrite the problem the system of equations as root-finding problem as follows

$$g(c^1, c^2) = \Phi(s)c^1 - (P \otimes \mathbf{I}_{N_a})[(1 - I^f(s))\odot\Phi(s)c^W + I^f(s)\odot\Phi(s)c^F],$$

$$g(c^1, c^2) = \Phi(s)c^2 - (P \otimes \mathbf{I}_{N_a})[I^e(s)\odot\Phi(s)c^W + (1 - I^e(s))\odot\Phi(s)c^F].$$

The Jacobian of this problem is

$$D(c^1, c^2) = \begin{bmatrix} Q_{11} & Q_{12} \\ Q_{21} & Q_{22} \end{bmatrix},$$

where

$$Q_{11} = \Phi(s) - \beta(P \otimes \mathbf{I}_{N_a})[(1 - I^f(s))\odot\Phi([a'(s), \epsilon, z])],$$

$$Q_{12} = -\beta(P \otimes \mathbf{I}_{N_a})[I^f(s)\odot\Phi([a'(s), \epsilon, z])],$$

$$Q_{21} = -\beta(P \otimes \mathbf{I}_{N_a})[I^e(s)\odot\Phi([a'(s), \epsilon, z])],$$

$$Q_{22} = \Phi(s) - \beta(P \otimes \mathbf{I}_{N_a})[(1 - I^e(s))\odot\Phi([a'(s), \epsilon, z])].$$

Finally, we have the updating scheme

$$\begin{bmatrix} c^1_{k+1} \\ c^2_{k+1} \end{bmatrix} = \begin{bmatrix} c^1_k \\ c^2_k \end{bmatrix} - D(c^1, c^2)^{-1} \begin{bmatrix} g(c^1_k, c^2_k) \\ g(c^1_k, c^2_k) \end{bmatrix},$$

where $D(c^1, c^2)^{-1}$ is the inverse of the Jacobian.

A.2 Transition Dynamics

In this subsection, we describe the algorithm for computing the transition dynamics discussed in Section 6.

1. Solve the steady-state equilibrium. Save the (expected) continuation values v^W_T, v^E_T, v^F_T as well as stationary distribution μ^W_0 and μ^E_0.[26]

[26] Since the credit shocks only last for 3 periods and then recover to pre-crisis level immediately, the initial

2. Guess a sequence of wages $\mathbf{w_0} = \{w_1, w_2, ..., w_T\}$ and compute the associated sequence of interest rates $\mathbf{r_0} = \{r_1, r_2, ..., r_T\}$. Moreover, construct a sequence of credit shocks $\Lambda = \{\lambda_1, \lambda_2, ..., \lambda_T\}$. We set $T = 300$.

3. Given the sequences of prices and credit shocks, we start from the final (expected) continuation values and iterate backward from $t = T$ to $t = 1$. We also solve the decision rules for optimal saving, entry (I_t^f), and exit (I_t^e).

4. For each period t, solve saving, entry, and exit decision rules on a finer grid and construct big transition matrix Q_t^W, Q_t^E, and Q_t^F using saving policy functions and exogenous transitions matrices.

5. Starting from μ_0^W and μ_0^E, the distribution of individuals over their asset, working productivity, entrepreneurial productivity, and occupation during transition will evolve as follows
$$\mu_{t+1}^E = Q_t^{E'}((1 - I_t^e)\mu_t^E) + Q_t^{F'}(I_t^f \mu_t^W),$$
$$\mu_{t+1}^W = Q_t^{W'}((1 - I_t^f)\mu_t^W) + Q_t^{W'}(I_t^e \mu_t^E).$$

6. For each t, aggregate across all individuals and compute aggregate labor supply, L_t^W, asset supply, A_t, entrepreneur's capital demand, K_t^E, corporate sector capital demand K_t^C, and corporate sector labor demand L_t^C.

7. Check if the convergence criterion $\| L_t^W - L_t^C - L_t^E \| < \zeta$ is satisfied. If yes, *STOP*. Otherwise, update wage rate $w_{t+1} = w_t - \phi_t(L_t^W - L_t^C - L_t^E)$ and their associated r_t for each t. Then, reconstruct $\mathbf{w_{k+1}}$ and $\mathbf{r_{k+1}}$ and go back to step 3.

and final value functions (as well as distributions) are identical as long as T is large.