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Emin M. Dinlersoz
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Emin M. Dinlersoz
U.S. Census Bureau

Henry R. Hyatt
U.S. Census Bureau and IZA

Hubert P. Janicki
U.S. Census Bureau

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IZA

P.O. Box 7240
53072 Bonn
Germany

Phone: +49-228-3894-0
Fax: +49-228-3894-180
E-mail: iza@iza.org

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ABSTRACT

Who Works for Whom? Worker Sorting in a Model of Entrepreneurship with Heterogeneous Labor Markets*

Young and small firms are typically matched with younger and nonemployed individuals, and they provide these workers with lower earnings compared to other firms. To explore the mechanisms behind these facts, a dynamic model of entrepreneurship is introduced, where individuals can choose not to work, become entrepreneurs, or work in one of the two sectors: corporate or entrepreneurial. The differences in production technology, financial constraints, and labor market frictions lead to sector-specific wages and worker sorting across the two sectors. Individuals with lower assets tend to accept lower-paying jobs in the entrepreneurial sector, an implication that finds support in the data. The effect on the entrepreneurial sector of changes in key parameters is also studied to explore some channels that may have contributed to the decline of entrepreneurship in the United States.

JEL Classification: L26, J21, J22, J23, J24, J30, E21, E23, E24

Keywords: entrepreneurship, borrowing constraints, financial frictions, labor market frictions, worker sorting, decline in entrepreneurship

Corresponding author:

Emin M. Dinlersoz
Center for Economic Studies
U.S. Census Bureau
4600 Silver Hill Road
Suitland, MD 20746
USA
E-mail: emin.m.dinlersoz@census.gov

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1 Introduction

Job creation by entrepreneurs is an important component of employment dynamics in the U.S. labor market. In a typical year, new firm startups account for about 3% of total employment but almost 20% of gross job creation.[1] The jobs entrepreneurs create, however, may not always be the most desirable ones. Entrepreneurial firms, which are generally young and small, provide lower earnings, on average, to their workers compared with older and larger firms.[2] They also tend to hire disproportionately from the pool of workers who are young and nonemployed.[3] Despite these differences in worker characteristics and earnings, the mechanisms by which workers sort across entrepreneurial versus other firms remain relatively less understood. What kind of individuals choose to work for entrepreneurs, and why? How do the productivity and wealth of workers differ across entrepreneurial versus other firms? How do financial and labor market frictions affect the nature of the match between workers and these two types of firms? These questions demand a framework where individuals face not only the decision to become entrepreneurs, but also the choice between working for entrepreneurial versus other firms, in the presence of financial and labor market frictions.

This paper develops a model of entrepreneurship to analyze what kind of individuals work for entrepreneurial versus other firms. In the model, individuals differ in wealth, as well as in ability (or productivity) as workers and entrepreneurs. Worker and entrepreneurial ability both fluctuate over time. Each individual can choose among not working, being an entrepreneur, or working as an employee in one of the two sectors: entrepreneurial and corporate–a label for the set of firms that don't face the constraints entrepreneurial firms do. These constraints are of two types. The entrepreneurial production is subject to diminishing returns that arise from the limits to entrepreneurs' span-of-control. In contrast, firms in the corporate sector can scale up production without such restrictions. In addition, entrepreneurs can borrow only up to a limit to operate their businesses–a constraint that does not apply to corporate sector firms.

The match between workers and firms is subject to frictions in the labor market. Not all nonemployed individuals who look for a job can find one, and workers can be separated from their employers involuntarily, in addition to voluntary separations. The extent of these labor market frictions vary across the entrepreneurial and corporate sectors. Job offers arrive at different

[1] At the same time, about 40% of the jobs created by startups also disappear due to exit within 5 years of entry. See Haltiwanger, Jarmin, and Miranda (2013).

[2] See, e.g., Brown and Medoff (1989) for the connection between firm size and earnings. Brown and Medoff (2003), Kölling, Schabel and Wagner (2002), and Dinlersoz, Hyatt, and Nguyen (2013) document, among others, the connection between age of establishment or a firm, on the one hand, and average earnings of workers, on the other.

[3] See, e.g., Ouimet and Zarutskie (2014) and Goetz, Hyatt, McEntartfer, and Sandusky (2015).

rates, and involuntary separations occur with different probabilities. At any point in time, an individual can get a job offer only from one of the two sectors. However, workers can flow in and out of the sectors over time, subject to the frictions described. The differences across the two sectors in production technology and labor market frictions together lead to divergence in sectoral wages per unit of worker efficiency. Given this wage differential, the heterogeneity in worker productivity and wealth implies that workers sort across the two sectors.

The model outlined above is related to a large class of models on entrepreneurship.[4] As in these models, it can account for the observed fraction of entrepreneurs in the population, as well as the distributions of wealth for entrepreneurs and workers. What distinguishes it from others, however, is the presence of sector-specific labor market frictions. This feature generates employment shares, worker earnings, and worker flows for the two sectors that are consistent with the observed counterparts. The labor market frictions also lead to differences in the types of workers the two sectors attract in terms of wealth and productivity. Changes in the labor market frictions for the two sectors influence the relative employment in the entrepreneurial sector, and the relative earnings and wealth of workers in that sector.

The model generates a lower wage per unit of worker efficiency and also lower average worker earnings in the entrepreneurial sector relative to the corporate sector. The average earnings differential is consistent with the well-documented firm age-worker earnings premium. In the model, higher average earnings in the corporate sector emerge due to a combination of factors. One factor is that job offers arrive at different rates from the two sectors. Other factors are the decreasing returns to scale and borrowing constraints in the entrepreneurial sector. As a result, the wages per unit of worker efficiency are not necessarily equalized across the two sectors. The wage gap implies that on average more productive individuals choose to work for the corporate sector, resulting in the average working earnings differential.

The calibrated model's equilibrium provides an answer to the central question of who works for whom. Workers in the entrepreneurial sector tend to be both less wealthy and less productive, on average. The asset differential is in part a consequence of the fact that individuals who work in the higher-wage corporate sector accumulate more wealth over time than their counterparts in the entrepreneurial sector. However, a stronger result also holds: individuals who *take* jobs in the entrepreneurial sector also tend to be less wealthy *at the time* they take these jobs. That is, the wealth and productivity differences across the two sectors apply even to individuals who are in their first period of employment following nonemployment. If a nonemployed individual receives an offer from the entrepreneurial sector, the worker has to decide whether to reject this

[4] See, among others, Quadrini (2000), Cagetti and De Nardi (2004), Kitao (2008), Buera and Shin (2011), Buera, Fattal-Jaef, and Shin (2015), and Bassetto, Cagetti, and De Nardi (2015).

offer and wait for an offer from the higher-wage corporate sector.[5] Individuals with lower levels of savings and productivity more readily accept job offers from the entrepreneurial sector rather than waiting. This sorting of individuals emerges in the absence of any inherent preference for working in entrepreneurial firms, or any form of compensation, other than wages, such firms can provide.

The model's key prediction, that workers with lower assets tend to work for entrepreneurial firms and take jobs in the entrepreneurial sector, is taken to data. Any empirical analysis of this prediction requires data on individuals' assets and the characteristics of their employers. While data on worker assets is available from a variety of sources, measuring workers' assets by employer type (e.g. employer size or age) and at the time when they start employment is more challenging. The model's prediction on asset sorting is tested with data on workers' net worth from the Survey of Income and Program Participation merged with the data at the worker-job level from the Longitudinal Employer-Household Dynamics program that captures employer characteristics and workers' job transitions. In the calibrated model's equilibrium, workers in the corporate sector have average asset holdings which are about 1.9 times the average asset holdings of those in the entrepreneurial sector. This ratio is about 1.5 when only the workers in their first quarter of employment are considered. The corresponding ratios in the data turn out to be approximately 1.5 and 1.6, respectively. These figures are close to the model's implied magnitudes.[6] These findings indicate a high degree of sorting based on wealth among individuals across young versus established firms.

For a further understanding of the model's mechanisms that lead to sorting, experiments are run to assess how the model's properties change as the parameters governing labor market frictions, financial constraints, and entrepreneurial ability shift. In each experiment, a key parameter is altered from its baseline value holding all else constant, and the resulting equilibrium is compared with the baseline. The experiments provide an assessment of how robust the main findings on worker sorting are with respect to the changes in parameters. The experiments are also informative on some of the reasons behind the well-documented decline of entrepreneurship in the United States.[7] Recent research has indicated a decades-long decline in several key mea-

[5] The role of asset heterogeneity in generating differential labor market outcomes has also been explored recently by Eeckhout and Sepahsalari (2014), and Herkenhoff, Phillips, and Cohen-Cole (2015). A similar mechanism is also at work in theoretical study of Browning, Crossley, and Smith (2007). While these studies include directed search in labor markets, they do not model an entrepreneurship versus work decision.

[6] Herkenhoff, Phillips, and Cohen-Cole (2015) provide empirical evidence that, among workers who undergo an involuntary job separation, those with more credit card debt spend less time in unemployment and accept lower wages, which is consistent with the evidence here that young and small (i.e., lower-paying) firms disproportionately hire workers with lower assets.

[7] Recent work on this decline include Siemer (2014), Pugsley and Sahin (2015) and Karahan, Pugsley and Sahin (2015). These studies focus mainly on the decline in firm startups (a flow measure), which are a subset

sures for the entrepreneurial sector that accelerated during the Great Recession. The share of young employers in the population of firms has been falling.[8] Workers are increasingly employed in older firms.[9] The decline in the number of business startups explains part of the decline in employment reallocation rates.[10] The new businesses that have formed recently tend to create fewer jobs.[11] Furthermore, the average worker earnings in young firms have fallen, relative to old businesses. The experiments provide insight into some of the channels behind these long-term trends. The results suggest that changes in labor market frictions or financial constraints can qualitatively capture many, but not all, of the long-run trends in the entrepreneurial sector.

The rest of the paper is organized as follows. The next section documents some facts about entrepreneurial firms. Section 3 introduces the model, followed by its calibration in Section 4. The properties of the baseline model are discussed in Section 5. Section 6 offers some empirical evidence on the predictions of the model on worker sorting. Section 7 contains the experiments with the model's key parameters. Section 8 concludes.

2 Some Observations on Entrepreneurial Firms

This section documents some facts about entrepreneurial firms to motivate the analysis. A fundamental question is what constitutes an entrepreneurial firm. Entrepreneurial firms are often characterized as young and small (in terms of employment) firms.[12] Although there are some young and small firms that may not be entrepreneurial in nature (e.g. new businesses created by established firms), and some entrepreneurial firms that are young but large, firm age and size are frequently used to approximate the population of entrepreneurial businesses. However, alternative definitions can also be provided.

Table 1 contains several definitions of the population of entrepreneurial firms and some accompanying statistics for the year 2000.[13] In all definitions, non-employer businesses are excluded, as the focus is on entrepreneurs with employees. In addition, each firm is assumed to have a single owner.[14] Assuming that the pool of potential entrepreneurs is the population aged 25-64 years,

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of entrepreneurial firms (a stock measure) in the economy at any point in time, and abstract from labor and financial markets.

[8] See Decker, Haltiwanger, Jarmin, and Miranda (2014a).

[9] See, e.g., Hathaway and Litan (2014a).

[10] See, e.g., Hyatt and Spletzer (2013).

[11] See Sedlacek and Sterk (2014).

[12] The authors' calculations based on the 2007 Survey of Business Owners confirms this view of entrepreneurial firms. Of young businesses (less than 5 years old), 69.1% of employment is in those owned by households, while among older businesses, only 45.7% of the employment is in firms operated by hoseholds. Of small firms (less than 50 employees), 88.4% of employment is in firms owned by households, but only 40.0% among larger firms.

[13] Except for the measures based on the Survey of Business Owners (SBO), which pertain to the year 2007.

[14] The datasets used to construct Table 1 have different definitions. For example, household surveys count

the fraction of the workforce who are entrepreneurs in the economy can then be approximated as the number of entrepreneurial firms divided by that population. Based on several age and size criteria applied to the universe of employer-businesses in the U.S. Census Bureau's Longitudinal Business Database (LBD), Table 1 reveals that the fraction of entrepreneurs ranges from a rather conservative estimate of 1.1% to a less stringent one of 3.7%. Alternatively, one can define entrepreneurial firms as those that are not publicly owned and that have indicated some ownership demographics in the U.S. Census Bureau's Survey of Business Owners (SBO). This approach yields an estimate of 3.8%. As another alternative, one can use the responses of surveyed individuals to the question regarding employer-business ownership in the Survey of Income and Program Participation (SIPP). The estimates in this case vary from 2.3% to 2.9%. Table 1 also indicates that employment share of entrepreneurial firms varies between 3.6% to 44.0% across various definitions. These definitions also imply a non-entrepreneurial firm average earnings premium in the range 16.6% to 49.8%.[15]

Consider now some important differences between entrepreneurial and other firms. For this purpose, define an entrepreneurial firm as one that is at most 5 years old.[16] Table 2 highlights some key differences between entrepreneurial and other firms relevant for the analysis here. Entrepreneurial firms offer lower earnings to their workers on average. In 1987, the median of the average worker earnings for entrepreneurial firms was about 85% of that for other firms, whereas by 2012 this figure dropped to about 75%. The average earnings premium for non-entrepreneurial firms is also highlighted in Table 2. The documented gap in average earnings is consistent with the empirical literature on firm-age and size premia in worker earnings.[17]

Table 2 also contains information on the prevalence and relative size of entrepreneurial firms. Entrepreneurial firms accounted for nearly half of all firms in 1987, but only one-third in 2012. Compared to their share of firms, entrepreneurial firms account for a relatively small share of total employment: nearly one-fifth in 1987, and only about one-tenth in 2012. The number

business owners who may operate multiple businesses, while business-level surveys do not identify which businesses have owners who also own other businesses.

[15] The average worker earnings premium is defined as excess average worker earnings in non-entrepreneurial firms expressed as a percentage of the average worker earnings in entrepreneurial firms.

[16] The findings summarized next are robust to some alternative definitions of an entrepreneurial firm in Table 1. For instance, using a 10-year threshold for an entrepreneurial firm does not make a substantial difference.

[17] Brown and Medoff (2003) find that average worker earnings are lower in younger firms in a sample of U.S. firms. This finding has repeatedly emerged in studies using a variety of datasets. For instance, Kölling, Schabel and Wagner (2002) largely confirm Brown and Medoff's (2003) findings using data that links establishments to workers in Germany. Heyman (2007) also finds a similar pattern in Swedish data. More recently, Dinlersoz, Hyatt, and Nguyen (2013) provide evidence that new manufacturing establishments in the U.S. provide lower average earnings to their workers than older ones. Ouimet and Zarutskie (2014) also observe a similar gap in average earnings in the matched employer-employee data for the U.S.

and employment share of entrepreneurial firms are in line with the typical high skewness in firm size and age distributions–much of the economic activity is concentrated in a relatively small fraction of firms in the right tail of these distributions. The average scale of entrepreneurial firms measured by employment is only about one-quarter of that for other firms.

Entrepreneurial firms also tend to have higher hiring and separation rates, and rely more on those individuals without jobs for filling vacancies, compared to other firms.[18] As documented in Table 2, entrepreneurial firms, defined by age or size, accounted for about 24% of quarterly gross hires from nonemployment, and about 21% of quarterly gross separations to nonemployment in 2000. Consider the share of hires that come from nonemployment (and separations that go to nonemployment) in entrepreneurial relative to non-entrepreneurial firms.[19] Both of these relative figures exceed one for the two years considered in Table 2, indicating that entrepreneurial firms disproportionately draw their workforce from nonemployment and lose their workers disproportionately to nonemployment, compared to non-entrepreneurial firms.

The differences in worker earnings, and hiring and separation patterns documented in Table 2 hint at potentially different labor market frictions for the two types of firms and their workers. Moreover, the discrepancy in their total employment and average scale may stem in part from the more stringent financial and managerial constraints entrepreneurs face. The model in the next section studies how these factors influence the sorting of workers across firms and give rise to differences in worker productivity, earnings, and wealth across the two types of firms.

3 The Model

Based on the stark differences between entrepreneurial and non-entrepreneurial firms highlighted in the previous section, the model considers an economy with two sectors, entrepreneurial and corporate.[20] The two sectors differ in production technologies, labor market frictions, and financial constraints. The model extends the framework of incomplete markets with occupational choice in the spirit of Quadrini (2000) and Cagetti and DiNardi (2006) to include heterogeneous labor markets, as in the "islands" economy of Lucas and Prescott (1974).[21] It features indivisible

[18] See Haltiwanger, Hyatt, and McEntarfer (2015) and Goetz et al. (2015).

[19] Specifically, define relative hires from nonemployment as $(H_e^N/H_e)/(H_c^N/H_c)$ where H_e^N is the total number of hires of entrepreneurial firms from nonemployment, H_e is the total number of hires by entrepreneurial firms, and H_c^N and H_c are the analogous measures for the non-entrepreneurial firms. Relative separations are defined analogously.

[20] For simplicity, there is no transition of entrepreneurial firms to the corporate sector. A more realistic approach would be to allow entrepreneurial firms to enter the corporate sector at some rate. However, it is not clear the added complications would yield substantially different insights to the sorting of workers between the two types of firms.

[21] See also Alvarez and Veracierto (2000).

labor choice characterized by frictions between production and leisure "islands", as in Krusell, Mukoyama, Rogerson, and Sahin (2011).

There is a unit mass of infinitely-lived individuals. Time, t, is discrete and the discount factor is $\beta \in (0,1)$. Each period an individual is endowed with one unit of time, which can be used for production as a worker or an entrepreneur. Individuals have identical preferences represented by the period utility

$$u(c_t, h_t) = \ln c_t - \alpha h_t,$$

where $c_t \geq 0$ is the consumption, $\alpha > 0$ is the disutility from labor, and $h_t \in \{0,1\}$ is an indicator of participation in the labor market.

Each individual possesses an amount, $a_t \geq 0$, of assets. Individuals also differ in their ability (or productivity), both as a worker and an entrepreneur.[22] Worker productivity is summarized by $z_t > 0$–the efficiency units of labor an individual can supply in a period. The productivity, z_t, evolves over time independently across individuals according to the process

$$\begin{aligned} \ln z_t &= \rho_z \ln z_{t-1} + \epsilon_t^z, \\ \epsilon_t^z &\sim N(0, \sigma_z). \end{aligned} \tag{1}$$

Similar to the worker ability, the entrepreneurial ability, θ_t, also evolves independently across individuals according to

$$\begin{aligned} \ln \theta_t &= (1-\rho_\theta)\mu + \rho_\theta \ln \theta_{t-1} + \epsilon_t^\theta, \\ \epsilon_t^\theta &\sim N(0, \sigma_\theta). \end{aligned} \tag{2}$$

There are two sectors of production: a corporate and an entrepreneurial sector, denoted by $j \in \{f, e\}$, respectively. Production technology differs across the two sectors. There is a representative firm in the corporate sector. It generates output, Y_t, by combining capital, K_t, and efficiency units of labor, L_t, by way of a constant-returns-to-scale production technology

$$Y_t = A K_t^\nu L_t^{1-\nu},$$

where $\nu \in (0,1)$, and $A > 0$ is the corporate sector's total factor productivity.

Each firm in the entrepreneurial sector is run by an entrepreneur with ability θ_t, who uses capital, k_t, and efficiency units of labor, l_t, to produce output, y_t, via a decreasing-returns-to-scale technology

$$y_t = \theta_t (k_t^\nu l_t^{1-\nu})^\xi, \tag{3}$$

where $\xi \in (0,1)$ is a span-of-control parameter, which reflects the diminishing returns to the entrepreneur's managerial ability.

[22] The index for an individual is suppressed for notational simplicity.

There are two types of frictions. The first type is the labor market frictions. Employment opportunities for nonemployed individuals arrive every period with probability λ. Job offers can come from the corporate sector or the entrepreneurial sector. Conditional on the arrival of a job offer, the offer is from the corporate sector with probability γ. Employed individuals maintain a deterministic match to the sector for the duration of their tenure. There is no on-the-job search, and individuals can receive job offers only when nonemployed. Every period workers can separate from their employers voluntarily or involuntarily. Involuntary separations occur in sector $j \in \{f, e\}$ with probability, ϕ_j. When an individual is separated from a firm or quits entrepreneurship, the individual has to stay nonemployed for at least one period before facing the decision to work again. The parameters $\{\lambda, \gamma, \phi_f, \phi_e\}$ govern the frictions in the labor market.

The second type of frictions is financial in nature. There are borrowing constraints for entrepreneurs, and individuals are not allowed to carry negative assets, $a_t \geq 0$. The amount of capital, k_t, an entrepreneur with assets, a_t, can access is bounded: $k_t \leq ba_t$, where $b \geq 1$ is an exogenously given borrowing limit. When $b = 1$, entrepreneurs can only use their accumulated assets to finance production. The parameter b is the only parameter that governs the financial frictions. Capital earns an interest rate, $r > 0$, and depreciates at a rate of $\delta \in (0, 1)$.

The timing of events within a period is as follows. Individuals first realize their current-period labor productivity. Each nonemployed individual then receives a job offer from one of the sectors. All individuals then make their decisions about whether to work, become an entrepreneur, or not work. Following this decision, all entrepreneurs realize their current-period abilities and choose their inputs for production. Each individual then chooses how much to consume and save. At the end of the period, some of the employed individuals get separated from their employers exogenously.

3.1 Individuals' Problems

Consider a stationary environment where policies and payoffs do not depend on calendar time. Let $s = (a, z, \theta)$ summarize an individual's assets, and worker and entrepreneurial ability in a period. In addition to s, each individual is differentiated by current-period labor status, which can be nonemployment (n), working in the corporate sector (f), working in the entrepreneurial sector (e), or being an entrepreneur (m). Similar to s, define $\widetilde{s} = (a, z, \theta_{-1})$ to be the individual's assets, worker, and entrepreneurial ability, before the current-period entrepreneurial ability, θ, is known. Note that $\widetilde{s}$ is identical to s except for its last element, which is the individual's previous-period entrepreneurial ability.

Consider now an individual who was a worker in sector j at the end of the previous period, or who has a job offer from sector j in the current period. This individual faces the choice between work in sector j, nonemployment (n), and entrepreneurship (m). The choice is made before the current period entrepreneurial ability is realized, but with the knowledge of current worker ability and assets. The expected value of this individual is then the maximum of the expected values from the three choices (j, n, m) available

$$E^j(\widetilde{s}) = \max\{\mathbb{E}_{\theta|\theta_{-1}}[V^j(s)], \mathbb{E}_{\theta|\theta_{-1}}[V^n(s)], \mathbb{E}_{\theta|\theta_{-1}}[V^m(s)]\}. \tag{4}$$

Consider next an individual who was not a worker in any sector at the end of the previous period, or who has no job offer in the current period. This individual faces the choice between nonemployment (n) and entrepreneurship (m), and his expected value is given by

$$U(\widetilde{s}) = \max\{\mathbb{E}_{\theta|\theta_{-1}}[V^n(s)], \mathbb{E}_{\theta|\theta_{-1}}[V^m(s)]\}. \tag{5}$$

Next, turn to the definitions of the value functions V^j, V^n, and V^m in (4) and (5). The value of a nonemployed individual can be written as

$$V^n(s) = \max_{c,a'\geq 0}\{\ln c + \beta \mathbb{E}_{z'|z}[\lambda[\gamma E^f(\widetilde{s}') + (1-\gamma)E^e(\widetilde{s}')] + (1-\lambda)U(\widetilde{s}')\}, \tag{6}$$

subject to the budget constraint

$$c + a' = (1+r)a,$$

where $\widetilde{s}' = (a', z', \theta)$ and (a', z') denotes the next period's assets and worker ability. Equation (6) reflects the fact that a nonemployed individual obtains the utility from consumption in the current period, and in the next period the expected value depends on whether a job offer is received, and the sector this offer comes from.

Denote by w_j the wage per unit of worker efficiency in sector $j \in \{f, e\}$. The value of an individual who works in sector j is given by

$$V^j(s) = \max_{c,a'\geq 0}\{\ln c - \alpha + \beta \mathbb{E}_{z'|z}[(1-\phi_j)E^j(\widetilde{s}') + \phi_j U(\widetilde{s}')]\} \tag{7}$$

subject to

$$c + a' = w_j z + (1+r)a,$$

The value in (7) is composed of two parts. An employed individual receives a current utility from consumption, reduced by the disutility of work. In the next period, the individual's expected value depends on whether he gets separated from his job.

Finally, the value of an entrepreneur is

$$V^m(s) = \max_{c,a'\geq 0}\{\ln c - \alpha + \beta \mathbb{E}_{z'|z}[U(\widetilde{s}')]\} \tag{8}$$

subject to

$$c + a' = \pi(s) + (1+r)a,$$

where the entrepreneurial profit, $\pi(s)$, is given by

$$\pi(s) = \max_{k,l \geq 0; k \leq ba} \{\theta(k^{\nu} l^{1-\nu})^{1-\xi} - w_e l - (r+\delta)k. \tag{9}$$

The entrepreneurial value in (8) consists of the current period utility that results from consumption and work, and the next period's expected value, which reflects the fact that in the next period the individual can continue to be an entrepreneur or choose to be nonemployed.

3.2 Equilibrium

Let $i \in \{n, f, e, m\}$ denote the labor status of an individual in any given period. In addition, let $d \in \{n, f, e, m\}$ be the "island" or "location" of the individual at the end of the previous period. A stationary competitive equilibrium for the model is a collection of value functions, $V^i(s)$, wage in each sector, w_j for $j \in \{f, e\}$, an interest rate, r, labor supply rules, $h^d(\widetilde{s})$, decision rules to become an entrepreneur, $m^d(\widetilde{s})$, saving and consumption rules, $a'^i(s)$ and $c^i(s)$, an entrepreneur's capital and labor utilization rules, $k(s)$ and $l(s)$, and measures of individuals by labor status, $\Psi^i(s)$, such that

1. The labor supply rules, $h^d(\widetilde{s})$, and the decision rules to become an entrepreneur, $m^d(\widetilde{s})$, solve the problems (4) and (5),

2. The saving and consumption rules, $a'^i(s)$ and $c^i(s)$, solve the individuals' problems defined in (6), (7), and (8),

3. The interest rate, r, and the corporate sector wage, w_f, satisfy

$$r = \nu A K^{\nu-1} L^{1-\nu} - \delta, \tag{10}$$

$$w_f = (1-\nu) A K^{\nu} L^{-\nu}, \tag{11}$$

4. The capital and labor choices, $k(s)$ and $l(s)$, solve the entrepreneur's problem in (9),

5. The measures, $\Psi^i(s)$, are consistent with the behavior of the individuals,

6. Labor, capital, and goods markets clear

$$\int l(s) d\Psi^m(s) = \int z d\Psi^e(s) \qquad \text{(entrepreneurial sector labor)} \tag{12}$$

$$L = \int z d\Psi^f(s) \qquad \text{(corporate sector labor)} \tag{13}$$

$$K + \int k(s) d\Psi^m(s) = \sum_i \int a d\Psi^i(s) \qquad \text{(capital)} \tag{14}$$

$$Y + \int y(s) d\Psi^m(s) = \sum_i \int c(s) d\Psi^i(s) + \delta \left(K + \int k(s) d\Psi^m(s) \right) \quad \text{(goods)} \tag{15}$$

where $y(s)$ denotes the output of an entrepreneur with state s.

While the corporate sector wage, w_f, depends on the representative corporate firm's labor choice (11), the entrepreneurial sector wage, w_e, is the value that equates the labor demand by all entrepreneurs to the labor supply of all workers in the entrepreneurial sector–equation (12). The amount of capital used by the two sectors must equal the total assets of all individuals in the economy, as ensured by (14). Finally, the total output of the economy must account for the total consumption by individuals and the replacement of the depreciated capital, as in (15). Appendix A outlines the algorithm that is used to solve for the stationary equilibrium numerically.

4 Calibration

The parameter values used in the calibration of the baseline model are shown in Table 3. Each period corresponds to one quarter. The discount rate, β, is set to 0.985, to match an annual interest rate of 4%. The process for labor productivity, z, in (1) is assigned the parameters $\{\rho_z, \sigma_z\} = \{0.97, 0.13\}$, based on Heathcoate, Storesletten, and Violante (2010).

The annual values of the parameters $\{\rho_\theta, \sigma_\theta\}$ of the process for managerial ability θ in (2) and the returns-to-scale parameter, ξ, are estimated separately for entrepreneurial firms (firms aged 0-5 years) versus non-entrepreneurial firms (firms aged 6+ years) in the manufacturing sector. The unavailability of data on inputs other than labor precludes the estimation of these parameters for firms in other sectors of the economy. The estimation follows the econometric methodology used in Abraham and White (2015), which allows joint estimation of the parameters $\{\rho_\theta, \sigma_\theta, \xi\}$ based on Castiglionasi and Ornaghi (2013) – see Appendix B.[23] The framework of Abraham and White (2015) has a number of desirable features. Most importantly, it allows for firm-fixed effects in productivity and for heterogeneity in the parameters $\{\rho_\theta, \sigma_\theta, \xi\}$ across industries. They demonstrate that restricting these parameters to be the same across industries can lead to significant upward bias in the estimate of the persistence parameter, ρ_θ.[24] The estimated parameters for the entrepreneurial ability process for θ at an annual rate turn out to be $\{\rho_\theta, \sigma_\theta\} = \{0.3, 0.18\}$, which are the averages across narrowly defined industries at the level of 4 digit SIC codes. The span-of-control parameter for young firms, ξ, has an average estimated

[23] See also the earlier version, Abraham and White (2006).

[24] Other recent approaches to estimating the productivity persistence parameter include Lee and Mukoyama (2015) and Foster, Haltiwanger and Syverson (2008). The former does not allow for heterogeneity of the persistence parameter, and the latter provides estimates for a special sample 11 narrowly defined manufacturing product categories. These approaches result in higher estimates for the persistence parameter.

value of 0.88 across industries. This value is smaller than the corresponding one for older firms (around 0.97), suggesting a lower span-of-control for young firms.

Following Kitao (2008) and Buera and Shin (2011), the borrowing constraint parameter, b, is set to 1.5, implying that an entrepreneur can borrow up to 50% of his assets at the beginning of the period. Based on the business-cycle literature, the capital's share of output, ν, is set to 0.36, and the quarterly depreciation rate, δ, is taken to be 0.015, which corresponds to an annual depreciation rate of 0.06. The productivity of the corporate sector, A, is normalized to $\exp(-1)$.

The remaining parameters, $\{\alpha, \lambda, \gamma, \phi_e, \phi_f, \mu\}$, are chosen to hit six different targets that constitute a system of non-linear equations. While these equations are simultaneous in nature and involve all relevant parameters of the model, each equation plays an instrumental role in setting a specific parameter. The values of the targets are chosen to be the average value of the empirical counterparts for the period 1999-2001. For the disutility of labor, α, the key target is the employment-to-population ratio (0.86) among individuals aged 25-64 years. Two other targets, the share of employment in non-entrepreneurial firms (88%) and the average worker earnings premium for these firms (33%), are important in pinning down a value for the job offer rate from the corporate sector, γ, and for the separation probability from entrepreneurial sector employment, ϕ_e. The job finding rate, λ, and the job separation rate from corporate sector employment, ϕ_f, are set so that the aggregate job separation rate (employment-to-nonemployment flows) is 1.9% as a fraction of total employment, and the aggregate job finding rate (nonemployment-to-employment flows) is 45%, based on Shimer (2012). Finally, the fraction of entrepreneurs, 3.1%, is targeted in assigning a value to the entrepreneurial ability parameter, μ. The fraction, 3.1%, is based on the estimates obtained from a wide-range of definitions and sources in Table 1.

5 Properties of the Baseline Model

The key features of the calibrated model's equilibrium are shown in Table 4. The model does a reasonable job in matching the targeted values. It produces an employment-to-population ratio of 0.86, consistent with its targeted value. Around 3.6% of the individuals choose to become entrepreneurs, a figure slightly higher than the targeted fraction of 3.1%, but well within the range of estimates in Table 1. As shown in Figure 1a, the individuals with a higher level of entrepreneurial ability tend to become entrepreneurs. Those who become entrepreneurs also tend to accumulate higher levels of assets (Figure 1b). Furthermore, entrepreneurial firms exhibit variation in their capital input, which has a skewed distribution (Figure 1c). The distribution of the labor input (in efficiency units) for the entrepreneurial firms in Figure 1d is also highly-skewed.[25]

[25] This shape is in line with the typical shape of the firm-level distributions of labor input in empirical studies. However, note that the labor input in the model (worker efficiency units) is different from the employment measure

The features of the model discussed so far also emerge in recent models of entrepreneurship, indicating that the model is able to capture the salient aspects of these models.[26]

The model's main distinguishing aspect, heterogeneous labor markets, enables it to provide further insight to the functioning of the labor markets and the nature of worker sorting. The calibrated model's equilibrium generates patterns that are broadly consistent with the behavior of the key metrics for the U.S. labor market. In the baseline model, 11% of the employees work for young firms, close to the value of 12% in the data, as seen in Table 4. The model also delivers a corporate earnings premium consistent with the observed value. The average worker earnings in the corporate sector is about 32% higher than that in the entrepreneurial sector, almost identical to the targeted value of 33%. Note that the average earnings in each sector depends on the distribution of worker productivity (z) in each sector, as well as the wages per efficiency units of labor (w_e, w_f). The values for w_e and w_f are obtained in the calibrated model's equilibrium, but there is no observable target to discipline their values. The wage per efficiency unit of labor in the corporate sector turns out to be 0.60, as opposed 0.58 in the entrepreneurial sector. In other words, the corporate sector offers about 3% higher wage per worker efficiency unit. The average worker productivity, on the other hand, is significantly higher in the corporate sector (1.64) than in the entrepreneurial sector (1.28). That is, a worker in the entrepreneurial sector is only about 78% as productive, on average, as a worker in the corporate sector. This sorting of individuals based on productivity drives in part the corporate earnings premium.

The model is calibrated to match the aggregate job finding rate (45%) from unemployment and the job separation rate from employment (1.9%). The calibrated model's equilibrium is broadly consistent with these worker flows–see, again, Table 4. However, a key question is whether the model also captures these flows by firm type, which are not targeted explicitly in the calibration. As shown in Table 4, the model does so quite well. In the data 21% of flows to nonemployment originate in entrepreneurial firms, and the model captures these flows closely (22%). Likewise, 23% of flows into employment go to entrepreneurial firms, as opposed to the model's figure of 16%. The model's ability to approximate the shares of flows in and out of employment accounted by entrepreneurial firms suggests that the model generates the appropriate amount of incentives for work among individuals facing employment prospects in entrepreneurial firms.

Figure 2a shows that individuals with higher managerial ability tend to become entrepreneurs. As managerial ability increases, individuals tend to shift from corporate sector employment to entrepreneurship, with little change in the allocation of individuals into entrepreneurial sector

(the number of workers) typically used in empirical studies of firm size.

[26]See, e.g., Quadrini (2000), Cagetti and De Nardi (2004), Kitao (2008), Buera and Shin (2011), Buera, Fattal-Jaef, and Shin (2015), and Bassetto, Cagetti, and De Nardi (2015).

work across managerial ability levels. Figure 2b illustrates how individuals at a given worker productivity level are allocated across the two sectors and entrepreneurship. As worker productivity increases, the fraction of individuals who work in the corporate sector increases, whereas the fraction of individuals who are entrepreneurs declines. However, the fraction employed in the entrepreneurial sector first decreases, and then increases at higher levels of productivity. As discussed below, this non-monotonicity is driven by how the distribution of assets across workers influences their decision to work in the entrepreneurial sector.

If entrepreneurial firms pay lower wages per efficiency unit, why does anyone work for them at all? Figure 2c shows the distribution of workers' assets by sector. The distribution in the entrepreneurial sector is much more skewed, with a high mass over the range of low asset levels. Table 4 indicates that average assets of the workers in the corporate sectors is nearly twice that of the workers in the entrepreneurial sector. When only the workers in their first quarter of a job is considered, the average assets for workers in the corporate sector is about 1.5 times that of those in the entrepreneurial sector – see Figure 2d for the distributions of assets by sector for these workers. That is, there is an average wealth differential not only between the workers in the two sectors, but also between the workers who have just *accepted* jobs (those in their first period of their employment spell) in these two sectors. The assets ratios in the model are also similar in magnitude to their empirical counterparts – see Section 6 for how these estimates are obtained. Because nonemployed individuals with low assets are not wealthy enough to secure a smooth stream of consumption while unemployed, they cannot afford to reject a job offer from the entrepreneurial sector and wait for a job offer from the corporate sector. In other words, the opportunity cost of waiting for a corporate offer is high for these individuals.

Figure 3a shows what types of individuals accept a job offer from the entrepreneurial versus corporate sector. The figure illustrates the acceptance/rejection regions for entrepreneurial and corporate offers by worker productivity and assets for a median realization of the managerial ability, θ. As an individual's assets increase, the threshold productivity for accepting a corporate sector job offer increases. Note also that, given assets, the productivity threshold for accepting a corporate sector offer always lies below the one for an entrepreneurial sector offer. In other words, individuals who take jobs in the entrepreneurial sector tend to be more productive. On the one hand, the wage differential implies a higher return to work in the corporate sector and generates an incentive for individuals to wait for a corporate job offer. On the other hand, the higher job separation rate in the corporate sector suggests that the return to work in corporate sector cannot be too large.

A notable feature of Figure 3a is that for an entrepreneurial job offer there is a portion of the rejection region that protrudes into the acceptance region, labeled as Region B. The presence of Region B indicates a non-monotonicity in the decision rule to accept employment in the entrepreneurial sector. Note that no such region exists for the decision rule for corporate sector work. Figure 3b shows the acceptance region for becoming an entrepreneur at the median managerial ability, θ. This figure indicates that individuals would not choose to become entrepreneurs inside the Region B highlighted in Figure 3a. In other words, individuals with types in Region B reject a job offer from the entrepreneurial sector in favor of continuing to be nonemployed and waiting for a corporate sector job offer.

One way to further understand the nature of Region B in Figure 3a is to examine the value functions for an individual with median entrepreneurial ability and median labor productivity, plotted in Figure 3c. The figure plots value functions for some subset of the parameter values underlying Region B. Note that in Figure 3c the value of leisure exceeds that of entrepreneurial work and both value functions are well-behaved. To understand the source of Region B further, consider the entrepreneurship choice in a partial equilibrium setting. Holding prices (w_f, w_e, r) fixed at their baseline values, suppose entrepreneurship is no longer available as a choice. What does the optimal decision rule look like for an individual with an entrepreneurial sector job offer? Figure 3d shows this new decision rule for an individual with median managerial ability. In this partial-equilibrium setting, individuals are much more choosy about accepting a job in the entrepreneurial sector. The main reason is that an incentive to work in order to accumulate assets to finance a potential entrepreneurial project in the future is now absent.[27] In other words, there is no incentive to accumulate capital outside the precautionary savings motive. As a result, the threshold productivity above which individuals would choose to work is higher than in the baseline economy.

Now consider an economy with a choice of entrepreneurship, but without any uncertainty in managerial ability at the time the entrepreneurship choice is made. That is, suppose that the timing is such that θ and z are both realized at the beginning of the period. The value from becoming an entrepreneur is now known before the entrepreneurship decision is made. The dashed line in Figure 3d represents the acceptance threshold in such an economy, with prices fixed again at their baseline values. In this economy individuals have a lower threshold for accepting employment opportunities, compared with the baseline economy. In particular, a region like Region B in Figure 3a is not present in Figure 3d. An individual with a realization of assets and productivity in Region B rejects a job in the entrepreneurial sector in the baseline economy, but accepts such a job in the economy without uncertainty about the managerial ability. The reason is that the uncertainty about the optimal scale of the entrepreneurial firm reduces the ex-ante return to working to accumulate assets to potentially become an entrepreneur in the future. This region disappears for low-asset individuals whose return from entrepreneurial activity is

[27] See also Hurst and Lusardi (2004) for evidence on the connection between household wealth and the decision to start a business under credit constraints.

smaller, and for high-asset individuals who can operate firms at their optimal scale even under the uncertainty.

6 Evidence on Worker Sorting by Assets

A key prediction of the baseline model is that the average asset holdings of workers in the entrepreneurial sector is lower than that of workers in the corporate sector. This difference emerges as a result of the sorting of workers into sectors based on both productivity and wealth. Workers holding fewer assets tend to accept job offers from the entrepreneurial sector. Is there empirical evidence on this type of sorting? The answer requires data on workers' assets and the characteristics of their employers.

Unfortunately, household survey data that include information on worker assets typically do not contain information on the age of a worker's employer. Towards addressing this shortcoming, the wealth data for workers in the Survey of Income and Program Participation (SIPP) are merged with the Longitudinal Employer-Household Dynamics (LEHD) data that captures employer characteristics for those workers. Specifically, the responses from the Asset and Liabilities Topical Module collected in several waves of the 2008 SIPP panel are used to create a net worth variable, excluding housing equity. The 2008 panel is chosen to maximize the number of possible linkages with the LEHD data due to limited number of participating states in earlier years of LEHD program. The net worth variable is calculated at the household level and used as the empirical counterpart to worker assets in the model. The workers in the SIPP sample are then linked to the LEHD data based on unique individual identifiers. For workers holding more than one job during the relevant quarter, firm age pertains to the firm where worker earnings were the greatest among all jobs held in that quarter. The sample is also restricted to prime age males with ages 25-54 who are not entrepreneurs, to be consistent with the baseline model's calibration. That is, the sample excludes those individuals whose sector-of-employment choices might be influenced by, for instance, schooling and retirement.

The top panel of Table 5 shows the mean and median net worth statistics by firm age. Both measures indicate a stark difference in average asset holdings of workers at young firms relative to others. In particular, workers in older firms have an average accumulated asset stock that is 50 to 200 percent higher than those of the workers in younger firms. It is also noteworthy that a larger fraction of the workers in younger firms are net borrowers, and report zero or negative net worth compared with the workers in more established firms. In general, higher wages in established firms relative to young firms would imply an asset differential even in the absence of sorting, as long as employment has some persistence. Further evidence on sorting of workers based on assets can be provided by examining the assets of recently employed workers only.

For this purpose, the sample is restricted to those workers who are in the first quarter of their employment spell after unemployment, based on the information on the quarter of employment in the LEHD data. This subsample allows for an approximation to the asset holdings of workers who have recently transitioned into employment from unemployment. The results are again shown in Table 5. There is a large net worth differential across workers in the two types of firms when measured by either the mean or median asset holdings. Therefore, the differential is not merely a result of the fact that working for higher-wage established firms allows individuals to accumulate more assets over time. Workers accepting jobs in these firms are on average wealthier to start with, in line with the model's prediction on sorting based on assets.

The bottom panel of Table 5 shows the extent to which worker sorting prevails when firm size is used instead of firm age to define entrepreneurial firms. Although the results are generally weaker, the net worth differential remains for the median asset holdings, with a slightly smaller magnitude. In particular, the median worker in larger firms has net worth of $20,642 compared with $9,397 in smaller firms. Finally, as a check of the representativeness of the SIPP subsample relative to the more aggregated statistics on worker earnings in Table 1, average worker earnings are calculated by firm age. The average earnings premium for workers in older firms (5+ years of age) in the sample containing all workers is 24%, versus 15% in the sample containing only the workers in their first quarter of employment. Both of these figures are within the range of estimates in Table 1, suggesting that these samples are not nonrepresentative.

7 Experiments

This section analyzes how the properties of the model's equilibrium respond to changes in the key parameters. The approach is to change each parameter from its baseline value holding all others constant at their baseline values, and compare the resulting equilibrium with the baseline. There are two motivations for this exercise. The first one is to understand the workings of the model in further detail: What kind of changes occur in the model's properties as one of the key parameters shifts? Does the main result on worker sorting survive? Under what cases does the sorting get weaker or stronger? The second motivation is to assess the model's ability to generate some of the trends documented for entrepreneurial firms in recent research. What changes in the parameters lead to a decline in the entrepreneurial sector of the model economy that is qualitatively consistent with the empirical trends exhibited by the key metrics for entrepreneurial firms?

Some of the trends for entrepreneurial firms are summarized in Figure 4 (see also Table 2). These trends have been the focus of recent research on the decline of entrepreneurial activity represented by new and young firms and are summarized in this section for convenience.[28] In particular, the number of young firms has been stagnant, even as the number of established firms grew (Figure 4a), the share of employment accounted by young firms has been falling (Figure 4b), the relative average worker earnings in young firms has been decreasing (Figure 4c), and the average size of young firms, as measured by employment, has been shrinking relative to that of established firms (Figure 4d).[29]

Many potential explanations for the decline in entrepreneurship have been proposed. One hypothesis is that changes in the technologies for workers' job search and firms' vacancy posting altered labor market frictions in a way to put entrepreneurial firms at a disadvantage relative to more established firms.[30] A lower worker mobility across firms, particularly for younger workers, has accompanied the decline in entrepreneurship. Given the evidence that young firms disproportionately draw their labor force from young and nonemployed individuals, the two trends are not independent. Increasing labor market frictions for young firms and workers, and a rise in the established firms' dominance in access to job seekers may have made it more difficult for entrepreneurial firms to match with the type of workers who would work for them.

Another potential reason behind the decline is increasing financial frictions for entrepreneurs. Recent research has focused on various implications of a tighter credit environment for businesses caused by the onset of the Great Recession.[31] In addition to impeding entry, limited availability of credit can also inhibit the expansion of entrepreneurial businesses. However, while financial constraints may have become more binding in the short run, they may have actually become less restrictive in the long run as a result of the changes in the financial sector. Thus, the effects of the financial environment on entrepreneurial firms may be different in the long- versus short-run.

Another hypothesis for the decline has to do with the supply of entrepreneurs. Some policies may have curbed the availability of able entrepreneurs and contribute to the underwhelming performance of the entrepreneurial sector.[32] Increasing costs of education, training, and more generally, human capital accumulation, can also reduce the pool of skilled entrepreneurs. De-

[28] See, e.g., Decker, Haltiwanger, Jarmin, and Miranda (2014a,b).

[29] The average size is the total employment in young firms divided by the number of young firms. This measure has the obvious counterpart in the model as ratio of the mass of individuals working for entrepreneurial firms to the mass of such firms, despite the fact that the size of an entrepreneurial firm is defined in efficiency units of labor, and the number of employees for any given entrepreneurial firm is therefore indeterminate.

[30] See Decker, Haltiwanger, Jarmin, and Miranda (2014a) for a discussion. Recent work on these issues include Cairo (2013), who analyzes the role of increasing training costs on job reallocation.

[31] See, for instance, Haltenhof, Lee, and Stebunovs (2014) for a study of the effects of tighter bank lending on consumers and firms. Other channels, such as the effects of the reduced housing assets of consumers who are potential entrepreneurs, have also been explored. See Decker (2015) for an analysis of this channel.

[32] For instance, Hathaway and Litan (2014b) argue that immigration policy in the U.S. may have limited the supply of skilled entrepreneurs.

mographic shifts in the form of an aging U.S. population may have also reduced the supply of able entrepreneurs and played a part in the declining dynamism of the entrepreneurial sector.[33] Some changes in the broader business climate (e.g. laws and regulations and taxes) may also have adversely affected new business formation and expansion.

The experiments with the parameters of the model aim to understand the relevance of some of the hypotheses discussed above. The analysis below does not, however, attempt to quantitatively match the trends in the entrepreneurial sector. The basic goal is to understand what factors in the model are capable of matching the directions of change in various metrics for the entrepreneurial sector highlighted in Figure 4. A quantitative assessment of the contribution of different channels to the decline in entrepreneurship is left for future work.[34] Of particular interest is whether the baseline model's key prediction of worker sorting based on assets and productivity changes in response to shifts in the parameters.

7.1 Labor Market Frictions

7.1.1 Job Finding Rate

In the baseline model, the job offer probability is $\lambda = 0.56$. In this experiment, λ is assigned the values in the set $\{0.2, 0.3, 0.6, 0.8\}$, to explore the effects of a change in the frictions in job finding. Lower values of λ imply that jobs are more scarce and it takes longer on average for a nonemployed individual to receive a job offer. A scarcity of jobs reduces the number of individuals who work. Both the entrepreneurial and corporate sectors now have to pay higher wages to attract workers. This effect leads to a rise in the cost of entrepreneurship. As shown in Figure 5a, the fraction of individuals who are entrepreneurs and who work in the entrepreneurial sector both decline as λ falls. At the same time, Figure 5b indicates that as λ decreases from 0.8 to 0.3 both the wage and average earnings in the corporate sector increase relative to their counterparts in the corporate sector. Average labor productivity and average assets of workers in the corporate sector relative to the entrepreneurial sector, both pictured in Figure 5c, increase as λ falls over the same range. A similar, but less pronounced pattern is seen when only the workers in their first quarter of a job is considered. In addition, average firm size in the entrepreneurial sector, as measured by the number of workers per firm, tends to increase as λ falls from 0.8 to 0.3 (Figure 5d).

Note, however, that as λ further decreases from 0.3 to 0.2, the directions of change in many of

[33] For the connection between aging and entrepreneurship, see, e.g., Liang, Wang, and Lazear (2014), who find a significant negative effect of aging on business formation rate across countries.

[34] One avenue for future work is to uncover how much a given parameter needs to change to generate the exact magnitudes of decline in the key metrics for the entrepreneurial sector.

the variables in Figures 5b,c,d reverse. The intuition behind this reversal is that in an economy where jobs are very scarce individuals become less choosy about where they work. They cannot afford to reject entrepreneurial sector job offers in favor of waiting for a corporate sector offer since the waiting time can be quite long when λ is very low. As a result, the sorting of workers across the two sectors becomes less pronounced, as indicated by falling relative average earnings, productivity, and assets, going from $\lambda = 0.3$ to $\lambda = 0.2$. Overall, this experiment demonstrates that an increasing scarcity of jobs is capable of leading to the observed directions of change in many aspects of entrepreneurship. One aspect that is not consistent with the observed patterns of entrepreneurial decline pictured in Figure 4 is the increase in the average employment of entrepreneurial firms as jobs become more scarce.

7.1.2 Entrepreneurial Sector Job Offer Rate

In the baseline case, the conditional probability that a job offer is from the corporate sector is $\gamma = 0.75$, which gives the corporate sector an advantage in hiring. In this experiment, the likelihood that an offer comes from the corporate sector is assigned values in the set $\{0.1, 0.3, 0.6, 0.8, 0.9\}$. This experiment explores whether increasing frictions in hiring for entrepreneurial firms may lead to a decline in entrepreneurship.

A decline in the (conditional) entrepreneurial sector job offer probability (a higher γ) has a negative effect on entrepreneurship (Figure 6a). Similarly, the share of employment in the entrepreneurial sector shrinks. Note that much of the drop in the variables in Figure 6a occurs as γ increases from 0.1 to 0.3, and little change takes place for higher values. In response to an increase in γ, the corporate earnings premium declines, along with the wages in the entrepreneurial sector (Figure 6b). When entrepreneurial sector jobs are harder to find (higher values of γ), this sector has to offer a higher wage per efficiency unit to attract workers, which results in higher relative average worker earnings in the entrepreneurial sector. Because the wage gap disappears as γ increases, workers are more evenly distributed across the two sectors based on average worker productivity and assets, as shown in Figure 6c. Hence, worker sorting by assets and productivity becomes less pronounced. A similar pattern applies to the case of workers in their first quarter of employment.

Average employee size of a firm in the entrepreneurial sector is non-monotonic over the range of values examined in this section. It increases for values of γ below 0.6, but decreases for values above 0.6 (Figure 6d). The decrease associated with larger values of γ stems from a smaller decline in the entrepreneurial sector workforce relative to the decline in the entrepreneurship rate. That is, for values of γ closer to its baseline value, changes in firm size are largely due to changes in the number of workers choosing to enter entrepreneurial employment, rather than changes in incentives to become an entrepreneur.

This experiment captures qualitatively some of the trends in Figure 4 that the entrepreneurial sector has exhibited. As γ increases, the decline that takes place in the rate of entrepreneurship and the share of employment in the entrepreneurial sector is consistent with the directions of observed trends. What is not consistent with the trends, however, is the erosion of the corporate earnings premium that accompanies an increase in γ.

7.1.3 Entrepreneurial Sector Job Separation Rate

Suppose now that the separation rate in the entrepreneurial sector, ϕ_e, increases gradually from its baseline value of zero to 0.03. The values of ϕ_e experimented with are $\{0.003, 0.006, 0.01, 0.03\}$. Recall that the separation rate in the corporate sector for the baseline model is 0.006. The purpose of this experiment is to assess the effect of employment spells becoming more temporary in the entrepreneurial sector.

In response to an increase in ϕ_e from its baseline value of zero, the fraction of entrepreneurs goes down, but the share of employment in the entrepreneurial sector is non-monotonic over the range of values experimented (Figure 7a). The relative wage in the entrepreneurial sector falls as ϕ_e increases (Figure 7b). However, relative average earnings first falls and then increases. This non-monotonicity mimics the pattern for worker sorting by productivity in Figure 7c. As ϕ_e increases, average productivity of workers in the corporate sector first falls relative to that in the corporate sector, but then increases. At the same time, worker sorting based on assets also changes, with relative average assets first falling and then increasing.

When the separation rate increases from zero, the return to work in the entrepreneurial sector initially declines. Workers with relatively high productivity and wealth are then less likely to reject employment in the entrepreneurial sector. As ϕ_e increases, these types of workers represent a higher fraction of entrepreneurial employment. In particular, note that when ϕ_e equals $\phi_c = 0.006$, the baseline model's sorting result is reversed: the relative average assets of workers in the entrepreneurial sector is now higher. However, as ϕ_e increases above 0.01, relative productivity of workers in the corporate sector again increases.

For values of ϕ_e between 0.006 and 0.025, workers in the corporate sector tend to have lower average assets relative to those in the entrepreneurial sector. In contrast, the average assets of workers in their first quarter of employment decline monotonically as ϕ_e increases (Figure 7c). Note also that the average size of an entrepreneurial firm initially declines as the separation rate increases and then rises (Figure 7d).

While a rise in the separation rate in the entrepreneurial sector leads to a decline in entrepreneurship, many of the key metrics in the entrepreneurial sector (relative average earnings, relative average assets, and average employment) are non-monotonic over the range of values considered. Nevertheless, an increase the separation rate from its baseline value would result in changes in equilibrium allocations that are broadly consistent with those established in Figure 4, with the exception of average employment in entrepreneurial firms.

7.2 Financial Frictions

In this experiment, the borrowing parameter b is assigned values in the set $\{1, 1.25, 2, 3, 4\}$, in addition to its baseline value of $b = 1.5$. The case $b = 1$ corresponds to an economy with no borrowing. Higher values of b correspond to increasingly relaxed borrowing constraints. It is important to consider several values for the parameter b, given that the literature on entrepreneurship has mainly relied on a limited set of values for this parameter.[35]

The effect of reducing borrowing to $b = 1$ from its baseline value of 1.5 is pronounced for all aspects of entrepreneurship, as shown in Figure 8a. An inability to borrow discourages entrepreneurship, and the fraction of entrepreneurs falls. There is an accompanying fall in the share of employment in the entrepreneurial sector. Note also that the marginal effect of the borrowing limit on entrepreneurship and the employment share in the entrepreneurial sector declines as the borrowing constraint is increasingly relaxed.

The corporate earnings premium increases sharply in response to a tightening in the borrowing limit from its baseline value (Figure 8b). A higher borrowing limit allows the entrepreneurial sector to offer a wage closer to that in the corporate sector, and the earnings differential between the two sectors shrinks. The gap between the average assets for workers in the two sectors also becomes smaller (Figure 8c). Thus, the baseline model's worker sorting based on assets vanishes at higher levels of b. A similar picture emerges for the average assets of workers in their first quarter of employment. Figure 8c also indicates that the average labor productivity in the entrepreneurial sector modestly declines as the borrowing limit increases, relative to that in the corporate sector. As b increases, the average size of an entrepreneurial firm also decreases for values of b close to 1.5, but increases for values above 3. This illustrates that changes in the borrowing parameter b around its baseline value has a larger impact on the number of entrepreneurs, rather than the employment in entrepreneurial firms. As b increases beyond a value of 3, there is less movement of individuals into entrepreneurship, but a more pronounced change in the employment share of the entrepreneurial sector.

The experiments indicate that when borrowing is more constrained, fewer individuals become entrepreneurs and hire less workers. The wage in the entrepreneurial sector and the average earnings of workers also fall relative to their corporate sector counterparts. Tighter constraints also have implications on what kind of workers are matched with entrepreneurial firms. As borrowing

[35] Several studies use a value of $b = 1.5$ (see, e.g., Kitao (2008) and Buera and Shin (2011)), but sensitivity with respect to this paramater is rarely explored.

becomes more difficult, relative productivity and wealth of workers in the entrepreneurial sector both increase, which we take as more pronounced evidence of worker sorting. This experiment suggests that tighter financial constraints are capable of generating a decline in many aspects of entrepreneurship consistent with the directions of change in key metrics summarized in Figure 4. However, the increase in average employment of an entrepreneurial firm induced by tighter borrowing constraints is not consistent with the slight decline average firm size documented in Figure 4d.

7.3 Entrepreneurial Ability

To assess the implications of a reduction in the quality of entrepreneurs, this experiment assigns values to the average entrepreneurial productivity, $\exp(\mu)$, over the range $(0.4, 0.5)$. Recall that in the baseline model, $\exp(\mu)$ is equal to 0.46. The changes in μ considered in this experiment are first-order stochastic shifts in entrepreneurial ability, that is, shifts in the mean of entrepreneurial ability, but no change in its variance. This experiment aims to explore the hypothesis that a fall in the supply of skilled entrepreneurs, brought about, for instance, by demographic shifts, aging, or some policies, led to the decline in the entrepreneurial sector.

Figure 9a indicates that a degradation in the average quality of entrepreneurs leads to a lower fraction of entrepreneurs in the economy. The share of employment in the entrepreneurial sector also falls. Corporate earnings premium increases substantially, even though the relative wage remains fairly stable (Figure 9b). The different patterns for wages and average earnings suggest that the sorting of the individuals into the two sectors is now more pronounced. The changes in sorting are highlighted in Figure 9c. The relative average assets of workers in the corporate sector goes up when entrepreneurial ability declines. The relative average productivity of workers in the entrepreneurial sector also increases. In other words, a degradation in the average quality of entrepreneurs is accompanied by a degradation in the average quality of workers who work for them, relative to those in the corporate sector. Again, these patterns continue to hold when only the workers in their first quarter of employment are considered.

Average employment of an entrepreneurial firm also declines as the entrepreneurial ability improve (Figure 9d). This is driven by the presence of a borrowing constraint. As the mean entrepreneurial ability, $\exp(\mu)$, increases, the fraction of individuals who choose to become entrepreneurs increases, but the scale of firms that can be financed does not increase proportionally since the borrowing constraint remains fixed at its baseline value. The result is an increase in the mass of entrepreneurial firms that do not achieve their optimal size, which induces a reduction in average employment in the entrepreneurial sector. Overall, this experiment suggests that a decline in entrepreneurial ability can generate patterns consistent with many facets of the observed decline in the entrepreneurial sector.

8 Conclusion

Entrepreneurial firms, which tend to be young and small, disproportionately hire younger workers and those who come from nonemployment. These firms also provide lower earnings to their workers, compared to older and larger firms. To account for these differences, this paper proposed a dynamic model of entrepreneurship, which features labor markets for two sectors, entrepreneurial and corporate, that vary in search frictions. The two sectors also possess different production technologies and face different financial constraints. These differences lead to a divergence in sectoral wages per unit of worker efficiency and induces sorting of workers across the two sectors based on both productivity and wealth.

The calibrated model's equilibrium offers an answer to the main question of who works for whom. Among individuals who look for work, less wealthy ones tend to take up job offers from the low-paying entrepreneurial sector, instead of waiting for a corporate job offer. This tendency results in a sorting of individuals across the two sectors by both wealth and productivity. The model is also able to account for the observed differences across the two sectors in employment shares, average worker earnings, and worker flows. The model's key prediction on worker sorting based on wealth finds support in the data. Both the workers employed in young firms and those who are in their first quarter of tenure in these firms possess, on average, lower assets than their counterparts in more established firms.

To understand further the mechanisms behind worker sorting, experiments were run by altering the key parameters of the model one at a time and comparing the resulting equilibria with the baseline. Two conclusions emerge from these experiments. First, the model is able to generate plausible equilibrium values for the variables of interest over a wide range of values for each key parameter. Worker sorting based on assets and productivity survives in many of the experiments, but the degree of sorting depends on the values of the key parameters governing labor market and financial frictions. Stronger sorting (higher relative average assets in the corporate sector) is observed when the overall job finding rate, the borrowing limit, and the average entrepreneurial ability is lower compared to their baseline values. Second, the experiments suggest that a variety of channels, including an increase in financial frictions and a decline in the quality of entrepreneurs, can qualitatively generate many of the observed trends in the recent literature on the decline of entrepreneurial activity. While these experiments are helpful in assessing the relevance of some potential channels at work in the decline of entrepreneurship, they are not meant to capture the quantitative aspects of the decline. A challenge for future work is to quantify the contribution of each potential channel and identify which channels are the most important.

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Table 1. Alternative measures of the fraction of entrepreneurs in the economy

Basis	**Fraction of entrep.**	**Non-entrep. Firm Pay Premium**	**Employment Share**	**Source**
Young and small firms (0-5 yr & emp $\leq$ 7)	1.1%	20.8%	3.6%	LBD
Young and small firms (0-5 yr & emp $\leq$ 15)	1.3%	18.5%	5.9%	LBD
Young firms (0-5 yr)	1.4%	17.2%	15.7%	LBD
Young (0-5 yr) + small old (6+ yr & emp $\leq$ 7) firms	3.1%	39.7%	20.8%	LBD
Young (0-5 yr) + small old (6+ yr & emp $\leq$ 15) firms	3.5%	44.7%	25.4%	LBD
Small firms (emp $\leq$ 10)	3.1%	33.5%	11.8%	LBD
Small firms (emp $\leq$ 20)	3.5%	36.7%	18.6%	LBD
Small firms (emp $\leq$ 25)	3.6%	37.4%	21.0%	LBD
Young firms (0-10 yr)	2.0%	16.6%	24.8%	LBD
Young (0-10 yr) + small old (11+ yr & emp $\leq$20) firms	3.7%	49.8%	33.1%	LBD
Firms classified with certainty as non-public	3.8%	45.2%	44.0%	SBO
Business owners with employees (Males 25-64)	2.9%	NA	NA	SIPP
Business owners with employees (Males 25-54)	2.8%	NA	NA	SIPP
Business owners with employees (All)	2.4%	NA	NA	SIPP
Business owners with employees (All 25-54)	2.3%	NA	NA	SIPP

Notes: The data sources are Longitudinal Business Database (LBD), Survey of Business Owners (SBO), and Survey of Income and Program Participation (SIPP). All estimates pertain to the year 2000, except for the case of SBO, in which case the reference year is 2007. The denominator used to calculate the fraction of entrepreneurs is the population 25-64 years of age unless indicated otherwise. The calculations assume that each entrepreneurial firm is owned by a single.

Table 2. Some facts about entrepreneurial firms

Metric	**Young Firms** (0-5 years of age) **1987**	**2000**	**2012**	**Small Firms** ($\leq$ 20 employees) **1987**	**2000**	**2012**
Share of firms	0.48	0.41	0.33	0.90	0.89	0.90
Share of employment	0.21	0.16	0.11	0.21	0.19	0.18
Relative median of the firm-level average earnings	0.79	0.85	0.75	0.72	0.73	0.76
Relative average firm employment	0.28	0.26	0.25	0.03	0.03	0.02
Share of hires from nonemployment	–	0.24	0.26	–	0.26	0.27
Share of separations to nonemployment	–	0.21	0.23	–	0.26	0.27
Relative share of hires from nonemployment	–	1.05	1.04	–	1.20	1.18
Relative share of separations to nonemployment	–	1.03	1.05	–	1.24	1.20

Notes: The data sources are Longitudinal Business Database (LBD) and Longitudinal Employer-Household Database (LEHD). A young firm is defined as one that is 0-5 years old. A small firm is defined as one that has at most 20 employees. "Relative" indicates that the value is expressed relative to that of the firms that are not young (more than 5 years old) . or that are large (have more than 20 employees).

Table 3. The parameter values for the baseline model

Parameter	Value	Target/Source
Disutility from labor, α	0.66	Fraction employed–25-64 yrs old males (0.86)
Discount rate, β	0.985	Annual interest rate (0.04) (Business cycle literature)
Job separation rates, $\{\phi_e, \phi_f\}$	$\{0.000, 0.006\}$	Separation rate from employment (1.9%)
Job offer rate, λ	0.56	Job finding rate from unemployment (45%)
Corporate sector job offer rate, γ	0.75	Share of employment in the corporate sector (0.88)
Labor productivity, $\{\rho_z, \sigma_z\}$	$\{0.97, 0.13\}$	Heathcoate et al. (2010)
Entrepreneurial ability (Persistence), $\{\rho_\theta, \sigma_\theta\}$	$\{0.30, 0.18\}$	Estimated based on Abraham and White (2015)
Entrepreneurial ability (Mean), μ	0.37	Fraction of entrepreneurs (3.1%)
Productivity of the corporate sector, A	0.36	Normalization
Borrowing limit, b	1.50	Kitao (2008)
Capital share in production, ν	0.36	Business cycle literature
Capital depreciation rate, δ	0.06	Annual depreciation rate
Returns-to-scale in entrepreneurship, ξ	0.88	Estimated based on Abraham and White (2015)

Notes: See Appendix B for the estimation of returns-to-scale for entrepreneurs and the parameters for the entrepreneurial ability process.

Job separation and finding rates are taken from Shimer (2012). The fraction of entrepreneurs is based on the estimates in Table 1.

Table 4. The properties of the baseline model

Variable	**Model**	**Data**
Employment-to-population ratio	0.86	0.86
Share of employment (Entrepreneurial)	0.11	0.12
Fraction of entrepreneurs	0.036	0.031
Average worker productivity (Corporate)	1.64	NA
Average worker productivity (Entrepreneurial)	1.28	NA
Corporate average earnings premium	0.33	0.32
Share of E-to-N transitions (Entrepreneurial)	0.22	0.21
Share of N-to-E transitions (Entrepreneurial)	0.16	0.23
Interest rate, r	0.010	0.010
Wage per efficiency unit, w_f (Corporate)	0.60	NA
Wage per efficiency unit, w_e (Entrepreneurial)	0.58	NA
Ratio of average worker assets (Corporate/Entrepreneurial)	1.92	1.50
Ratio of average worker assets in first quarter of job (Corporate/Entrepreneurial)	1.49	1.57

Notes: Employment-to-population ratio is based on the population 25-64 years old. Share of employment in the entrepreneurial sector and corporate earnings premium are based on the Longitudinal Business Database (LBD). Fraction of entrepreneurs is based on the estimates in Table 2. The estimates for average worker assets are based on Survey of Income and Program Participation (SIPP)–see Section 6. E-to-N and N-to-E transitions are taken from Shimer (2012).

Table 5. Household net worth by firm age and size

	Household Net Worth			
	Mean		Median	
Firm Age:	0-5 **Yrs.**	6+ **Yrs**	0-5 **Yrs.**	6+ **Yrs**
Net Worth (All)	$79,019	$118,192	$6,950	$18,657
	(6,019)	(5978)	(885)	(633)
Fraction with non-positive net worth	28.2%	21.1%		
	(0.52)	(0.19)		
N	2,110	23,827	2,110	23,827
Net Worth (At First Quarter of Job)	$42,410	$66,740	$4,930	$5,820
	(4,411)	(3,189)	(1,053)	(772)
Fraction with non-positive net worth	33.7%	30.9%		
	(1.31)	(0.71)		
N	306	1,385	306	1,385
Earnings (All workers)	$9,680	$12,053	$6,994	$9,348
	(172)	(74)	(180)	(94)
N	2,110	23,827	2,110	23,827
Earnings (At first quarter of job)	$5,773	$6,650	$3,270	$4,002
	(362)	(128)	(273)	(162)
N	306	1,385	306	1,385
Firm Size:	$<$ 50 **Emp.**	50+ **Emp.**	$<$ 50 **Emp.**	50+ **Emp.**
Net worth (All workers)	$121,349	$113,061	$9,397	$20,642
	(13,570)	(5,981)	(551)	(839)
Fraction with non-positive net worth	25.5%	20.7%		
	(0.38)	(0.21)		
N	6,131	19,806	6,131	19,806
Net worth (At first quarter of job)	$54,592	$66,069	$5,011	$6,049
	(4,289)	(3,523)	(845)	(726)
Fraction with non-positive net worth	32.0%	31.1%		
	(1.12)	(0.78)		
N	540	1,151	540	1,151
Earnings (All workers)	$9,255	$12,639	$7,221	$9,896
	(120)	(84)	(89)	(102)
N	6,131	19,806	6,131	19,806
Earnings (At first quarter of job)	$5,257	$7,066	$3,404	$4,124
	(222)	(149)	(236)	(149)
N	540	1,151	540	1,151

Notes: Standard errors in parentheses. The data sources are Longitudinal Employer-Household Database (LEHD), and Survey of Income and Program Participation (SIPP).

Figure 1. The distributions of entrepreneurial ability, assets, capital input and labor input – baseline model

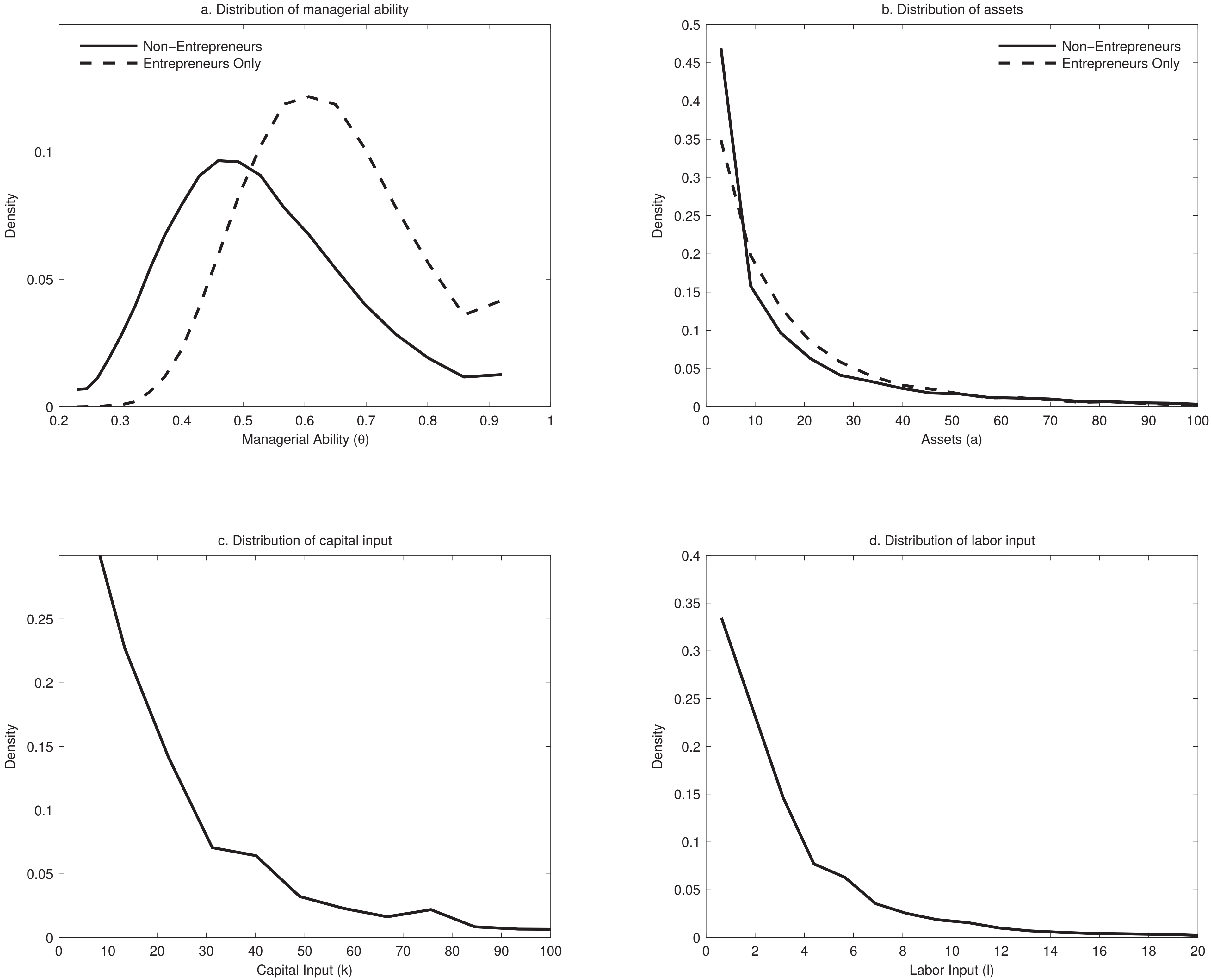


Figure 2. Allocation of individuals – baseline model

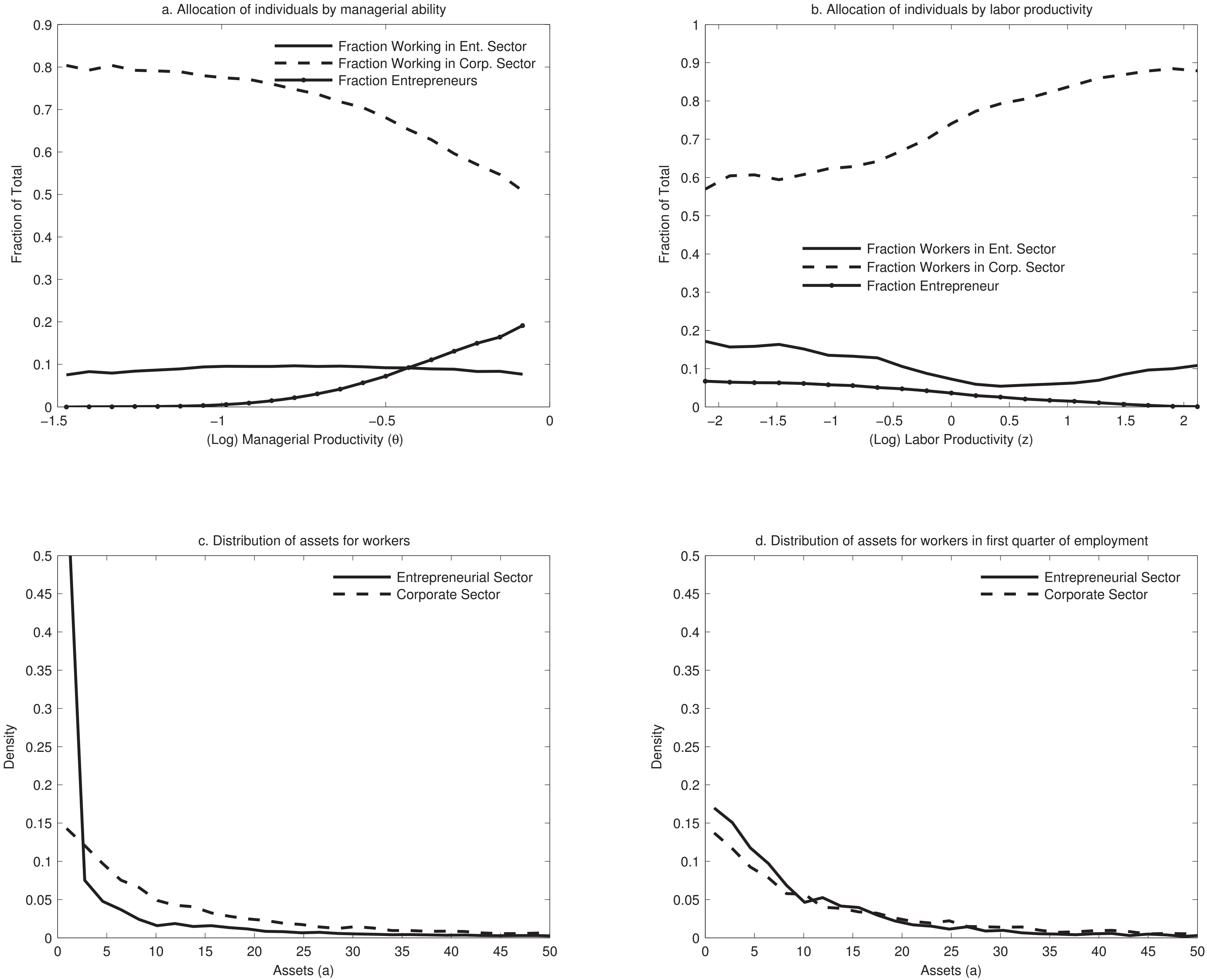


Figure 3. Individual value functions and decision rules – baseline model

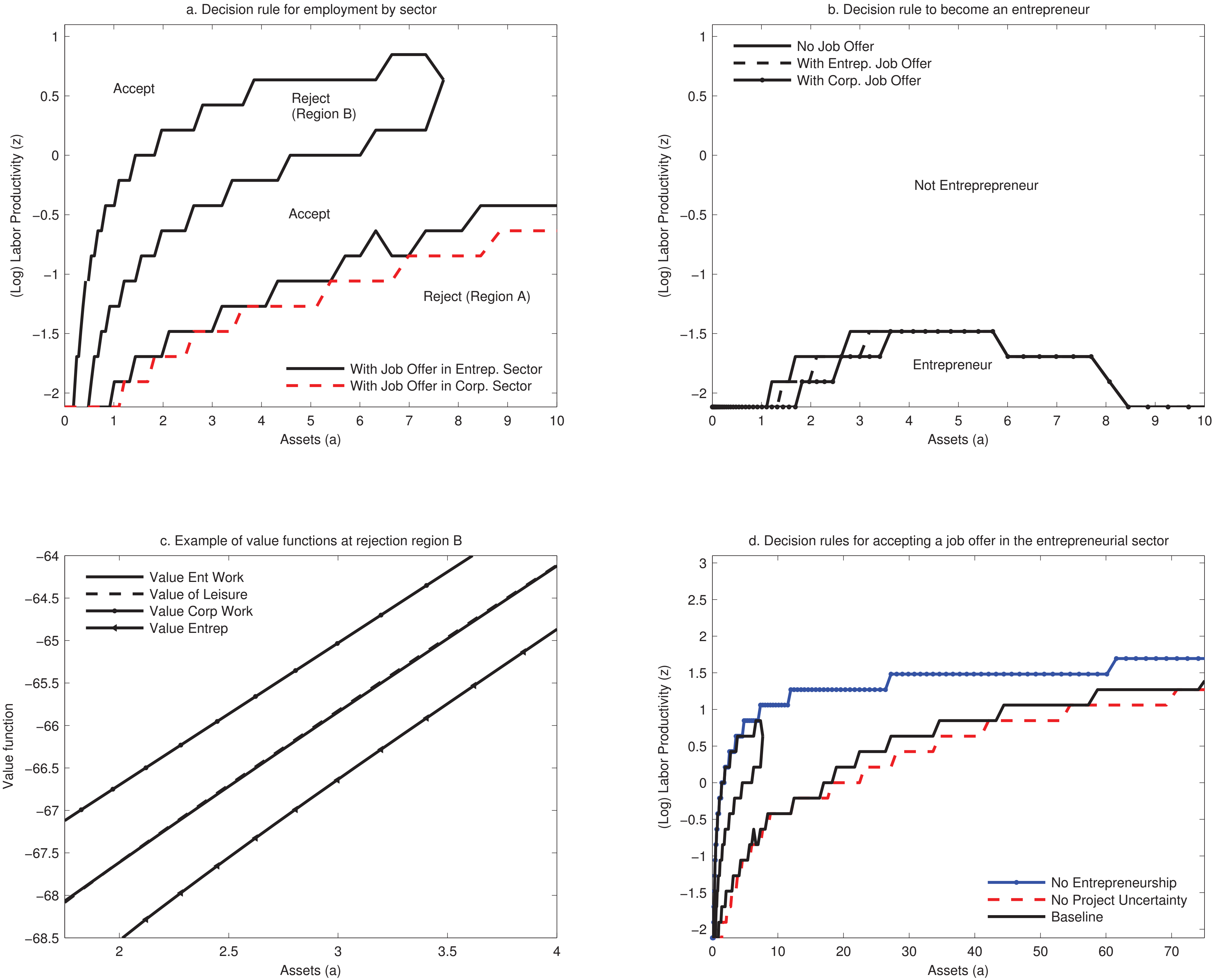


Figure 4. Various dimensions of decline of entrepreneurial firms in the U.S.

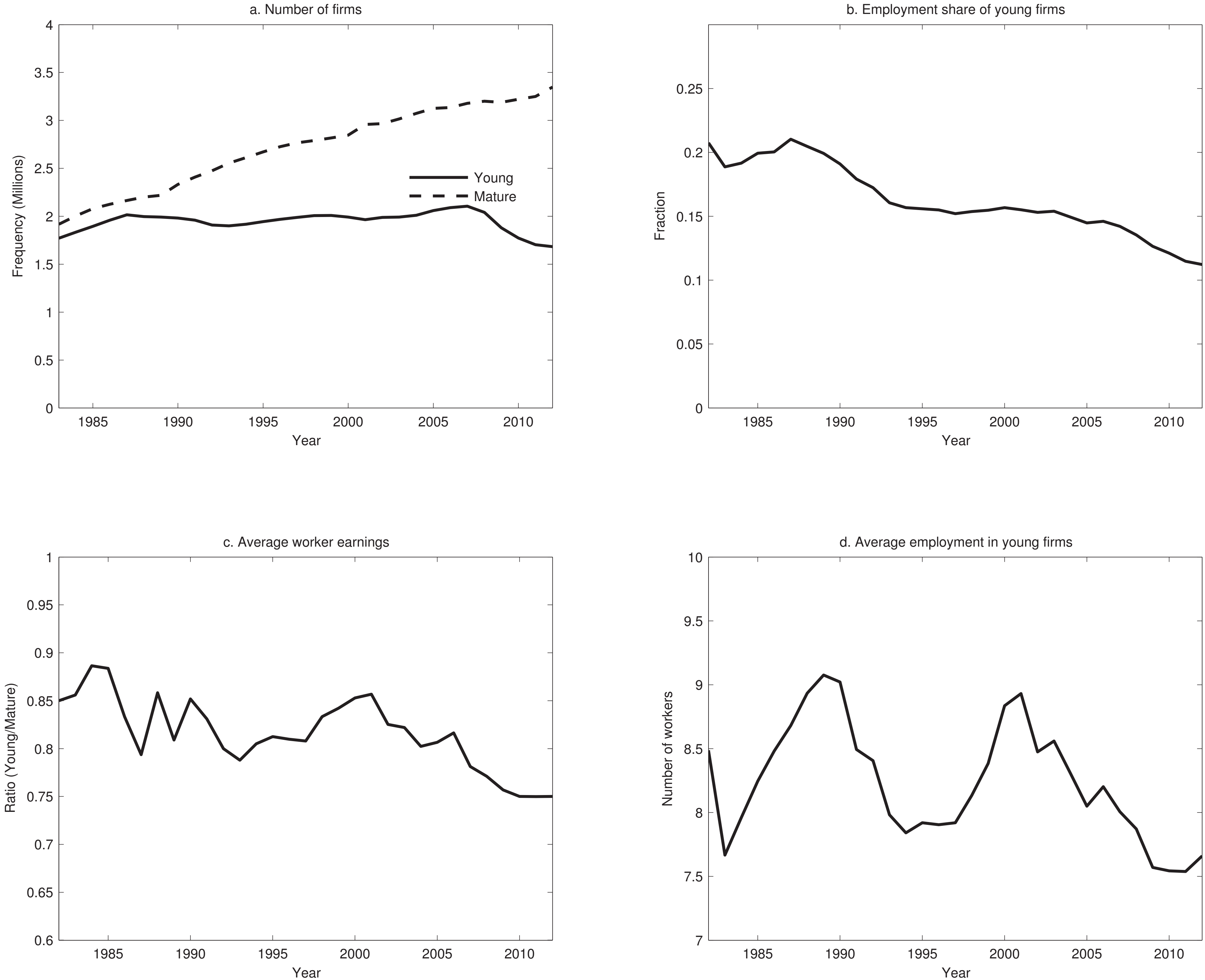


Figure 5. Experiments with job finding rate – vertical dashed line indicates baseline value (0.56)

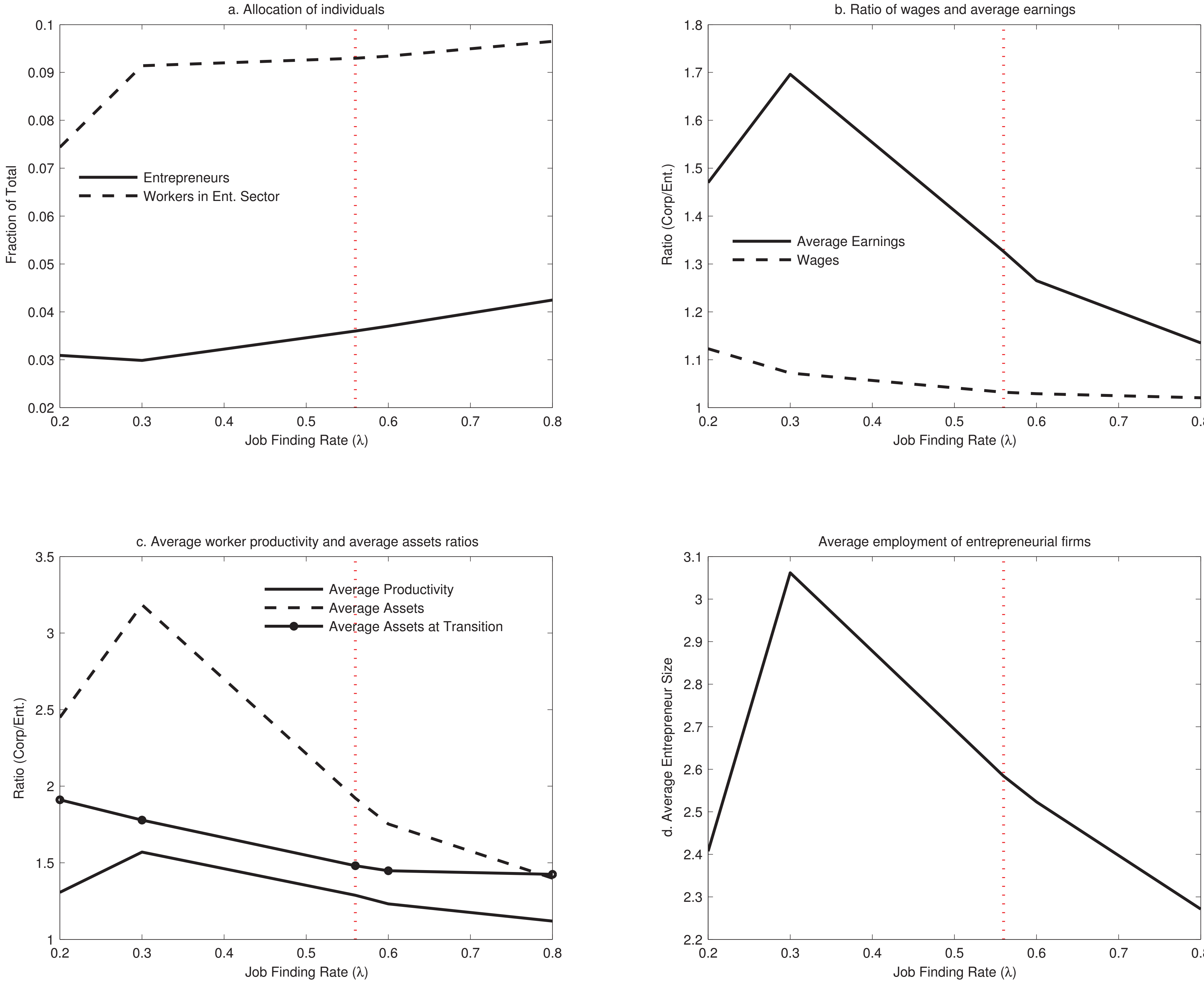


Figure 6. Experiments with corporate sector job offer rate – vertical dashed line indicates baseline value (0.75)

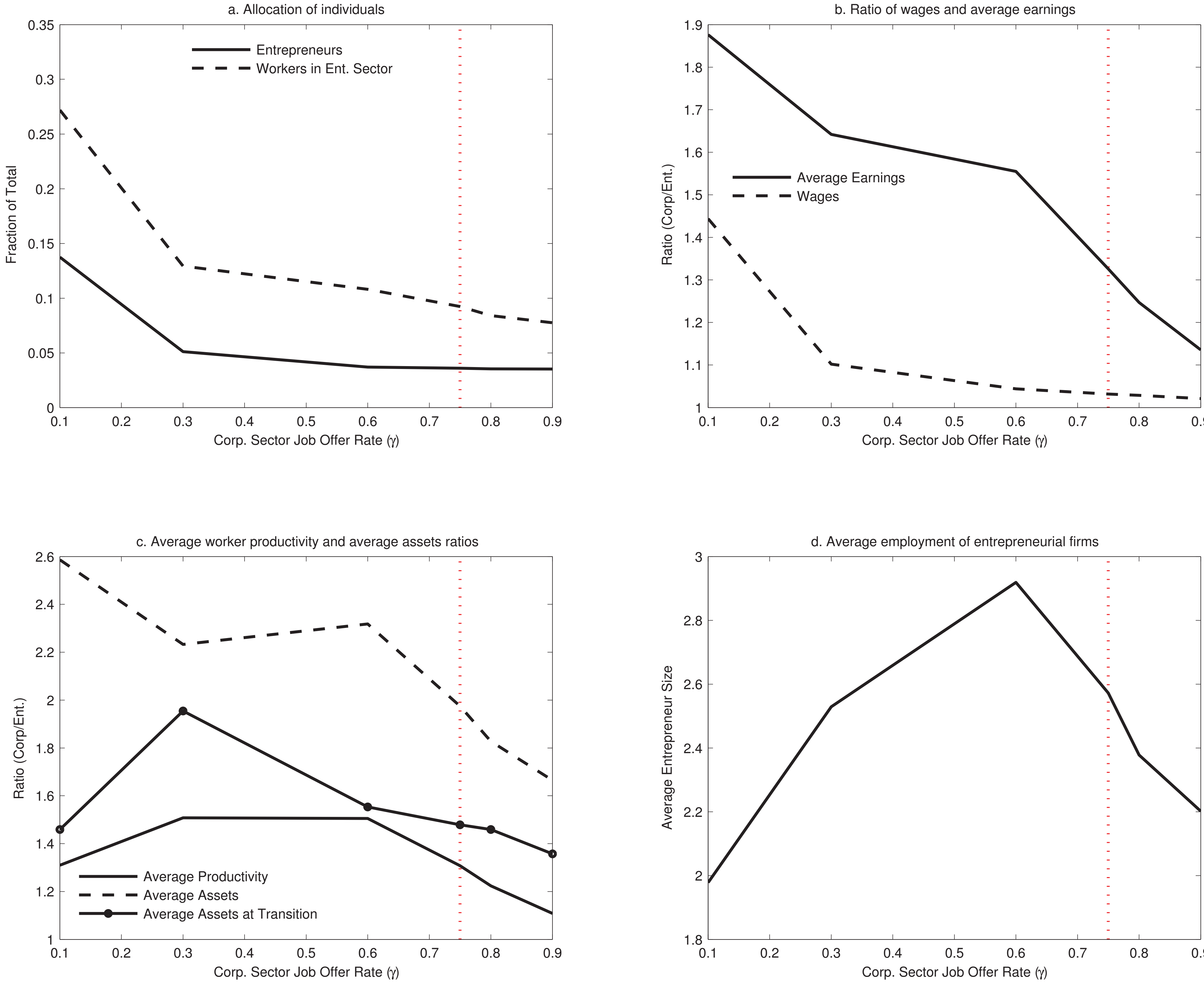


Figure 7. Experiments with entrepreneurial sector separation rate – vertical dashed line indicates baseline value (0.0)

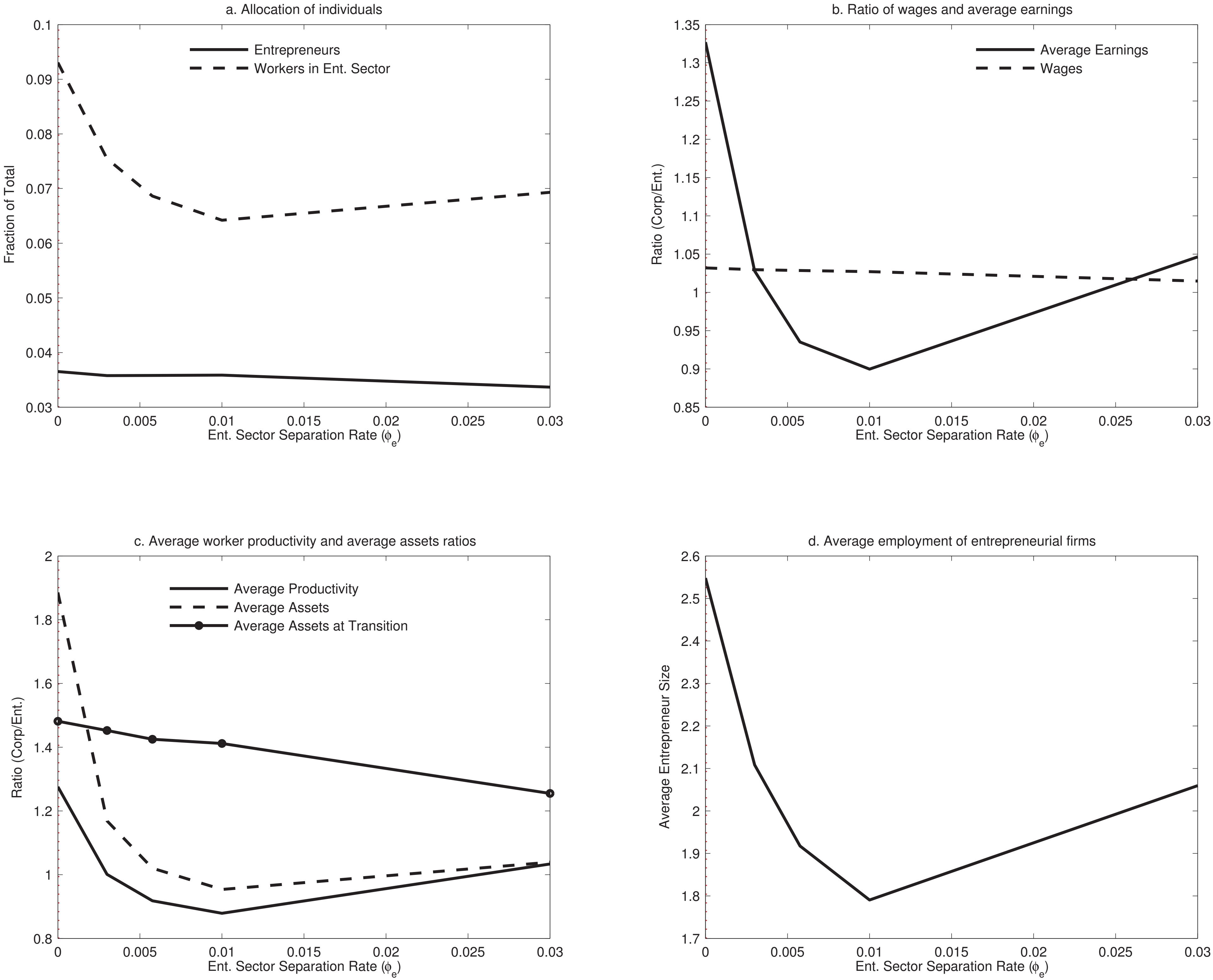


Figure 8. Experiments with borrowing limit – vertical dashed line indicates baseline value (1.5)

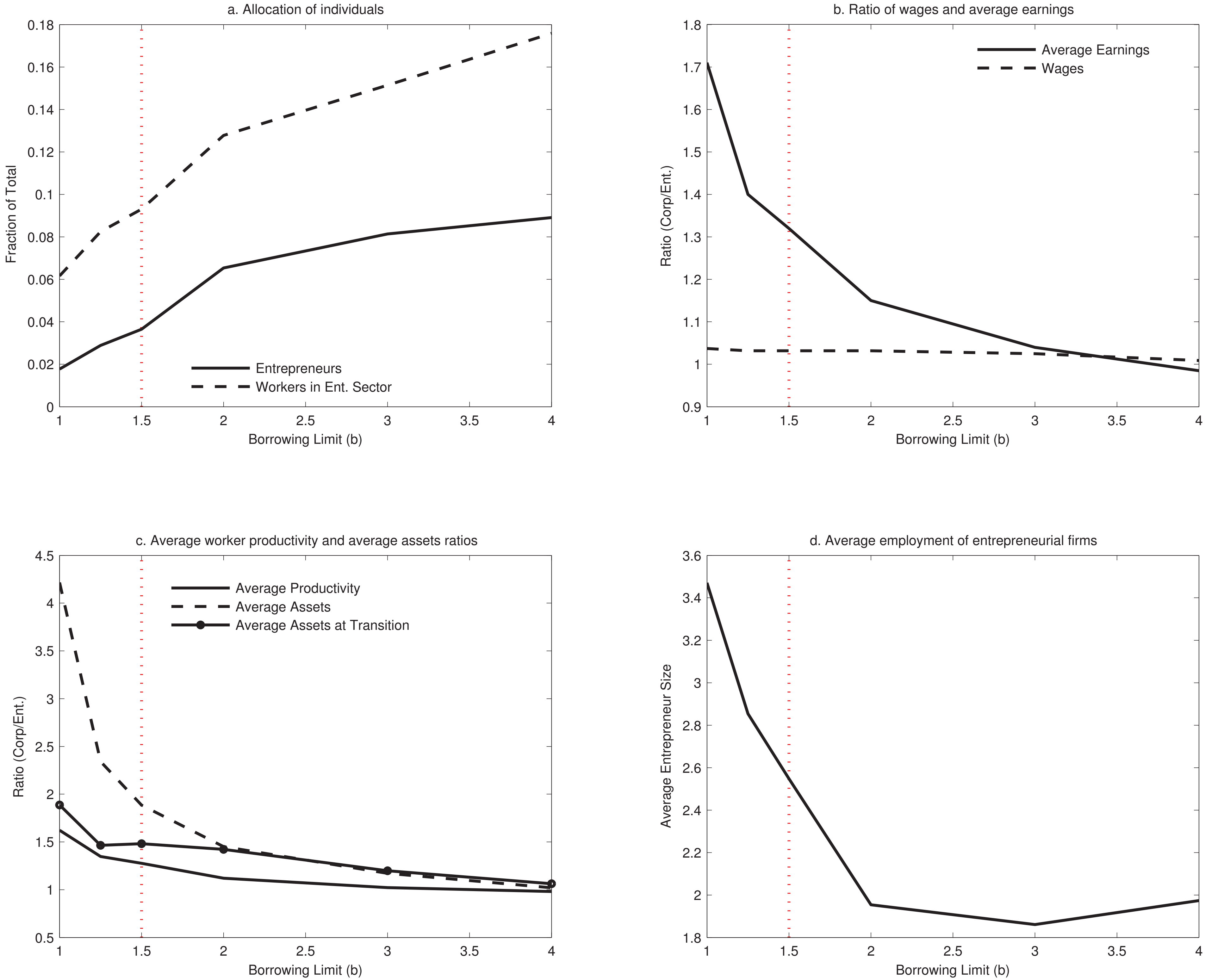
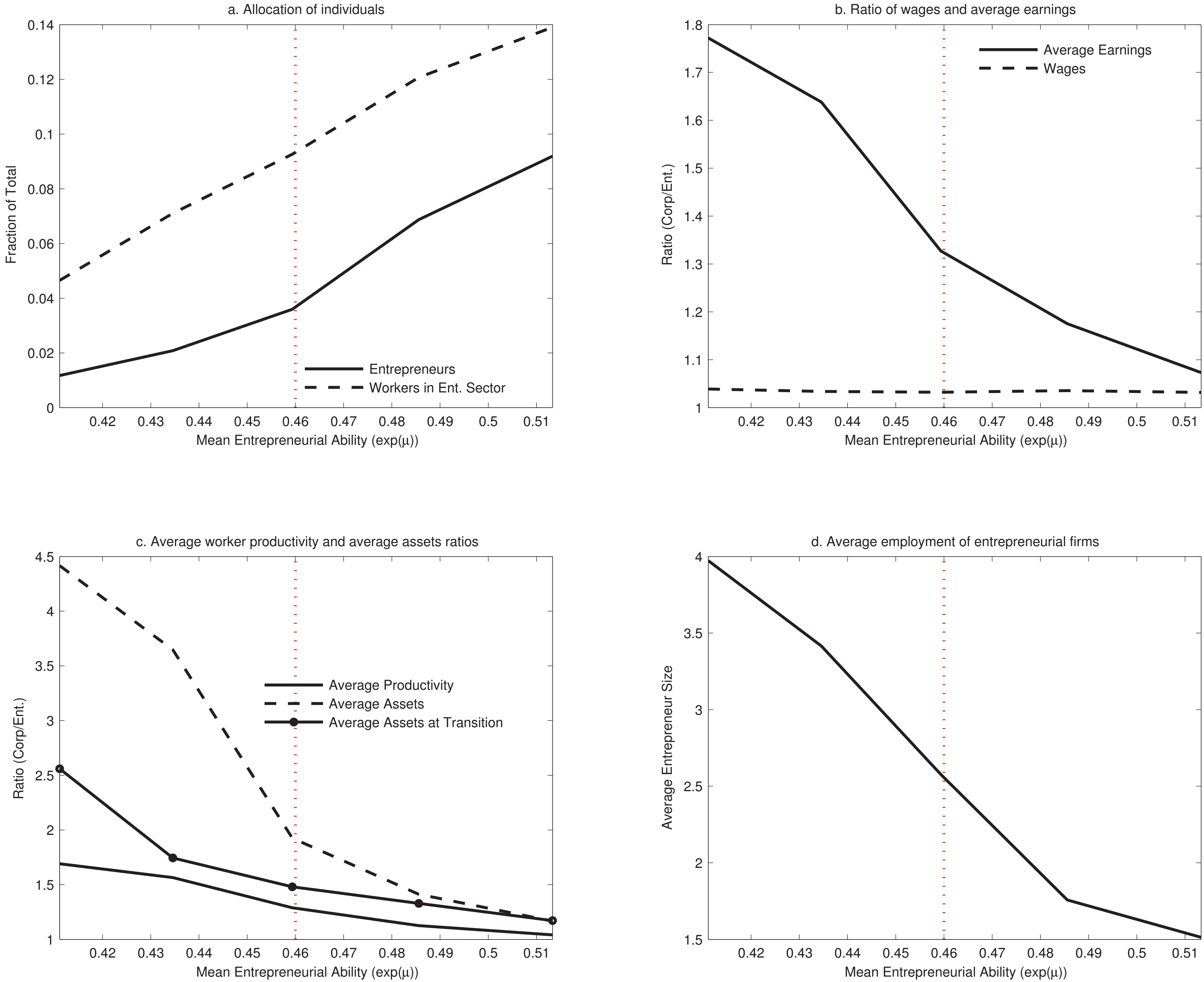


Figure 9. Experiments with mean entrepreneurial ability – vertical dashed line indicates baseline value (0.46)



Appendix

A Algorithm for Solving The Model's Equilibrium

A stationary equilibrium of the model is computed using an algorithm based on Huggett and Ventura (1999). The algorithm finds an equilibrium by iterating over value functions and decision rules over a discretized state space. Discretization of the continuous worker and entrepreneurial ability processes in (1) and (2) is done using the Tauchen (1986) algorithm with a 21-point support for the distribution implied by the process. The support is bounded below and above the mean by 2.5 times the standard deviation. The asset grid is discretized to 201 points. The spacing between points on the asset grid increases with asset levels. Asset gridpoints are placed according to $a_1 = 0$, $a_j = \psi j^{\chi}$ for $j = 2, ..., 201$, where $\chi = 3.4$, $\psi = \bar{a}/(201^{\chi})$ and $\bar{a}$ is an upper bound. The algorithm is as follows.

1. Guess a value for the capital-labor ratio in the corporate sector, K/L,
2. Calculate the values $w_f = (1-\nu)AK^{\nu}L^{-\nu}$ and $r = \nu AK^{\nu-1}L^{1-\nu} - \delta$,
3. Set the initial value for the entrepreneurial sector wage equal to the corporate sector wage: $w_e = w_f$,
4. Calculate the optimal decision rules $c^i(s)$, $a^{i\prime}(s)$, $h^d(\widetilde{s})$, $m^d(\widetilde{s})$, $k(s), l(s)$, $(i, d \in \{n, f, e, m\})$
5. Calculate K'/L', $\int l(s)d\Psi^m(s)$, and $\int zd\Psi^e(s)$ implied by the optimal decision rules,
6. If the values of $|K'/L' - K/L| < \delta$ and $|\int l(s)d\Psi^m(s) - \int zd\Psi^e(s)| < \eta$ for some small $\delta > 0$ and $\eta > 0$ then a stationary equilibrium has been found. Otherwise, update K/L and w_e, and repeat steps 4-6.

B Estimation of the Parameters $\rho_\theta, \sigma_\theta$, and ξ

The estimation of the decreasing returns parameter, ξ, for entrepreneurial firms, and the parameters for the entrepreneurial productivity process, $\{\rho_\theta, \sigma_\theta\}$, is based on the framework of Abraham and White (2015).[34] The framework allows the estimation of the parameters $\{\rho_\theta, \sigma_\theta, \xi\}$ simultaneously. Consider a production function for a manufacturing firm i in the form of

$$y_{it} = \theta_{it}\left(k_{it}^{a_k} l_{it}^{a_l} x_{it}^{1-a_k-a_l}\right)^{\xi}, \tag{16}$$

[34] Also see Castiglionesi and Ornaghi (2013) for a similar estimation methodology.

which includes materials and energy, x_{it}, as an input, and a productivity process $\ln\theta_{it} = (1-\rho_\theta)\mu_i + \delta_t + \rho_\theta \ln\theta_{it-1} + \epsilon_t$, where μ_i is a firm-specific productivity parameter, δ_t is a year effect that captures general changes in productivity that apply to all firms, and $\epsilon_t \sim N(0, \sigma_\theta)$. The parameters ρ_θ and σ_θ are allowed to vary across industries. The inclusion of the materials and energy in the production function controls for the use of intermediate inputs (materials and energy) in estimating the underlying total factor productivity process. The estimation also allows for a markup, η, common to all firms in an industry, which can be thought of as the average markup across firms that is assumed to be constant over time. Abraham and White (2015) estimate the parameters, ξ, ρ_θ and σ_θ in a GMM framework using the log-linear form of the production function and the Solow residual obtained from the gross output and cost shares of the inputs. See Abraham and White (2015) or Castiglionesi and Ornaghi (2013) for a derivation of the exact model estimated.

The data used for the estimation is the U.S. Census Bureau's Annual Survey of Manufactures (ASM), which provides an unbalanced panel of manufacturing establishments for the period 1972-2009. The data include, for each establishment, annual measures of output (value of shipments) and inputs (employment, materials/energy use, capital). This information is aggregated to the firm level. The age of the firm is also available, which is the age of the oldest establishment of the firm. The establishments included in the ASM sampling frame typically have size 20 employees or more, so the parameter estimates are not representative of very small firms. The model yields estimates of ξ, ρ_θ, and σ_θ for young versus old firms at the 4-digit SIC industry level. The estimated values for young firms are then averaged across industries to be used in the calibration of the baseline model. The analysis is limited to the manufacturing sector because of the unavailability of similar data for other sectors of the economy to calculate the revenue-based productivity of an establishment.

A remark is in order for how the estimated parameters of the three-input production function in (16) are used to calibrate the model's two-factor production function in (3). In the production function (16) used for estimation, the decreasing returns parameter, ξ, is the same for each of the three inputs. Because the decreasing returns parameter is common to all inputs, in the model's calibration the estimated decreasing returns parameter $\xi = 0.88$ is applied to the two-factor production function in (3). Similarly, the total factor productivity process is not specific to any input (i.e. Hicks neutral) in (16). Therefore, the estimated productivity process based on the three-factor production function in (16) is assumed to apply to the two-factor production in (3).