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Entrepreneurship, Frictions, and Wealth

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Abstract

Although the role of financial constraints on entrepreneurial choices has received considerable attention, the effects of these constraints on aggregate capital accumulation and wealth inequality are less known. Entrepreneurship is an important determinant of capital accumulation and wealth concentration and, conversely, the distribution of wealth affects entrepreneurial choices in presence of borrowing constraints. We construct a model that matches wealth inequality very well, for both entrepreneurs and non-entrepreneurs. We find that more restrictive borrowing constraints generate less wealth concentration, but also reduce average firm size, aggregate capital, and the fraction of entrepreneurs. We also find that voluntary bequests are an important channel that allows some high-ability workers to establish or enlarge an entrepreneurial activity: with accidental bequests only, there would be fewer large firms, fewer entrepreneurs, and less aggregate capital, but also less wealth concentration.

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1 Introduction

Although many empirical studies argue that potential and existing entrepreneurs face borrowing constraints, there has been so far little work on how these constraints affect aggregate capital accumulation and wealth inequality through entrepreneurial choices. Do these financial constraints hamper aggregate capital accumulation and if so, how big is this effect? What effect do these constraints have on wealth inequality: do they exacerbate it or mitigate it? These are potentially important forces to understand the consequences of policy reforms that affect the tightness of these borrowing constraints, such as changes in the leniency of bankruptcy laws and in the degree of enforcement of property rights.

In this paper we analyze the role of borrowing constraints as determinants of entrepreneurial decisions (entry, continuation, investment, and saving), and their effects on wealth inequality and aggregate capital accumulation, in a framework that matches the observed wealth inequality very closely. In presence of borrowing constraints, the decision to invest, the fraction of entrepreneurs, and the size distribution of firms depend on the distribution of assets in the economy. Because of this interaction, it is key to perform such an analysis in a model that matches well the extreme concentration of wealth observed in the data.

We find that more restrictive borrowing constraints generate less inequality in wealth holdings, but also reduce average firm size, the number of people engaging in entrepreneurial activities, and aggregate capital accumulation. Our results also indicate that voluntary bequests are an important channel allowing some high-ability workers to establish or enlarge an entrepreneurial activity. If there were only accidental bequests there would be fewer large firms, fewer entrepreneurs, and less aggregate capital, but also less wealth concentration.

These findings are based on a quantitative life-cycle model with altruism across generations and entrepreneurial choice, in an environment in which debt repayment cannot be perfectly enforced. The amount that entrepreneurs can borrow depends on their observable characteristics, and the entrepreneurs' assets act as collateral for their debts. Since the implicit rate of return for entrepreneurs is higher than the rate for workers, and consistently with the data, entrepreneurs have a higher saving rate. We calibrate the parameters of the model to match key moments of the data and discuss the implications of the model and its components for entrepreneurial choice and wealth inequality. We show that our model with entrepreneurial choice matches very well the observed distribution of wealth, for both entrepreneurs and non-entrepreneurs.

This paper is closely related to the quantitative literature on wealth inequality and entrepreneurial choice. (See Cagetti and De Nardi [12] for a comprehensive survey.) Castañeda, Díaz-Giménez, and Ríos-Rull [15] adopt a dynastic model with idiosyncratic shocks and reconstruct an exogenous labor income process that matches earnings and wealth dispersion. The resulting labor income process implies very large earning risk for the highest income earners. De Nardi [19] evaluates the importance of bequest motives in explaining wealth dispersion in a life-cycle model. Neither of these papers models entrepreneurial decisions. Quadrini [41] first showed that modeling entrepreneurship is important in explaining the observed concentration of wealth, but does not study the effects of financing constraints. Other work by Heaton and

Lucas [27], Li [34], Carranza, Galdòn-Sànchez, and Fernandez-Villaverde [13], and Chari, Golosov, and Tsyvinski [16], focus on various aspects of entrepreneurial choice but don't match the observed wealth inequality.

Section 2 first documents the relationship between wealth and entrepreneurship, and then surveys the evidence that entrepreneurs are borrowing constrained. Section 3 describes the model and our calibration procedure. Section 4 discusses the role of entrepreneurship and voluntary bequests in generating large wealth concentration, and studies the aggregate effects of changing the borrowing constraints. Section 5 inspects further the mechanisms at work in our model and compares their observable implications to those in the observed data. Section 6 concludes.

2 Wealth, entrepreneurship, and borrowing constraints

We first document the relationship between wealth and entrepreneurship, and we then survey the empirical evidence on the effects of borrowing constraints on entrepreneurial choice.[2]

[2]Whenever possible we use data from the Survey of Consumer Finances (SCF). Unlike other data sets, the SCF oversamples rich households and thus provides important advantages. First, it gives a better picture of the concentration of wealth and of the asset holdings of richer households, which include a large share of entrepreneurs. Second, as shown by Curtin, Juster, and Morgan [18] and Juster, Smith, and Stafford [31], the total wealth implied by the SCF is very close to the total wealth implied by aggregate data; the SCF can thus be used to calibrate aggregates (for instance, the share of entrepreneurial wealth and the percentage of entrepreneurs) in a general equilibrium model such as the one developed in this paper.

2.1 Who are the rich households?

Wealth holdings are massively concentrated in the hands of a small fraction of households, and this wealth concentration is much larger than the one documented for labor earnings and total income. This observation begs the question of which saving motives generate the amplification in the concentration of wealth with respect to the one in income. (An extensive survey of both data and models is contained in Cagetti and De Nardi [12].)

When looking at the data it is clear that there is a tight relationship between being an "entrepreneur" and being rich. We begin by documenting this relationship, using different definitions of entrepreneurship, and we then discuss alternative ways of acquiring wealth.

The SCF asks several questions that we can use to classify a household by its occupational status:

1. "Do you work for someone else, are you self-employed, or what?"

2. "Do you (and your family living here) own or share ownership in any privately-held businesses, farms, professional practices or partnerships?"

3. "Do you (or anyone in your family living here) have an active management role in any of these businesses?"

Table 1[3] shows the fraction of people in a given occupation and the total fraction of aggregate net worth that they hold. The first line refers to people

[3] All of the statistics that we report here use data from the 1989 wave of the SCF. The data for the 1992 and 1995 waves are similar. The results are available from the authors upon request.

	Perc. in population	Share of total wealth
Business owners or self employed	16.7	52.9
All business owners	13.3	48.8
Active business owners	11.5	41.6
All self-employed	11.1	39.0
Self-employed business owners	7.6	33.0

Table 1: Percentage of various definitions of entrepreneurs in the population and corresponding share of total wealth held.

that declare that they are either business owners or self-employed (that is, who answer yes to either question (1) *or* (2)). This group makes up for about 17% of the population, and owns more than half of the total net worth. The second line refers to all households that own privately held business, but do not necessarily manage them (that is, who answer yes to question (2)), while the third one focuses on the business owners that effectively manage their own business(es) (that is, who answer yes to question (3)). The fourth line refers to those that report being self-employed (yes to question (1)) and the fifth line to those that are both self-employed and business owners with an active management role (yes to questions (1), (2) and (3)). The self-employed business owners are 7.6% in the population, and yet hold 33% of the total net worth.

The key message of table 1 is that, regardless of the specific definition of entrepreneurship used, entrepreneurs are a relatively small fraction of the population and hold a large fraction of the total net worth.

Table 2 shows that most rich people are entrepreneurs. The first line shows that the households in the top 1% of the wealth distribution hold around

Top %	1	5	10	20
Whole population percentage of total net worth held	30	54	67	81
Business owners or self-employed percentage of households in a given percentile	81	68	54	39
All business owners percentage of households in a given percentile	76	62	49	36
Active business owners percentage of households in a given percentile	65	51	42	30
Self-employed percentage of households in a given percentile	62	47	38	26
Self-employed business owners percentage of households in a given percentile	54	39	32	22

Table 2: First row: percentage of total net worth held by the top percent of the wealth distribution. Other rows: percentage of a given definition of entrepreneurs among the households in the top percent of the wealth distribution.

30% of total net worth, and those in the top 5% hold more than half of the total. The other lines report, respectively, the fraction of various definitions of entrepreneurs in the corresponding wealth quantile. A whopping 81% of those that belong to the top 1% of the wealth distribution declare that they are either self-employed or business owners. All business owners are 76% of the richest 1% of households, while the fraction of the business owners that actively manage their own business(es) is 65%, hence some of the business owners are "investors" that own a business that is managed and run by someone else. The self-employed make up for 62% of the households in the top 1% of the wealth distribution, while the self-employed business owners are 54%.

Table 3 reports mean and median asset holdings by occupational status. Regardless of the specific definition of entrepreneurship, entrepreneurs are

	median	mean
Whole population	47	189
Business owners or self-employed	172	599
All business owners	205	695
Bus owners but not active mgmt	293	768
Business owners not self employed	179	470
All self-employed	169	665
Self-employed (active) business owners	265	829
Self-employed and not business owners	36	224

Table 3: Median and mean networth (in thousands of dollars).

much richer than non entrepreneurs. The business owners, however, tend to be richer than the self-employed. Not surprisingly, the poorest are those that declare being "self-employed", but not "business owners"; some of these households might be the low-wage workers that turn to self-employment for lack of better opportunities[4], or people that are self-employed as a hobby. Interestingly, the business owners that do not have an active management role in the business are very rich, and are likely to use the business as an investment opportunity.

We have seen that many of the rich people are entrepreneurs, but who are the others, and how did they become rich? Unfortunately the SCF provides only very coarse classifications by occupation, for example lumping together

[4]Rissman [42] documents that in the National Longitudinal Survey of Youth (NLSY) more than one quarter of all younger men experience some period of self-employment, and many of them return to wage work. She argues that for these workers self-employment is a low-income alternative to wage work and provides an alternative source of income for unemployed workers. Rissman also finds that young men are more likely too become self-employed when their wage opportunities are more limited, as in periods of economic downturns.

managers, professionals, singers, performers, etc, and thus provides very little data to answer this question. The other nationally representative samples miss the very rich. We study the *Forbes magazine* list of the 400 richest people in the United States. While this is a very restricted sample, it certainly focuses on the rich. According to this data set, of the 400 wealthiest American people in various years, 61% to 80% were self-made (typically by individuals that started a firm), while the rest inherited the family's fortune, which was typically originated by one or more businesses started by one of their parents or grandparents.[5] Extremely few entries in this list were people such as entertainers or sportsmen, who acquired their wealth through high incomes without starting as entrepreneurs. By cross-comparing the 2004 list with the one for the top 100 "celebrities" for the same year (also compiled by Forbes), we find that only 3 of the top 100 "celebrities" make it to the list of the top 400 richest Americans: George Lucas, Oprah Winfrey, and Steven Spielberg. Interestingly, Steven Spielberg put up $33 million for 22% of his upstart studio in 1994, and thus used a significant amount of his own money to start his empire.

2.2 Entrepreneurship and borrowing constraints

To estimate the severity of borrowing constraints on entrepreneurial entry and continuation decisions one would want to know how much potential and existing entrepreneurs would like to borrow, at what interest rate, and how

[5]The fraction of heirs in the Forbes 400 list was 39% in 2004 (our computations), while it varies between 20% and 30% in other years according to Smith [43]. This fraction is quite volatile due to the small sample size of this list.

much they are actually able to borrow, and at what price. Unfortunately such data are not available.

Many papers have used a variety of data sets, methodologies, and different definitions of entrepreneurship to shed light on these questions. Some of these papers estimate structural models of entrepreneurship in presence of borrowing constraints, while others look at indirect evidence to assess the severity of borrowing constraints on entrepreneurial choices.

Among the former group, Evans and Jovanovic [21], and Buera [9] estimate structural models of entrepreneurship in presence of borrowing constraints and find evidence of borrowing constraints. Gentry and Hubbard [23] use a combination of theory and data to argue that costly external financing (coupled with potentially high returns on those investments) has important implications for the saving, investment, and entry decisions of continuing and potential entrepreneurs.

Among the latter group, Holtz-Eakin, Joulfaian, and Rosen [28] study the effects of receiving a bequest on both potential and existing entrepreneurs. They find that the receipt of a bequest (and thus an increase in wealth) increases the probability of starting a business. They also find that existing sole-proprietors who receive a bequest not only are more likely to stay in business, but also experience a substantial increase in the enterprise's receipts.

A different type of indirect evidence studies how a firm's investment spending is sensitive to the availability of internal finance, or cash flows. For example Fazzari, Hubbard, and Petersen [22], and Hall [26] find evidence of this type of sensitivity and interpret it as evidence of the existence of financing constraints to the investment of existing firms. Analogously, Eisfeldt and Rampini [20] document that firms that are likely to be constrained according to some indicators are also more likely to purchase used capital, which is cheaper to acquire but more expensive to maintain than new capital, and interpret this as additional evidence of borrowing constraints on firms' investment decisions.

More recently, Hurst and Lusardi [30] have disputed the relevance of borrowing constraints to entrepreneurial entry. Their key result is that the probability of entering entrepreneurship as a function of initial wealth is first flat over a large range of the wealth distribution, and it then increases for the richest workers. We will show that a model of entrepreneurial choice with borrowing constraints is capable of generating this type of entry probabilities as a function of one's own wealth.

The need to accumulate assets in presence of borrowing constraints may also generate high saving rates among entrepreneurs (or households planning to become entrepreneurs). Using different data sets, Gentry and Hubbard [23] and Quadrini [40] show higher saving rates for entrepreneurs than for the rest of the population, and Buera [9] shows higher saving rates also in the years before entry into entrepreneurship.

Another finding can be interpreted as indirect evidence of borrowing constraints is that the portfolios of entrepreneurs, even the richest ones, are very undiversified. Moskowitz and Vissing-Jørgensen [38] show that the share of one's own wealth invested in one's business is high for all quantiles of the wealth distribution. Almost a half of the net worth is constituted by business wealth for entrepreneurs both in the top and in the bottom of the distribution.

To provide more evidence on the existence of borrowing constraints we also look at the data on entrepreneurs using their collateral for their business, and on entrepreneurs declaring that they have been turned down for credit, or that they did not apply for credit because they thought that they would be turned down.

The SCF asks explicitly about whether some of the debts are explicitly collateralized with the entrepreneur's own private assets. These numbers are just an indication, because they include the use of only personal assets (other than the business itself) and do not indicate the relation between the amount borrowed and the size of the business, nor the amount of borrowing desired by the entrepreneur. Among the *self-employed business owners*, 29% declare that they currently use their own personal assets as collateral to finance their business. Within this group, the median ratio of personal collateral to business value is 21%, the top decile is 77%, and the top 5% is 100%. These fractions do not change significantly across quantiles of the wealth distribution, thus suggesting that many businesses do need to put up collateral in order to borrow, regardless of their size.

Among the *self-employed business owners* 18% report that they have been turned down for credit, and 9% state that they thought of applying, but changed their mind because they thought they might be turned down.

The severity of borrowing constraints potentially depends on bankruptcy laws. Berkowitz and White [6] show that the higher exemption levels on personal bankruptcy, the higher the probability of being denied credit and the smaller the amount of loans made. This suggests that higher exemptions lower the incentive to repay, and thus generate more stringent borrowing constraints.

3 The model

3.1 Demographics

We adopt a life-cycle model with intergenerational altruism. To make the results quantitatively interesting, we need short time periods. To make the model computationally manageable, we have to keep the number of stages of life small. To reconcile these two necessities, we adopt a modeling device introduced by Yaari [48] and Blanchard [8] and generalized by Gertler [24] to a life-cycle setting.

Households go through two stages of life, young and old age. A young person faces a constant probability of aging during each period $(1 - \pi_y)$, and an old person faces a constant probability of dying during each period $(1 - \pi_o)$. When an old person dies, his offspring enters the model, carrying the assets bequeathed to him by the parent. Appropriately parameterized, this framework generates households for which the average lengths of the working period and the retirement period are realistic. Our model period is one year.

There is a continuum of households of measure 1. The households are subject to idiosyncratic shocks, but there is no aggregate uncertainty, as in Bewley [7].

3.2 Preferences

The household's utility from consumption is given by $\frac{c^{1-\sigma}}{1-\sigma}$. The households discount the future at rate β, and, in addition, they discount the utility of their offspring at rate η.

To study the role of bequests, our model nests life-cycle and fully altruistic households as two extreme cases. In the purely life-cycle version of the model individuals put no weight on the utility of their descendants ($\eta = 0$). In the perfectly altruistic version, individuals care about their descendants as much as themselves ($\eta = 1$). We assume exogenous labor supply.

3.3 Technology

Many firms are not controlled by a single entrepreneur and are not likely to face the same financing restrictions that we stress in our model. Therefore, as in Quadrini [41], we model two sectors of production: one populated by the entrepreneurs and one by "non-entrepreneurial" firms. The non-entrepreneurial sector is represented by a standard Cobb-Douglas production function:

$$F(K_c, L_c) = AK_c^{\alpha} L_c^{1-\alpha} \tag{1}$$

where K_c and L_c are the total capital and labor inputs in the non-entrepreneurial sector and A is a constant. In both sectors, capital depreciates at a rate δ.

Each person possesses two types of ability, which we take to be exogenous, stochastic, positively correlated over time, and uncorrelated with each other. Entrepreneurial ability (θ) is the capacity to invest capital more or less productively. Working ability (y) is the capacity to produce income out of labor.

Workers can save (but not borrow) at a riskless, constant rate of return.

Entrepreneurs can borrow and invest capital in a technology whose return depends on their own entrepreneurial ability: those with higher ability levels have higher average and marginal returns from capital. When the entrepreneur invests k, the production is given by θk^{ν}, where $\nu \in [0, 1]$. Entrepreneurs thus face decreasing returns from investment, as their managerial skills become gradually stretched over larger and larger projects (as in Lucas [36]). Hence, while entrepreneurial ability is exogenously given, the entrepreneurial rate of return from investing in capital is endogenous and is a function of the size of the project that the entrepreneur implements.

Note that there is no within-period uncertainty regarding the returns of the entrepreneurial project. The ability θ is observable and known by all at the beginning of the period. We therefore ignore problems arising both from partial observability and costly state verification and from diversification of entrepreneurial risk. The simplification is adopted to focus only on the effect of the borrowing constraint.

We assume that the entrepreneurs work on their own projects without hiring labor and that all workers are hired by the non-entrepreneurial sector.

In equilibrium the prices are given by the marginal products of each factor of production, and the rate of return from investing in capital in the non-entrepreneurial sector must equate the risk-free rate that equates savings and investment.

3.4 Credit market constraints

As in Albuquerque and Hopenhayn [1], Kehoe and Levine [32], Marcet and Marimon [37], and Cooley, Marimon, and Quadrini [17], the borrowing constraints are endogenously determined in equilibrium and stem from the assumptions that contracts are imperfectly enforceable.

Imperfect enforceability of contracts means that the creditors will not be able to force the debtors to fully repay their debts as promised, but that the debtors fully repay only if it is in their own interest to do so. Since both parties are aware of this feature and act rationally, the lender will lend to a given borrower only an amount (possibly zero) that will be in the debtor's interest to repay as promised.

In particular, we assume that the entrepreneurs who borrow can either invest the money and repay their debt at the end of the period or run away without investing it and be workers for one period. In the latter case, they retain a fraction f of their working capital k (which includes their own assets and borrowed money), and their creditors seize the rest.

In absence of market imperfections, the optimal level of capital is only related to technological parameters and does not depend on initial assets. In our framework, instead, the higher is the amount of an entrepreneur's own wealth invested in the business, the larger is the amount that the entrepreneur would loose in case of default, the lower the temptation to default, and the larger is the sum that creditor is willing to lend to the entrepreneur. Hence, the entrepreneur's assets act as collateral, although the loan need not be fully collateralized.

As a result, not all potentially profitable projects receive appropriate funding. Households with little wealth can borrow little, even if they have high ability as entrepreneurs. Since the entrepreneur forgoes his potential earnings as a worker, he will choose to become an entrepreneur only if the size of the firm that he can start is big enough; that is, he is rich enough to be able to borrow and invest a suitable amount of money in his firm.

3.5 Households

At the beginning of each period, before making any economic decisions, the current ability levels are known with certainty, while next period's levels are uncertain.

Each young individual starts the period with assets a, entrepreneurial ability θ, and worker ability y and chooses whether to be an entrepreneur or a worker during the current period.

An old entrepreneur can decide to keep the activity going or retire, while a retiree cannot start a new entrepreneurial activity. We allow entrepreneurs to remain active when old to capture the fact that, while most workers retire before age 65, entrepreneurs often continue their activity until much later.

3.5.1 The young's problem

The young's state variables are his current assets a, working ability y, and entrepreneurial ability θ. His value function is

$$V(a, y, \theta) = \max\{V_e(a, y, \theta), V_w(a, y, \theta)\}, \tag{2}$$

where $V_e(a, y, \theta)$ is the value function of a young individual who manages an entrepreneurial activity during the current period. In order to invest k, the young entrepreneur borrows $(k-a)$ from a financial intermediary at the interest rate r, which is the risk-free interest rate at which people can borrow and lend in this economy. Consumption c is enjoyed at the end of the period. We have

$$V_e(a, y, \theta) = \max_{c,k,a'} \{u(c) + \beta \pi_y EV(a', y', \theta') + \beta(1 - \pi_y) EW(a', \theta')\} \tag{3}$$

$$a' = (1 - \delta)k + \theta k^{\nu} - (1 + r)(k - a) - c \tag{4}$$

$$u(c) + \beta \pi_y EV(a', y', \theta') + \beta(1 - \pi_y) EW(a', \theta') \geq V_w(f \cdot k, y, \theta) \tag{5}$$

$$a \geq 0 \tag{6}$$

$$k \geq 0. \tag{7}$$

The expected value of the value function is taken with respect to (y', θ'), conditional on (y, θ), $F(y', \theta'|y, \theta)$ is a first-order Markov process, and $W(a', \theta')$ is the value function of the old entrepreneur at the beginning of the period, before he has decided whether he wants to stay in business or retire.

The function $V_w(a, y, \theta)$ is the value function for the young who chooses to be a worker during the current period. We have

$$V_w(a, y, \theta) = \max_{c,a'} \{u(c) + \beta \pi_y EV(a', y', \theta') + \beta(1 - \pi_y) W_r(a')\} \tag{8}$$

subject to eq. (6) and

$$a' = (1 + r)a + w\, y - c, \tag{9}$$

where w is the wage. When the worker becomes old, he is retired, and $W_r(a')$ is the corresponding value function.

3.5.2 The old's problem

The old entrepreneur can choose to continue the entrepreneurial activity or retire. The old person's state variables are therefore his current assets a, his entrepreneurial ability θ, and whether he was a retiree or an entrepreneur during the previous period.

The value function of an old entrepreneur is

$$W(a, \theta) = \max\{W_e(a, \theta), W_r(a)\}, \tag{10}$$

where $W_e(a, \theta)$ is the value function for the old entrepreneur who stays in business, and $W_r(a)$ is the value function of the old, retired person.

We denote with η the weight on the utility of the descendants. If $\eta = 0$, the household behaves as a pure life-cycle; if $\eta = 1$ the household behaves as a dynasty. We have:

$$W_e(a, \theta) = \max_{c,k,a'}\{u(c) + \beta\pi_o EW(a', \theta') + \eta\beta(1 - \pi_o)EV(a', y', \theta')\} \tag{11}$$

subject to eq. (4), eq. (7), and

$$u(c) + \beta\pi_o EW(a', \theta') + \eta\beta(1 - \pi_o)EV(a', y', \theta') \geq W_r(f \cdot k). \tag{12}$$

The offspring of an entrepreneur is born with ability level (θ', y'). The expected value of the offspring's value function with respect to y' is computed using the invariant distribution of y, while the one with respect to θ' is conditional on the parent's θ and evolves according to the same Markov process that each person faces for θ while alive. This is justified by the assumption that the offspring of an entrepreneur inherits the parent's firm.

A retired person (who is not an entrepreneur) receives pensions and social security payments (p) and consumes his assets. His value function is

$$W_r(a) = \max_{c,a'}\{u(c) + \beta\pi_o EW_r(a') + \eta\beta(1-\pi_o)EV(a',y',\theta')\} \tag{13}$$

subject to eq. (6) and

$$a' = (1+r)a + p - c. \tag{14}$$

The expected value of the child's value function is taken with respect to the invariant distribution of y and θ.

3.6 Equilibrium

Let $x = (a, y, \theta, s)$ be the state vector for our economy, where s distinguishes young workers, young entrepreneurs, old entrepreneurs, and old retired. From the decision rules that solve the maximization problem and the exogenous Markov process for income and entrepreneurial ability, we can derive a transition function $M(x, \cdot)$, which provides the probability distribution of x' (the state next period) conditional on x.

A stationary equilibrium is given by

$$\begin{cases} \text{a risk-free interest rate } r \text{ and wage rate } w, \\ \text{allocations } c(x), a(x), \text{ occupational choices, and investments } k(x), \\ \text{and a constant distribution of people over the state variables } x\text{: } m^*(x) \end{cases}$$

such that, given r, w, the following hold:

- The functions c, a, and k solve the maximization problems described above.

- The capital and labor markets clear. The total labor supplied by the workers equals the total labor employed in the non-entrepreneurial sector. The total savings in the economy equal the sum of the total capital employed in the non-entrepreneurial and in the entrepreneurial sectors.

- The wage and interest rates are given by the marginal products of each factor of production, and the rate of return from investing in capital in the non-entrepreneurial sector must equate the risk-free rate that equates savings and investment.

- The distribution m^* is the invariant distribution for the economy.

3.7 Calibration

The empirical definition of entrepreneurship that we use for the calibration must be consistent with the notion of entrepreneur in our framework. In our model an entrepreneur runs his own business, invests his own wealth in it, has a potentially high return from investing his business, and faces borrowing constraints to start or expand his firm. Our entrepreneur is not simply a manager in a firm, is not an "investor" (who does not have a key role in managing the firm), and is not a person working on his own because he is virtually unemployable in any other firm. For this reason we use the SCf data to classify as *entrepreneurs* the households who declare that they are self-employed, that they do own a business (or a share of one), and that they have an active management role in it. Our definition thus eliminates managers (who are not likely to think of themselves as self-employed) and the business owners that do not manage the business that they own. It is thus likely to eliminate (at least part) of "reverse causation": people that for example are rich and acquire business for investment or as a hobby, but do not have an active management role in it. By taking the intersection of the self-employed and the active business owners, our definition is also likely to eliminate the self-employed households that either mostly invest their (possibly considerable) human capital in the business, but very little physical capital; or that are self-employed only because their wage opportunities are very poor. Although for different reasons, none of these households are entrepreneurs in the sense of our model, nor are likely to be borrowing constrained to start a profitable business.

Our general calibration strategy is to reduce the number of parameters that we use to match the data as much as possible. We thus divide our parameters in two sets. The first set of parameters can either be easily estimated from the data without using our model (for example the length of young and old age), or has been estimated by many previous studies (for example risk aversion). We use the second set of parameters to match relevant moments of the data, none of which include measure of wealth concentration. We use the implications of the model in this respect as a check of the reliability of our model.

Table 4 lists the parameters of the model. The first panel of table 4 shows the set of parameters that we take from other studies and do not use to match moments of the data.

Fixed Parameter	Value	Source(s)
σ	1.5	Attanasio et al. [3]
δ	0.06	Stokey and Rebelo [44]
α	0.33	Gollin [25]
A	1.0	Normalization
π_y	0.98	See text.
π_o	0.91	See text.
P_y	See text.	Huggett [29], Lillard and Willis [35]
p	40% of average yearly income	Kotlikoff, Smetters, and Walliser [33]
η	1.0	Perfect Altruism

Calibrated Parameter	Value
β	0.865
θ	[0, 0.51]
P_θ	See text
ν	0.88
f	75%

Table 4: Parameters of the model.

We take the coefficient of relative risk aversion to be 1.5, a value close to those estimated by, among others, Attanasio et al. [3]. As is standard in the business cycle literature, we choose a depreciation rate δ of 6%. The share of income that goes to capital in the non-entrepreneurial sector is 0.33, and the scaling factor A is normalized to 1. The probability of aging and of death are such that the average length of the working life is 45 years, and the average length of the retirement period is 11 years. The logarithm of the income y process for working people is assumed to follow an AR(1). We take its persistence to be 0.95, as estimated by, for instance, Storesletten, Telmer, and Yaron [46]. The variance is chosen to match the Gini coefficient for earnings of 0.38, the average found in the Panel Study of Income Dynamics (PSID). We assume that the income and the entrepreneurial ability processes evolve independently. We show in Appendix A that this assumption generates key moments that match those measured in the data. We also experiment with positive correlation among ability levels, with little effect on the results. The exact values for the income and ability processes and a discussion of the effects of assuming positive correlation are described in appendix A. The social security replacement rate is 40% of average income, net of taxes. (See Kotlikoff, Smetters, and Walliser [33].) In the baseline case we set $\eta = 1$ (perfect altruism) and then study the no-altruism case.

The second panel of table 4 lists the remaining parameters of the model: β, θ, P_θ, ν, and f and their corresponding values in the baseline calibration. We consider only two values of entrepreneurial ability: zero (no entrepreneurial ability) and a positive number. This implies that P_θ is a two-by-two matrix. Since its rows have to sum to one, this gives us two parameters to calibrate, corresponding to the persistence of each of the two ability states. We also have to choose values for ν, the degree of decreasing returns to scale to entrepreneurial ability, and f, the fraction of working capital the entrepreneur can keep in case he defaults. This gives us a total of six parameters to calibrate to the data.[6]

We use these six parameters to pin down the following moments generated by the model: the capital-to-output ratio, the fraction of entrepreneurs in the population, the fraction of entrepreneurs exiting entrepreneurship during each period, the fraction of workers becoming entrepreneurs during each period, the ratio of median net worth of entrepreneurs to that of workers, and the fraction of people with zero wealth.

Given the features matched in the calibration, we analyze how well the model matches the overall distribution of wealth and the distributions of wealth for entrepreneurs and workers. We then study the role of borrowing constraints and voluntary bequests.

4 Results

We first study the two versions of our model (one without and one with entrepreneurs) and discuss their ability to reproduce the observed inequality in wealth. We also highlight the key intuition of the underlying saving behavior and its implications for wealth concentration.

[6]Note that we do not impose an exogenous minimum firm size or investment level, nor start-up costs. We experimented adding a fixed start-up cost and a minimum firm size (both on the order of $5,000–20,000), but doing so had no significant impact on our numerical results.

We then study the effect of borrowing constraints and voluntary bequests on both inequality and aggregate capital accumulation.

The first row in table 5 displays the aggregate capital-output ratio and several statistics on the wealth distribution in the United States. The notion of capital that we use includes residential structures, plant, equipment, land, and consumer durables, and it implies a capital-output ratio of about 3 for the period 1959–92 (Auerbach and Kotlikoff [4]). (The ratio of average wealth to average income is also about 3.) The data pertaining to the distribution of wealth come from the 1989 SCF. The waves for other years are similar.

In the other rows of the table, we report the corresponding statistics generated by the simulations of various versions of our model economy.

Capital-output ratio	Wealth Gini	Perc. entr.	Percentage wealth in the top 1%	5%	20%	40%	Perc. at zero
U.S. data							
3.0	.78	7.6%	30	54	81	94	14%
Baseline without entrepreneurs							
3.0	.58	0.0%	4	20	58	95	9%
Baseline with entrepreneurs							
3.0	.79	7.6%	29	57	81	94	14%

Table 5: U.S. calibration

4.1 The model without entrepreneurs

The second row of table 5 refers to the model economy without entrepreneurs. In this run, we assign zero entrepreneurial ability to everyone and change the household's discount factor to match the same capital-to-output ratio. All other parameters, including the general equilibrium prices, are the same as in the benchmark economy. These results thus refer to a model economy

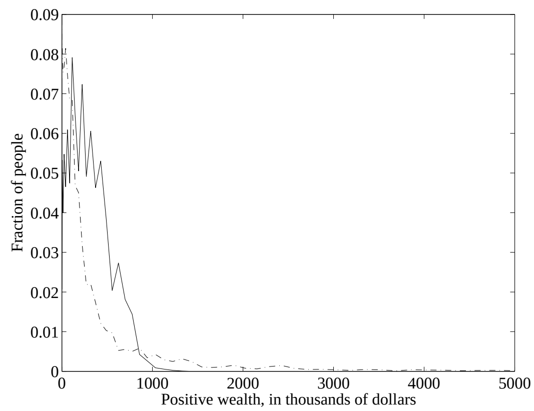

Figure 1: Distribution of wealth for the whole population. Dash-dot line: data; solid line: model without entrepreneurs.

with labor earnings risk and a simplified life-cycle structure. As we can see from the table, this model economy produces a distribution of wealth that is much less concentrated than that in the data and that, in particular, does not explain the emergence of the large estates that characterize the upper tail of the distribution of wealth. Figure 1 compares the data on the distribution of wealth (SCF, 1989 in thousands of dollars) with the one implied by the model without entrepreneurial choice. While the data on wealth display a fat tail, in the model without entrepreneurial choice all households hold less than \$1.1 million.

4.2 The model with entrepreneurs

The third row of table 5 refers to the benchmark economy with entrepreneurs. In our baseline simulation the equilibrium interest rate r is 6.4%, the share of total wealth held by entrepreneurs is 29%, compared with 33% in the data, and the degree of decreasing returns to scale to the entrepreneurial technology is 0.88, which is a value consistent with those estimated by Burnside, Eichenbaum, and Rebelo [10] and Basu and Fernald [5].

This parameterization matches the distribution of wealth very well (figure 2) both for the overall population and for that of the entrepreneurs. Figure

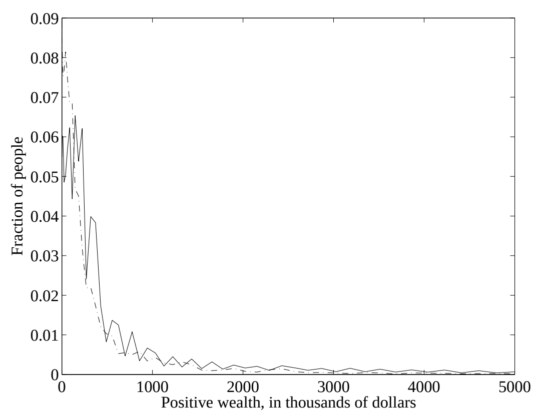

Figure 2: Distribution of wealth for the whole population. Dash-dot line: data; solid line: baseline model with entrepreneurs.

3 compares the wealth distributions generated by the model for entrepreneurs and workers. Figure 4 shows the wealth distribution for the subpopulation of entrepreneurs for the model and the data. These pictures reveal two important features of the baseline model. First, and consistently with the data, the distribution of wealth for the population of entrepreneurs displays a much fatter tail than the one for workers. Second, contrary to the model without en-

trepreneurial choice, the baseline model generates distributions of wealth for both entrepreneurs and non-entrepreneurs with a significant mass of people who have more than $1.1 million. In the model, the non-entrepreneurs in the right tail of the wealth distribution are former entrepreneurs or descendants of entrepreneurs who have not continued the business of the parents.

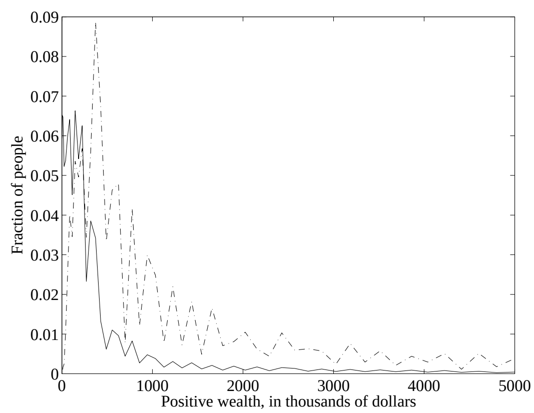

Figure 3: Distribution of wealth in the baseline model with entrepreneurs. Solid line: workers; dash-dot line: entrepreneurs.

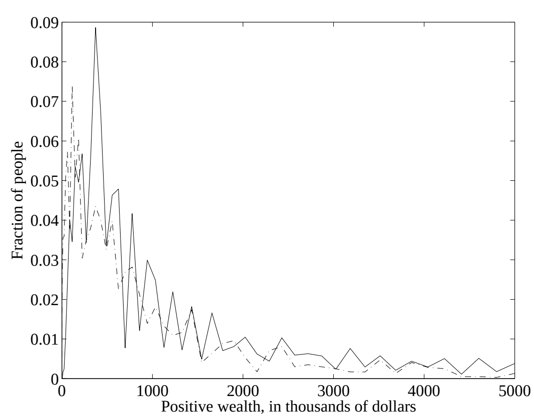

Figure 4: Distribution of the entrepreneurs' wealth. Dash-dot line: data; solid line: baseline model.

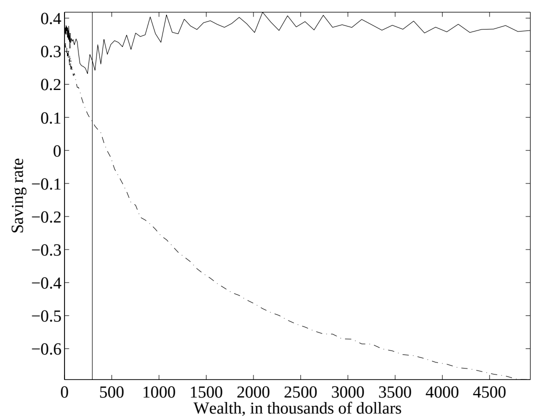

Figure 5: Saving rate for highest-ability workers. Solid line: with high entrepreneurial ability; dash-dot line: with no entrepreneurial ability; vertical line: asset level at which high-entrepreneurial-ability individuals enter entrepreneurship.

In order to explain entrepreneurial behavior, figure 5 displays the saving rate[7] for people who have the highest ability level as workers during the current period. The solid line refers to the people who get the high entrepreneurial ability level during the current period, while the dash-dot line refers to those who get the low entrepreneurial ability draw. Given the same asset level (and potential earnings as workers), the people with high entrepreneurial ability have a much higher saving rate.

Those with low entrepreneurial ability (who are thus workers) exhibit the buffer-stock saving behavior highlighted by Carroll [14]: if their assets are low, they save because they are experiencing a high ability level as workers and want to build up their buffer-stock. If their assets are high enough, they dissave, and the richer they are, the higher their rate of dissaving. In this simulation,

[7]The saving rate in the graph is defined as assets in a given period minus assets in the previous period, divided by total income during the period.

the asset level at which the saving rate goes from positive to negative is below $1 million.

The people with high entrepreneurial ability, as explained in section 3.4, become entrepreneurs only if their wealth is above a certain level, denoted in the graph by a vertical line. The saving rate of those with high entrepreneurial ability who do not own enough assets to become entrepreneurs is higher than the one for the workers because ability is persistent, and the workers with high entrepreneurial ability save to have a chance to start a business in the future. In this region, the distance between the solid line and the dash-dot line is solely due to the higher implicit rate of return from saving that one could obtain becoming an entrepreneur in the future: all households become workers in this range and earn the same income, but the desire to become entrepreneurs generates a higher saving rate for those who have such ability.

The saving rate of those with high entrepreneurial ability and enough assets to become entrepreneurs is positive and considerably higher than that for workers. The return on the entrepreneurial activity is high, and the entrepreneur would like to increase the size of the firm by borrowing capital. However, the borrowing constraint limits the size of the firm. In order to expand the business, the entrepreneur must in part self-finance the increase in capital. The combination of higher returns from the business together with the budget constraint thus generates a very high saving rate for entrepreneurs. As the firm expands, the returns decrease. Therefore, the saving rate will also eventually decrease. (We truncate the axis of the graph for easier readability.)

With only one positive level of entrepreneurial ability (as we assume in our calibration) and in absence of borrowing constraints, there would be only one

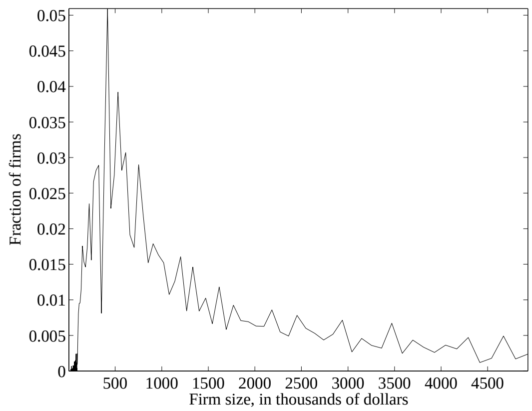

Figure 6: Firm size distribution, baseline model with entrepreneurs.

optimal firm size. Figure 6 shows how in our framework borrowing constraints can generate a large amount of heterogeneity in the firm size distribution. The distribution generated by the model exhibits high dispersion and a fat tail; the tail is generated by the entrepreneurs who have remained in business for a long period (and have possibly inherited the firm from the parents) and have thus had time to save and increase the size of their firms.

4.3 The borrowing constraints

In this section, we examine the effect of changing the tightness of the borrowing constraints. To make the constraints more stringent, we increase f, the fraction of working capital that cannot be seized by creditors, from 0.75 to 0.85. The more the entrepreneur can appropriate in case of default, the stronger the incentive to default for a given collateral level, and the less the creditor is willing to lend. This increase in f could be interpreted as less efficient enforcement of property rights by the courts, or as more lenient bankruptcy

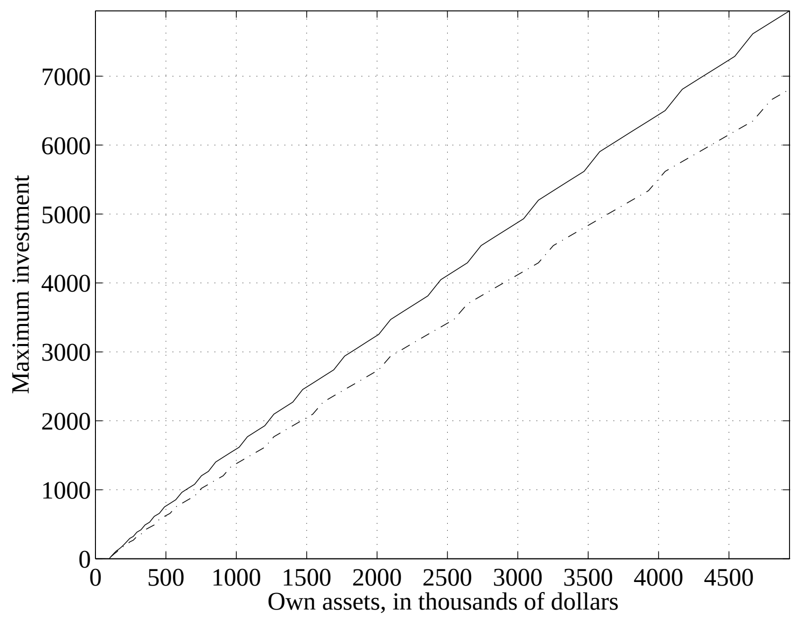

Figure 7: Maximum investment. Solid line: baseline; dash-dot line: more restrictive borrowing constraints.

laws. Figure 7 shows the maximum amount of investment (including one's own assets and borrowed funds) for a young entrepreneur who has the highest ability level as a worker as a function of his own assets. The solid line refers to the baseline model, while the dash-dot line refers to the model with more restrictive borrowing constraints (and nonrecalibrated β). In both economies the entrepreneurs with few assets cannot borrow. The amount of collateral necessary to borrow a positive amount in the two economies coincides at low levels of assets. The entrepreneur with the lowest ability level as a worker must have at least \$11,000 in order to borrow some funds; this amount increases to \$104,000 for the entrepreneur with the highest ability level as a worker. This happens because a more able worker is better off in case of default; therefore, he has to provide more collateral. The key difference in the two economies is that richer entrepreneurs can borrow and invest less in the economy with more restrictive borrowing constraints. For this reason they need more initial assets to implement a project of a given size, and it takes them longer to become rich and own and run a large firm. If the entrepreneur is rich enough, he is unconstrained.

Capital-output ratio	Wealth Gini	Perc. entr.	Percentage wealth in the top 1%	5%	20%	40%	Perc. at zero
U.S. data							
3.0	.78	7.6%	30	54	81	94	14%
Baseline with entrepreneurs							
3.0	.79	7.6%	29	57	81	94	14%
More stringent borrowing constraints: $f = 0.85$							
2.7	.72	6.8%	22	45	73	91	14%
No altruism: $\eta = 0$, only involuntary bequests							
2.5	.72	7.3%	19	43	72	91	15%
$\eta = 0$, recalibrated β							
3.0	.78	7.9%	26	53	79	93	15%

Table 6: Borrowing constraints and bequests.

The third line of table 6 reports the effects of more restrictive borrowing constraints. The capital-to-output ratio drops drastically, from 3.0 to 2.6, and the fraction of entrepreneurs falls from 7.6% to 6.8% as fewer high-ability individuals can now borrow and start a firm. The decrease in the fraction of entrepreneurs happens despite an increase of the equilibrium interest rate from 6.3% to 7.6%, which makes it easier (and faster) for savers with high entrepreneurial ability to accumulate enough capital to start a business.

An increase in the tightness of the borrowing constraint, as seen in figure 7, forces entrepreneurs, and in particular rich ones, to borrow less and run smaller firms. They make fewer total profits and save less, and, as a result, they are poorer. The distribution of wealth becomes less concentrated; for instance, the share of total net worth held by the richest 1% decreases from 29% in the baseline calibration to 22%, and the share of total net worth held by entrepreneurs decreases from 29% to 24%.

Hence, as the collateral requirements rise, wealth inequality falls, but this comes at the expense of lower capital accumulation and output.

4.4 Bequests

In the baseline economy households are altruistic toward their offspring; therefore, the total amount of bequests includes both voluntary and accidental bequests due to life-span risk. We use our model to study what happens to entrepreneurial choice and to wealth inequality when households do not care about their descendants and all bequests are accidental.

The fifth line of table 6 displays how the aggregates change when we set to zero the degree of intergenerational altruism. The absence of the voluntary bequest motive reduces the incentives to accumulate capital and run larger and larger firms. On the one hand, younger people are bequeathed less wealth, and in presence of borrowing constraints, this means that young potential entrepreneurs have fewer resources to start and increase their businesses. On the other hand, the equilibrium interest rate increases to 8.8%, thus allowing more high-ability individuals to use the increased proceedings from their earnings to start a business activity. The net effect on the total fraction of entrepreneurs is a small decrease from 7.6% to 7.3%.

The effects on aggregate capital accumulation are large: in absence of a voluntary bequest motive to save, the total capital of the economy would decrease from 3.0 to 2.5. The concentration of wealth would also drop substantially: the Gini coefficient of inequality would go from 0.79 to 0.72, and the fraction of wealth held by the richest 1% from 29% to 19%. As also shown by De Nardi [19] voluntary bequests are fundamental in explaining the concentration of wealth.

In this model economy, voluntary bequests provide an additional incentive to save to rich entrepreneurs and also generate the intergenerational transmission of large fortunes (and firms) across generations.

To better understand the role of voluntary bequests, we run another experiment, in which we increase the discount factor β (last line of the table) to match a capital-output ratio of 3.0. The fraction of entrepreneurs increases compared to the baseline model, from 7.6% to 7.9%. This effect is due to an increase in the general equilibrium interest rate, which has the same effect we have discussed above, and to the increase in the household's discount factor (β). In this calibration, households have no bequest motive, but are more patient. This implies that the younger households accumulate more wealth than in the baseline model, while the old decumulate faster, and thus keep less wealth, because of the lack of altruism. More people of working age become entrepreneurs, and the old have fewer incentives to continue and expand the entrepreneurial activity and pass to their offspring less wealth and smaller firms. This reduces the number and the size of large firms. For these reasons, the wealth concentration generated by this experiment is lower than the one in the benchmark economy; for instance, the share of total net worth held by the richest 1% drops to 26%, down from 29%.

5 Further tests of the model

Recent literature has cast doubt on the relevance of borrowing constraints to entrepreneurial entry (Hurst and Lusardi [30]) and on the size of the returns to entrepreneurship (Moskowitz and Vissing-Jørgensen [38]).

Occupational choice in presence of borrowing constraints and potentially high returns is the key mechanism that generates high wealth inequality in our model. We check here if the observable implications generated by our model are consistent with the observed data that are the focus of these two papers.

5.1 Borrowing constraints

The key finding of Hurst and Lusardi [30] is that the probability of entering entrepreneurship is almost flat over a large portion of the wealth distribution and it then increases for the richest workers.

Let us now look at the entry probability that is implied by our model. To make this comparison, we use our model to construct confidence interval for this estimated relationship as follows. We generate many samples of households from our model, each of which is of the same size of Hurst and Lusardi's sample. We then use each sample to estimate a probit regression, according to which the probability of entering entrepreneurship is a function of a fifth order polynomial in the household's own wealth, controlling for income, age, and previous entrepreneurial status.[8] We finally use the estimated probit coefficients from all of these samples to construct 95% confidence intervals for the estimated probability of entry as a function of wealth (we fix all other controls at their mean).

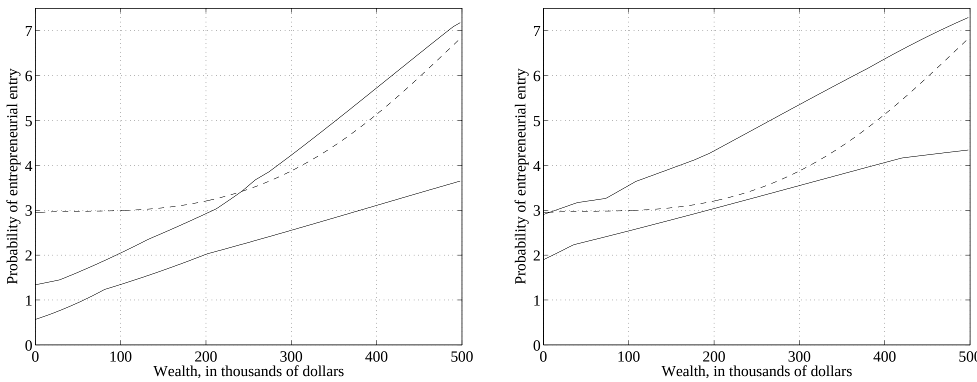

Figure 8: Probability of entering entrepreneurship as a function of own wealth as estimated by Hurst and Lusardi (dashed line), and confidence interval generated by two versions of the model (solid lines). Left panel: benchmark model. Right panel: benchmark with a small fraction of "non-entrepreneurial self-employed".

The two panels in figure 8 plot Hurst and Lusardi's estimated function (dashed line), and the confidence intervals (between the two solid lines) generated by two versions of our model.

The left panel refers to our benchmark model. Two features are worth noticing: first, the entry probabilities implied by the benchmark model are lower than in Hurst and Lusardi's sample. This makes sense since the relevant notion of entrepreneurship for our model (7.6% of households are entrepreneurial households) is more restricted than the one in the Hurst and Lusardi's

[8]We do not need to condition on education, gender, marital status, and race, as such dimensions of heterogeneity are absent from our model.

sample (they do not report the exact number, but our calculations with the PSID bound it between 11% and 13%). If the relevant fraction of "entrepreneurs" in the population is higher, so is the entry probability.

Second, our confidence intervals are consistent with an entry probability that is a convex function of wealth over the range considered by Hurst and Lusardi. The intuition is linked to the endogeneity of both wealth and entry into entrepreneurship. Even with our very simple process for entrepreneurial ability, the wealth at which different potential entrepreneurs choose to enter is heterogeneous. At higher levels of wealth, relatively more of the workers are those have high ability both as entrepreneurs and as workers and that have been saving to accumulate enough wealth to enter entrepreneurship with a scale that justifies giving up their high outside opportunities.

Our estimates for this definition of entrepreneurship predict a steeper positive relationship at low levels of wealth than the one estimated by Hurst and Lusardi. As we discussed, there is a lot of heterogeneity among the households that report being "self-employed" or "business owners" and those that are called "entrepreneurs" in the data (and in Hurst and Lusardi's paper as well,) are not necessarily all entrepreneurs in the sense of our model. The second panel in figure 8 estimates the same regression in the case in which a subset of the simulated agents that are workers for the purposes of our model[9] are classified as self-employed workers, and counted as entrepreneurs for the

[9]Notice that being an "entrepreneur" in our model is a statement about the household's production function and rate of return from saving. It is not a statement on who the household employer is, nor concerning where they work, nor the flexibility of hours worked and so on.

purpose of comparing our results with the survey data.[10] While stylized, this experiment is very instructive: the function estimated by Hurst and Lusardi now falls within our 95% model-generated confidence interval. Given that we assume only one type of entrepreneurial ability, and that none of the calibrated parameters were chosen to match this aspect of the data, it is remarkable how our model is not inconsistent with flat entry probabilities over large sections of wealth holdings.

Consistently with our findings, Buera [9] estimates a model of entrepreneurial choice, and finds that allowing for a slightly more general formulation of entrepreneurial heterogeneity can do an even better job of matching the estimated entry probability.

5.2 Returns from private business ownership

Moskowitz and Vissing-Jørgensen's [38] computations cast doubt on the assumption that entrepreneurs face potentially high rates of returns. Their computations are complex because their goal is to compare aggregate returns to private and public equity, and they thus need to adjust their computations for firms entry and exit.

Given that our goal is to compare returns to entrepreneurship in the data and in our model, and that our framework explicitly deals with entrepreneurial

[10] We choose this fraction so that the "entrepreneurs" (including the true ones in the sense of our model) in our model-generated data are about 12% (a number similar to the one in Hurst and Lusardi's sample). We assume all workers across the wealth distribution have a constant probability of becoming "non-entrepreneurial self-employed," and that this probability is uncorrelated to all other characteristics. We also assume that the probability of exiting the "non-entrepreneurial self-employed" status is the same as exiting entrepreneurship, but the results are not very sensitive to this assumption.

	25th	50th	75th	90th
Only income from business	0%	3%	25%	143%
Including wages and salaries	10%	40%	125%	520%

Table 7: Distribution of rates of returns for self-employed business owners. Returns: entrepreneurial income divided by business net worth. First line: entrepreneurial income includes only income or loss from business. Second line: also includes wages and salaries received by the business owner.

mobility, we compare the cross-sectional distribution of returns to entrepreneurship in a given period in our model and in the data. Consistently with our model, we compute this distribution of returns for the self-employed business owners (who are a subset of all of those who hold private equity) using the 1989 SCF wave (Table 7). These returns are computed as entrepreneurial income divided by business net worth.

Interestingly, we find that the size of the returns to private equity crucially hinges on how income from the firm is divided between entrepreneurial wages and return to capital. It is well known that this split is in practice arbitrary and likely to depend on tax incentives and possibly other considerations. In the SCF data, if one does not include the self-reported wages and salaries, such rate of return is 25% for the entrepreneurs at the 50th percentile, and 143% for those at the top 10%. If, as an extreme case, all wages and salaries received by the entrepreneurs are included in the computation of such return, the corresponding numbers become 40% and 520%, which are far bigger numbers.

In our model, it is not clear how one should compute wages for the entrepreneurs. One could take the view that their labor income is the shadow one, meaning the one that they could make if they were to work as workers (which is not observed in the SCF data). But one could equally plausibly assume that entrepreneurial profits should be computed as the amount of entrepreneurial capital times the rate of return from capital in our economy (which is 6.4%), while the rest of the entrepreneurial income is due to entrepreneurial talent, and should thus attributed to entrepreneurial wages. Given the arbitrariness of this split, we believe the returns to be compared in our model and the data should be computed by dividing *total income* from the entrepreneurial business activity, both in our model and in the data.

Given that our model, by design, abstracts from many aspects of entrepreneurial choice, the distribution of returns is less disperse in our model than in the data. We thus compare the median distribution of returns, which is 47% in our model, compared to 40% in the data. Our median entrepreneurial return is thus only a little higher in our model than in the SCF data.

There are two reasons why our computed return is overstated compared to the one computed in the SCF data. First, households tend to underreport income. Research by Internal Revenue Service (IRS) [39] computes business income underreporting for the 1985 to 1992 period ranging from 28% to 40%. The SCF data are not collected for tax purposes, and it is possible that the households underreport less to the SCF than to the IRS. To be conservative, we compute the implied median return in our economy for 10% to 20% business income underreporting. The corresponding median returns become 40% and 35% respectively.

Second, the computed return from our model does include capital gains (which, for the purpose of our model, are indistinguishable from other entrepreneurial income), while, due available data limitations, the returns computed from the SCF do not include capital gains.

We thus conclude that entrepreneurial returns in our model are consistent with those measured in the data.

6 Conclusions

We developed and solved numerically a model of occupational choice, wealth accumulation, and bequests in which entrepreneurs face an endogenous borrowing constraint that limits the amount that they can borrow. The entrepreneur's wealth acts as collateral, so the richer the entrepreneur, the higher the amount that he can borrow.

Our model generates a wealth distribution that matches the one observed in the data, both for entrepreneurs and for workers. It also produces returns from entrepreneurship, and household's entry probabilities into entrepreneurship as a function of one's wealth, that are consistent with the ones measured in the data. None of the parameters of the model were chosen to obtain these results.

The key mechanism is that many entrepreneurs face potentially high rates of returns but are constrained in the amount that they can borrow. To expand their firm, these entrepreneurs keep saving. In doing so, they become richer and richer. The most successful dynasties share their fortunes with their children, some of which will keep the family firm going, thus expanding the dynasty's fortune even more.

We show that the tightness of borrowing constraints and voluntary bequests are key forces in determining the number of entrepreneurs, the size of their firms, the overall wealth concentration in the population, and the aggregate capital accumulation.

These results have implications for policy analysis, such as subsidized loans to entrepreneurs and estate taxes. Subsidized loans would make it cheaper for the entrepreneurs to borrow, but would also change their incentives to default, making the effects of this policy a priori ambiguous. Taxing bequests may decrease inequality, while at the same time reduce the amount of entrepreneurial wealth that could be used as collateral, and thus affect both the number of entrepreneurs and the total capital of the economy, as shown by Cagetti and De Nardi [11].

We have assumed that an agent can exploit one's own entrepreneurial ability only by starting and developing a business. In presence of borrowing constraints the entrepreneur might want to sell his idea or project to another, potentially less constrained, party. In many situations, however, markets for ideas or projects do not seem to exists. Potential explanations for this, first expressed in Arrow's work [2], are that informational problems may prevent potential buyers from evaluating the entrepreneur's project, and also that the innovating entrepreneur may have problems in appropriating the returns from his idea because it might be too complex to write or enforce a contract specifying the usage of the idea and the payments for information. In our model there are two sectors: entrepreneurial and non-entrepreneurial firms. Only part of the productive and inventive activity is generated by the constrained sector, while the rest is generated by non-entrepreneurial firms, which face no borrowing constrains, and where it does not matter who develops the idea and who implements it. We leave all of these issues for future research.

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A Income and entrepreneurial ability processes

As explained in section 3.7, we assume that the income process is AR(1) and approximate it with a five point discrete Markov chain, using the method described in Tauchen and Hussey [47]. We use an autocorrelation coefficient of 0.95 (in line with the high persistence found in many microeconomic estimates, such as Storesletten, Telmer, and Yaron [45]) and choose the variance to match the Gini coefficient of earnings of 0.38. The resulting gridpoints y for the income process (normalized to an average of 1) are

$$\begin{bmatrix} 0.2468 & 0.4473 & 0.7654 & 1.3097 & 2.3742 \end{bmatrix}$$

and the transition matrix P_y is

$$\begin{bmatrix} 0.7376 & 0.2473 & 0.0150 & 0.0002 & 0.0000 \\ 0.1947 & 0.5555 & 0.2328 & 0.0169 & 0.0001 \\ 0.0113 & 0.2221 & 0.5333 & 0.2221 & 0.0113 \\ 0.0001 & 0.0169 & 0.2328 & 0.5555 & 0.1947 \\ 0.0000 & 0.0002 & 0.0150 & 0.2473 & 0.7376 \end{bmatrix}.$$

We assume that the entrepreneurial ability process is uncorrelated with the income process. The two values for ability θ are 0 (meaning no entrepreneurial ability) and a positive value (0.51), and the transition matrix P_θ is

$$\begin{bmatrix} 0.963 & 0.037 \\ 0.204 & 0.796 \end{bmatrix}.$$

The values for θ and P_θ are calibrated as explained in section 3.7.

A.1 Correlation between abilities

We have so far assumed that working ability (y) and entrepreneurial ability (θ) are uncorrelated. It is difficult to measure such correlation in the data. While many entrepreneurs are high ability individuals who would have high earnings if employed by a company, others successful entrepreneurs may do poorly if they were to work for a corporation.

One important piece of evidence in favor of our specification is that we replicate the income of entrepreneurs prior to starting their businesses fairly well. Using the PSID, one can compare household previous labor incomes for individuals that subsequently decide to either enter entrepreneurship or remain workers in a given period. Hurst and Lusardi [30] report that the labor earnings over the previous five years of those that enter entrepreneurship in a given period is 1.32 times the labor income during the previous 5 years of those that choose to remain workers in the same period. Our simulations reproduce this feature: the ratio of the incomes for the two groups (entrants and non-entrants) is 1.38. This correlation arises endogenously in our model. Because of borrowing constraints high entrepreneurial-ability workers save to reach their constrained optimal firm size at entry. Among the high entrepreneurial ability workers, those that receive high labor earnings realizations can save more and are thus more likely to accumulate enough capital and to enter entrepreneurship.

Moreover, as a robustness check we also study the effects of allowing for positive correlation between these two ability processes. To make this comparison as clean as possible we keep the marginal distributions and transition probabilities as in the baseline case. We then assume that the two processes have a positive correlation of 0.4. All other parameters are as in the baseline economy, except for the discount factor β, which we recalibrate to obtain the same capital-income ratio as in the benchmark. In this economy, the ratio of labor income over the previous five periods for entrants and non-entrants becomes 1.8, which is much higher than the one observed in the data. The resulting wealth distribution is very close to the one in our benchmark economy: the richest 1% hold 27% of the total wealth, and the richest 5% hold 57%. The main difference is that in this economy the number of entrepreneurs decreases to 5.8%. This happens because in presence of positive correlation between the two dimensions of abilities, people with high entrepreneurial ability tend to have a higher option value of remaining in the non-entrepreneurial sector, and are thus less less likely to become entrepreneurs. It is worth noting that this feature does not significantly affect the right tail of the wealth distribution and the saving and investment behavior of the richest entrepreneurs. As we have already mentioned, this tail is composed of the few entrepreneurs who have remained successful for several periods and who have therefore managed to grow their business.

B The algorithm

The algorithm proceeds as follows.

- Construct a grid for the state variables. The maximum asset level is chosen so that it is not binding for the household's saving decisions.
- Fix an interest rate r and a wage rate w. Taking r and w as given, solve for the value functions using value function iteration.
- Construct the transition matrix M. Compute the associated invariant distribution of wealth, starting from a guess for π and iterating on $\pi' = M\pi'$ until $(\pi' - \pi)$ is smaller than a given convergence criterion.
- Compute total savings and total capital invested in the entrepreneurial sector implied by the invariant distribution. Total capital invested by the non-entrepreneurial sector is given by the difference between total savings and total capital invested by the entrepreneurs.
- Compute r and w implied by the above quantities and the non-entrepreneurial aggregate production function, update the wage and interest rate used to solve the problem, and iterate until convergence on the factor prices is reached.

The computation of the value functions is nonstandard because of the endogenous borrowing constraints. For each state x, the endogenous borrowing constraint specifies a maximum amount $\hat{k}(x)$ that an entrepreneur can borrow. The specific function $\hat{k}$ depends, however, on the value functions themselves. In the algorithm we exploit the fact that, for a given set of state variables, if an entrepreneur runs away with a given level of capital $\tilde{k}$, he would also run away with any $\tilde{k} + \epsilon$, where $\epsilon \geq 0$. We adopt the following algorithm: initialize $\hat{k}(x) = k_{max}$, the maximum investment level in the economy. We solve the value functions, iterating until convergence, conditional on this borrowing constraint. For each value of x, we compare the value function associated with remaining an entrepreneur and repaying the debt with the value function associated with default; we find the maximum level of investment (and borrowing) for which the entrepreneur would not default and set the new $\hat{k}(x)$ to this new value, and compute again the value functions conditional on this updated constraint. This procedure is iterated until $\hat{k}$ does not change across iterations.

Because we do not constrain the $\hat{k}(x)$ functions to be decreasing when we iterate on them, we are not imposing convergence. Together with the initialization of these functions at the maximum possible level of borrowing, this implies that if the model has more than one solution, and if the algorithm converges monotonically, then we converge to the "best" solution, that is, the one that allows for the borrowing in the economy. In all of our simulations the algorithm did converge monotonically.

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