What can calibration exercises say about the tightness of borrowing constraints on entrepreneurs?

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Abstract

This paper finds that the standard general equilibrium model of occupational choice developed by Cagetti and De Nardi (2006) results in extremely binding borrowing constraints for entrepreneurs. Their desire to match the wealth distribution mandates very slow decreasing returns to scale on the entrepreneurial technology. An undesired consequence of the slow decreasing returns to scale is that borrowing constraints are considerably tighter in the model than in the data.

Next, I recalibrate the model to match measures of firm size and slack in the financial constraint given by the real estate equity available for borrowing on the entrepreneur’s primary home. Finally, two policy experiments are analyzed. I show that the recalibration of the model, which yields faster decreasing returns to scale and a lower concentration of wealth, considerably dampens the effects of alternative redistributive policies aimed at favoring either high-ability would-be entrepreneurs or poor agents.

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1 Introduction

It is widely accepted that credit constraints can have important implications for the economy. There is rich literature on the subject ranging from theoretical studies of the consequences of financial constraints on business-cycle fluctuations and long-term growth, as well as empirical papers that focus on highlighting evidence and costs of financial constraints.

Bernanke and Gertler (1989) and Kiyotaki and Moore (1997) are examples of theories of how credit constraints affect business cycles. Other theoretical papers like Banerjee and Newman (1993) and Galor and Zeira (1993) study the effect of financial frictions on occupational choice, growth, and development. Empirical papers on the subject are equally as numerous. Some key examples are Fazzari, Hubbard and Petersen (1987) and Gilchrist and Himmelberg (1995) who discuss in detail the role of cash flow for investment. In turn, Petersen and Rajan (1994) study the benefits of lending relationships between small businesses and their creditors, associating close relationships to an increase in lending. Rajan and Zingales (1998) provide evidence that the development of sectors that are more dependent on external financing is slower in countries with less-developed capital markets.

There is, however, controversy on the tightness of the borrowing constraints affecting small firms in the United States. The issue of credit constraints for entrepreneurs is particularly important when considering that small firms are often the beneficiaries of redistributive policies (Li (1998)). In addition, recent literature on occupational choice identify borrowing constraints for entrepreneurs as the key mechanism in generating saving patterns and a wealth distribution similar to that of the US economy. If borrowing constraints do not play a crucial role for entrepreneurship in the US, then this literature is overstating the aggregative impact of financial frictions and missing the explanation for wealth disparity altogether.

The literature on borrowing constraints for entrepreneurs is mixed. On one hand, earlier
papers like Holtz-Eakin, Joulfaian, and Rosen (1994), Evans and Leighton (1989), Blanchflower and Oswald (1998), and Evans and Jovanovic (1989) among others find that poorer agents are less likely to become entrepreneurs even after some attempts to control for the possible endogeneity between wealth and entry into entrepreneurship\(^1\). On the other hand, Hurst and Lusardi (2004) find that for the vast majority of the population of the US there is no relationship between net worth and entry into entrepreneurship. They argue the relationship is highly nonlinear: flat for most of the wealth distribution and only positive for the richest 5% of the population. Moreover, they conclude that using inheritances as an exogenous measure of wealth, as the aforementioned studies were doing, is not appropriate since both past and future inheritances predict entry into entrepreneurship. Hence, inheritances suffer from the same endogeneity concerns as wealth.

In addition, portfolios of entrepreneurs, particularly their holdings of mortgage debt and financial assets such as stocks and bonds, as analyzed in a companion paper, provide further evidence that entrepreneurs are not severely constrained. If they were, it would be puzzling that they did not incur in higher mortgage debt than workers, specially in light of the financial liberalization that the US mortgage market experienced since the 1970s and at least until the onset of the financial and housing crisis that started in 2007.

This paper uses a general equilibrium framework of occupational choice under credit frictions to evaluate the tightness of borrowing constraints for entrepreneurs both in the archetypal model and in the data. Specifically, I use Cagetti and De Nardi’s (2006) standard model in which agents are free to enter and exit from entrepreneurship and choose the size of their investments subject to borrowing constraints\(^2\).

\(^1\)There may be a third variable such as ability, work ethic, preferences or entrepreneurial spirit that may be driving both net worth and entry into self-employed entrepreneurship.

\(^2\)Other models in this vein are Quadrini (2000) and Li (2002), however, the Cagetti and De Nardi (2006) paper is more parsimonious and well-referenced.
I extend the original model to measure the slackness or the inverse of the tightness of the borrowing constraints as the difference between actual borrowing and maximum borrowing allowed for each agent. I then compare this to an estimate of the empirical measure of the slackness of the borrowing constraint: the fraction of home equity owned by the entrepreneur and available for borrowing. This and the companion papers in this package are the first to exploit the idea that financially constrained entrepreneurs may choose to tap into their home equity to finance their businesses. Home equity left for borrowing is, of course, an underestimate of the slackness of the borrowing constraint since it is only one of many sources of financing available to entrepreneurs, such as other secured loans and unsecured loans including credit card debt, personal loans, lines of credit and business loans.

In this paper, I show that borrowing constraints are extremely binding in the model, though not in the data. This observation is important in light of the conventionally accepted explanation that tight borrowing constraints for entrepreneurs are the force behind understanding wealth dynamics and wealth distributions as skewed as that of the US. The tight constraints in the model are due to calibration exercises designed to match the wealth distribution therefore resulting in slow decreasing returns to scale in the entrepreneurial technology that lead to implausibly high first-best levels of capital for the entrepreneurial firms and binding constraints for all agents, including the wealthiest.

Next, I recalibrate the model by making some changes to the set of empirical moments that I am requiring the model to match. The purpose of this exercise is computing an economy that matches firm sizes and borrowing availability more closely, by allowing the generated wealth distribution to be less concentrated.

Finally, I use two policy experiments to further highlight the idea that the implications of redistributive policies will depend on the tightness of borrowing constraints. The nice fit
of the Cagetti and De Nardi (2006) model with empirical observations, position it as a useful framework for the implications of policy experiments. Using their calibrated parameters, I study the effects of taxing wealth according to two different criteria. First, I tax the low-ability agents, while subsidizing the high-ability agents such that the net effect on the government balance is zero. Second, I tax high-wealth agents and offset the tax’s effect with a subsidy on low-wealth agents. The positive effect that such redistributive policies have on the fraction of entrepreneurs, GDP, and capital in the entrepreneurship sector of the original calibration vanish almost completely in the recalibrated version of the model in which borrowing constraints are, realistically, less binding. The close-to-zero effect of the redistributive policies both on the extensive and intensive margins of entrepreneurship, is at a sharp contrast with President Obama’s array of tax-cuts targeted to entrepreneurs\(^3\). According to my results, such transfers do not affect the fraction of agents in entrepreneurship and do not increase the size of firms nor their production because entrepreneurs are typically wealthy enough that they are not severely financially constrained.

The rest of the paper is organized as follows. Section 2 describes the data and the model, including the details of the calibration. Section 3 presents the results of the original calibration highlighting the unrealistic tightness in the borrowing constraints even for very rich agents in subsection 3.1, as well as the results of the recalibration in 3.2. Section 4 studies the consequences of redistributive policies on both calibrations. Section 5 concludes.

### 2 Data and model

The general equilibrium framework used in this paper draws heavily on Cagetti and De Nardi (2006). As they do, I use the Survey of Consumer Finances (SCF) as my data source.\(^3\)Similar policies are popular in European and other OECD economies.
The SCF is the preferred dataset for studying occupational choice in calibrated general equilibrium models for two reasons: first it oversamples the wealthy and hence gives a more accurate description of entrepreneurs (given that they are typically in the upper tail of the wealth distribution), and second, as Curtin, Juster, and Morgan (1989) point out, the aggregate wealth implied by the SCF is close to that resulting from the Federal Reserve’s Flow of Funds Account, which makes it appropriate for the calibration of aggregates. As in the companion papers, I use the 1983-89 panel dataset of the SCF. Whenever cross-sectional one-year data is needed, as opposed to data on dynamics, the 1989 year is used. All dollar values are in dollars of 1989.

I use a standard definition of entrepreneur which is discussed in full extent in the companion papers. Further information on characteristics of the SCF and of both entrepreneurs and workers can be found there as well.

The rest of this section will briefly describe Cagetti and De Nardi’s (2006) model for completeness. This study uses their model and extends their paper in three ways: first, it compares the tightness of borrowing constraints generated in the model to those of the data and argues that they are unrealistically binding even for rich entrepreneurs; then, it recalibrates the model to match firm sizes and an empirical measure of borrowing constraints yielding faster decreasing returns to scale and a lower concentration of wealth; and finally, it studies the effects of two alternative redistributive policies both in the original model and in the recalibrated version of the model, highlighting how the results of the policies depend on the different degrees of tightness of the borrowing constraints.

The Cagetti and De Nardi framework uses a life-cycle model of intergenerational altruism where agents face two stages of life: young and old. The probability of aging and dying are

\(^{4}\)I am very grateful for MariaCristina De Nardi for providing me with the FORTRAN code for their model. I recoded the model for MATLAB and extended it for the purpose of this paper.
parametrized such that the average duration of life and retirement are realistic. There is a continuum of infinitely lived households of measure one. Each household faces idiosyncratic risk but there is no aggregate uncertainty, as in Bewley (1977).

2.1 Preferences

The household’s utility from consumption is given by a constant relative risk aversion utility function \( c^{1-\sigma}/1 - \sigma \). The household discounts the future at a rate of \( \beta \), and discounts the utility of their offspring at a rate of \( \eta \).

2.2 Technology

There are two sectors of production. The first one refers to entrepreneurs who use their labor in their own business, invest in capital, and don’t hire outside workers. The production in the entrepreneurial technology is given by \( \theta k^v \), where \( k \) is the entrepreneur’s investment and \( v \in [0, 1] \) is smaller for stronger decreasing returns in the entrepreneurial technology.

The second sector of production is the corporate sector, in which firms are not controlled by a single entrepreneur and are not subject to financial constraints. The corporate sector has a Cobb-Douglas production function

\[
Y_c = F(K_c, L_c) = AK_c^\alpha L_c^{1-\alpha},
\]

where \( K_c \) and \( L_c \) are the total capital and labor inputs in the corporate sector. \( A \) is constant and capital depreciates in both sectors at a rate of \( \delta \). Capital’s share of income in the corporate sector is given by \( \alpha \).
2.3 Financial Constraints

There is imperfect enforceability of contracts, meaning that debtors cannot be coerced into paying their obligations and that debtors can only obtain external financing for an amount that would be in their best interest to pay back. In particular, if an entrepreneur decided not to repay, he could run away with a fraction, $f$, of the firm’s capital, $k$, and would become a worker next period.

2.4 Households

Each agent starts the period with assets $a$, an entrepreneurial ability $\theta$, and a working ability $y$, which are his state variables. The ability is revealed at the beginning of each period, hence there is no within-period uncertainty about ability levels. However, next period’s ability levels are unknown.

**Young agent’s problem** At the beginning of each period, young agents decide whether to be workers or entrepreneurs

$$V(a, y, \theta) \equiv \max\{V_e(a, y, \theta), V_w(a, y, \theta)\},$$

where $V_e(a, y, \theta)$ is the value function of the young entrepreneur and $V_w(a, y, \theta)$ is the value function of the worker.

**The Entrepreneur** Households that choose to be entrepreneurs invest $k$ into their firms and borrow $k - a$ from a bank at an interest rate of $r$. The agent, who remains young
with a probability $\pi_y$, will maximize

$$V_e(a, y, \theta) = \max_{(c,k,a')} \{ u(c) + \beta \pi_y EV(a', y', \theta' | y, \theta) + \beta (1 - \pi_y) EW(a', \theta' | \theta) \}, \quad (2)$$

where the labor and entrepreneurial ability follow first-order Markov processes. $W(a', \theta')$ is the value function of the old entrepreneur which will be defined later. The young entrepreneur maximizes (2) subject to the budget constraint (3); the incentive compatibility constraint (4), that restricts agents from borrowing more than what they would be willing to pay if defaulting means running away with a fraction $f$ of the capital invested in the firm; and non-negativity constraints for assets and capital, (5) and (6), respectively.

$$a' = (1 - \delta)k + \theta k^v - (1 + r)(k - a) - c, \quad (3)$$

$$u(c) + \beta \pi_y EV(a', y', \theta' | y, \theta) + \beta (1 - \pi_y) EW(a', \theta' | \theta) \geq V_w(f \cdot k, y, \theta), \quad (4)$$

$$a \geq 0, \quad (5)$$

$$k \geq 0. \quad (6)$$

**The Worker**  Similarly, the worker maximizes the value function $V_w$

$$V_w(a, y, \theta) = \max_{(c,a')} \{ u(c) + \beta \pi_y EV(a', y', \theta' | y, \theta) + \beta (1 - \pi_y) W_r(a') \}, \quad (7)$$

where $W_r$ is the value function of the worker who becomes old and retires, as will be explained in the following subsection.
The worker’s problem is subject to (5) and the budget constraint where $\tau$ is a tax on labor income $wy$ that is used to finance social security

$$a' = (1 + r)a + (1 - \tau)wy - c.$$  

(8)

### 2.5 Old agent’s problem

Old entrepreneurs have two state variables, assets $a$ and entrepreneurial ability $\theta$. They choose to either remain entrepreneurs or retire:

$$W(a, \theta) \equiv \max\{W_e(a, \theta), W_r(a)\}.$$  

(9)

**The Entrepreneur** If they remain entrepreneur’s they may die with a probability $(1 - \pi_o)$. They then bequest their firm to their offspring and discount their offspring’s utility by $\eta$. They solve

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

subject to (5), (6), (3) and the incentive compatibility constraint that defines the borrowing constraint for the old entrepreneur

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

(10)

**The Retired** Retired agents can no longer join the workforce or become entrepreneurs. They then solve
$$W_r(a) = \max_{(c,a')} \{ u(c) + \beta \pi_\alpha W_r(a') + \eta \beta (1 - \pi_\alpha) EV(a', y', \theta') \},$$

subject to (5) and the budget constraint

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

where $p$ is a social security transfer.

### 2.6 Equilibrium

A steady state equilibrium in this economy is given by the risk-free interest rate $r$, the wage $w$, the proportional labor income tax $\tau$, the allocations $c$, investments $k$, the occupational choices and a constant distribution of people over the state variables $(a, \theta, y)$, such that:

- The allocations $c, a, k$ and occupational choices maximize the agent’s problem as described above.

- Capital and labor markets clear. The total wealth in the economy equals the sum of the total capital employed in the entrepreneurial and corporate sectors. Entrepreneurs use their own labor, and the total labor employed by the corporate sector equals the number of workers in the economy.

- The factor prices $w$ and $r$ are given by the marginal products of each factor and the rate of return of investing in capital in the corporate sector equals the interest rate that clears savings and investment.

- The labor income tax $\tau$ funds the retired agents’ pensions and is set such that the government’s budget is balanced.
• The distribution of workers and entrepreneurs over the state variables \((a, \theta, y)\) is constant.

2.7 Calibration

Many parameters of the model can be estimated directly from the data without using the framework above or have been estimated time and time again by previous studies. These parameters are fixed in the model and not calibrated. A second set of parameters have unknown values and are calibrated to match moments of the data.

The original Cagetti and De Nardi (2006) estimation uses \(\beta\), the high ability component of \(\theta\) (since the low ability productivity is normalized to zero), \(v, f\), and two elements of the \(2x2\) Markov-transition matrix for entrepreneurial ability \(P_\theta\) (since the sum of each column should be 1) to pin down six moments generated by the data. These moments are: the capital-output ratio, the fraction of entrepreneurs in the population, the fraction of entrepreneurs who exit, the fraction of workers who enter entrepreneurship, the ratio of the median net worth for entrepreneurs to that of workers, and the Gini coefficient for the wealth distribution. For a list of the calibrated and fixed parameters, please refer to the Appendix.

3 Results

3.1 From original calibration

General results and characteristics of the model are in the Cagetti and De Nardi (2006) paper. In this study I will include only results that pertain to the role of borrowing constraints in the model that are not in the original paper.

Occupational choice models that assume tight borrowing constraints for entrepreneurs
are considered very successful in fitting many empirical observations, including the wealth distribution in the cross-section for entrepreneurs and workers, as well as patterns of wealth accumulation for the transitions to and from entrepreneurship that occur over time. These results rely crucially on the assumption of capital market imperfections that lead entrepreneurs to accumulate wealth to invest in their businesses. The purpose of this exercise is to compare the tightness of the borrowing constraints that entrepreneurs a la Cagetti and De Nardi (2006) face to the tightness of similar constraints in the data. If borrowing constraints in the model are significantly tighter than what the available home equity implies, then the aggregative impact of borrowing constraints, namely its effect on wealth accumulation and occupational choice, may be overstated.

In the absence of financial market imperfections, firm size would not depend on the wealth of entrepreneurs and would be a function of technological parameters. However, Cagetti and De Nardi introduce borrowing constraints in their model by assuming that there is imperfect enforceability of contracts, meaning that debtors cannot be coerced into paying their obligations and that debtors can only obtain external financing for an amount that would be in their best interest to pay back. In particular, if an entrepreneur decided not to repay, he could run away with a fraction, \( f \), of the firm’s capital, \( k \), and would become a worker next period. Because the entrepreneur borrows \( k - a \), the higher the agent’s wealth invested in their own business the higher the loss if he defaults and hence the lower the incentive to default. Therefore, the wealthier the entrepreneur, the more he is able to borrow from his creditors. Within the context explained above, each agent chooses his optimal capital level given an upper bound or maximum capital level, \( \tilde{k} \), set by his borrowing constraint.

I have replicated Cagetti and De Nardi’s (2006) life-cycle model of occupational choice.
Using their baseline parameter values, I have computed several statistics referring to investment and borrowing by entrepreneurs. I study the distribution of actual borrowing and maximum possible borrowing in the model. I then compare the difference between the maximum and actual borrowing to an empirical measure of the slackness of borrowing constraints: a fraction of home equity. The implicit assumption here is that entrepreneurs who are borrowing constrained may choose to pay the fix cost to tap into their home equity to finance their businesses. Hence, entrepreneurs’ holdings of home equity provide a measure of the inverse of the tightness of the borrowing constraint. Moreover, focusing on home equity is a clear understatement of the borrowing abilities of agents in the US given that there are many other avenues to obtain external financing. Nevertheless, available home equity provides a lower-bound for the difficult task of quantifying the slackness of the financial constraint.

As can be seen in Figure 1, actual firm size, $k$, follows the maximum firm size allowed by the borrowing constraint, $\bar{k}$, very closely in the Cagetti and De Nardi economy. This is because in their paper the optimal capital in the absence of financial frictions is extremely high. In the baseline specification, if an entrepreneur were rich enough not to face borrowing constraints he would invest $2.32$ billion dollars in his firm. Hence, there is an overwhelming incentive for entrepreneurs to invest as much capital as possible given that the optimal capital in the absence of credit frictions is orders of magnitude beyond the maximum firm size considered in the model which is $75.8$ million dollars$^5$.

It is not straightforward to find an empirical measure of the optimal capital level in the absence of credit market frictions, however actual firm sizes may provide a clue, especially since most entrepreneurs are wealthy and it is plausible that some of them might not suffer from binding financial constraints. In the 1983-89 panel SCF, the median business assets

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$^5$This is the maximum capital included in the gridspace for capital.
Figure 1: Distributions of maximum allowed and actual firm size in the model. Solid line: maximum allowed, dashed line: actual capital.
of entrepreneurs in 1989 was $100 thousand dollars of 1989; the 95% percentile of the distribution of business assets was $1.5 million dollars, still considerably below the frictionless optimal in Cagetti and De Nardi’s paper. Figure 2 compares the cumulative distribution function of capital both in the data and in the model. Following the argument stated above it is no surprise that firms are much larger in size in Cagetti and De Nardi’s model than they are in the data. In fact the median firm in the model is four times as large as that in the data.

Another standard of comparison is the free-from-borrowing-constraints optimal firm size in similar papers. A companion paper provides a calibration of an occupational choice model

Figure 2: Cumulative distribution functions for the size of the firm. Solid line: model, dashed line: data.
that substitutes borrowing constraints for uncertainty about ability. That paper has the same technological specification as Cagetti and De Nardi but arrives at much smaller measures of optimal capital, ranging from $39 thousand to $103 thousand dollars depending on the agent’s belief of his entrepreneurial ability\(^6\).

The reason that the optimal capital levels differ in spite of the same technological specification is large differences in the calibration of the parameter referring to the curvature of the entrepreneurial technology. Specifically, the production technology in both papers is \(\theta k^v\), where \(\theta\) is a measure of ability and \(v\) is a measure of decreasing returns from investment. In Cagetti-De Nardi, the calibration result for \(v\) is 0.88 which is close to that of other calibration exercises presented in Quadrini (2000) and Li (2002), but is more than double that of the companion paper of 0.4 which is closer to the evidence from household-level estimations performed by Evans and Jovanovic (1989) and plant-level estimations by Cooper and Haltiwanger (2000) as well as the calibration results presented by Buera (2008).

The key difference between these two strands of literature is that the first set of papers above, Cagetti and De Nardi (2006), Quadrini (2000) and Li (2002), rely on borrowing constraints for calibration exercises that try to match the wealth distribution of the US. It is therefore not surprising that they need low decreasing returns to capital -equivalently, high \(v\)- to have large optimal firm sizes triggering binding borrowing constraints that drive entrepreneurial households to accumulate high wealth. On the other hand, in the second set of papers a smaller \(v\) implies strong decreasing returns for the firm and allows optimal capital to be smaller, diminishing the bite of borrowing constraints.

Maximum borrowing and actual borrowing for entrepreneurs are also very similar. This

\(^6\)In Cagetti and De Nardi (2006) there is effectively only one level of optimal capital. They consider two different ability levels but normalize one of them to zero so that low ability agents always choose to be workers.
is a direct implication of maximum and actual firm size being closely linked, given that in the model entrepreneurs borrow $k - a$ and their maximum borrowing is given by $\bar{k} - a$. Hence, the only difference between figures 1 and 3 is that the later one subtracts financial wealth from firm size.

Figure 4 presents the distribution of the difference between the maximum and actual borrowing. Even though maximum and actual borrowing are very closely linked, 52% of entrepreneurs are borrowing below the maximum they could get from their creditors. There are of course no closed-form solutions for such an exercise but analyzing the policy functions and the functions that provide the maximum level of capital, two distinctive patterns emerge.
The first one is unsurprising: for a given level of entrepreneurial and labor ability, there is a cut-off level of wealth, \( a_1 \), below which everybody is a worker and above which everybody is an entrepreneur. This is a direct implication of the borrowing constraint mechanism explained above in which the wealthier the entrepreneur, the more he is able to borrow. Consequently, if the agent is poor enough it would not be optimal for him to enter entrepreneurship even if he is of high entrepreneurial ability.

The second pattern is less straightforward and may even seem counterintuitive at first. There is another cut-off level of wealth, \( a_2 (> a_1) \). Up to numerical error, all agents with wealth in between \( (a_1 < a < a_2) \) are not borrowing as much as their creditors will allow, whereas those with \( a > a_2 \) are borrowing as much as they are able to. It may seem counterintuitive that the wealthier have binding borrowing constraints but not the agents below the threshold of \( a_2 \). The reason for this is that the first best capital level is much higher than the highest capital level allowed in Cagetti-De Nardi’s computation of the model, as was explained in detail earlier. Hence, even the richest entrepreneurs have an incentive to invest as much as their borrowing constraint allows. Actually, the second pattern provides a clue for why maximum and actual borrowing differ in 52% of the firms in spite of low decreasing returns to scale. Entrepreneurs decide each period whether to allocate their available funds to their business, accumulate financial wealth, or consume today. There is a strong incentive provided by the low decreasing returns to scale to allocate as much as possible to the firm. This incentive is countered, especially for the relatively poor entrepreneurs, by the desire for consumption-smoothing. The persistence in the entrepreneurial ability implies that Cagetti-De Nardi’s entrepreneurs are likely to be of high ability in the future periods so they will probably remain entrepreneurs and transition to higher wealth classes over time\(^7\).

\(^7\)The cross-occupation and wealth groups transition matrices is exhibited in Cagetti and Denardi (2009) for the model augmented by the main elements of the US tax structure. Similar cross-occupation and wealth
Consequently, poorer entrepreneurs would like to smooth their consumption and have higher consumption today at the cost of investing below the maximum allowed by their creditors.

Next, with data from the SCF, I compute the home equity that can be used for borrowing, which I am taking as a measure for the slackness or inverse of the tightness of borrowing constraints. The data for 1989 in the 1983-89 panel SCF includes a question on the value of the home and another one on the home equity owned by the agent. I can use these two variables to measure how much is currently owed on the home. I then assume that agents must own at least 10% of their home so the maximum that can be borrowed is 90% of the home's value. The groups matrices can be found in the companion paper “Entrepreneurship, Learning, and Wealth”, Taveras (2009).
house value, to accommodate for down payments\textsuperscript{8}. Finally, an empirical measure of how much more entrepreneurs can borrow using their home equity as collateral, can be obtained by subtracting what the agent has already borrowed from his home from the maximum that he can borrow. Figure 5 summarizes the fraction of entrepreneurs for each level of home equity available for borrowing.

Next, I compare the measure of slackness of financial constraints both in the model and in

\textsuperscript{8}The assumption of a minimum down payment of 10\% comes from Haurin, Hendershott, and Wachter (1996) who use the National Longitudinal Survey of Youth to study the relationship between wealth accumulation and home ownership during 1985-89. They mention 10\% as the minimum down payment at that time.
the data. Recalling the argument above, a summary measure of the slackness of the financial constraint in the model is the difference between maximum capital and optimal capital. The larger the difference the less binding the constraint. In the data, the level of home equity available for financing provides a measure of the slackness of the financial constraint. The comparison is provided in Figure 6, which provides three cumulative distribution function: the solid line is produced by the model, and the dashed and dotted line are generated from the data assuming that agents can borrow a maximum of 75% and 90% of their home equity, respectively. According to Figure 6, the financial constraints are tighter in the model than they are in the data, for both down payment assumptions.

Table 1 presents a summary of the distribution of several variables relating to the slackness of borrowing constraints in the data. First it exhibits the size of firms measured by the level of active business assets, as well as the home equity owned by entrepreneurs, and the home equity left for borrowing as defined earlier. The last row of the table shows the ratio of home equity left for borrowing to active business assets, which is a measure of the slackness in the financial constraint. A ratio of 0, for example, means that the entrepreneur cannot borrow any amount using his home as collateral; whereas a fraction of 1 means that if the entrepreneur took full advantage of his home equity to finance his business he would double his business assets. As table 1 summarizes, the median entrepreneur can use his home equity to increase his firm size to almost one-third of the original; entrepreneurs in the 95th percentile have enough home equity that they can multiply their business assets by a factor of eight if they wanted to. The data reveals that a large fraction of entrepreneurs do not suffer from binding constraints if one considers that they can make use of their home equity to finance their business activities.
Figure 6: Cumulative distribution function for the slackness in the borrowing constraint. Solid line: model (obtained from the gap between maximum and actual borrowing), dashed line: data (agents can borrow up to 90% of the house value), dotted line: data (agents can borrow up to 75% of house value).
Table 1: **Firm size, home equity, and slackness of the borrowing constraint in the data**

<table>
<thead>
<tr>
<th>Percentile</th>
<th>5th</th>
<th>25th</th>
<th>50th</th>
<th>75th</th>
<th>95th</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) Active business assets</td>
<td>5,019</td>
<td>36,667</td>
<td>100,000</td>
<td>216,333</td>
<td>1,472,485</td>
</tr>
<tr>
<td>(2) Home equity</td>
<td>0</td>
<td>18,083</td>
<td>44,333</td>
<td>84,000</td>
<td>381,733</td>
</tr>
<tr>
<td>(3) Home equity left for borrowing $^a$</td>
<td>0</td>
<td>10,999</td>
<td>33,287</td>
<td>69,499</td>
<td>340,667</td>
</tr>
<tr>
<td>(4) Ratio of (3)-to-(1)</td>
<td>0</td>
<td>0.042</td>
<td>0.281</td>
<td>0.827</td>
<td>8.338</td>
</tr>
</tbody>
</table>


$^a$ Assumes entrepreneurs can borrow up to 90% of their house value.

### 3.2 Recalibration

This paper’s recalibration of the model sets out to match firm sizes and borrowing availability more closely, as opposed to wealth disparity and inter-occupational moments of the wealth distribution, as in the original calibration. I preserve the same set of fixed and calibrated parameters to keep things as comparable as possible. Hence there are again six parameters $\beta, \theta, v, f$, and two elements of the Markov-transition matrix for entrepreneurial ability $P_0$, to match six moments of the data. Four of these moments are the same as in the original paper: the capital-output ratio, the fraction of entrepreneurs in the population, the fraction of entrepreneurs who exit, and the fraction of workers who enter entrepreneurship. The remaining two are the ratio of the median firm size-to-networth for entrepreneurs and the median funds available for borrowing as a fraction of firm size.

Given the features that the model sets out to match, I present how well the model matches other moments such as the distribution of firm size, the slackness in the borrowing constraints and the wealth distribution. Matching the ratio of median firm size-to-networth,
has consequences on the resulting distribution of firm sizes but a model may match the ratio and miss the distribution of firm sizes altogether. The same can be said about the ratio of the median funds available for borrowing-to-firm size and the distribution of the slackness of the borrowing constraint.

As could be anticipated from the previous section, the recalibration results in firms that are smaller and, for most of the distribution, closer to the size of firms in the data by yielding faster decreasing returns to scale, that is a lower $v$, which goes from 0.88 in the original model to 0.4 in the recalibration (for the full set of calibrated parameters, please refer to the Appendix).

Figure 7 presents the cumulative distribution function for the size of firms in the data and in the model. The distribution functions follow each other closely for the lower 90% of the distribution, and are in fact considerably closer than the analogous curves resulting from the Cagetti-De Nardi’s (2006) calibration and presented in Figure 2. The largest 10% of firms in the model are smaller than the largest 10% of firms in the data, as can be seen in Figure 7.

Next, the recalibration very closely matches the availability of borrowing constraints for entrepreneurs. The original calibration in Cagetti-De Nardi’s (2006) paper resulted in very binding constraints for entrepreneurs. This paper argues that home equity can be a source of financing for entrepreneurs. More specifically, when analyzing the portfolios of entrepreneurs in the data, entrepreneurs have considerable holdings of home equity from which they could borrow. Figure 8 displays the distribution of the difference between the maximum that an entrepreneur can borrow and his actual debt in the recalibrated model (the solid line) against two measures the home equity left for borrowing, that is the home equity available after taking into account that agents can borrow up to a “down payment" of 10% (dotted
Figure 7: Cumulative distribution functions for the size of the firm. Solid line: model, dashed line: data.
Figure 8: Cumulative distribution function for the slackness in the borrowing constraint. Solid line: model (obtained from the gap between maximum and actual borrowing), dashed line: data (agents can borrow up to 90% of the house value), dotted line: data (agents can borrow up to 75% of house value).

As anticipated, calibrating the model to match the desired moments listed above comes with an important drawback, which is that the fast decreasing returns to scale in the entrepreneurial production function generates a distribution of wealth that is far less skewed than in the data. Table 2 exhibits several statistics referring to the distribution of wealth as well as other characteristics of both calibrations and the data. As can be seen, all of the measures of wealth inequality reveal that wealth is more equally distributed in the new calibration. It would be interesting to see whether a model that includes borrowing constraints for entre-
preneurs and a richer entrepreneurial ability structure\textsuperscript{9} could match firms sizes, slackness in the borrowing constraints, and wealth inequality.

Table 2: **Comparing data and models**

<table>
<thead>
<tr>
<th></th>
<th>K/Y</th>
<th>i</th>
<th>% Entrepreneur</th>
<th>Wealth gini</th>
<th>% Wealth on top</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>5%</td>
</tr>
<tr>
<td>Data</td>
<td>3</td>
<td>6.8%</td>
<td>0.8</td>
<td>54</td>
<td>81</td>
</tr>
<tr>
<td>Original calibration \textsuperscript{a}</td>
<td>3</td>
<td>6.5%</td>
<td>7.5%</td>
<td>0.8</td>
<td>60</td>
</tr>
<tr>
<td>Recalibration \textsuperscript{b}</td>
<td>2.8</td>
<td>10%</td>
<td>7.8%</td>
<td>0.6</td>
<td>12</td>
</tr>
</tbody>
</table>

\textsuperscript{a} Reproduced by the author but also available in Cagetti-DeNardi (2006).
\textsuperscript{b} Recalibration with a different set of moments to match as explained in this section

Comparing the original calibration of Cagetti and De Nardi (2006) to this calibration, the risk free interest rate $i$ is 3.5 basis points higher in the recalibration. The faster decreasing returns to scale in the entrepreneurial technology allows borrowing constraints to be less binding which results in would-be-entrepreneurs having lower savings rates in the recalibration because they no longer need to accumulate financial wealth to escape binding borrowing constraints when investing in their business activities. As a result, the supply of savings in the economy is lower, and the risk-free interest rate is higher. Table 3 in the next subsection, exhibits how the recalibration affects key aspects of the model. The smaller firms in the recalibrated version of the model provide lower gross entrepreneurial product. Equally, the capital in the corporate sector is also lower in the recalibration because the higher interest rates translate into higher costs of capital. Hence, gross domestic product in the recalibrated economy is below that of the original calibration.

\textsuperscript{9}While there are two levels of entrepreneurial ability in this model, the low ability is normalized such that it is not profitable for low ability agents to become entrepreneurs. Hence, in this model all entrepreneurs possess the same level of high ability.
4 Policy experiments

The original model includes one proportional payroll tax that is levied on young workers and pays for the social security pensions that retired agents receive. In this section, I build on this set-up and add two alternative redistributive policies to the tax structure, highlighting how the consequences of these policies depend on the tightness of the borrowing constraints. In summary, the faster decreasing returns to scale in the recalibration dampens the effect of the redistributive policies in the economy. On the second column, Table 3 shows the no-policy benchmark for both the original and my calibration. This column presents key aspects of the economy such as the dollar level of GDP, total savings, and capital in the entrepreneurial sector, as well as the interest rate and the fraction of entrepreneurs. The columns to the right exhibit the effect of the different redistributive policies.

First, I consider a policy that takes wealth from the low-ability agent and transfers it to the high-ability one. Specifically, I model a 1% proportional tax on wealth of the low-ability households accompanied by a lump-sum subsidy to high-ability households. The lump-sum subsidy, shown as the last element in each column, is such that the budget remains balanced, keeping other aspects of fiscal policy as in the original model. This exercise relaxes the borrowing constraint for the high-ability agent, while tightening it for the low-ability one. In effect, this policy transfers a positive lump-sum to all entrepreneurs, given that entrepreneurs all have high ability in equilibrium in this model (low-ability agents are better off as workers).

Such a policy has more impact on GDP, total savings, fraction of entrepreneurs, and capital in the entrepreneurial sector in the original calibration than with the faster decreasing returns to scale present in the recalibration of the model. Whereas GDP increases by almost 12% in the original calibration and the fraction of entrepreneurs in the economy goes from 7.5 to 10.4%, in the recalibration of the model GDP increases by 2.8% and the fraction
of entrepreneurs goes from 7.8 to 8.1%. The intuition here is that a wealth transfer from low-ability to high-ability is a direct transfer to would-be entrepreneurs. Hence it facilitates entry into entrepreneurship and relaxes borrowing constraints for those that are already entrepreneurs. Since borrowing constraints are less binding in the recalibration of the model, a redistributive policy like this one would have a dampened effect on the economy.

Next, I model a policy that taxes wealthy agents and subsidizes poor agents. I consider a proportional tax of 1% of wealth to agents that have a net worth of $500,000 and assign a lump-sum subsidy to households with a net worth below the same threshold, such that the subsidy balances the government budget. The selection of the $500,000 carefully considers that the recalibration yields a more equitable distribution of wealth. For example, if the threshold is set at one million dollars, less than a ten thousandth of the population has wealth above $500,000 and would be affected by the tax in the recalibrated version of the model (5% in the original Cagetti-De Nardi’s calibration). The redistributive policy would then have close to no effect on the recalibrated model. In turn, with the $500,000 threshold, about 9.5% of the population has wealth beyond the threshold and would pay the tax on wealth in the recalibrated model, while 8% of the population would do so in the original version (as can be seen the fraction of the population above the $500,000 threshold is very similar in both calibrations, even though the wealth distribution in the original version of the model has a thicker right tail).

Four versions of this policy that taxes the wealthy and subsidizes the poor are considered, each with a different target group. The first version limits its taxes and subsidies to young entrepreneurs. The second one, broadens the target population to both young and old entrepreneurs. Next, I broaden the target population even further to include everybody except the retired agents. Finally, all agents even those who have retired are affected by
either taxes or subsidies, depending on their wealth level.

In the original calibration, in which borrowing constraints are severely binding, policies (I) and (II), which target the transfers to the population of entrepreneurs only, result in a larger fraction of the population becoming entrepreneurs. As shown in the first panel of Table 3, transferring wealth from rich to poor in the original calibration of the model allows poor high-ability agents to amass enough wealth, escape borrowing constraints, and enter entrepreneurship. This leads to higher capital in entrepreneurial firms and higher GDP. These results are in part muted when the transfer from rich to poor is not targeted to entrepreneurs. In policies (III) and (IV) young workers and old retired agents respectively are affected by the policy. In these two types of interventions, wealth from some of the rich entrepreneurs ends up in the hands of poor workers, resulting in lower increases in GDP, capital in entrepreneurial firms, and fraction of the population in entrepreneurship. Furthermore, since rich agents save a higher fraction of their wealth than poor agents do, a transfer from rich to poor lowers aggregate savings. Consequently, the drop in the supply of savings increases equilibrium interest rate. With regards to the lump-sum subsidy that poor agents receive, the inclusion of workers and retired agents in the policy’s target group triggers sharp decreases in the level of the subsidy. The lower subsidies are due to the inclusion of more poor agents as a fraction of the target group since most rich agents are entrepreneurs. Hence, the revenues of the taxes on the rich are being divided among a higher number of agents with the broadening of the target group.

In turn, in the recalibration of the model, borrowing constraints are not as binding as in the original version. Hence, the effects of transferring wealth from rich to poor agents are severely dampened, as can be seen in the second panel of Table 3. The fraction of entrepreneurs in the population is not affected regardless of the target population of the
policy. The GDP and total capital in the entrepreneurial sector increase at a much lower rate than in the original calibration, meaning that the size of firms does slightly increase with the transfer. The level of the subsidy required to balance the budget is much lower in the recalibrated version of the model than in the original, because taxing rich agents in the recalibrated version of the model translates into lower revenues for the government than in the original version of the model. The lower revenues are a direct consequence of the recalibration resulting in a more equitable wealth distribution.

In summary, the general result is that redistributive policies in the recalibrated model are less effective in terms of changes to the fraction of the population in entrepreneurship, capital in the entrepreneurial sector, and GDP.
Table 3: Redistributive policies in both calibrations

<table>
<thead>
<tr>
<th></th>
<th>No-policy</th>
<th>Change from no-policy to taxing</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Low-ability</td>
<td>Rich</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>I</td>
<td>II</td>
<td>III</td>
<td>IV</td>
</tr>
<tr>
<td>Original Calibration</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GDP</td>
<td>68,000</td>
<td>11.9%</td>
<td>7.2%</td>
<td>8.6%</td>
<td>3.8%</td>
<td>0.6%</td>
</tr>
<tr>
<td>Total savings</td>
<td>188,631</td>
<td>18.9%</td>
<td>10.4%</td>
<td>13.1%</td>
<td>6.1%</td>
<td>-1.8%</td>
</tr>
<tr>
<td>Interest rate</td>
<td>6.5%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0.8%</td>
<td>1.0%</td>
</tr>
<tr>
<td>% entrepreneurs</td>
<td>7.5%</td>
<td>2.9%</td>
<td>2.7%</td>
<td>2.7%</td>
<td>1.2%</td>
<td>1.3%</td>
</tr>
<tr>
<td>Capital in entrepreneurial sector</td>
<td>55,643</td>
<td>49.7%</td>
<td>31.8%</td>
<td>35.8%</td>
<td>13.7%</td>
<td>11.8%</td>
</tr>
<tr>
<td>Subsidy</td>
<td>NA</td>
<td>11,712</td>
<td>9,639</td>
<td>8,456</td>
<td>1,041</td>
<td>675</td>
</tr>
<tr>
<td>Recalibration</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GDP</td>
<td>55,638</td>
<td>2.8%</td>
<td>0.8%</td>
<td>0.6%</td>
<td>1.8%</td>
<td>1.4%</td>
</tr>
<tr>
<td>Total savings</td>
<td>105,750</td>
<td>8.8%</td>
<td>2.8%</td>
<td>2.3%</td>
<td>6.4%</td>
<td>5.3%</td>
</tr>
<tr>
<td>Interest rate</td>
<td>10.0%</td>
<td>0.3%</td>
<td>0.2%</td>
<td>0.2%</td>
<td>0.6%</td>
<td>0.6%</td>
</tr>
<tr>
<td>% entrepreneurs</td>
<td>7.8%</td>
<td>0.3%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Capital in entrepreneurial sector</td>
<td>17,154</td>
<td>3.5%</td>
<td>4.5%</td>
<td>3.4%</td>
<td>5.2%</td>
<td>4.0%</td>
</tr>
<tr>
<td>Subsidy</td>
<td>NA</td>
<td>11,709</td>
<td>450</td>
<td>450</td>
<td>225</td>
<td>225</td>
</tr>
</tbody>
</table>

\(^a\) % Change from no-policy for all variables except for the subsidy which is in dollars. For GDP, total savings, and capital in entrepreneurial sector the % change is the variable with the policy divided by the no-policy minus 1, whereas the change in interest rate and the fraction of entrepreneurs is the rate with the policy minus the rate without the policy.

\(^b\) There are several specifications all with the same threshold of $500,000: I. Taxes rich young entrepreneurs, subsidizes poor young entrepreneurs; II. Taxes rich young and old entrepreneurs, subsidizes poor young and old entrepreneurs; III. Taxes rich, subsidizes poor (both entrepreneurs and workers, excluding retired agents); IV. Taxes rich, subsidizes poor (entrepreneurs and workers, including retired agents).
5 Conclusions

While the archetypal model of occupational choice is able to match the skewness of the wealth distribution, this achievement comes with important drawbacks. Slow decreasing returns to scale in the entrepreneurial technology are needed to match the highly unequal distribution of wealth in the US. The slow decreasing returns to scale translate into firms that are much larger than in the data and borrowing constraints that are strictly binding, even for extremely rich entrepreneurs. Firms in the model are several times greater than those in the data. In turn, a comparison of borrowing constraints in the model and the data reveals that borrowing constraints are tighter in the model even when limiting financing to what, according to the data, could be derived from home equity taking into account down payments and outstanding loans on the home. Hence, matching the wealth distribution mandates important sacrifices in the characteristics of small firms and entrepreneurs, which is precisely the topic that the occupational choice models set out to study.

The disadvantages of modeling entrepreneurs that are far more financially constrained than in the data becomes even more evident when studying the effects of redistributive policies that set out to aid high-ability would-be entrepreneurs or poor agents. These policies alleviate some of the financing constraints that entrepreneurs face, resulting in a higher fraction of population in entrepreneurship, higher capital used in entrepreneurship, and higher GDP for the original calibration. Recalibrating the model to match firm sizes and a degree of slackness in the borrowing constraints comparable to the data, yields very different results for the same redistributive policies. The policies have a much dampened effect in the fraction of entrepreneurs (in fact a zero change in all the cases involving transfers from the rich to the poor), GDP, and capital used in entrepreneurship.

Perhaps a more satisfactory way to reconcile the characteristics of firms and entrepreneurs
as well as the unequal distribution of wealth in the US is by augmenting the model to include a richer ability structure. In a companion paper, it is shown how, in the absence of borrowing constraints, a richer ability structure can produce wealth accumulation and occupational transition patterns that match many stylized facts in the data. An even richer model that encompasses borrowing constraints and several ability levels for entrepreneurs may reproduce firms that are small in size and thick tails in the wealth distribution. Nevertheless, the computational needs of such a model must not be underestimated, though without doubt this will be less time-consuming in the future as computing capabilities progress further.

References


6 Appendix

6.1 Description of calibration

| A. Fixed parameters (taken directly from Cagetti-De Nardi (2006)) |
|---|---|
| **Value** | **Source** |
| $\sigma$ | 1.5 | Attanasio et al (1999) |
| $\delta$ | 0.06 | Stokey and Rebelo (1995) |
| $\alpha$ | 0.33 | Gollin (2002) |
| $A$ | 1 | Normalization |
| $\pi_y$ | 0.978 | Average length of working life: 45 years |
| $\pi_o$ | 0.911 | Average length of retirement: 11 years |
| $P_y$ | 5-state discretized labor income | Storesletten et al. (1999) |
| $p$ | 40% of yearly income | Kotlikoff et al (1999) |
| $\eta$ | 1 | Perfect altruism |

| B. Calibrated parameters. |
|---|---|
| Cagetti-De Nardi (2006) | Recalibration done in this paper |
| $\beta$ | .865 | .867 |
| $\theta$ | [0, .51] | [0, 1.84] |
| $P_\theta$ | 0.964 0.036 | 0.964 0.036 |
| | 0.206 0.794 | 0.33 0.67 |
| $v$ | .88 | .40 |
| $f$ | 75% | 90% |