Wealth Taxation and Entrepreneurship

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Abstract

This paper studies wealth taxation in a heterogeneous agent economy with entrepreneurship. Entrepreneurs face borrowing constraints and stochastically receive the opportunity to sell their firm to outside investors. With the help of a novel panel dataset on household wealth, I show that this possibility for entrepreneurs to sell their firm is crucial to simultaneously account for both the stylized facts of the wealth distribution and year-to-year changes in wealth. In a subsequent policy experiment, I show that the effects of a wealth tax depend on how frequently entrepreneurs receive the opportunity to sell their firm. In an economy where this probability is low, taxing wealth reduces output by affecting the capacity of entrepreneurs to invest in their firm. In an economy where entrepreneurs can easily sell their firm, taxing their wealth has little aggregate effect. The policy implication is that improving financial markets reduces the output losses due to a wealth tax.

1 Introduction

What are the effects of a wealth tax in an economy where entrepreneurs are overrepresented among the wealthy? In a representative-agent setting, the effects of taxing

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wealth are straightforward and well known. However, this approach misses an important empirical fact: the burden of a wealth tax is mainly borne by a very specific and small subgroup of households, the wealthy, among which there are many entrepreneurs. Suppose for instance that, due to imperfect financial markets, entrepreneurs rely on their personal wealth when creating and growing their firms. Then taxing wealth would diminish entrepreneurial investment and firm-creation. Since entrepreneurial firms contribute directly to the overall productivity level of the economy, the negative effects of a wealth tax would then go much further than the well-known effect on the capital level. Suppose now to the contrary that the wealthy are in fact retired entrepreneurs who "cashed in" and sold their firm. In that case a wealth tax has very little distortive effects, since it is mainly borne by agents whose wealth is not vital to the growth of credit-constrained entrepreneurial firms, and therefore has no positive external effects on productivity.

I study the quantitative effects of a wealth tax on aggregate productivity by constructing a quantitative heterogeneous-agent general-equilibrium model that explicitly allows for the wealthy to be of two types: active entrepreneurs, who crucially need their wealth to grow their firms, and the inactive wealthy, ex-entrepreneurs or their offspring, who have "made it" and who simply manage their wealth but play no direct role in production. In my model, entrepreneurs are credit-constrained and can only borrow a multiple of their own assets. I introduce a stochastic opportunity for entrepreneurs to sell their firm and "cash in" on their accumulated equity. If they do so, they sell their firm to an outside investor who is not financially constrained and runs the firm at its efficient scale. At the intuitive level I argue that this second mechanism is a key determinant of the effects of a wealth tax: in a model where entrepreneurs cannot sell their firm, a wealth tax would by construction be particularly detrimental since personal wealth is the only means for entrepreneurs to grow their firm. Thus a wealth tax would affect aggregate productivity and wages by slowing down the rate of growth of entrepreneurial firms. Empirically, I exploit a new panel-data set on household wealth. This allows me to construct a period-to-period wealth transition matrix showing the frequency of households transferring from one wealth-quantile to the next (or even higher). I show that this "cashing in" mechanism allows me to account for a so-far overlooked dimension of the data, wealth mobility, that simpler models — built solely on the patient accumulation of wealth by entrepreneurs — cannot explain.

I then compare the steady state output of my model economy with and without a wasteful wealth tax. The conclusion is that a 1.2% wealth tax diminishes output by 1.5% by reducing the number of entrepreneurs by 1.9% and their output by 6.7%. This puts the cost of 1€ of wealth tax income at 0.45€ of lost output and illustrates the negative effect of the tax very well: entrepreneurial output is reduced by more than total output through the negative effect of the wealth tax on the capacity of entrepreneurs to raise capital for their firms.

I then conduct the same policy experiment in several versions of my model by loosening or restricting the firm-selling mechanism. The results confirm the effects just described: the more entrepreneurs can sell their firm, the lower the negative effects of the wealth tax. In model economies with better financial markets output is higher and less affected by a wealth tax. In the context of my model, this leads to the policy conclusion that improved financial markets both increase output, by allowing more firms to be run at their efficient scale, and decrease the distortive effects of capital taxation by making aggregate investment less reliant on the personal wealth of entrepreneurs.

The remainder of the paper is structured as follows. After an overview of the relevant literature in section 2, I describe the new model in section 3. In sections 4 and 5 I describe my dataset, compute the empirical wealth transition matrix and calibrate my model. Section 6 conducts the tax experiment and section 7 concludes. An appendix collects the computational details.

2 Literature

The main facts of the U.S. wealth distribution are documented by Diaz-Gimenez, Quadrini, and Rios-Rull (1997), Quadrini (1999) and Cagetti and De Nardi (2006), with Cagetti and De Nardi (2008) providing a nice survey. Specifically, for the United States in 2003 the net income and wealth Gini indexes are 0.38 and 0.78 and the top 5% and 1% own resp. 58% and 33% of all household wealth. Entrepreneurs, although representing only ca. 11% of households, hold about 41% of total household wealth, and they represent 50% and 62% of households in the top 5% and 1%.

Previous research has shown that explicitly modeling entrepreneurship is a successful strategy when aiming to construct a model that quantitatively replicates the U.S. wealth distribution[1]. Such models are built on the premise that credit-constrained entrepreneurs are endowed with a very profitable non-transferable idea that requires funding. To exploit their idea, they need assets of their own to relax the borrowing constraint. Hence they face very large incentives to save: the return of an extra dollar of assets equals the marginal return of investing in their entrepreneurial firm multiplied by the leverage multiple, i.e. the additional borrowed investment that this extra dollar of assets allows. Thus entrepreneurs accumulate huge assets because it is the only way for them to exploit their idea, and this drives the skewness of the wealth distribution.

In the context of such a model, several papers have studied taxation. Meh (2005) studies the effect of proportional and progressive income taxation and shows that in the presence of entrepreneurs, progressive taxation does very little to alleviate wealth

[1] See my discussion in Appendix A.2 and the reviews in Cagetti and De Nardi (2008) and Quadrini (2009).

inequality. Meh and Terajima (2009) show that in a context of investment risk and underaccumulation of capital, lowering the capital income tax has beneficial general-equilibrium effects. Kitao (2008) discusses various forms of capital taxation and concludes that reducing the taxation on business income is the most promising avenue of capital income tax reform. Cagetti and De Nardi (2009) look specifically at estate taxation in a carefully calibrated quantitative model with inheritable entrepreneurial talent. They show that lowering the estate tax would have a positive effect out the capital level and on output by affecting the investment capacity of larger firms. However, their sobering conclusion is that, although output and capital are unambiguously increased, a repeal of the estate tax would yield a welfare loss, most agents (the non-super rich) loose slightly more from the new taxes than they gain from the repeal of the estate tax and its consequences on investment and wages[2].

The driving force in all these results is that interfering with the capacity of entrepreneurs to reinvest their accumulated wealth has non-negligible effects on aggregate productivity since it reduces the size of the entrepreneurial sector. For the latter paper, the second driving force is the inheritability of entrepreneurial talent. Simply put: taxing capital tightens the borrowing constraint of those who are the best investors. None of these papers considers the possibility that entrepreneurs with sufficiently large firms may "cash-in" and retire, leaving the firm to an outside, non credit-constrained, investor.

3 The model

3.1 Setup

The model is set in discrete time, with each time period corresponding to 1 year. There is no aggregate growth and I concentrate on the steady state. All shocks happen in between periods and are revealed at the beginning of the next period. Since the model displays only idiosyncratic uncertainty, I will assume that this uncertainty "washes out" in the aggregate. Hence all prices, wages and interest rates are constant in a steady state. To keep notation as legible and clear as possible, I use t (time) and i (name) subscripts only when necessary to prevent confusion.

3.1.1 Ideas and firms

An idea θ allows its owner to start a firm. θ is a dichotomous variable with a value of either 0 (no idea) or $\bar{\theta}$. The one-period profit function $F(\cdot)$ net of all factor costs of

[2] In itself this is an interesting result: no representative agent economy could yield a model where a rise in output and capital leads to a drop in expected utility by most agents. The very skewed ownership of capital is crucial for this conclusion.

this firm is as follows:

$$F(k) = \max_{l \geq 0} \left[\bar{\theta}(k^{\alpha} l^{1-\alpha})^{\nu} + (1-\delta)k - wl \right]$$

with $\nu < 1$ the decreasing-returns-to-scale factor, k the capital invested in the firm, l the hired labor and δ the depreciation rate of capital. A firm is thus simply an idea that has been put into practice. Note that the creation of a firm carries no immediate uncertainty: θ is known at the beginning of the period and the profit function above includes the return of invested funds (minus depreciation). Ideas arrive at random (see section 3.1.2) and have a stochastic lifetime. At the beginning of each period an existing idea has a probability π_0 of dying (i.e. switching to $\theta = 0$ forever after), and a firm's lifetime is identical to the lifetime of the underlying idea. From a financial viewpoint, a firm is thus a cash-flow stream with an uncertain lifetime[3].

A firm (and the idea that goes with it) can either be entrepreneurial or publicly-owned. Ownership only determines who provides the invested capital and receives the profits, it does not affect the stochastic θ-process nor the production function. An entrepreneurial firm is owned by an individual, called an entrepreneur, who provides all invested capital and collects all profits. Publicly-owned firms are entrepreneurial firms that were sold off in the past (see section 3.1.3) and belong to investors. Invested capital is rented per-period and profits (net of capital rental costs) are paid out to the owners. I assume that these firms are well monitored so that net profits are maximized and neither profits nor capital can be fraudulently appropriated by managers. Let k^* be the optimal level of investment of a firm:

$$k^* = \arg\max_{k \geq 0} F(k) - (1+r)k$$

Since these firms face no financing constraints, their capital level is k^* and they pay a periodic dividend of

$$D = F(k^*) - (1+r)k^*.$$

It is important to be clear about the timing of the risks faced by the various stakeholders. Entrepreneurs only face the risk that, with probability π_0, their firm might die next period. They do not risk losing any investments since profits are paid out in the same period as the investment is made. The risk faced by the investor is identical to the entrepreneur: the idea underlying his firm has an uncertain finite life. Once a firm has died the stock is worthless. Bond holders of publicly-owned firms do not face any risks: these are one-period bonds that are paid back when profits are paid out.

[3]Heuristically, one can think of an idea as an innovation — for instance a new product or a technological or business improvement — that is "ahead" of the market in that allows its owner to earn an above-market return on investments. Since all innovations end up being competed away or overtaken by better innovations, these rents are only temporary.

3.1.2 Agents and preferences

I adopt a life-cycle model with perfect intergenerational altruism. To allow for both long spells of young and old age under the computational constraint of a small number of life-stages, I follow Cagetti and De Nardi (2006, 2009) by using the modeling device of stochastic life-stage transitions[4].

The economy is populated by young and old "bachelor" households. Each period, a young agent faces a constant probability of aging of π_{a} and an old agent faces a constant probability of dying of π_{d} . When an old agent dies, his offspring enters the economy as a young agent, inheriting the old's assets. Agents derive time-separable utility from their own consumption c. Instantaneous utility is given by

$$u(c) = \frac{c^{1-\sigma}}{1-\sigma}$$

and future utility is discounted at rate β. Old agents care about their offspring as much as about themselves.

Each agent starts the period with four state variables: his asset level a, a working ability y, possibly an idea ($\theta = \bar{\theta}$) and possibly the opportunity to sell his idea to outside investors, noted by the variable ϵ. The first variable is a choice variable and the latter three are stochastic and vary between periods. All uncertainty is revealed at the beginning of the period.

A young agent faces three choices: his activity (worker or entrepreneur), his asset level next period and, if allowed, whether to sell his idea. If he chooses to be a worker, he sells y on the labor market for the (equilibrium) wage w. Labor supply is inelastic (there is no disutility of working) so all workers sell all of their productivity-adjusted hours y. If the agent chooses to be an entrepreneur, he invests k in an entrepreneurial firm based on his idea. Such investment is limited by a borrowing constraint: entrepreneurs may not borrow more than a multiple f of their assets: $k \leq (1+f)a$. An old agent can neither work ($y = 0$) nor draw new ideas, although an old agent may retain his idea from the previous period, conditional of course on that idea still being alive. Hence an old agent faces a simpler choice. If he does not have a surviving idea, he is a retiree and draws a fixed pension p. His only choice variable is next period's asset level. If he still has an (old) idea, he faces the additional choice of retiring (and losing his idea) and drawing a pension p or running an entrepreneurial firm with the same constraints on borrowing as a young agent. Lastly, each agent with an idea, young or old, may have the opportunity to sell his idea to an outside investor ($\epsilon = 1$). The details covering the selling-off of an idea to an outside investor are covered in section 3.1.3. An agent who chooses to do this loses his idea and reverts back to being a worker or retiree.

y follows a Markov process. Old agents have no ability to work and newborn agents draw y from the invariant distribution of the underlying Markov process. Ideas

[4]See Blanchard (1985) and Gertler (1999) for the original idea.

are drawn by young agents. Each period, a young agent who does not already have an idea ($\theta = 0$) has a probability π_θ of drawing one ($\theta = \bar{\theta}$). As noted in the previous section, an existing idea has a probability π_0 of dying. Old agents cannot draw new ideas but hold on to their existing idea until it dies. Newborn agents inherit their ancestor's idea. Agents with an idea meet an investor ($\epsilon = 1$) with probabity π_ϵ. The stochastic processes governing y, ϵ and θ are independent from each other and across agents.

3.1.3 Financial sector

The financial sector is modeled as the intermediary between the supply and demand of funds. In equilibrium, it makes neither a profit nor a loss[5]. Summing up the preceding paragraphs, there are several types of securities: stock in publicly-owned firms, one-period bonds sold by entrepreneurs and publicly-owned firms, and household savings. On the supply side for funds, the financial sector borrows all funds saved by households. On the demand side for funds, the financial sector holds the entire portfolio of assets: it lends to entrepreneurs and publicly-owned firms and holds stock[6] .

Since all savings and lendings are riskless and the financial sector is competitive, they all trade at the same interest rate r, determined in equilibrium. A publicly-owned firm only faces the idiosyncratic uncertainty of losing its idea in-between periods. Therefore it pays the same dividend D until it disappears. Furthermore, I assume that idiosyncratic risk "washes out" in the aggregate. In other words, I assume that the market portfolio is riskless. This implies, in accordance with standard portfolio theory, that the discounting rate used by the financial sector to value expected dividends is the riskless rate r. Putting these facts and this assumption together, the value P of a publicly-owned firm at the beginning of a period is the value of the discounted expected

[5]It might be helpful to visualize the financial sector as a large number of small competitive banks with no market power who compete for funds and investment opportunities.

[6]It should be noted that this set-up is for expository clarity and is without loss of generality. The financial sector here acts as a simple clearinghouse for the demand and supply of funds. In principle, there is no need for this separate financial sector: one could simply let households directly buy bonds and stocks and let prices (i.e. the interest rates of bonds and prices of shares) be set in general equilibrium. To have a complete view of the financial markets, one would then need to develop a portfolio theory for the households and keep track of all the stocks and bonds of each firm held by each household.

However, as noted before, all bonds are riskless, so they all carry the same interest rate r and are undifferentiated from the buyers' viewpoint. Furthermore, as shown below, full diversification makes the market portfolio of stocks riskless too: the survival of individual firms is uncertain but, through a law-of-large-numbers type property, the fraction of firms dying each period is certain. Therefore all households would simply hold a fraction of the riskless market portfolio. It is easier (but not restrictive) to model the financial transactions of the model with a separate financial sector.

dividends, i.e.:

$$P = \sum_{t=0}^{\infty} \frac{(1-\pi_0)^t D}{(1+r)^{t+1}} \quad \Rightarrow \quad P = \frac{D}{r+\pi_0}$$

When selling his firm, it is assumed that all bargaining power lies with the entrepreneur. There is no asymmetric information: investors understand the production function of the firm and can project future dividend payments based on the optimal level of invested capital k^*. Therefore, P is also the price paid by the financial sector for an entrepreneurial firm that is sold by its entrepreneurial owner. Furthermore, this means that an entrepreneur who has the opportunity to sell his firm always will. He is risk-averse and possibly finance-constrained so he values the expected value of the future cash-flows at the optimal capital level k^* more than the risky and possibly lower cash-flows that the continued ownership of his firm would offer him.

The exact timing of the selling of a firm is as follows. At the very beginning of a period the entrepreneur discovers whether his idea has died and, if it hasn't, whether he can sell it. The entrepreneur then pockets the proceeds of the sale, P. He loses his idea and all control over the firm and next period reverts back to being a worker (if he is young) or a retiree (if he is old).

3.1.4 Taxes and social security

Workers pay a tax τ_l on their wages and a wealth tax τ_w on their assets holdings. Old workers receive a pension p. In the baseline model, the wealth tax will be 0 and the labor tax exactly finances the pensions. In Section 6 the wealth tax will be positive.

3.2 Solving the model

I solve the model recursively for the steady state. In the following, E denotes the expectations operator, where y, θ and ϵ follow the stochastic processes described above and aggregate state variables r and w are anticipated through rational expectations and taken as given by individual agents. The financial sector is as described above (i.e. competitive and making neither losses nor profits), thus k^*, $P(\cdot)$ and D are defined and known. Let V, V_e, and V_w be the value functions of respectively a young agent before he makes the choice of being a worker or an entrepreneur, a young entrepreneur and a young worker; respectively, let W, W_e, and W_r be these same value functions for an old agent before he makes his choice, an old entrepreneur and a retiree.

3.2.1 The young's optimal policy

With all the former definitions:

$$V(a; y, \theta, \epsilon) = \max \{V_e(a; y, \theta, \epsilon), V_w(a; y, \theta)\}$$

The worker has to choose next period's asset level. His value function solves

$$V_w(a;y,\theta) = \max_c \left[u(c) + \beta(1-\pi_\text{a})E[V(a';y',\theta',\epsilon')] + \beta\pi_\text{a}E[W_w(a')]\right]$$

$$\begin{aligned} \text{subject to} \quad & a' = wy(1-\tau_l) - c + (1+r)(1-\tau_w)a \\ \text{and} \quad & a' \geq 0. \end{aligned}$$

A young entrepreneur with $\epsilon = 0$ has to choose both next period's asset level and this period's investment level in his firm, the latter being limited by the borrowing constraint. His value function solves

$$V_e(a;y,\theta,0) = \max_{c,k} \left[u(c) + \beta(1-\pi_\text{a})E[V(a';y',\theta',\epsilon')] + \beta\pi_\text{a}E[W(a';\theta',\epsilon')]\right]$$

$$\begin{aligned} \text{subject to} \quad & a' = F(k) + (1+r)\left(a(1-\tau_w) - k\right) - c \\ \text{and} \quad & a' \geq 0 \\ \text{and} \quad & 0 \leq k \leq (1+f)a. \end{aligned}$$

A young entrepreneur with $\epsilon = 1$ always sells his firm, since, as explained previously, he is risk-averse and is being offered the expected value of maximum future profits. His value function solves

$$V_e(a;y,\theta,1) = \max_c \left[u(c) + \beta(1-\pi_\text{a})E[V_w(a';y',0)] + \beta\pi_\text{a}E[W_r(a')]\right]$$

$$\begin{aligned} \text{subject to} \quad & a' = P + (1+r)(1-\tau_w)a - c \\ \text{and} \quad & a' \geq 0. \end{aligned}$$

3.2.2 The old's optimal policy

An old agent who was an entrepreneur last period and whose idea is still alive has the choice to continue running his firm for another period or to retire. Thus:

$$W(a;\theta,\epsilon) = \max\left\{W_e(a;\theta,\epsilon), W_r(a)\right\}$$

and the policy function of an old entrepreneur is:

$$W_e(a;\theta,0) = \max_{c,k} \left[u(c) + \beta(1-\pi_\text{d})E[W(a';\theta',\epsilon')] + \beta\pi_\text{d}E[V(a';y',\theta',\epsilon')]\right]$$

$$\begin{aligned} \text{subject to} \quad & a' = F(k) + (1+r)\left(a(1-\tau_w) - k\right) - c \\ \text{and} \quad & a' \geq 0 \\ \text{and} \quad & 0 \leq k \leq (1+f)a \end{aligned}$$

and

$$W_e(a;\theta,1) = \max_c \left[u(c) + \beta(1-\pi_\text{d})E[W_r(a')] + \beta\pi_\text{d}E[V_w(a';y',0)]\right]$$

$$\begin{aligned} \text{subject to} \quad & a' = P + (1+r)(1-\tau_w)a - c \\ \text{and} \quad & a' \geq 0. \end{aligned}$$

An old retired agent has a simple maximization problem: optimally running down his assets. Thus

$$W_r(a) = \max_c \left[u(c) + \beta(1-\pi_{\rm d})E[W_r(a')] + \beta\pi_{\rm d}E[V(a';y',\theta',\epsilon')]\right]$$

$$\text{subject to} \qquad a' = p - c + (1+r)(1-\tau_w)a.$$

3.3 Recursive stationary equilibrium

Given aggregate prices and taxes, the preceding Bellman equations can be solved, which will lead to optimal policies for the choice variables $c(\cdot)$ and $k(\cdot)$. Let $\sigma = (a; y, \theta, \epsilon, \xi)$ denote the state of an individual, where ξ denotes the age (young or old) of an individual and let m denote the distribution of σ over all individuals.

A recursive stationary equilibrium is defined by prices r and w and policy functions such that

- The policy functions $c(\cdot)$ and $k(\cdot)$ solve each agent's maximization problem given the aggregate variables and distributions of the economy;
- The competitive financial sector makes neither losses nor profits;
- The markets for goods and labor clear;
- The government runs a balanced budget;
- m and the mass of publicly owned firms are invariant.

This definition of a recursive equilibrium is standard with one novelty: the mass of publicly owned firms. Let $\mu_{\rm p}$ be the mass of publicly owned firms and $\mu_{\rm ent}$ the mass of entrepreneurial firms[7]. Then $\mu_{\rm p}$ follows the equation:

$$\mu'_{\rm p} = \pi_\epsilon \mu_{\rm ent} + (1-\pi_0)\mu_{\rm p} \tag{1}$$

In equilibrium, we have $\mu'_{\rm p} = \mu_{\rm p}$.

4 The data

4.1 The Dutch income tax

The Dutch income tax makes a distinction between labor income and investment income. Labor income, defined in the broadest sense possible, covers wages, benefits, "wage-like" income such as pensions, unemployment insurance, welfare etc. and entrepreneurial income. For political reasons that lack an economic justification the net income from home-ownership, i.e., the rent saved by owning rather than renting a home

[7]This can be computed by integrating m over the set of entrepreneurs.

minus the interest costs of the mortgage, is also counted as labor income. Labor income is taxed according to a progressive schedule. Investment income (such as rental income, dividends or realized capital gains), however, is not taxed. Since 2001 a proportional tax of 33% is levied on a *notional* yield of 4% of the value of the net end-of-year asset holdings, independently of actual earnings and capital gains. Economically, this is equivalent to an *ad valorem* wealth tax of 1.2%[8].

Since entrepreneurial income is taxed differently from dividend income, there is an obvious potential tax optimization scheme for entrepreneurs who own an incorporated[9] firm. They can either pay themselves a wage or a (tax free) dividend. To avoid this, dividend received from a company over which an individual has "substantial control" ("aanmerkelijk belang") is taxed at a rate similar to the top bracket of the labor income tax and the value of these substantial-control shares is excluded from investment wealth for tax purposes. An individual is said to have substantial control over a firm if he or his family own more than 5% of all outstanding shares (see Stevens, 2009, chap. 13).

The Dutch tax authority thus needs to keep track of individuals' investment wealth and reappraise its value each year. This is done as follows. All individuals are assigned a "citizens number" (BSN, "burgerservicenummer") at birth. This is the functional equivalent of a US Social Security number and uniquely identifies them and links them to their assets and debt. Investment wealth is defined as bank and savings account(s), financial assets (except ownership of "substantial control"-shares), real estate (except if owner-occupied), objects of value and, on the negative side, mortgage and other debt. Entrepreneurial wealth is defined as ownership of an unincorporated firms or substantial control of an incorporated firms, and, as explained above, is excluded from the wealth tax since entrepreneurial income is already taxed. It is straightforward to estimate the value of the components of investment wealth. Bank accounts, financial assets and all debt are directly reported by the financial institutions to the tax authority, using market values for stocks and bonds. Real estate values are reappraised every year

[8] This description is, of course, a simplification. I do not discuss deductions, exceptions, negative income, etc., nor the specific rules that determine whether a given type of income is taxed at the individual or household level. These rules have no impact on the data work in this paper. For a detailed and exhaustive overview of the Dutch tax system from an economic viewpoint, and specifically the reasons that led to using a notional yield rather than a realized return for the taxation of investment income, the interested reader is referred to Stevens (2009).

[9] The tax authority distinguishes between incorporated and unincorporated firms. An *unincorporated* firm is a firm whose assets are not legally separated from the owner's assets. This is a liability issue: an entrepreneur with an unincorporated firm still has the obligation to keep separate accounts for his firm, but in the event of a bankruptcy, all his assets are at risk. These firms are typically very small with (almost) no employees. An *incorporated* firm is a legal entity owned by its shareholders. These shareholders do not risk more than the value of their shares, their assets are shielded from the firm's liabilities (i.e., it is a limited liability company). These firms can be of any size, and shareholdership can go from very concentrated (100% owned by the founder and his family) to very diluted (a large company quoted on the stockmarket).

by the municipality, which also taxes them separately. This is done by using the sale prices of real estate transactions nearby. Durable belongings such as cars and household electronics are not recorded with the exception of valuable art and antiquities, the so-called objects of value. These are self-reported by individuals (and cross-checked with insurance records during tax audits).

4.2 The dataset

The Dutch Statistical Office[10] (CBS) provides an income panel dataset, the IPO ("Inkomstenpanelonderzoek"). The IPO follows about 100,000 individuals through time at a yearly frequency and contains income and socio-demographic data on each individual. They are randomly drawn from the population and identified by their BSN. These individuals are called "core" persons. Each year, the CBS identifies the members of each core person's household through municipal data and adds these members to the dataset. This allows me to aggregate data at the household level. Note that all municipal databases (GBA, "Gemeentelijke basisadministratie") are built on the same platform and are directly accessible by the CBS, so a move within the Netherlands would have no detrimental impact on the dataset. Among core persons, there is no attrition except for emigration and death (about 1.5% per year) and each year, the IPO is replenished with newborns and a representative sample of new immigrants. Only core persons are followed through time, so if a household changes composition from one year to another, say a child leaves the home or a couple divorces, these ex-household members drop out of the database.

I merge this dataset with the CBS dataset on household wealth statistics ("Vermogensstatistiek") for the years 2005-2007. This dataset has 9 wealth components for each household: bank and savings account(s), financial assets (except ownership of "substantial control"-shares), owner-occupied home, other real estate, objects of value, two types of entrepreneurial wealth (unincorporated firms and substantially controlled incorporated firms), mortgage debt and other debt. With the exception of both forms of entrepreneurial wealth, all the data comes from the Dutch tax administration. I thus have a 3-year panel dataset on household wealth. Its strong point, aside from being a panel dataset, is that it contains only administrative and tax data, there is no survey data or self-reporting. I therefore avoid the usual biases associated with survey data such as errors in self-reporting, attrition bias, participation bias etc.

Entrepreneurial wealth is estimated and not directly taken from tax data (see section 4.1). The proper economic estimate of the value of an entrepreneurial firm for which there is no obvious market value would be the net present value of future profits, using an appropriately risk-adjusted discount factor. Such a valuation is not possible

[10]Centraal Bureau voor de Statistiek, www.cbs.nl.

in practice. If the entrepreneurial firm is unincorporated, the CBS uses the book value (i.e., the equity) of the firm. If the firm is incorporated, the CBS makes an estimate based on past dividends and, if possible, the market value of shares (see Claessen, 2010).

In the model, the distinction between entrepreneurial wealth and other wealth is not made. Nevertheless, for unincorporated entrepreneurs, the definition of total wealth in the data correspond quite closely to the definition of assets in the model. In the data, unincorporated entrepreneurs use all their assets to obtain a leveraged loan which they then use as capital in their firm. Their entrepreneurial borrowings are covered by their personal and entrepreneurial assets so their net worth is the value of all their assets minus their personal and entrepreneurial debt. This is exactly how the model computes net worth. For incorporated firms, the notion of entrepreneurial wealth in the data is somewhat at odds with definition used in the model, since market value (or a proxy thereof) is used. However, when selling their firms, entrepreneurs in the model are paid the expected profits of their firm, which is exactly the spirit of the definition of incorporated entrepreneurial wealth in the data. Therefore, the data captures the net worth of entrepreneurs who cashed in (even if only partially, which is most often the case) in the same way as my model captures the net worth of these ex-entrepreneurs.

It should be noted that one wealth component is entirely absent from the dataset (and from the Dutch tax system): accrued pension benefits. The Dutch have both a pay-as-you-go system and funded pension plans, usually of the defined benefit type. Both are in principle components of household wealth, but there is no useable data available on these. I ignore pension wealth in the remainder of the paper.

4.3 Main findings

Entrepreneurial households are defined as households with either entrepreneurial wealth or entrepreneurial income exceeding 20% of total net income. I use this low threshold since households can have non-entrepreneurial income produced by other members, or one of the members can receive a wage from the entrepreneurial firm. With this definition, the number of entrepreneurial households in my dataset in 2007 is 16.7%. This definition, the only possible with the data at hand, has one drawback compared to the one usually used when working with U.S. survey data (Cagetti and De Nardi, 2008): it is too broad. When using U.S data, to fit the definition entrepreneurs must play a managing role in their firm and the self-employed are not counted. This implies that my count of entrepreneurs will be higher than the U.S. count and I won't observe status changes from one year to the next: entrepreneurs who sell out usually retain a fraction of their firm as an investment, which still identifies them as entrepreneurs in my dataset. As a reference point, when using my broader definition, the U.S. also has

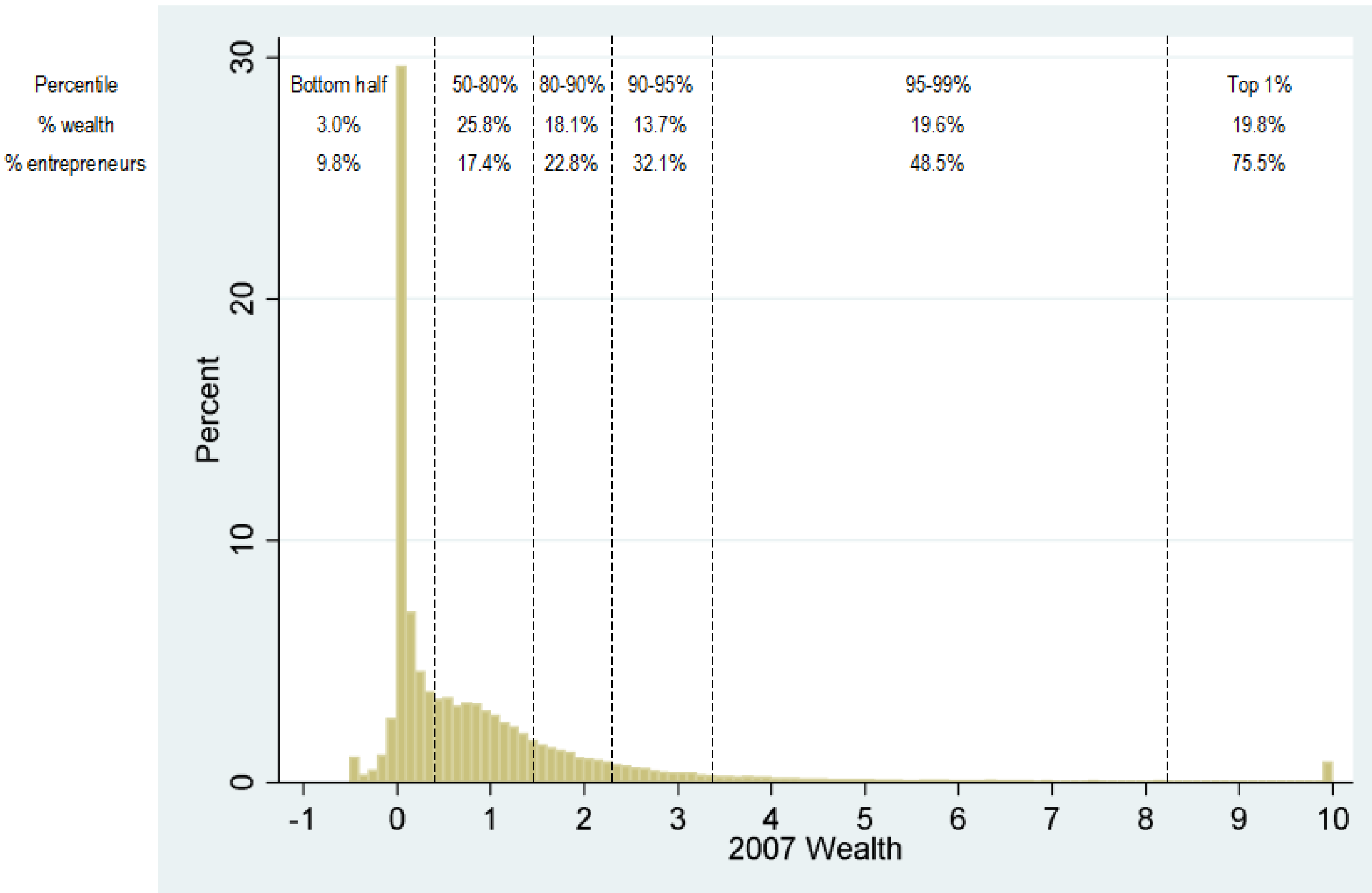

Figure 1. Distribution of net household wealth in The Netherlands on 12/31/2007. The x-axis is normalized by mean wealth (205,841€)

Percentile	max wealth		% of wealth	% entrepreneurs
0-50%	k€	80	3.0%	9.8%
50-80%	k€	296	25.8%	17.4%
80-90%	k€	471	18.1%	22.8%
90-95%	k€	693	13.7%	32.1%
95-99%	k€	1,777	19.6%	48.5%
99-100%			19.8%	75.5%

Table 1. Quantile characteristics of the distribution of net household wealth in The Netherlands on 12/31/2007.

16.7% of entrepreneurial households. With the standard, more narrow definition, that percentage is 7.6.

Graph 1 illustrates the household wealth distribution for 2007 for the Netherlands and Table 1 summarize the main distributional facts. Compared to the U.S., the usual stylized facts are qualitatively true for the Netherlands, albeit with less skewness. The Gini indexes for after-tax-and-transfers income and wealth are 0.31 and 0.74, and the top 5% and 1% own 39.4% and 19.8%, respectively, of total household wealth. Entrepreneurs own 38% of total Dutch wealth and Table 1 shows clearly that they are vastly overrepresented at the top of the wealth distribution. This is confirmed by Table 2, which shows the composition of wealth per quantile. Housing wealth is an important component of household wealth up to the 95$^{\text{th}}$ percentile, but above that investment wealth and entrepreneurial wealth together are more important.

Percentile	0-50%	50-80%	80-90%	90-95%	95-99%	99-100%
Average wealth (2007 k€)	12.5	177	372	562	1,008	4,077
Bank account/savings (net)	86.1%	19.3%	18.0%	19.1%	17.8%	10.4%
Financial assets	14.1%	5.0%	5.6%	7.9%	13.4%	18.1%
Owner-occupied house (net)	−9.1%	70.3%	67.7%	58.5%	40.9%	14.6%
Other real estate (gross)	21.7%	6.7%	8.5%	12.5%	19.1%	13.5%
Entrepreneurial wealth (not incorporated)	19.4%	1.2%	1.7%	2.9%	5.4%	1.1%
Entrepreneurial wealth (incorporated)	0.4%	0.3%	0.6%	1.6%	7.3%	47.4%
Other wealth	2.1%	0.7%	1.0%	1.7%	3.0%	4.1%
Other debt	−34.7%	−3.5%	−3.2%	−4.2%	−6.9%	−9.2%

Table 2. Composition of wealth per quantile in The Netherlands on 12/31/2007.

Next I turn towards wealth mobility. The question is to see by what extent household wealth changes each year. I exploit the panel structure of the dataset to follow households through time. As explained previously, the panel structure is built around "core" individuals, not households. If a core individual has a substantial change in household composition from one year to the next, a large spurious change in wealth could potentially show up in the dataset. Examples would be a marriage or a divorce, where a wealthy partner leaves or enters the dataset, or an 18-year old core-member leaving a wealthy family behind when leaving home to study. These observed changes in wealth are artifacts, since they correspond to wealth entering or leaving the dataset due to the structure of the dataset, not real changes in asset values. In order to correct for this, I drop these two cases (i.e., couples divorcing and students) from my dataset. Relative mobility in the wealth distribution, i.e., the wealth transition matrix, is summarized in Table 3.

2006/2007	0-50%	50-80%	80-90%	90-95%	95-100%
0-50%	91.1%	7.3%	**1.1%**	**0.3%**	**0.2%**
50-80%	9.2%	83.5%	5.8%	**1.1%**	**0.4%**
80-90%	2.3%	17.1%	71.0%	7.8%	**1.9%**
90-95%	1.9%	4.7%	16.0%	66.7%	10.5%
95-100%	0.8%	1.6%	3.2%	10.3%	84.1%

Table 3. Frequency of transition from one quantile to another.

The main two facts to take away from this Table are how different the diagonal is from 1 (which would mean perfect immobility of households in the wealth distribution) and the upper triangle. Although these percentages may seem low, it is important to stress that they apply to large quantiles and high levels of wealth, so in absolute terms they matter. The upper six percentages (in bold), for instance, represent 18% of all upwardly mobile households and 44% of all upwardly mobile wealth.

5 Calibration

The goal of the calibration procedure is to match both the salient facts of the wealth distribution and the wealth transition matrix. The set of parameters is divided in two categories, fixed and calibrated parameters. The first set contains those parameters that have been estimated in previous studies or can easily be estimated from the data without referring to the model. The second set of parameters are "free" parameters that are used to calibrate the model such that it matches certain moments. I do not pick any mobility facts when calibrating these parameters. The empirical discipline is provided by verifying that the calibrated model does indeed match the wealth transition matrix from the data.

The fixed parameters and their values are summarized in Table 4. The value for the coefficient of relative risk aversion σ is 1.5, taken from Cagetti and De Nardi (2006) and the previous studies cited therein. For the capital share in production and the rate of capital depreciation, α and δ, I pick the values 0.33 and 0.06 that have become standard in the real business cycle literature. The probability of aging is taken to match an average working life of 45 years (age 20-65) and the probability of dying is chosen such that in steady state the ratio of retirees over workers is 0.3, which is taken directly from Dutch data. The probability of having an idea, π_θ, is set equal to 2%. This value comes from the number of yearly firm creations, and is identical to the value used in Cagetti and De Nardi (2006). The value of pensions is 25% of average yearly labor pre-tax income, taken directly from Dutch data. The stochastic labor income process is chosen as a 5-point Markov process approximating an AR(1) with a persistence of 0.95 for which the resulting labor income process has a Gini index of 0.31. The details of this approximation are in appendix A.1. The borrowing constraint f is set at 1.00. This was originally estimated on U.S. data at 0.73 by Evans and Jovanovic (1989), and a reestimation with newer data by Xu (1998) gave 1.01. Using italian data, Colombo and Grilli (2007) suggest a value between 0.9 and 1.1. Finally, θ, the productivity of an idea, is normalized at 1.0.

Parameter	Description	Value
σ	relative risk aversion	1.5
α	capital share in production	0.33
δ	depreciation	0.06
π_{a}	probability of aging	0.022
π_{d}	probability of dying	0.074
p	pensions (% of average yearly labor income)	25%
π_θ	probability of having a new idea	0.02
y and y-process	stochastic labor productivity process	see appendix A.1
$\bar{\theta}$	productivity of an idea	1.0
f	borrowing constraint	1.0

Table 4. Values for fixed parameters.

The set of calibrated parameters, four in total, are summarized in Table 5. They are used to match the following moments: a capital-output ratio of 3, a Gini coefficient of the wealth distribution of 0.74, a ratio of labor employed by the entrepreneurial sector over total employment of 0.33 [11] and the proportion of entrepreneurs in the economy. It would not be correct to try and match the percentage of entrepreneurs in the data (16.7), since that number is overvalued by the counting of the self-employed and the ex-entrepreneurs retaining a piece of their old firm. These are not entrepreneurs in the spirit of the model. For the same reason, I cannot aim to match the percentage of wealth held by entrepreneurs in the data. Nevertheless, to put empirical discipline on the number of entrepreneurs, I aim to match the same value as Cagetti and De Nardi (2006), i.e., 7.5%. Given my dataset and the dataset these authors use (the U.S. Survey of Consumer Finances) contain the same percentage (16.7%) of entrepreneurs using the broad definition that includes the self-employed and the "sleeping owners", it does not seem unrealistic to assume that for the tighter definition — the one that corresponds most closely to the definition of entrepreneurs in the model but which I cannot use in my dataset — these percentages would also be very close.

Parameter	Description	Value
β	discount factor	0.90
ν	decreasing returns of scale factor	0.65
π_0	probability for an idea to disappear	0.15
π_ϵ	probability of meeting an outside investor	0.10

Table 5. Values for calibrated parameters.

The solution procedure is as follows. I numerically solve the model by using a Downhill Simplex method. For each set of prices, I can compute the policy functions by solving the value functions by iteration on a grid with a cubic spline interpolation, and then find the invariant distribution over states and the invariant distribution of public sector firms. This then allows to compute the aggregate supply and demand of capital and labor. The minimization procedure finds prices such that the distance between supply and demand of K and L is minimized.

Table 6 shows how well the model does on the target moments. The calibration is successful in as much as it meets its explicit targets. The external validation comes from how well it matches the wealth transition matrix, which was not in any way an explicit target of the calibration. The wealth transition matrix is shown in Table 7. It does a far better job of matching the wealth transition matrix from the data. This is not a foregone conclusion: in appendix A.2 I compute the mobility of the main models cited in the literature. I calibrate these models following the same calibration strategy as for my own model and, with the exception of the Aiyagari (1994) model,

[11] This number comes from Dutch data, namely the employment of firms with less than 100 full-time employees.

these models match the wealth distribution as well as mine does. However, they do not, and by far, match the wealth transition matrix, all display far too little mobility (i.e., the diagonals are very close to ones) and very few quantile jumps. This is not surprising, for all these models the driving force is the patient accumulation (and slow decumulation) of wealth.

Description	Goal	Actual result
Gini index	0.74	0.74
% of employment in the entrepreneurial sector	33	33
% of entrepreneurs	7.5	7.6
Capital-output ratio	3.0	2.8

Table 6. Comparing data and the results of the model.

Of course, all free parameters influence all target moments, but, to get an intuitive understanding of the model, I identify the following first-order effects. π_0 and π_ϵ directly influence the size of the entrepreneurial sector by governing the exit rate from entrepreneurship through equation (1). Furthermore, π_ϵ and ν govern the employment share of the non-entrepreneurial sector. ν directly impacts the wealth of entrepreneurs who sell out, hence also the Gini index. β mostly influences the capital-output ratio and, to a lesser extent, the Gini index.

$n/n+1$	0-50%	50-80%	80-90%	90-95%	95-100%
0-50%	97.2%	2.4%	0.0%	0.0%	0.4%
50-80%	4.7%	92.7%	1.5%	0.0%	1.1%
80-90%	0.0%	9.5%	86.5%	2.3%	1.7%
90-95%	0.0%	0.0%	17.6%	78.4%	4.0%
95-100%	0.0%	0.0%	0.0%	16.8%	83.2%

Table 7. Frequency of transitions from one quantile to another for the main model.

6 Taxing wealth

I now conduct the following tax experiments. I assume the model economy is a small open economy with an interest rate fixed by the outside world. I make this assumption for two reasons. First, I use Dutch data to calibrate the model and The Netherlands are indeed a small open economy. Furthermore, a wealth tax affects domestic households but not foreign households. Therefore any upwards effects of a wealth tax on the interest rate would simply be a costless gain for foreign households: they would face the same risks as before when investing in the domestic economy but obtain a higher return. As long as there are no capital controls, the effects of this gain would be to attract more foreign investment until the interest rate is back to its previous equilibrium level[12]. I introduce a wealth tax of $\tau_w = 1.2\%$ and compare the results for different values of π_ϵ. The results are summed up in Table 8.

First, looking at the baseline model ($\pi_\epsilon = 0.10$), the output lost due to a wealth tax is 1.5%. This puts the average cost of 1€ of government income at 0.45€, meaning each euro of wealth tax earnings decrease output by 0.45€. This is sometimes called the (marginal) cost of public funds (Dahlby, 2008). Furthermore, wages drop by 1.9%. It is important to notice that, since the interest rate is constant, this is solely the effect of the wealth tax on entrepreneurs: in a model with no entrepreneurs (i.e., $\pi_\epsilon = 1.00$ in my model), there is no output lost at all due to the tax. Actually, the output lost by entrepreneurs accounts for 199% of total output lost, since the publicly-owned sector increases production due to the decrease in wages. This decrease in output can be attributed to two effects: fewer entrepreneurs and less entrepreneurial production. There are fewer entrepreneurs since more potential entrepreneurs have an initial asset level that does not make it profitable for them to start a firm. This accounts for 23% of the drop in entrepreneurial production. Second, entrepreneurs produce less, since they have less capital to run their firms. This accounts for the remaining 77% of the output drop. Lastly, the Gini index goes up since fewer entrepreneurs become rich by growing their own firm, but the same number still sells its firm.

To study the importance of the cashing-in mechanism, I run the same policy experiment in models varying π_ϵ from 0.05 to 1.00. The first observation is that economies with a higher π_ϵ have higher output, higher wages and less entrepreneurs. This is a direct consequence of the firm-selling mechanism: with higher π_ϵ, more firms are run by outside investors who are not credit constrained. Hence at $\pi_\epsilon = 1.00$ the economy is fully efficient, all firms are run at their optimal size. Secondly, the effects on output of a wealth tax diminish when π_ϵ goes up. For a low π_ϵ, we have a 1.9% loss of output and a cost of 0.56€ per euro. For a high π_ϵ, these numbers are 0.3% and 0.10€. Of course, for $\pi_\epsilon = 1.00$ there is no output loss nor cost. This leads to the conlusion that improving the access of entrepeneurs to outside investors has two effects: it improves the allocative efficiency of capital (higher output), in the sense that entrepreneurial firms are farther from their efficient scale that publicly owned firms, and reduces the

[12]It should be noted that home bias or other frictions have no role in this argument. Even if there is a wedge between the domestic and the world interest rate, there is no reason to think that a wealth tax — which does not affect the risks faced by foreign investors — would widen or narrow that wedge. Therefore foreign investors would still compete away any effect of the wealth tax and reduce the gap between the world and the domestic interest rate back to its original value.

	$\pi_\epsilon = 0.05$			$\pi_\epsilon = 0.10$			$\pi_\epsilon = 0.25$			$\pi_\epsilon = 0.50$			$\pi_\epsilon = 1.00$		
tax rate (in %)	0.0	1.2		0.0	1.2		0.0	1.2		0.0	1.2		0.0	1.2	
output	0.963	0.945	(−1.9%)	1.000	0.985	(−1.5%)	1.056	1.045	(−1.0%)	1.099	1.095	(−0.3%)	1.138	1.138	(−0.0%)
wage	0.939	0.916	(−2.4%)	1.000	0.981	(−1.9%)	1.072	1.062	(−1.0%)	1.118	1.113	(−0.5%)	1.153	1.153	(−0.0%)
% of entrepreneurs	9.03	8.91	(−1.3%)	7.56	7.42	(−1.9%)	4.98	4.88	(−2.0%)	3.12	3.02	(−3.3%)	1.96	1.96	(−0.0%)
% of output produced by entrepreneurs	55.0	52.6	(−4.2%)	37.9	35.4	(−6.7%)	16.8	14.9	(−11.2%)	6.1	5.2	(−15.1%)	0.0	0.0	(−0.0%)
Gini index (in %)	77.8	80.2		74.2	77.2		69.4	72.9		66.1	70.2		64.1	68.4	
Cost (in €, see text)		0.56			0.45			0.28			0.10			0.00	

Table 8. Effects of a 1.2% wealth tax in function of π_ϵ (with constant r). Output and wage are given relative to the baseline case (i.e., $\tau_w = 0.0\%$ and $\pi_\epsilon = 0.10$). The cost of the tax is in €'s of output lost for 1€ raised by the wealth tax.

detrimental effects of wealth or capital taxation (lower drop of output when taxed), since firm size is less dependent on the personal wealth of entrepreneurs. Quantitatively, the first effect is 2-4 times larger than the second (depending on the starting value of π_ϵ).

7 Conclusion

This paper makes three contribution. First, I construct a quantitative model of entrepreneurship that includes a novel mechanism, namely entrepreneurs selling their firm. Secondly, I show the relevance of this mechanism by exploiting a new panel dataset that allows me to construct a matrix of wealth mobility, i.e., the frequency of households moving up or down the wealth distribution from one year to the next. I show that my model matches these new facts well whereas previous models of entrepreneurship do not. Thirdly, I study the effects of a wealth tax in my model concentrating on a small open economy. I compute an estimate of the output cost of a 1.2% wealth tax and show that the channel through which this wealth tax affects output is the drop in entrepreneurial capital, and thus of entrepreneurial firm size.

In a subsequent policy experiment, I study the effects of this wealth tax by letting the ease with which entrepreneurs meet an outside investor vary. I show that the easier it is for an entrepreneur to cash in on his accumulated equity and retire from his firm, the less a wealth tax diminishes output. In the extreme case where all entrepreneurs can immediately sell their idea, a wealth tax has no effect on output. Again, the channel of this effect (or lack thereof) is the role personal wealth plays in the capacity of entrepreneurs to grow their firm. In an economy where entrepreneurs can hardly find an outside investor, they are solely dependent on their own wealth to obtain credit for investments. In a world where investors are easy to find, personal wealth plays a much smaller role and hence its taxation has no effect on output.

For future research, it would be interesting to explore the role entrepreneurs could play in the growth rate of an economy. If one believes that entrepreneurs play a crucial role in expanding the technological frontier (Aghion and Howitt, 2005), then this paper suggests a link between the growth rate of an economy, its wealth inequality and the functioning of its financial markets. Furthermore, one might then explore the effects of a wealth tax, or more general forms of capital taxation, on the growth rate of the economy through the effects such a tax might have on entrepreneurs' capacity to implement technological innovations.

A Appendix

A.1 Calibration

I assume that the income process is AR(1) and lognormal. I approximate it by a five-point Markov process following Rouwenhorst (1995). Kopecky and Suen (2010) have shown this method to be superior to the better known Hussey and Tauchen (1991) method for highly persistent processes. The resulting grid points for y are:

$$\begin{bmatrix} 0.3357 & 0.5428 & 0.8376 & 1.2925 & 2.0897 \end{bmatrix}$$

and the Markov matrix is

$$\begin{bmatrix} 0.9037 & 0.0927 & 0.0036 & 0.0001 & 0.0000 \\ 0.0232 & 0.9055 & 0.0696 & 0.0018 & 0.0000 \\ 0.0006 & 0.0464 & 0.9061 & 0.0464 & 0.0006 \\ 0.0000 & 0.0018 & 0.0696 & 0.9055 & 0.0232 \\ 0.0000 & 0.0001 & 0.0036 & 0.0927 & 0.9037 \end{bmatrix}.$$

A.2 Wealth mobility in earlier models

Aiyagari (1994) is the first attempt to model the wealth distribution as the equilibrium outcome of a general equilibrium production economy with heterogeneous agents and incomplete markets. This is done in a "Bewley" setting where ex-ante identical agents face a stochastic income process and a borrowing constraint. This model fails in obtaining the skewness of the data, and the reasons for the quantitative failure of this model reveals the inherent difficulty of a quantitative replication of the wealth distribution. When the sole source of heterogeneity is idiosyncratic non-insurable shocks to labor income, the "rich" do not save enough. The only motivation for saving in such a setting is consumption smoothing and precautionary saving (i.e. staying away form the borrowing limit). The latter does not apply to the rich and the former, driven by a simple Euler equation, is not enough to replicate the existing wealth inequalities under reasonable assumptions, given the low equilibrium interest rate in these models. Simply put, to replicate the US Lorenz curve, the rich have to save much more that is rational from a consumption-smoothing viewpoint .

This is easiest to understand through an intuitive exploration of the Euler equation faced by household. In a standard setting, this equation is :

$$\frac{du}{dt}\left[(1+r)a + w - a'\right] = \beta(1+r')\mathbf{E}\left[\frac{du}{dt}\left[(1+r')a' + w' - a''\right]\right] \tag{2}$$

with u the utility function, β the discount factor, r the interest rate, w the wage rate, a assets and next period's values indicated by a prime. To obtain a skewed distribution of a, one needs the very rich to save, or at least to dissave slowly. However, for high asset levels, u is very flat and, for a typical stochastic w that isn't "too" variable (i.e. for which Jensen's inequality does not drop the expected utility much lower than the utility of expected income), the expectation operator does not add much curvature. Together with the equilibrium fact that $\beta(1 + r') < 1$, it is inevitable that for very high a, only a much lower a' satisfies the Euler equation. There are essentially three ways out of this problem: (1) changing the income process of the rich (the stochastic w-process) to add curvature to the RHS, (2) changing the saving behavior of the rich (raise β) and (3) the return to savings (raise r), both to get $\beta(1 + r')$ closer to 1.

Castaneda, Diaz-Gimenez, and Rios-Rull (2003) implement the first option by making the upper incomes hugely variable so as to induce high saving rates by the rich for consumption smoothing reasons. The issue is that the conditional variance in income needed to match the data is implausibly high. Krusell and Smith (1998) implement the second option by making some agents (the eventual rich) more patient. Taken at face value, the resulting wealth inequality would then be the consequence of the optimal saving behavior of a few very patient agents, leaving no role for entrepreneurship.

The third option has been implemented by Cagetti and De Nardi (2006), building on ideas by Quadrini (2000). They add varying entrepreneurial talent and bequests to an Aiyagari (1994) model. Specifically, they construct a simplified life-cycle model with young and old agents, stochastic age transitions and bequests, where entrepreneurs are defined by the fact that they can create their own firm, i.e. they are lucky enough to be born with a high-yield diminishing-returns individual-specific technology. They are withheld from exploiting their entrepreneurial ability to the fullest extend (i.e. before diminishing returns kick in) by a borrowing constraint and need to put up a fraction of the capital required for their firm. Thus young entrepreneurs save in order to increase the capital in their own firm and exploit its high returns. Old entrepreneurs save because their offspring will likely be entrepreneurs too[13]. The model is closed with non-entrepreneurial workers with varying income and a non-entrepreneurial production sector with CRS technology. Properly calibrated, this model replicates both the extreme wealth concentration in the US and the entrepreneurial wealth distribution very well.

A.2.1 Stochastic labor income models

The Aiyagari (1994) model is a much simplified version of my model: no entrepreneurs and no life-cycle (i.e., infinitely-lived agents). The production sector is CRS with a standard Cobb-Doublas production function. The resulting wealth mobility matrix is as follows:

[13]The stochastic process that determines entrepreneurial ability at birth favors entrepreneurs' decedents.

$n/n+1$	0-50%	50-80%	80-90%	90-95%	95-100%
0-50%	98.7%	1.3%	0.0%	0.0%	0.0%
50-80%	1.8%	97.5%	0.7%	0.0%	0.0%
80-90%	0.0%	3.2%	95.3%	1.5%	0.0%
90-95%	0.0%	0.0%	3.8%	94.1%	2.1%
95-100%	0.0%	0.0%	0.0%	2.9%	97.1%

Table 9. Frequency of transitions from one quantile to another for the Aiyagari (1994) model.

A.2.2 Stochastic discount factors

This model is inspired by Krusell and Smith (1998). It is built like the Aiyagari (1994) model with stochastically varying discount factors. Specifically, β can take three values, 0.91, 0.88 and 0.85, which change stochastically every period. The Markov matrix of this process is calibrated such that in steady state 80% of households have the middle β and 10% the extreme values, and such that in expectation β change once every generation (i.e., once every 40 periods). The resulting wealth mobility matrix is as follows:

$n/n+1$	0-50%	50-80%	80-90%	90-95%	95-100%
0-50%	98.5%	1.5%	0.0%	0.0%	0.0%
50-80%	2.5%	96.4%	1.1%	0.0%	0.0%
80-90%	0.0%	3.6%	94.2%	2.2%	0.0%
90-95%	0.0%	0.0%	4.5%	93.1%	2.4%
95-100%	0.0%	0.0%	0.0%	2.5%	97.5%

Table 10. Frequency of transitions from one quantile to another for a Krusell and Smith (1998)-like model.

A.2.3 Cagetti-De Nardi model

The Cagetti and De Nardi (2006)-type model is similar to mine with two simplifications: entrepreneurs cannot sell their firm (i.e., $\pi_\epsilon = 0$) and there is an additional CRS production sector with a Cobb-Douglas production function. This sector is calibrated to produce two thirds of total output. The resulting wealth mobility matrix is as follows:

$n/n+1$	0-50%	50-80%	80-90%	90-95%	95-100%
0-50%	98.2%	1.8%	0.0%	0.0%	0.0%
50-80%	3.1%	95.0%	1.9%	0.0%	0.0%
80-90%	0.0%	5.9%	90.4%	3.7%	0.0%
90-95%	0.0%	0.0%	7.6%	88.3%	4.1%
95-100%	0.0%	0.0%	0.0%	4.2%	95.8%

Table 11. Frequency of transitions from one quantile to another for a Cagetti and De Nardi (2006)-like model.

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