Income taxation with uninsurable endowment and entrepreneurial investment risks

Sagiri Kitao*
New York University

Preliminary

January 30, 2005

Abstract

This paper studies macroeconomic effects of income taxation in an economy where agents face two sources of uninsurable risks: stochastic process of wage earnings ability and idiosyncratic return from entrepreneurial business. Precautionary saving driven by uninsurable income risk leads to overaccumulation of capital, while under-investment results when return premium is required for undertaking risky projects. Additional capital market imperfections such as borrowing constraints faced by entrepreneurs would exacerbate the effects. Analyzing the incidences of income taxation on returns from saving and investment decisions calls for a model that captures differential effects of taxation on heterogeneous classes of agents. We construct a dynamic general equilibrium model where agents make an occupational choice between running a business as an entrepreneur and supplying labor as a worker. Our model is fairly simple yet captures the key incentive channels that affect tax incidences.

Preliminary results suggest low capital tax encourages saving and increases capital stock and aggregate production, but general equilibrium effects (higher wage and higher after-tax return from saving, and compensating tax on non-capital income) discourage entrepreneurial investments. A higher capital tax generates the opposite effects, but comes at a cost of increased inequality. A more progressive tax system reduces inequality, but curtails both aggregate and entrepreneurial activities. The effects of investment policies that effectively target investments can be imperfectly mimicked if we reduce income tax on entrepreneurs' investment income by taxing their income separately at corporate and individual levels without double taxation.

*I thank Mariacristina De Nardi, Jess Benhabib, Pierpaolo Benigno, Mark Gertler, Martin Schneider and Gianluca Violante and seminar participants at NYU and University of Tokyo for constructive criticisms, useful comments and discussions. I am especially grateful to Tom Sargent for helpful suggestions, guidance and continuous encouragement. All errors are mine.

1 Introduction

We study macroeconomic implication of income tax system in an economy where agents face two sources of uninsurable uncertainties. First, each agent is endowed with labor productivity which follows a stochastic Markov process. Markets are incomplete and the only way to protect themselves against an uneven flow of consumption is by way of riskless saving. Second, agents are also endowed with idiosyncratic entrepreneurial ability, which also evolves stochastically. This ability affects the productivity of the agent's enterprize and profitability from investment. Instead of earning wages as a worker, agents can choose to undertake an investment project and run a business. We assume entrepreneurs can manage only one enterprize and the investment risk cannot be diversified away over multiple projects. The return from entrepreneurial investment is uncertain when an agent makes an occupational decision.

The two sources of uninsurable risk (labor productivity risk and entrepreneurial investment risk) jointly affect the economy's capital stock and incidences of income taxation. Uninsurable earnings risks created by productivity shocks drive precautionary saving motive and lead to overaccumulation of capital with a lower interest rate in equilibrium compared to the complete market level. Capital income taxation discourages overaccumulation and may restore the capital closer to the level that would be an outcome in the complete market (see Aiyagari (1995)). Progressive labor income tax and positive capital tax can potentially play a substitutive role for the missing insurance market as we discuss in Conesa, Kitao, and Krueger (2004). On the other hand, riskiness in investment caused by stochastic entrepreneurial productivity creates a premium on its return and equilibrium investment demand is lower than it would be in the market without such risks. Other sources of incompleteness such as borrowing constraints faced by entrepreneurs due to information problem or limited enforcement can exacerbate the problem. Increasing tax on return may discourage investment further below the level that would prevail absent such frictions.

Findings in the literature suggest that various policies to mitigate imperfections in the capital market and to encourage entrepreneurial investments can be very powerful, but must be carefully structured as the policy incidences on the heterogeneous classes of agents are far from uniform. In addition, the required adjustments towards the fiscal balance as a consequence of the revenue shift could create undesired distributional or aggregate effects.

The current paper studies the effect of income taxation in an economy populated by workers and entrepreneurial investors. We build a dynamic general equilibrium model that is relatively simple, yet captures the key channels through which income taxation and investment policies affect heterogeneous agents' behaviors. In our model, an agent makes an occupational choice between earning wages in the market as a worker and running his own business as an entrepreneur. Workers choose consumption, savings and labor. They have an access to one-period riskless saving, which is restricted to be positive, but there is no insurance against uncertain income path. Entrepreneurs determine project size optimally by choosing capital and labor inputs. They can access credits to finance investment, subject to a borrowing constraint that depends on their wealth. Entrepreneurs also make consumption and saving decisions given disposable assets after the production. Entrepreneurial investment is risky, since the return is unknown when making an occupational decision.

Preliminary results suggest zero or low capital tax encourages saving and raises capital accumulation and aggregate production, but general equilibrium effects (a higher wage and a higher after-tax return from saving) discourage entrepreneurial business. A higher capital tax generates the opposite effects, but comes at a cost of increased inequality. A proportional income tax system will bring aggregate effects similar to the case of zero or low capital tax, but entrepreneurial investments will be higher since many entrepreneurs face a lower marginal tax on investment returns. Although the ex-ante welfare that we define is higher, the wealth distribution becomes more skewed. A more progressive tax system reduces wealth inequality, but curtails both aggregate and entrepreneurial activities. Various policies to stimulate entrepreneurial investment, including accelerated depreciation expensing or loan premium subsidy, will effectively increase their investment as well as aggregate activities. The effects of such policies can be imperfectly mimicked by reducing income tax on entrepreneurial investment return if we tax on their income at the firm and individual levels separately.

The rest of the paper is organized as follows. The next section briefly reviews the related literature. Section 3 presents the model, which is followed by the definition of stationary equilibrium. Section 5 describes the calibration. Sections 6 and 7 discuss the benchmark economy and policy experiments. The last section concludes.

2 Related literature

This paper is related to the existing work along different lines of macro literature. We build on the study of income taxation in incomplete market models, by adding an additional sector of entrepreneurs and risks in their investment returns. Our work is also related to the recently growing literature that investigates the roles of entrepreneurship both theoretically and empirically. We rely on the development of the computational technique of solving a dynamic general equilibrium model with heterogeneous classes of agents. We attempt to provide a brief sketch of the literature and highlight papers that are most closely related to the current paper.

Idiosyncratic endowment risks, macroeconomy and taxation: In the Bewley (1986) class of models, agents face uninsurable endowment risks but have access only to riskless saving. Implication to the macroeconomy in this class of economy has been well explored.[1] Precautionary saving motive drives overaccumulation of capital, compared to the complete market where risks are insured away.

There is also a large literature on the income taxation in this type of incomplete of economies. Aiyagari (1995) shows in an infinitely lived agents model with incomplete insurance and borrowing constraints, that it is optimal to tax on capital income even in the long run. It contrasts with the classic result of optimality of zero capital income tax in the complete market framework as demonstrated by Chamley (1986) and Judd

[1] See for example Bewley (1986), Huggett (1993), Aiyagari (1994), Krusell and Smith (1998), Davila, Krusell, and Ríos-Rull (2003), etc.

(1985). Golosov, Kocherlakota, and Tsyvinski (2003) derive optimality of positive capital tax when agents' skills are private information. Providing proper incentives for truthful revelation becomes more costly when savings are high, and therefore decentralizing a planning problem implies optimality of positive tax on investment returns to discourage overaccumulation of capital.

Erosa and Gervais (2002) use a life-cycle model and show that the government finds it optimal to use age-dependent tax for consumption and labor income. It is demonstrated that if tax rates can't be conditioned on age, a nonzero tax on capital income is optimal as it can imperfectly mimic the optimal tax system.

Conesa and Krueger (2004) endogenously solve for the optimal tax system in a dynamic general equilibrium model with overlapping generations and present a reform proposal of a flat tax rate with a fixed deduction. Conesa, Kitao, and Krueger (2004) introduce a more flexible form of tax scheme that distinguishes the sources of income and find positive capital taxation combined with a progressive labor tax schedule is optimal in the classes of tax functions considered.

Entrepreneurship, risky investment, macroeconomy and taxation: The other line of studies that we attempt to build on is the literature on entrepreneurial activities and investments involving idiosyncratic risks. Entrepreneurs' roles are critical in many issues of macroeconomics and public policies since entrepreneurial activities play important roles for innovation, economic growth and capital accumulation and they constitute a large fraction of economic activities in the U.S. Many papers studied both theoretically and empirically what distinguishes entrepreneurs from the rest of the population and how they evolve in response to changes in economic and policy environments.[2]

Some authors studied macroeconomic implication of idiosyncratic investment risks in the presence of private information. Khan and Ravikumar (2001) study the impact of incomplete risk sharing on growth and welfare. Idiosyncratic productivity process is private information and risk sharing contract with incentive compatibility constraint for truth-telling results in a growth rate below the complete market level. In a related paper, Meh and Quadrini (2004) show that in an economy where agents can run a risky technology, under-accumulation of capital is possible in the absence of complete markets. They contrast the complete market economy with two economies, one with state-contingent securities but with private information and another economy with only riskless bonds. They discuss implication for institutional reforms.

There is a vast literature on the effect of taxation on aggregate investment activities of the economy, but relatively less has been explored in terms of taxation and entrepreneurial investment. King and Levine (1993) argue that development of financial markets mobilize efficient resource allocation towards promising entrepreneurial projects and policies towards this goal would contribute to a higher long-run growth. In a series of papers, Carroll, Holtz-Eakin, Rider, and Rosen (2000a, 2000b, 2001) study the effect of changes in income tax rates using tax returns filed before and after the Tax Reform Act of 1986. They show that reduction in the marginal tax rates results in an increase in investment

[2] See for example Evans and Jovanovic (1989), Quadrini (2000), Cagetti and De Nardi (2003, 2004a) and Gentry and Hubbard (2004).

expenditures, employment and growth of firms. Cagetti and De Nardi (2003) build a life-cycle model with entrepreneurs facing an endogenous borrowing constraint and with intergenerational linkage through perfect altruism and study their effects on accumulation and distribution of wealth. Their calibrated model successfully replicates the concentration of wealth in the U.S. Cagetti and De Nardi (2004a) study the effect of estate tax reforms and demonstrate the significant effects on aggregate variables as the reduction in estate tax relaxes the financial constraints faced by entrepreneurs and encourages their investments. Our model is similar, but differs from theirs in that entrepreneurs face a within-period uncertainty about the entrepreneurial investment return and that occupational decision entails sunk costs. Also, in their model, entrepreneurs do not use labor inputs for production and workers' labor supply is fixed. Therefore, it is difficult to study the potentially important effects of taxation through these channels, which the current paper tries to explore focusing on the effects of income taxation. We abstract from life-cycle and an explicit intergenerational linkage.

Quadrini (2000) builds a general equilibrium model to examine entrepreneurship and demonstrates its critical role in explaining the concentration of wealth in the U.S. Meh (2002) takes Quadrini (2000)'s model and studies the effect of flat income tax reform. In the models of Quadrini and Meh, labor supply is exogenously fixed and tax distortions on the work incentives are absent. Also, the size distribution of entrepreneurial firms is exogenously determined. The current paper attempts to build these features into the model and study the incentive effects of taxation on these endogenous decisions. We will consider more varieties of fiscal policies distinguishing the sources of income.

There are papers that study the effects of policies associated with financial conditions and credit access of entrepreneurs and implications for institutional reforms. Li (2002) constructs a model with an occupational choice to study the effect of credit subsidy policies. She simulates alternative subsidy programs and demonstrates the program that targets poor and capable entrepreneurs will more effectively promote entrepreneurial investment and total output than the existing policies. Fernández-Villaverde, Galdón-Sánchez, and Carranza (2003) build a model where entrepreneurs face an endogenous borrowing constraint due to imperfect enforceability of contracts and study the effect of credit market imperfections. They show that the borrowing constraints significantly hamper the efficient allocation of resources and reduce undertakings of productive entrepreneurial business, and argue that institutional reforms could considerably increase output and enhance welfare as well.

Angeletos and Calvet (2004) model the two sources of risks and study their effects on capital accumulation and implications for business cycle. The CARA-normal specification allows them to nicely derive a closed form solutions for the interest rate and aggregate capital. In their calibrated model, the reduction in investment demand due to idiosyncratic production risk dominates the increase in capital due to precautionary saving motives, and results in under-accumulation of capital compared to the complete market. Our model is more quantitatively oriented so that we can study practical policy implications.

Some facts about entrepreneurship and taxation: We construct a model with two sectors of production and try to capture some key features of entrepreneurial business in the U.S. economy. We focus on entrepreneurs that are defined as those who own and actively manage their own firm and business, rather than working for some firm as wage earners. Our definition of entrepreneurship differs from that of venture capitals that in fact constitute a small fraction of economics activities.[3] Entrepreneurs in our model are owners of an enterprize and combine their managerial ability and efforts together with employed capital and labor for production.

Gentry and Hubbard (2004) define an entrepreneurs as "someone who combines up-front business investments with entrepreneurial skill to obtain the chance of earning economic profits". They use the Surveys of Consumer Finances (SCF) data and show 8.7% of households defined as entrepreneurs own 38% of household assets and entrepreneurs constitute a significant fraction in the higher income and wealth groups.[4] Quadrini (2000) use two sets of survey data, SCF and Panel Study of Income Dynamics (PSID) and demonstrates a strong concentration of wealth among entrepreneurs relative to workers. Moskowitz and Vissing-Jorgensen (2002) use SCF, Flow of Funds Accounts (FFA) and National Income and Product Accounts (NIPA) data and study the returns to investing in U.S. non-publicly traded business. They show that the total value of private equity is similar in magnitude to the public equity and presents characterization of entrepreneurs' investment portfolios and returns.

Another important characteristic of the entrepreneurial sector is the existence of borrowing constraints, which has been well-studied in many papers.[5] Borrowing limits and financial intermediation costs imply that the level of asset holdings is critical in the occupational choice and the optimal determination of the enterprize size. In our model, entrepreneurs are constrained by a borrowing limit that is an increasing function of their net worth and they face a borrowing premium over the riskless rate. Also, we assume an entrepreneur can not manage more than one business simultaneously and the business suffers from undiversifiable idiosyncratic risks. It reflects the fact that entrepreneurs invest a significant fraction of wealth in their own business and their portfolio remains undiversified and highly concentrated, mostly devoted to one firm.[6]

In terms of organizational structure of business, many entrepreneurs choose to form a business so that they can avoid double taxation as with regular C corporations. In the study of Gentry and Hubbard (2004), sole proprietorships constitute 49% of businesses, partnership 24%, S corporations (pass-through entities) 11% and C corporations 14%. In our benchmark model, entrepreneurs are not subject to double taxation, i.e.

[3]Venture capitals account for less than one percent of the entire private equity market (Moskowitz and Vissing-Jorgensen (2002)).
Entrepreneurs own a more diverse set of businesses than venture businesses. Among the samples in the study of Gentry and Hubbard (2004), agriculture comprises 26%, retail 16%, construction 13%, professional practices 11%, personal and business services 10% and manufacturing services 5%.

[4]The fraction 8.7% is based on the definition requiring business assets of at least $5,000. Gentry and Hubbard (2004) also report 11.5% of households are entrepreneurs owning 40.8% of assets, if entrepreneurs are defined as households that report owning any active business assets, even if they report market value of zero.

[5]See, for example, Evans and Jovanovic (1989), Cagetti and De Nardi (2003), Gentry and Hubbard (2004) and Fernández-Villaverde, Galdón-Sánchez, and Carranza (2003).

[6]See, for example, Moskowitz and Vissing-Jorgensen (2002) and Gentry and Hubbard (2004). Moskowitz and Vissing-Jorgensen (2002) show that in 1989-1998, 73 $\sim$ 78% of private equity was held in one actively managed firm for households with positive private equity.

entrepreneurs' profits from business are not subject to corporate tax and passed-through and added to other sources of individual income, so that they are subject only to individual income taxation. In one of the policy experiments, we study the effects of separating entrepreneurs' taxation into the firm and individual levels.

3 The model

This section describes the economy. The first three subsections introduce the household endowment, preference and technological opportunities, which are followed by the description of intermediary and government sectors and finally households' problem.

3.1 Household endowment

Households are infinitely-lived. Every period each agent is endowed with a fixed amount of time normalized to a unity and decides an occupation, and allocations according to their occupational choice. Entrepreneurs in our model are defined as agents who choose to own and run a business of his own, instead of supplying labor for wage in the market. Workers are the rest of the agents who are not entrepreneurs.

In each period, agents are endowed with labor productivity η, which follows a finite-state Markov process drawn from a set $\mathbb{H} = \{\eta_1, ...\eta_{N_\eta}\}$, with probability $p_\eta(\eta, \eta') = prob(\eta_{t+1} = \eta' | \eta_t = \eta)$. It represents efficiency units of work per unit of work hours. Agents are also endowed with entrepreneurial ability θ, which is drawn from the set $\Theta = \{\theta_1, ...\theta_{N_\theta}\}$, with probability $p_\theta(\theta, \theta') = prob(\theta_{t+1} = \theta' | \theta_t = \theta)$. The parameter θ represents how productively the household can manage the business and produce given capital and labor inputs. We call the variable θ as either entrepreneurial ability or productivity shocks interchangeably.

We assume entrepreneurs can borrow from an intermediary but they face a borrowing limit and a premium over the riskless rate. More details on borrowing are discussed in Section 3.4. Workers face no borrowing constraint.

3.2 Preference

Preferences are assumed to be time-separable with a constant subjective time discount factor β. Agents rank a sequence of consumption and labor supply $\{c_t, l_t\}_{t=0}^{\infty}$ according to the expected discounted utility given as

$$E_0 \left\{ \sum_{t=0}^{\infty} \beta^t U(c_t, l_t) \right\}. \tag{1}$$

The utility from consumption and leisure in each period takes the following functional form that is additively separable in the arguments.

$$U(c, l) = u(c) + v(l) = \frac{c^{1-\sigma_1}}{1-\sigma_1} + \chi \frac{(1-l)^{1-\sigma_2}}{1-\sigma_2},$$

where $c \geqslant 0$ is consumption, $l \in [0,\ 1]$ is labor supply, where the total disposable time available to each agent is normalized to unity. σ_1 is the coefficient of relative risk aversion and the inverse of intertemporal elasticity of substitution of consumption. $1/\sigma_2$ is the intertemporal elasticity of leisure. We choose this functional form as it allows for different curvatures on consumption and leisure. We can assign parameter values based on the existing extensive micro studies, which we discuss in the calibration section. The functional form is not compatible with an economy with a balanced growth path (unless $\sigma_1 = 1$), but the assumption is not a critical issue in our study and we choose to abstract from it.

3.3 Technology and production

We model two sectors of production. One sector consists of entrepreneurial firms engaged in risky projects and the other one is populated by larger firms. We call the former as the non-corporate or entrepreneurial sector and the latter the corporate sector. A household deciding to undertake a project will operate a firm in the non-corporate sector. Description of each sector follows.

Non-corporate sector: A household can manage only one entrepreneurial business at one time. Each entrepreneur runs his own technology and produces output according to the following production function.

$$y = f(k, n, \theta) = \left[\theta k^{\alpha} n^{1-\alpha}\right]^{\nu},$$

where k is invested capital, n is efficiency units of labor employed in the firm and θ is the stochastic entrepreneurial ability. α is the input share of capital and $(1 - \nu)$ is the share of output retained as rents by an entrepreneur for managing the investment project. $\nu \in (0, 1)$ and the production function exhibits decreasing returns to scale, which can be interpreted as the diminishing returns to the owner's ability and to limited "span of control" as in Lucas (1978), i.e. it becomes harder for an entrepreneur to effectively oversee and manage the firm and maintain a most efficient use of capital and labor inputs as the business becomes expanded. Capital k depreciates at a constant rate δ after the production.

Note that a higher productivity θ implies a higher output both on average and at the margin for a given level of capital and labor inputs.

Corporate sector: The corporate sector consists of competitive firms with an identical Cobb-Douglas production function, $Y = F(K, N) = AK^{\alpha}L^{1-\alpha}$, where K and N are the total capital and labor used in the sector, A is a constant and α is the capital share. Capital K is rent from households through an intermediary at the riskless rate. Factor prices are determined competitively by the marginal productivity conditions. Capital depreciates at a constant rate δ.

3.4 Borrowing and intermediary sector

The intermediary sector consists of competitive banks, which collect deposits from households and lend the proceeds to firms in corporate and non-corporate sectors. We assume there is a fixed cost ϕ per unit of funds intermediated to the non-corporate sector, while the bank can lend costlessly to the corporate sector. Entrepreneurs' cost of borrowing from a bank is $r_d = r + \phi$, where r is the risk-free rate, at which the corporate sector borrows from the bank and the bank pays to the depositors as interest.

We don't allow for a default by entrepreneurial firms. We assume there is no enforcement problem and entrepreneurs borrow up to what can be repaid after the production. Therefore the loan premium ϕ could be interpreted as the fixed cost per unit of loan incurred by the bank for monitoring the borrowing entrepreneurs and ensuring the fulfilment of debt services.

We assume an entrepreneur can borrow but only up to the amount determined as an increasing function of his own assets. Entrepreneurial ability θ is not publicly observed and the borrowing limit can not depend on this parameter. Therefore, even if an agent is fortunate to possess a high entrepreneurial skill and production capability, lack of assets could constrain him from expanding the business as he would do without any borrowing constraint. It could also prevent an agent from starting up a business because earning from a small-scale project is less attractive than earning wage as a worker. We make an assumption that the borrowing limit is proportional to the entrepreneur's net worth as in Evans and Jovanovic (1989) and the maximum leverage ratio is set at d, which is common across agents, i.e. with assets a, an entrepreneur can invest no more than $(1 + d)a$.[7]

3.5 Government

The government raises tax to finance its consumption and investment expenditures G. Balanced budget is imposed every period.

Income taxes are described by a function $T(I)$ of the income I of an entrepreneur or a worker, which is calibrated to capture the progressive income tax system in the U.S. The government also taxes on consumption at a constant rate τ_c.

3.6 Households' problem

In this subsection, we will first describe the timing of various events and present the optimization problem of households.

Timing of events: An agent's occupation is predetermined from the previous period. At the beginning of the period, agents' ability shocks (labor productivity η and entrepreneurial ability θ) are realized. Given these shocks, agents make allocational decisions and choose an occupation for the next period. Since there is no other uncertainty between the realization of shocks in this and next periods, all the decisions including next

[7]In our model, entrepreneurs do not have an incentive to renege on the contract. These interesting issues of endogenous borrowing constraints due to imperfect enforceability of contracts (and information problem) are discussed in many papers including Albuquerque and Hopenhayn (2004), Cagetti and De Nardi (2003) and Fernández-Villaverde, Galdón-Sánchez, and Carranza (2003), but not pursued here mainly for simplicity and tractability. We take the simplest possible way of capturing the facts that entrepreneurial investment requires some initial assets and that outside finance is more costly, facts that are well-documented by many papers, for example, Evans and Jovanovic (1989), Gentry and Hubbard (2004), etc.

period's occupation can be made right after the realization of current shocks.[8] Workers decide allocation of time for work and leisure and how much to consume and save. Entrepreneurs decide capital and labor inputs used in their production technology and allocations for consumption and saving.

Later in the period production takes place, which is followed by factor payments and repayment for loans. Agents pay tax on their taxable income, consume part of the disposable assets and move to the next period with the remaining assets.

Optimization problem: Denote by $s = (a, \eta, \theta, \xi)$ an agent's state vector at the beginning of the period after the realization of current shocks, where a is asset holding from previous period, η is worker ability, θ is entrepreneurial ability and $\xi \in \{W, E\}$ is the agent's occupation in the current period.

Agents make allocational decisions to maximize the present discounted utility as in equation (1) that depends on the sequence of consumption and leisure. In what follows, we solve the problem in a recursive way.

1. **A worker's problem**

   Denote by $V(s)$ the value function of an agent in state s. A worker's problem is given as follows.

$$V(s|\xi = W) = \max_{c,l,a',i_\xi} \{U(c,l) + i_\xi \beta EV(s'|\xi' = W) + (1 - i_\xi)\beta EV(s'|\xi' = E)\} \quad (2)$$

   subject to

$$(1 + \tau_c)c + a' = \eta wl + (1 + r)a - T(I) \quad (3)$$

$$I = \eta wl + ra \quad (4)$$

$$a' \geq 0, \quad c \geq 0, \quad l \in [0,\ 1], \quad i_\xi \in \{0,\ 1\}$$

   where i_ξ is an indicator function that takes a value 1 if the agent is a worker in the next period and 0 otherwise. The expectation operator in equation (2) is with respect to the stochastic process of productivities η and θ.[9] I in equation (4) represents the worker's taxable income, which consists of labor income, ηwl, and capital income from saving, ra. Equation (3) is a worker's flow budget constraint. Labor income and assets plus interest net of income tax are allocated between consumption and saving for the next period.

2. **An entrepreneur's problem**

   An entrepreneur's problem is given as follows.

$$V(s|\xi = E) = \max_{c,a',i_\xi} \{U(c,l) + i_\xi \beta EV(s'|\xi' = W) + (1 - i_\xi)\beta EV(s'|\xi' = E)\} \quad (5)$$

[8] In other words, assuming the occupational choice occurring at the end of the period makes no difference. What is important about the timing assumption is that the occupation must be chosen prior to the realization of the shocks.

[9] More precisely, $EV(s'|\xi') = EV(a', \eta', \theta', \xi') = \sum_{\theta'} \sum_{\eta'} V(a', \eta', \theta', \xi') p_\eta(\eta, \eta') p_\theta(\theta, \theta')$ for $\xi' = W, E$.

subject to

$$
\begin{aligned}
&(1+\tau_c)c + a' = \pi^E(s) \qquad (6)\\
&a' \geq 0, \quad c \geq 0, \quad l = l_E, \quad i_\xi \in \{0,\ 1\}
\end{aligned}
$$

We assume that entrepreneurs do not choose hours of work but they must work for at least a fixed amount of hours, and that they derive disutility from work corresponding to the average hours of in the economy, l_E.[10]

$\pi^E(s)$ in equation (6) is the net-of-tax assets available to the entrepreneur after the production, factor payments and repayment of loans and income tax, which is determined as follows.

$$\pi^E(s) = \max_{k,n}\{f(k,n,\theta) + (1-\delta)k - (1+\tilde{r})(k-a) - wn - T(I) + w_E\} \qquad (7)$$

where

$$
\begin{aligned}
&I = f(k,n,\theta) - \delta k - \tilde{r}(k-a) - wn + w_E \qquad (8)\\
&k \leq (1+d)a \qquad (9)
\end{aligned}
$$

and

$$\tilde{r} = \begin{cases} r & \text{if } k \leq a \\ r_d = r + \phi & \text{if } k > a. \end{cases}$$

I is the entrepreneur's taxable income as defined in equation (8). The first term on the RHS is the output from the production. The second term $-\delta k$ is the depreciation deduction applied to the investment k. If the agent is a net borrower, i.e. $k > a$, the interest payment for the borrowing is deducted as operational costs. If only part of his assets are invested, i.e. $k \leq a$, the remaining $(a-k)$ earns a riskless return, which is added to the tax base of the entrepreneur as capital income. w_E is the wage income paid to entrepreneur's own work, $w_E = w \cdot \min\{n, l_E \cdot \eta\}$, i.e. entrepreneurs are paid "fair" wages for their own work, but they cannot exceed the payment to what is actually used in the production as labor inputs. Equation (9) is the borrowing constraint.

4 Stationary competitive equilibrium

We define a stationary competitive equilibrium of the economy. At the beginning of the period, agents are heterogeneous in four dimensions summarized by a state vector $s = (a, \eta, \theta, \xi)$, i.e. asset holdings a, labor productivity shock η, entrepreneurial ability shock θ, and occupation $\xi \in \{W, E\}$. Let $a \in \mathbb{A} = \mathbb{R}_+$, $\eta \in \mathbb{H}$, $\theta \in \Theta$ and $\xi \in \Xi$. Also denote by $\mathbb{S} = \mathbb{A} \times \mathbb{H} \times \Theta \times \Xi$ the entire state space. The equilibrium is given by

[10]Their own labor contribution l_E is counted as part of labor demanded for the entrepreneur's project, though partially if the optimally chosen demand is less than l_E times his labor productivity. The normalized disutility from entrepreneurial labor can also be thought of as a fixed cost of running a business in terms of utility. It is also similar to entry cost, but not exactly since this disutility occurs every period as long as the household remains in an entrepreneurial business.

- interest rate r and wage rate w,
- occupational choice and allocation functions for each state vector s. Allocations are $\{c, l, a'\}$ for workers and $\{c, k, n, a'\}$ for entrepreneurs,
- government tax system: income tax function $T(I)$ and consumption tax τ_c,
- an intermediary,
- a set of value functions $\{V(s)\}_{s\in\mathbb{S}}$, and
- distribution of agents over the state space $\mathbb{S}$ given by $\Phi(s)$, $s \in \mathbb{S}$,

such that

1. Given the interest rate, the wage and the government tax system, the allocations solve the above described maximization problem for a households of each state vector s.
2. The riskless rate r and wage rate w satisfy marginal productivity conditions, i.e. $r = F_K(K, N) - \delta$ and $w = F_N(K, N)$, where K and N are total capital and labor employed in the corporate sector.
3. Government budget is balanced.
$$G = \int [\tau_c c(s) + T(I(s))]\, d\Phi(s)$$
4. The intermediary sector is competitive. Banks receive deposits from households and pay interest r, and offer loans to corporate and non-corporate sectors at rate r and $r + \phi$ respectively, where ϕ is the costs to intermediate funds to entrepreneurs.
5. Capital and labor markets clear.
$$\begin{aligned} \int k(s)d\Phi(s) + K &= \int a(s)d\Phi(s) \\ \int n(s)d\Phi(s) + N &= \int l(s)d\Phi(s) \end{aligned}$$
6. The distribution Φ is time-invariant. Law of motion for the distribution of agents over the state space $\mathbb{S}$ satisfies
$$\Phi = R_\Phi(\Phi),$$
where R_Φ is a one-period transition operator on the distribution, i.e. $\Phi_{t+1} = R_\Phi(\Phi_t)$.[11]

The computation algorithm used to derive stationary equilibrium is described in Appendix A.

[11] In computation, $\Phi_{t+1}(s')$ for any $s' \in \mathbb{S}$ is given by $\Phi_{t+1}(s') \equiv \Phi_{t+1}(a', \eta', \theta', \xi') = \sum_{\eta'} \sum_{\theta'} \Phi_t(a, \eta, \theta, \xi) p_\eta(\eta, \eta') p_\theta(\theta, \theta') i_{a'} i_{\xi'}$, where $i_{a'}$ is an indicator function that takes a value 1 if $a(s) = a'$ and similarly for $i_{\xi'}$.

5 Calibration of the benchmark economy

5.1 Preference

For the parameters in the utility function defined in equation (1), the coefficient of relative risk aversion σ_1 is set to 2.0 (Prescott (1986) and Gourinchas and Parker (2002)). We set the inverse of the intertemporal elasticity of leisure σ_2 to 3.2 so that the implied intertemporal elasticity of labor supply is 0.5 when the fraction of a worker's discretionary time spent on leisure is as observed in the U.S. in a steady state, which is set to 0.383 based on the study in Heathcote, Storesletten, and Violante (2004).[12] χ is calibrated so that the ratio of work time out of total disposable time matches this number. As discussed in the model section, we assume that entrepreneurs need to spend certain time for running the business and do not choose hours of work as workers do. Entrepreneurs' disutility from work is normalized at $v(l_E)$, where l_E is set to the average hours of work in the economy, a fraction 0.383 of the total disposable time. Subjective time discount factor β is set to 0.955 so that the economy attains the aggregate capital-output ratio of 3.0 in a stationary equilibrium.

5.2 Endowment and technology

We assume logarithm of stochastic component of labor income, η, follows a first-order autoregressive process and transform the process into the one in the discrete space with $N_\eta = 5$ possible values of η, using the method of Tauchen and Hussey (1991). The process in continuous space is given as

$$\ln \eta_t = \rho_\eta \ln \eta_{t-1} + \varepsilon_{\eta,t},$$

where $\varepsilon_{\eta,t} \sim N(0, \sigma_\eta^2)$. The AR(1) coefficient ρ_η and the residual variance σ_η^2 take the values 0.9426 and 0.0198 respectively, taken from the study of Heathcote, Storesletten, and Violante (2004). One period transition matrix over $N_\eta = 5$ states is denoted as P_η with each element $p_\eta(\eta, \eta') = prob(\eta_{t+1} = \eta' | \eta_t = \eta)$. The vector of η is normalized so that the unconditional mean of $\ln \eta$ is zero. The calibrated Markov process of η is presented in Appendix B.

Entrepreneurs use capital k and labor n and produce output y. Recall the production function.

$$y = f(k, n, \theta) = \left[\theta k^\alpha n^{1-\alpha}\right]^\nu$$

$(1-\nu) \in (0,1)$ is the share of output retained as rents by an entrepreneur for managing the investment project. Li (2002) computes the percentage of total income earned by entrepreneurs using data from the Panel Study of Income Dynamics (PSID) and set the

[12] The estimates of the Frisch labor supply elasticity in the literature vary in a wide range. Browning, Hansen, and Heckman (1999) contains a survey. $0.1-0.4$ by MaCurdy (1982), $0.0-0.35$ by Altonji (1986), 1.61 by Heckman and MaCurdy (1982). We set the elasticity at 0.5, which is towards the higher end of the estimates. Domeij and Floden (2003) argue there is a downward bias of 50% when there is a borrowing constraint.

entrepreneurs' income share at 12%, implying $\nu = 0.88$.[13] We set it to 0.88. θ is the entrepreneurial ability. We assume it evolves according to the following AR(1) process.

$$\ln \theta_t = \rho_\theta \ln \theta_{t-1} + \varepsilon_{\theta,t},$$

where $\varepsilon_{\theta,t} \sim N(0, \sigma_\theta^2)$. We discretize the process into $N_\theta = 10$ values of θ with a 10×10 transition matrix P_θ, with each element $p_\theta(\theta, \theta') = prob(\theta_{t+1} = \theta' | \theta_t = \theta)$. We calibrate the parameters ρ_θ and σ_θ and a normalization factor for the vector of θ so that the model attains the following three target moments in equilibrium: the fraction of entrepreneurs in the economy, the exit rate of entrepreneurs and the share of income earned by entrepreneurs. Quadrini (2000) reports the fraction of entrepreneurs of 12% using the average of the PSID data for the period 1970-1992 and the SCF data for 1989-1992.[14] Gentry and Hubbard (2004) use the SCF data in 1989 and report a fraction of entrepreneurs according to three alternative definition of entrepreneurs. Households who reported owning active business assets without restriction on the asset size constitute 11.5% of the sample population. We set a target fraction of 12% in our model. The fraction of total income earned by entrepreneurs is set at 22%, which Quadrini (2000) found using the PSID samples for 1984, 1989 and 1994. He also reports the exit rate of business owners from entrepreneurship as 24.2%, taking the average over 1973-1992 period.[15] We use these numbers as targets in our model. The calibrated Markov process of θ is presented in Appendix B.

In the corporate sector, the production function is given as $Y = F(K, L) = AK^\alpha N^{1-\alpha}$. We set a constant parameter A normalized to 1. The share of income that goes to capital, α, is fixed at 0.36 in both sectors (Cooley and Prescott (1995)). Depreciation rate δ is set at 6% (Stokey and Rebelo (1995)).

5.3 Intermediary sector

The loan premium ϕ represents the spread between household borrowing and lending rates. Díaz-Giménez, Prescott, Fitzgerald, and Alvarez (1992) report interest rates paid and earned by household of different types on borrowing and lending. Based on the study, they set in the model the deposit rate at 4% and loan rate at 9.5%, resulting in the spread of 5.5%. We set ϕ at 5% in the benchmark model. The maximum leverage ratio d is set to 50%.[16]

[13] Cagetti and De Nardi (2004a) calibrate the parameter jointly with some other parameters in equilibrium and obtained the value corresponding to $\nu = 0.88$. Fernández-Villaverde, Galdón-Sánchez, and Carranza (2003) calibrate the degree of decreasing returns to scale at 11% (implying $\nu = 0.89$ in our model) to generate a percentage of income earned by entrepreneurs at around 22%.

[14] Quadrini (2000) defines entrepreneurs as families that own a business or have a financial interest in some business enterprize, as we do in our model. The identification of entrepreneurs is based on an interview question. See Quadrini (1999) for more details.

[15] The entry rate is 3.7% for the same samples.

[16] Evans and Jovanovic (1989) estimated the parameter to be in the range of (0.31, 0.59) with 99% confidence.

5.4 Government

The government spending G is assumed to be exogenously given as a fixed fraction of GDP in the benchmark economy. The ratio is set at 18%, which is computed as the share of the government consumption and gross investment excluding transfers, at the federal, state and local levels (*The Economic Report of the President* (2004)).

The consumption tax rate is fixed at $\tau_c = 5.0\%$, which is computed using data for 2003 following the computation method of effective tax rates described in Mendoza et al. (1994).

To approximate the U.S. income tax system, we employ a parametric assumption about the functional form of tax schedules constructed from applying the equal sacrifice principle.[17]

$$T(I) = a_0 \left\{ I - (I^{-a_1} + a_2)^{-1/a_1} \right\}, \tag{10}$$

where I is the total taxable income of an individual and $\{a_0, a_1, a_2\}$ are parameters that determine the shape of a tax function.[18] Gouveia and Strauss (1994) use individual tax return data provided by the IRS and estimate this version of the parametric class of tax function. Their definition of income (taxable base) include all sources of income identifiable from tax returns, including labor income, interest, dividends, capital gains and sole proprietorship income. They define tax as the final liabilities of the individual tax return.[19] They obtain estimates of $a_0 = 0.258$ and $a_1 = 0.768$ to approximate the effective tax system in the U.S. In a separate study, Cagetti and De Nardi (2004a) use data from the Panel Study of Income Studies (PSID) and obtain a set of parameter estimates of similar values for the shape of tax schedule.[20] We use these parameter values in the benchmark model and compute a_2 so that the government budget is balanced.[21]

6 Benchmark economy

This section provides some description of the benchmark economy and characterization of the channels through which income tax policies affect the agents' behavior and aggregate activities.

[17]For more details about equal sacrifice principle in taxation and the functional form, see Berliant and Gouveia (1993) and Young (1990). They observe that the tax rates of the U.S. conformed to the equal sacrifice model, that is, the tax function is chosen such that for some income level I, $u(I) - u(I - \tau) = s$, where τ is the amount of tax and s is the notion of sacrifice common across agents. Applying a standard isoelastic utility function in this formula yields the tax function of the above form.

[18]The parameter a_2 varies with the unit of measurement, i.e. for income scaled by a factor $\lambda > 0$, we need to adjust a_2 so that $\widetilde{a}_2 = a_2 \lambda^{-a_1}$ to proportionally raise tax liabilities.

[19]They exclude from the definition of tax the sums that pertain to social security obligations. For more details of the data and measurement, see p.320-321 in Gouveia and Strauss (1994).

[20]Cagetti and De Nardi (2004a)'s estimates for the parameters using the whole sample of workers and entrepreneurs are $a_0 = 0.30$ and $a_1 = 0.82$

[21]The samples used in Gouveia and Strauss (1994) are individual income and tax data filed at the Internal Revenue Service. Income consists of all sources received for federal tax purposes. For tax, they consider final liabilities and this tax function is called *effective* tax function as opposed to statutory tax function prescribed by the law. The former represents the relation between the pre-tax income and actual tax liabilities, which is the notion that pertains to the current context.

Table 2(a) displays some moments in the benchmark economy and compares with the data in the U.S. economy. Capital-output ratio, the fraction of entrepreneurs, entrepreneurs' exit rate and earnings share of entrepreneurs are the moments that we match through calibration. There is a fair degree of inequality in our model economy. Gini coefficient of wealth is 62% and the wealthiest 10% own about half of the total assets. Although the degree of inequality is less than that observed in the U.S., we will not attempt to exactly match the distribution in our model by calibration as there are many other factors that are missing in our model that would contribute to a more skewed wealth distribution.[22] We are interested in studying the tax incidence through the features that we have in our model, hence we prefer not to force the limited features of our model to generate and explain the exact degree of the U.S. wealth distribution.

Entrepreneurs in our model are characterized by a higher level assets and entrepreneurial productivity θ. Figure 1 plots the cumulative distribution of assets for workers and entrepreneurs. While there are many workers with zero or few assets, entrepreneurs possess a greater amount of assets. Figure 2 displays the probability distribution of assets for workers and entrepreneurs. The distribution of entrepreneurs has a much thicker tail towards the higher end of wealth distribution. Figure 3 shows the fraction of entrepreneurs across different levels of assets. Few agents become entrepreneurs with assets very close to zero. As described in the model section, agents face a borrowing limit which depends on their wealth. Even if an agent draws the highest entrepreneurial ability θ, lack of assets and inability of investing at the desired level can make entrepreneurial business less attractive than earning a market wage as a worker. The fraction of entrepreneurs increases in assets and flattens out as the borrowing limit ceases to constrain agents from making an optimal size of investments. However, the fraction gradually decreases as the asset level becomes very high (see the assets level 20-30 in the figure). These agents earn a significant amount of return by simply saving their assets. Even if they are lucky to have a high entrepreneurial ability, marginal utility from entrepreneurial business is low compared to the disutility from earning by undertaking entrepreneurial work, which can be thought of as a fixed cost of running a business. Figure 4 displays the distribution of θ for the entire population and for entrepreneurs. Agents with a highest productivity draw θ (those at the right end of distribution) are highly likely to be entrepreneurs. The fraction of entrepreneurs decreases as the value of θ goes down. Table 2(b) displays more characterization of entrepreneurs across different values of θ.

Figure 5 displays the investment by entrepreneurs across different levels of assets. We plot the investment by the agents with the three highest θ's (θ_{10}, θ_9 and θ_8), who together constitute more than 95% of all the entrepreneurs in the economy as shown in Table 2(b). First, look at the curve on the top, the investments by entrepreneurs with $\theta = \theta_{10}$. The distance between the curve and a 45 degree line when a curve lies above the line represents the borrowing from an intermediary. Many of the entrepreneurs with the highest $\theta = \theta_{10}$ are borrowing to finance their investment. As the investment increases, the marginal return decreases since the production function exhibits decreasing returns

[22]The factors that our model does not capture and would help a model generate more wealth inequality include life-cycle saving motives, intergenerational linkages, heterogenous preferences, human capital accumulation, among others. Cagetti and De Nardi (2004b) provides an excellent survey of various models in this literature.

to scale. Once the level of investment reaches the point where the marginal return from investment equals a borrowing cost, it no longer pays to borrow for investment by paying a premium. From there on, the same level of investment is maintained and the leverage ratio decreases as the fraction of own assets used for the investment increases, as shown in the flat part of the line for θ_{10}. For entrepreneurs with a lower θ, financing investment with the costly external borrowing incurs a marginal loss. They invest all of their assets up to the point where the decreasing return hits the opportunity cost of investing, i.e. riskless saving with the intermediary. After this point, the investment levels off.

Several features contribute for the model to generate an endogenously determined non-degenerate distribution of firms' size. The decreasing returns to scale technology generates endogenous determination of optimal firm size. Having a constant returns to scale technology instead would have agents desire an amount of investment solely based on the productivity draw θ.[23] The existence of borrowing constraints precludes those with few assets from expanding business or even starting up one. The borrowing premium contributes to another dimension of heterogeneity. For a given level of assets, the stochastic productivity generates heterogeneous break-even points of investment and the optimal amount of borrowing.

7 Policy experiments

In this section, we will conduct the following experiments to study the policy effect and tax incidences in the model we have constructed. Throughout the experiments, we fix the government expenditures at the level obtained in the benchmark economy.

1. capital income taxation
    - abolishing capital income tax
    - constant capital income tax (5%, 10%, ..., 35%)
2. different degrees of progressivity in the existing income tax system
    - flat income tax
    - more/less progressive income tax system
3. investment-targeted policies
    - accelerated/increased depreciation expense
        - entrepreneurs' investment
        - all investments (both in entrepreneurial and corporate sectors)
    - loan interest subsidy and reduction in entrepreneurs' borrowing costs
4. Separate treatment of entrepreneurs' investment income without double taxation

[23]It can possibly depend on the labor productivity η, but the effect is relatively small.

7.1 Welfare measure

We evaluate welfare under different tax regimes according to the following social welfare function.

$$W(T) \equiv (1-\beta)\int V(s)d\Phi(s) = \int u(c(s), l(s))d\Phi(s)$$

where T represents a particular tax system.[24] The social welfare function is defined from the Rawlsian perspective of 'behind the veil of ignorance' (Rawls (1971)), a ranking according to an agent as if he was to rank before he was born to the economy.

We compare welfare across different tax systems by computing consumption equivalent variation (CEV). Welfare gain ($\Delta_{A\to B}$) by switching from a tax system A denoted by the tax schedule T^A to another tax system B denoted by T^B is defined as

$$W\left[T^A | \{c_A^*(s)(1+\Delta_{A\to B}), l_A^*(s)\}_{s\in\mathbb{S}}\right] = W\left[T^B | \{c_B^*(s), l_B^*(s)\}_{s\in\mathbb{S}}\right]$$

where $\{c_A^*(s), l_A(s)\}$ is the set of optimally chosen consumption and labor supply for each individual in state s under the system A. $\Delta_{A\to B}$ measures the constant increment in percentage of consumption in every state that is required for an agent to be indifferent between the two systems.[25]

7.2 Capital income tax

In this section, we implement a flat capital income tax, with a rate ranging from 0% (i.e. abolishing the capital income tax) up to 35% by a 5% increment and study how the economy reacts to the change. We use the proportional tax rate $\tau_{\tilde{I}}$ on other sources of income to balance the government budget constraint. Let $\tilde{I}$ denote the total income I minus capital income, and I_K denote the capital income, i.e. $I = \tilde{I} + I_K$. The total income tax liabilities of an agent who earns capital income I_K and non-capital income $\tilde{I}$ are given by:

$$T(I_K, \tilde{I}) = a_0\left\{\tilde{I} - (\tilde{I}^{-a_1} + a_2)^{-1/a_1}\right\} + \tau_K I_K + \tau_{\tilde{I}}\tilde{I}$$

where τ_K is the flat tax rate on the capital income.

Results are summarized in Tables 3(a) and 3(b). Lower capital income tax encourages the saving and raises the level of aggregate capital and output. Interest rate goes down in the capital tax rate with an increasing capital labor ratio in the corporate sector. Table 3(b) displays the resulting economic activities in non-corporate sector. Investments by entrepreneurs fall when capital income tax is low. To understand this, firstly, notice that entrepreneurs find saving as a more attractive use of assets relative to the entrepreneurial investment than before, now that the net-of-tax return from saving is higher and the

[24] To see the intermediate steps, notice $W(T) = (1-\beta)\int\left[\sum_{t=0}^{\infty}\beta^t u(c_t, l_t)\right]d\Phi(s) = (1-\beta)\sum_{t=0}^{\infty}\beta^t\left[\int u(c(s), l(s))\, d\Phi(s)\right]$. Simplification is possible as we are studying a stationary equilibrium.

[25] For example, if A is the benchmark economy and B is the flat tax system, and the CEV ($=\Delta_{A\to B}$) is 1.035% as shown in Table 4(b). It means that an agent prefers ex-ante the flat tax system to the benchmark. The consumption across all the states in the benchmark system must be 1.035% higher so that the agent is indifferent between remaining in the benchmark economy and living in the proportional tax system.

return from non-capital income is taxed at a higher rate to compensate for the reduction in the tax revenue. The pre-tax interest rate is lower, but for agents who face a sufficiently high marginal tax rate, the favorable effect of reduced capital taxation dominates the net effect on after-tax return.

Secondly, in terms of input costs, the increase in wage brings pressure on the production costs for all the entrepreneurs, while reduction in interest benefits only a fraction of entrepreneurs who are borrowing from the intermediary. Entrepreneurs rely more heavily on labor inputs and capital-labor ratio of the sector is lower than in the corporate sector, as their access to capital is limited by the borrowing constraints and a loan premium. Therefore entrepreneurial production is more severely hurt by an increase in wage. As shown in Table 3(a), when the capital tax is zero, wage is 3.09% higher than in the benchmark, which pushes down the production in the non-corporate sector by 4.90%. The total labor used in the sector is lower by as much as 7.44%. Table 3(b) also displays the leverage ratio of entrepreneurs, which is a fraction of invested capital financed by borrowing. With a low capital tax, the size of entrepreneurial investment decreases, but now that the borrowing cost of capital input is lower they rely more on leverage than on their own assets to finance the projects.

Reduction in capital tax favors workers. A higher wage and a lower tax on return from saving increase their disposable income. This effect, together with the low entrepreneurs' investment, reduces the share of entrepreneurs' income in the economy, as shown in Table 3(b). As a consequence, the economy is more equal in wealth distribution as reflected in a lower Gini coefficient shown in the same table. Lower tax rates on saving will benefit agents earning large income on their assets and further increase their wealth, but the effect is mitigated by the lower interest rate in the economy and does not dominate in determining the direction of wealth inequality.

7.3 Different degrees of income tax progressivity

In this section, we study the effect of implementing income tax system with a different degrees of progressivity.

7.3.1 Flat tax system

The first experiment is an extreme case of zero progressivity, i.e. flat income tax system. The total income tax for a taxable income I is simply given as $T(I) = \tau_I I$, where τ_I is determined so that the tax revenue covers the expenditures.

Results are summarized in Tables 4(a) and 4(b). It turns out the flat income tax rate that balances the government budget is 17.79%, which is higher than the marginal tax faced by low-income households and lower than the limiting marginal tax rate of 25.8% in the benchmark economy. The policy benefits agents with high income and hurts the poor. Agents with large assets enjoy higher after-tax returns from saving and investment, which further encourages accumulation of capital. Capital-output ratio of the economy is 3.11, significantly higher than the benchmark level of 3.00. The wealth distribution of the economy becomes more unequal, but not so dramatically as workers also benefit from the higher wage and working longer hours on average.

Ex-ante welfare expressed in terms of CEV is higher compared to the benchmark economy. When we contrast the results to the experiments of abolishing capital tax in the previous section, the aggregate effects are similar (higher capital and output, low interest and high wage), but the distributional effects are very different. With no capital tax, entrepreneurs have an incentive to allocate more resources to saving and total investment in the non-corporate sector is lower than in the benchmark, while under the flat tax system entrepreneurial production is higher as the after-tax return from investment is higher. Gini coefficients move in the opposite directions under the two policies.

7.3.2 Changing progressivity

Next we study the effect of less/more progressive tax system. We adjust the parameter a_0 of the income tax function. We will increase and reduce the parameter up to 25% and -25% by a 5% increment.[26] A higher value of this parameter implies an increased slope of an average and marginal tax schedules and the tax burden falls more heavily on agents with higher income. A constant income tax τ_I will adjust to achieve the government budget balance. The total tax payment for a taxable income I is given by

$$T(I) = \tilde{a}_0 \left\{ I - (I^{-a_1} + a_2)^{-1/a_1} \right\} + \tau_I I, \tag{11}$$

where $\tilde{a}_0$ varies from $0.75 \times a_0 = 0.1935$ to $1.25 \times a_0 = 0.3225$ in the experiments.

Results are summarized in Tables 5(a) and 5(b). With a more progressive tax system, agents earning high income face an increase in the marginal tax, which discourages entrepreneurs' investments, e.g. with a_0 that is 25% above the benchmark, total investment of entrepreneurs is 2.07% lower. With a decreased labor demand, wage is also lower, but the marginal tax of workers in a very low income class is lower due to the negative tax τ_I on income since a more progressive tax schedule will raise more revenue from the rich.

7.4 Investment-targeted policies

This section is a slight digression from the study of income taxation and we study the effect of policies to encourage investment by entrepreneurs. We assess the qualitative as well as quantitative effects of such policies, and in the following section, we ask if we can achieve the results of such policies by structuring the tax system in a particular way.

In the first experiment, we study the policy of accelerated depreciation expense (or investment credit), which is followed by an experiment of loan interest subsidy.

7.4.1 Accelerated depreciation expensing

This subsection studies the effect of allowing an accelerated depreciation expensing. The Jobs & Growth Tax Relief Reconciliation Act of 2003 (JGTRRA 2003) that was passed in the current administration brought favorable tax treatments for businesses allowing an increased depreciation expensing. There are two major changes in the law, one is designed

[26] We do not present all the results in the tables to save the space in the paper. Complete results ar available upon request.

to target small businesses and the other one is for general investments.[27] We study the effect of such policies by experimenting increased tax deduction for entrepreneurs in one case and for general investments in the other.

Accelerated depreciation expense for entrepreneurial investments: In the first experiment, entrepreneurs are allowed to apply depreciation expense at a rate $\lambda\delta$, where $\lambda > 1$, instead of the actual depreciation rate of δ. For a given entrepreneurial investment of k, the effect of this policy is to reduce the tax base by $(\lambda - 1)\delta k$. Therefore, the effect of this policy can be interpreted in the same way as providing credits for investment by decreasing the tax base proportionally to the amount of investment at a rate $(\lambda - 1)\delta$.

We use the proportional income tax rate τ_I to balance the government budget constraint. The total income tax payment of an agent who earns income I is given by

$$T(I) = a_0 \left\{ I - (I^{-a_1} + a_2)^{-1/a_1} \right\} + \tau_I I. \tag{12}$$

In the experiments, we increase the depreciation expense by 50% and 100%, i.e. $\lambda = 1.5$ and 2.0. Results are summarized in Tables 6(a) and 6(b). The policy has a strong effect in encouraging investments by entrepreneurs. The policy, however, hurts most of workers. Although the wage is slightly higher with an increased labor demand by entrepreneurs, a higher proportional tax τ_I will take away most of the gains. In addition, a lower interest rate erodes their income from saving.

Accelerated depreciation expense for general investments: We now allow accelerated depreciation in both entrepreneurial and corporate sectors. The effect on entrepreneurs' tax base is the same as what we described above. For the capital used in the corporate sector, it will in effect raise the return from households' saving. Firms in the corporate sector operate a CRS technology and make no profit, paying marginal returns to factors as before. In the benchmark economy, households pay the tax on the return from

[27] Here's a brief explanation of the regulations.

1. Small business expensing: Before passage of the JGTRRA 2003, businesses could elect to deduct from their taxes up to $25,000 of the cost of tangible business property placed in service during the taxable year. The full benefit, however, could be realized only when qualifying property did not exceed $200,000 and This deduction is reduced dollar-for-dollar by the amount by which the cost of all qualifying property placed in service during the taxable year exceeded $200,000. The new law increased the maximum that can be deducted and expands the categories of property that qualifies for this treatment. Beginning in 2003, the amount of the qualifying expenses that may be deducted is increased to $100,000. In addition, the phase-out starting point is increased to $400,000 and will be indexed for inflation in 2004 and 2005. It is scheduled to revert back to $25,000 in 2006 unless further action is taken the government.
2. Increase and extension of first year bonus depreciation: The JGTRRA expands upon a law passed in 2002 that allows a first-year depreciation deduction equal to 30% of certain qualified property. The JGTRRA permits taxpayers to recognize a first-year depreciation deduction equal to 50% of the adjusted basis of qualified property for property acquired after May 5, 2003, and before January 2005.

It is estimated that small business will be the primary beneficiary of the new regulations. Larger businesses will also benefit although there is a dollar limitation on equipment purchases for expensing. There is no limitation in the bonus depreciation.

the saving, and the capital income tax base is given as $ra = (F_K - \delta)a$. With accelerated depreciation, the tax base is given as $(F_K - \lambda\delta)a = (F_K - \delta - (\lambda - 1)\delta)a = (r - (\lambda - 1)\delta)a$, i.e. the policy reduces the tax base by $(\lambda - 1)\delta$ for each unit of saving a. The government uses the proportional income tax τ_I to balance the budget as in equation (12). We conduct experiments where allowed depreciation expense is raised by 10, 20, 30 and 40% on top of the actual depreciation, i.e. λ =1.1, 1.2, 1.3 and 1.4.[28]

Results are summarized in Tables 7(a) and 7(b). The policy encourages production in both corporate and entrepreneurial sectors by increased saving and entrepreneurial investment. With an increased wage and after-tax return from saving, workers also benefit from the policy.

7.4.2 Loan interest subsidy

Next we study the effect of government subsidy for entrepreneurs' borrowing from the intermediary. In the benchmark model, entrepreneurs face the borrowing premium $\phi =$ 5% over the riskless rate. In the experiment, the government takes over part of the premium as a subsidy so that the borrowing premium that a borrower must pay will be $\tilde{\phi} < \phi$. We experiment five values of $\tilde{\phi}$ = 4%, 3%, 2%, 1% and 0%. The government uses the proportional income tax τ_I to balance the budget as in equation (12). The subsidy payment is additional expenditures of the government and added to the other expenditures G, which must be financed by the tax revenues.

Results are summarized in Tables 8(a) and 8(b). The effects on entrepreneurial activities are similar to the case of accelerated depreciation policy for entrepreneurs. Reduction in loan premium pushes up the break-even point of investment financed by borrowing and raises the investments by entrepreneurs. With zero premium (full subsidy of 5%), the leverage ratio increases to 25.44%, about 6% higher than the benchmark level.

7.5 Separate treatment of entrepreneurs' investment income without double taxation [preliminary]

In this section, we consider a system that distinguishes entrepreneurs' investment return at the firm level for the purpose of taxation, and treats it separately from the other sources of individual income. The return from an entrepreneur's business is given as

$$I_{E1} = f(k, n, \theta) - \delta k - wn - rk - \phi \max\{0, k - a\}, \tag{13}$$

where the last term $-\phi \max\{0, k - a\}$ represents the part of interest expense subtracted from the tax base in case some fraction of investment is financed by borrowing with a loan premium ϕ. Income taxed at the individual level is given as

$$I_{E2} = w_E + ra. \tag{14}$$

where w_E is the wage income for the entrepreneur's labor used in his own firm and ra is the capital income earned on his assets a.

[28] Allowing further expensing, e.g. 50% would make the capital income tax base negative and the computation unfeasible unless we add an assumption about how to treat such cases of negative tax base.

When we consider what would be an appropriate benchmark tax system applied for the entrepreneurs' income at the firm level, it is difficult to compare with the corporate tax system in the U.S. Although the U.S. government levies a relatively high statutory tax rates on corporate profits,[29] the actual collection of tax from corporations is very small in size, only 1.4% of GDP,[30] implying the shape of the effective tax on the profits such as those defined in our model is very different from that of the statutory tax system, and it is a very challenging task to estimate such a function. Therefore, we do not try to mimic or make a comparison to the statutory U.S. corporate tax schedule, and conduct experiments on some simple forms of effective tax function on the entrepreneurial profits as we discuss below.

7.5.1 Flat tax system for entrepreneurs' income at the firm level

In this experiment, we apply a proportional tax rate to the entrepreneurs' investment income. The income at the individual level is taxed based on the same progressive tax schedule as in the benchmark system. There is no change in workers' tax schedule. A proportional tax τ_I on all the income is used to balance the government budget. The total tax liabilities of an entrepreneur earning income I_{E1} (business income) and I_{E2} (individual income) as defined in equations (13) and (14) are given as

$$\begin{aligned} T(I_{E1}, I_{E2}) &= \tau_{E1} I_{E1} + a_0 \left\{ I_{E2} - (I_{E2}^{-a_1} + a_2)^{-1/a_1} \right\} + \\ &\quad + \tau_I (I_{E1} + I_{E2}). \end{aligned}$$

where τ_{E1} is the proportional tax rate applied for business income of entrepreneurs. For workers earning income I_W, the tax liabilities are given as

$$T(I_W) = a_0 \left\{ I_W - (I_W^{-a_1} + a_2)^{-1/a_1} \right\} + \tau_I I_W.$$

We conduct experiments over the flat tax rate τ_{E1} and vary it from 0% to 25% by a 5% increment. Preliminary results are summarized in Tables 9(a) and 9(b). A low marginal tax effectively increases entrepreneurs' investment and output is higher both in entrepreneurial and corporate sectors. Due to the increased level of economic activities, the required proportional tax τ_I on all the sources of income is not so large, even with an extreme (and highly unlikely in reality) case of zero tax on entrepreneurs' business income, or with very low marginal rates such as 5% or 10%.

The qualitative effects of reducing tax burden for the business return are similar to what we observed in the experiments of investment policies targeting entrepreneurs' investment in the previous section (accelerated depreciation expense for entrepreneurs and loan interest subsidy), that is, they increase entrepreneurial production, with a greater increase in investment and a moderate and limited effect on labor demand due to a rise in the wage rate. Entrepreneurs benefit from such policies and enjoy increased after-tax earnings. Both with this tax policy and with the two entrepreneurial investment policies, wealth inequality becomes substantially increased with ex-ante welfare that is lower than in the benchmark, though very slightly with less than 0.5% loss in terms of CEV except for a few extreme cases.

[29] The top marginal corporate tax rate is 35% in the U.S., while the average rate among OECD countries is 28.5% in 2003, according to the OECD Tax Database (2004).

[30] Based on the sum of federal, state and local tax on corporate profit in 2001 (OECD (2003)).

8 Conclusion

We studied effects of income taxation in an economy where agents have an access to a risky production technology by choosing to become an entrepreneur. The addition of an occupational heterogeneity among households upon a classic Bewley class model introduced a set of additional channels through which fiscal policies affect the economic activities. We have shown that reduction in tax on interest income encourages saving and raises aggregate production, but entrepreneurial investments are reduced due to the general equilibrium effects. Especially, a higher wage pushes up the input cost of entrepreneurs' production since they rely more heavily on labor as a factor of production due to the capital market imperfections and constraints they face in raising capital. For the same reasons, entrepreneurial investments increase when capital tax is higher. A high tax on capital income reduces attractiveness of saving. In addition, increased tax revenue from capital taxation enables the government to reduce taxes on other sources of income and can further encourages entrepreneurial investments. It is shown, however, the policy exacerbates the wealth inequality and ex-ante welfare becomes lower. Increasing the progressivity of income tax schedule will slightly reduce the inequality, but the entrepreneurial investments as well as aggregate activities are curtailed.

We have also confirmed various non-tax policies to encourage entrepreneurial investments are effective, despite the distortions as a consequence of required tax increase to maintain the fiscal balance. We then demonstrated, if we treat the investment income of entrepreneurs separately and apply a lower tax than the top marginal income tax of the individual tax schedule, the policy can generate similar effects as the investment-targeted policies do. Despite a lower tax rate on the investment return, increased economic activities raise the tax revenue and distortions by an additional tax on other sources of income are limited.

We have demonstrated that the departure from a single-occupation model of incomplete markets provides interesting and possibly very important implications for income tax policy. Our study is positive in analyzing effects of an exogenous change in one dimension of various policies at one time. An interesting study would be to integrate the policies affecting constraints faced by agents in incomplete markets and search for desirable institutional arrangements. This is left for future research.

Appendix

A Computation algorithm

This appendix describes a solution algorithm to compute a stationary equilibrium of our model. Fortran code used to produce the results presented in this paper and more detailed description of computation is available upon request once the paper is finalized (eventually and hopefully).

Step 1: Guess on a set of value functions for each state, tax function,[31] the capital labor ratio and compute factor prices r and w.

Step 2: Solve individual problems and derive policy functions for each state and a new set of value functions.

Step 3: Given the transition rules derived in Step 2, compute an invariant distribution Φ.

Step 4: Compute aggregate capital K and aggregate labor L using the invariant distribution and compute a new capital labor ratio. Check if the value functions and the capital labor ratio are the same as before. If so, go to Step 5. If not, adjust them and go back to Step 2.

Step 5: Compute total tax revenue. Check if the government budget is balanced. If not, adjust tax and go back to Step 2.

B Calibration details

Workers' productivity η: The Markov process of workers' productivity η is given as follows.

$$\begin{aligned}
\eta \text{ grid} &= \begin{bmatrix} 0.66897 & 0.82634 & 1.00000 & 1.21016 & 1.49483 \end{bmatrix} \\
\text{stationary distribution} &= \begin{bmatrix} 0.16561 & 0.21846 & 0.23187 & 0.21846 & 0.16561 \end{bmatrix} \\
\text{transition matrix} &= \begin{bmatrix} 0.73105 & 0.25300 & 0.01578 & 0.00017 & 0.00000 \\ 0.19163 & 0.55507 & 0.23580 & 0.01737 & 0.00013 \\ 0.01126 & 0.22208 & 0.53333 & 0.22208 & 0.01126 \\ 0.00013 & 0.01737 & 0.23580 & 0.55507 & 0.19163 \\ 0.00000 & 0.00017 & 0.01578 & 0.25300 & 0.73105 \end{bmatrix}
\end{aligned}$$

[31]The tax parameters to be adjusted differ across experiments. In the benchmark case, for example, the parameter a_2 is adjusted to achieve the government budget balance.

Entrepreneurs' productivity θ: The Markov process of entrepreneurial productivity θ is given as follows.

$$\theta \text{ grid} = \begin{bmatrix} 0.093 & 0.138 & 0.194 & 0.267 & 0.361 & 0.488 & 0.662 & 0.908 & 1.276 & 1.896 \end{bmatrix}$$

$$\text{stationary distribution} = \begin{bmatrix} 0.051 & 0.082 & 0.106 & 0.125 & 0.136 & 0.136 & 0.125 & 0.106 & 0.082 & 0.051 \end{bmatrix}$$

$$\text{transition matrix} = \begin{bmatrix} 0.629 & 0.316 & 0.052 & 0.003 & 0.000 & 0.000 & 0.000 & 0.000 & 0.000 & 0.000 \\ 0.194 & 0.455 & 0.281 & 0.064 & 0.006 & 0.000 & 0.000 & 0.000 & 0.000 & 0.000 \\ 0.024 & 0.215 & 0.414 & 0.270 & 0.069 & 0.007 & 0.000 & 0.000 & 0.000 & 0.000 \\ 0.001 & 0.041 & 0.228 & 0.395 & 0.259 & 0.068 & 0.007 & 0.000 & 0.000 & 0.000 \\ 0.000 & 0.004 & 0.054 & 0.239 & 0.388 & 0.249 & 0.062 & 0.006 & 0.000 & 0.000 \\ 0.000 & 0.000 & 0.006 & 0.062 & 0.249 & 0.388 & 0.239 & 0.054 & 0.004 & 0.000 \\ 0.000 & 0.000 & 0.000 & 0.007 & 0.068 & 0.259 & 0.395 & 0.228 & 0.041 & 0.001 \\ 0.000 & 0.000 & 0.000 & 0.000 & 0.007 & 0.069 & 0.270 & 0.414 & 0.215 & 0.024 \\ 0.000 & 0.000 & 0.000 & 0.000 & 0.000 & 0.006 & 0.064 & 0.281 & 0.455 & 0.194 \\ 0.000 & 0.000 & 0.000 & 0.000 & 0.000 & 0.000 & 0.003 & 0.052 & 0.316 & 0.629 \end{bmatrix}$$

References

Aiyagari, S. R. (1994). Uninsured idiosyncratic risk and aggregate saving. *Quarterly Journal of Economics 109*(3), 659–684.

Aiyagari, S. R. (1995). Optimal capital income taxation with incomplete markets, borrowing constraints, and constant discounting. *Journal of Political Economy 103*(6), 1158–1175.

Albuquerque, R. and H. A. Hopenhayn (2004). Optimal lending contracts and firm dynamics. *Review of Economic Studies 71*, 285–315.

Angeletos, G.-M. and L.-E. Calvet (2004). Idiosyncratic production risk, growth and business cycle. mimeo, MIT and Harvard.

Berliant, M. and M. Gouveia (1993). Equal sacrifice and incentive compatible income taxation. *Journal of Public Economics 51*, 219–240.

Bewley, T. F. (1986). Stationary monetary equilibrium with a continuum of independently fluctuating consumers. In W. Hildenbrand and A. Mas-Colell (Eds.), *Contributions to Mathematical Economics in Honor of Gerald Debreu*. Amsterdam: North-Holland.

Browning, M., L. P. Hansen, and J. J. Heckman (1999). Micro data and general equilibrium models. In J. Taylor and M. Woodford (Eds.), *Handbook of Macroeconomics*, Volume 1. Amsterdam: North-Holland.

Cagetti, M. and M. De Nardi (2003). Entrepreneurship, frictions and wealth. Federal Reserve Bank of Minneapolis, Staff Report 322.

Cagetti, M. and M. De Nardi (2004a). Taxation, entrepreneurship and wealth. Federal Reserve Bank of Minneapolis, Staff Report 340.

Cagetti, M. and M. De Nardi (2004b). Wealth inequality: Data and models. mimeo, University of Minnesota.

Carroll, R., D. Holtz-Eakin, M. Rider, and H. S. Rosen (2000a). Entrepreneurs, income taxes, and investment. In J. B. Slemrod (Ed.), *Does Atlas Shrug? The Economic Consequences of Taxing the Rich*. Harvard University Press.

Carroll, R., D. Holtz-Eakin, M. Rider, and H. S. Rosen (2000b). Income taxes and entrepreneurs' use of labor. *Journal of Labor Economics 18*(2), 324–351.

Carroll, R., D. Holtz-Eakin, M. Rider, and H. S. Rosen (2001). Personal income taxes and the growth of small firms. In J. M. Poterba (Ed.), *Tax Policy and the Economy*, Volume 15, pp. 121–147. NBER, MIT Press.

Chamley, C. (1986). Optimal taxation of capital income in general equilibrium with infinite lives. *Econometrica 54*(3), 607–622.

Conesa, J. C., S. Kitao, and D. Krueger (2004). Capital income tax: Not a bad idea after all. mimeo.

Conesa, J. C. and D. Krueger (2004). On the optimal progressivity of the income tax code. mimeo, University of Pennsylvania.

Cooley, T. F. and E. C. Prescott (1995). Economic growth and business cycles. In T. F. Cooley (Ed.), *Frontiers of Business Cycle Research*. Princeton: Princeton University Press.

Council of Economic Advisors (2004). *Economic Report of the President.*

Davila, J., P. Krusell, and J.-V. Ríos-Rull (2003). Optimal allocations in the one sector neoclassic growth model with uninsurable idiosyncratic shocks. mimeo, University of Pennsylvania.

Díaz-Giménez, E. C. Prescott, T. Fitzgerald, and F. Alvarez (1992). Banking in computable general equilibrium economies. *Journal of Economic Dynamics and Control 16*, 533–559.

Díaz-Giménez, J., V. Quadrini, and J.-V. Ríos-Rull (1997). Dimensions of inequality: Facts on the U.S. distribution of earnings, income, and wealth. *Federal Reserve Bank of Minneapolis, Quarterly Review 21*(2), 3–21.

Erosa, A. and M. Gervais (2002). Optimal taxation in life-cycle economies. *Journal of Economic Theory 105*, 338–369.

Evans, D. S. and B. Jovanovic (1989). An estimated model of entrepreneurial choice under liquidity constraints. *Journal of Political Economy 97*(4), 808–827.

Fernández-Villaverde, J., J. E. Galdón-Sánchez, and L. Carranza (2003). Entrepreneurship, financial intermediation and aggregate activity. mimeo, University of Pennsylvania.

Gentry, W. M. and R. G. Hubbard (2004). Entrepreneurship and household saving. *Advances in Economic Analysis & Policy 4*(1).

Golosov, M., N. Kocherlakota, and A. Tsyvinski (2003). Optimal indirect and capital taxation. *Review of Economic Studies 70*(3).

Gourinchas, P.-O. and J. A. Parker (2002). Consumption over the life cycle. *Econometrica 70*(1), 47–89.

Gouveia, M. and R. P. Strauss (1994). Effective federal individual income tax functions: an exploratory empirical analysis. *National Tax Journal 47*(2), 317–339.

Heathcote, J., K. Storesletten, and G. L. Violante (2004). The cross-sectional impliations of rising wage inequality in the United States. mimeo.

Huggett, M. (1993). The risk-free rate in heterogeneous-agent incomplete-insurance economies. *Journal of Economic Dynamics and Control 17*(5-6), 953–969.

Judd, K. L. (1985). Redistributive taxation in a simple perfect foresight model. *Journal of Public Economics 28*, 59–83.

Khan, A. and B. Ravikumar (2001). Growth and risk-sharing with private information. *Journal of Monetary Economics 47*(3), 499–521.

King, R. G. and R. Levine (1993). Finance, entrepreneurship, and growth. *Journal of Monetary Economics 32*, 513–542.

Krusell, P. and A. A. Smith, Jr. (1998). Income and wealth heterogeneity in the macroeconomy. *Journal of Political Economy 106*(5), 867–896.

Li, W. (2002). Entrepreneurship and government subsidies: A general equilibrium analysis. *Journal of Economic Dynamics and Control 26*, 1815–1844.

Lucas, R. E. J. (1978). On the size distribution of business firms. *Bell Journal of Economics 9*(2), 508–523.

Meh, C. A. (2002). Entrepreneurship, inequality, and taxation. Bank of Canada Working Paper 2002-14.

Meh, C. A. and V. Quadrini (2004). Uninsurable investment risks. mimeo, New York University.

Mendoza, E. G., A. Razin, and L. L. Tesar (1994). Effective tax rates in macroeconomics: Cross-country estimates of tax rates on factor incomes and consumption. *Journal of Monetary Economics 34*, 297–323.

Moskowitz, T. J. and A. Vissing-Jorgensen (2002). The returns to entrepreneurial investment: A private equity premium puzzle? *American Economic Review 92*(4), 745–778.

OECD (2003). *Revenue Statistics 1965-2002*. Organizations for Economic Co-operation and Development.

Prescott, E. C. (1986). Theory ahead of business cycle measurement. *Federal Reserve Bank of Minneapolis, Quarterly Review 10*(4).

Quadrini, V. (1999). The importance of entrepreneurship for wealth concentration and mobility. *Review of Income & Wealth 45*, 1–19.

Quadrini, V. (2000). Entrepreneurship, saving, and social mobility. *Review of Economic Dynamics 3*, 1–40.

Rawls, J. (1971). *A Theory of Justice*. Cambridge, Massachussetts: Harvard University Press.

Stokey, N. L. and S. Rebelo (1995). Growth effects of flat-rate taxes. *Journal of Political Economy 103*(3), 519–550.

Tauchen, G. and R. Hussey (1991). Quadrature-based methods for obtaining approximate solutions to nonlinear asset pricing models. *Econometrica 59*(2), 371–396.

Young, H. P. (1990). Progressive taxation and equal sacrifice. *American Economic Review 80*(1), 253–266.

Table 1: Parameters calibration

Parameter	Description	Values
σ_1	relative risk aversion	2.0
σ_2	inverse of IES for leisure	3.2
χ	preference weight for leisure	0.798
β	discount factor	0.956
α	capital share	0.36
ν	non-corporate production parameter	0.88
δ	depreciation rate of capital	0.06
ρ_η	autoregressive coefficient for η process	0.9426
σ_η	AR(1) error variance for η process	0.0198
ρ_θ	autoregressive coefficient for θ process	0.9437
σ_θ	AR(1) error variance for θ process	0.0962

Table 2: Benchmark economy

(a) Aggregate variables

	K/Y ratio	interest rate	% of entrep.	earning E/(E+W)	exit rate of E→W	entry rate of W→E	Wealth Gini	wealth in the top 10%	20%
US data	3.00	-	12%	22%	24%	3.7%	.78	66%	79%
Model	3.00	3.89%	12%	22%	24%	3.3%	.62	47%	64%

The U.S. figures for wealth concentration are from Díaz-Giménez et al. (1997).

(b) Non-corporate activities by entrepreneurial ability θ

θ grid	θ value	% in pop.	% in entrep.	avg. k	avg. a
θ_1	0.093	0.000	0.000	0.1845	3.4560
θ_2	0.138	0.000	0.000	0.2686	3.4708
θ_3	0.194	0.000	0.000	0.4500	3.4921
θ_4	0.267	0.000	0.000	0.5306	3.5206
θ_5	0.361	0.002	0.013	0.7271	3.5620
θ_6	0.488	0.042	0.349	0.8166	3.6309
θ_7	0.662	0.468	3.884	1.3460	3.7610
θ_8	0.908	2.245	18.636	2.1095	4.0493
θ_9	1.276	4.788	39.750	3.8371	4.7074
θ_{10}	1.896	4.501	37.368	7.6985	6.2286

Table 3: Flat capital income tax: Experiments in Section 7.2

(a) Aggregate variables

capital tax rate τ_K	$\tau_{\tilde{I}}$	Y	K	L	K/Y	r	w	G/Y
Benchmark	-	1.0000	1.0000	1.0000	3.00	3.89%	1.0000	0.1800
0%	2.53%	1.0201	1.0813	0.9927	3.18	3.37%	1.0309	0.1765
5%	1.91%	1.0178	1.0681	0.9950	3.15	3.47%	1.0249	0.1769
10%	1.34%	1.0131	1.0491	0.9967	3.11	3.58%	1.0182	0.1777
15%	0.72%	1.0093	1.0303	0.9998	3.07	3.70%	1.0110	0.1784
20%	0.09%	1.0050	1.0113	1.0022	3.02	3.82%	1.0041	0.1791
25%	-0.53%	1.0003	0.9931	1.0037	2.98	3.96%	0.9961	0.1799
30%	-1.17%	0.9952	0.9717	1.0067	2.93	4.12%	0.9873	0.1809
35%	-1.81%	0.9909	0.9533	1.0091	2.89	4.28%	0.9787	0.1816

(b) Entrepreneurial activities, wealth Gini and CEV

capital tax rate τ_K	Y_E	K_E	L_E	Leverage ratio	% of entrep.	Entrep. income	Wealth Gini	CEV (%)
Benchmark	1.0000	1.0000	1.0000	19.38%	12.04%	21.77%	0.6164	-
0%	0.9510	0.9565	0.9256	20.51%	12.07%	21.16%	0.5736	1.914
5%	0.9704	0.9806	0.9508	20.13%	12.07%	21.32%	0.5813	1.681
10%	0.9717	0.9769	0.9559	19.89%	12.07%	21.44%	0.5914	1.263
15%	0.9788	0.9756	0.9697	19.96%	12.05%	21.55%	0.6025	0.829
20%	0.9982	0.9971	0.9969	19.51%	12.05%	21.70%	0.6134	0.366
25%	1.0058	1.0038	1.0082	19.27%	12.10%	21.92%	0.6263	-0.147
30%	1.0214	1.0184	1.0325	18.97%	12.10%	22.08%	0.6386	-0.732
35%	1.0332	1.0210	1.0529	18.91%	12.12%	22.29%	0.6477	-1.257

Table 4: Flat income tax system: Experiment in Section 7.3.1

(a) Aggregate variables

	Y	K	L	K/Y	r	w	G/Y
Benchmark	1.0000	1.0000	1.0000	3.00	3.89%	1.0000	0.1800
Flat rate 17.79%	1.0279	1.0642	1.0109	3.11	3.57%	1.0185	0.1751

(b) Entrepreneurial activities, wealth Gini and CEV

	Y_E	K_E	L_E	Leverage ratio	% of entrep.	Entrep. income	Wealth Gini	CEV (%)
Benchmark	1.0000	1.0000	1.0000	19.38%	12.04%	21.77%	0.6164	-
Flat rate 17.79%	1.0121	1.0518	0.9937	18.92%	11.97%	21.55%	0.6281	1.035

Table 5: Different degrees of progressivity: Experiments in Section 7.3.2

(a) Aggregate variables

a_0			τ_I	Y	K	L	K/Y	r	w	G/Y
Benchmark $a_0 = 0.2580$			-	1.0000	1.0000	1.0000	3.00	3.89%	1.0000	0.1800
0.3225	25%	⇑	-4.40%	0.9916	0.9797	0.9973	2.97	3.98%	0.9949	0.1815
0.2967	15%	⇑	-2.63%	0.9944	0.9866	0.9982	2.98	3.96%	0.9961	0.1810
0.2709	5%	⇑	-0.88%	0.9977	0.9941	0.9995	2.99	3.92%	0.9985	0.1803
0.2451	5%	⇓	0.89%	1.0013	1.0033	1.0004	3.01	3.88%	1.0009	0.1798
0.2193	15%	⇓	2.65%	1.0049	1.0116	1.0017	3.02	3.85%	1.0026	0.1792
0.1935	25%	⇓	4.41%	1.0082	1.0197	1.0027	3.04	3.81%	1.0050	0.1786

(b) Entrepreneurial activities, wealth Gini and CEV

a_0			Y_E	K_E	L_E	Leverage ratio	% of entrep.	Entrep. income	Wealth Gini	CEV (%)
Benchmark $a_0 = 0.2580$			1.0000	1.0000	1.0000	19.38%	12.04%	21.77%	0.6164	-
0.3225	25%	⇑	0.9920	0.9793	0.9964	19.48%	12.10%	21.86%	0.6142	-0.392
0.2967	15%	⇑	0.9955	0.9892	0.9983	19.33%	12.09%	21.84%	0.6150	-0.273
0.2709	5%	⇑	0.9977	0.9962	0.9985	19.40%	12.06%	21.80%	0.6156	-0.074
0.2451	5%	⇓	0.9997	1.0018	0.9985	19.38%	12.04%	21.76%	0.6173	0.036
0.2193	15%	⇓	1.0022	1.0078	0.9995	19.37%	12.03%	21.74%	0.6194	0.208
0.1935	25%	⇓	1.0039	1.0128	0.9994	19.31%	12.02%	21.71%	0.6211	0.356

Table 6: Accelerated depreciation expense for entrepreneurs: Experiments in Section 7.4.1

(a) Aggregate variables

depreciation expense	τ_I	Y	K	L	K/Y	r	w	G/Y
Benchmark 6.0%	-	1.0000	1.0000	1.0000	3.00	3.89%	1.0000	0.1800
9.0%	0.61%	1.0078	1.0253	0.9980	3.05	3.77%	1.0068	0.1786
12.0%	1.36%	1.0152	1.0493	0.9973	3.10	3.65%	1.0143	0.1773

(b) Entrepreneurial activities, wealth Gini and CEV

depreciation expense	Y_E	K_E	L_E	Leverage ratio	% of entrep..	Entrep. income	Wealth Gini	CEV (%)
Benchmark 6.0%	1.0000	1.0000	1.0000	19.38%	12.04%	21.77%	0.6164	-
9.0%	1.0403	1.0945	1.0312	19.67%	12.06%	21.83%	0.6367	-0.143
12.0%	1.0703	1.1895	1.0482	19.82%	12.29%	21.95%	0.6568	-0.484

Table 7: Accelerated depreciation expense for general investments: Experiments in Section 7.4.1

(a) Aggregate variables

depreciation expense	τ_I	Y	K	L	K/Y	r	w	G/Y
Benchmark 6.0%	-	1.0000	1.0000	1.0000	3.00	3.89%	1.0000	0.1800
6.6% (10% up)	0.52%	1.0035	1.0132	0.9989	3.03	3.78%	1.0062	0.1794
7.2% (20% up)	1.05%	1.0099	1.0373	0.9968	3.08	3.66%	1.0135	0.1782
7.8% (30% up)	1.63%	1.0152	1.0574	0.9947	3.13	3.55%	1.0203	0.1773
8.4% (40% up)	2.25%	1.0201	1.0754	0.9935	3.17	3.42%	1.0281	0.1765

(b) Entrepreneurial activities, wealth Gini and CEV

depreciation expense	Y_E	K_E	L_E	Leverage ratio	% of entrep.	Entrep. income	Wealth Gini	CEV (%)
Benchmark 6.0%	1.0000	1.0000	1.0000	19.38%	12.04%	21.77%	0.6164	-
6.6% (10% up)	0.9982	1.0064	0.9935	19.64%	12.04%	21.65%	0.6141	0.224
7.2% (20% up)	0.9944	1.0212	0.9793	19.88%	12.03%	21.56%	0.6105	0.623
7.8% (30% up)	1.0014	1.0417	0.9813	20.05%	12.06%	21.51%	0.6064	0.946
8.4% (40% up)	1.0049	1.0565	0.9802	20.20%	12.05%	21.41%	0.6030	1.280

Table 8: Loan interest subsidy: Experiments in Section 7.4.2

(a) Aggregate variables

Loan premium $\tilde{\phi}$		τ_I	Y	K	L	K/Y	r	w	G/Y_1*	G/Y_2*
Benchmark 5.0%		-	1.0000	1.0000	1.0000	3.00	3.89%	1.0000	0.1800	-
4.0%	1.0% subsidy	0.12%	1.0029	1.0095	0.9988	3.02	3.87%	1.0014	0.1795	0.1810
3.0%	2.0% subsidy	0.27%	1.0030	1.0089	0.9990	3.02	3.84%	1.0029	0.1795	0.1825
2.0%	3.0% subsidy	0.42%	1.0039	1.0105	0.9992	3.02	3.83%	1.0039	0.1793	0.1842
1.0%	4.0% subsidy	0.61%	1.0066	1.0179	0.9992	3.04	3.81%	1.0049	0.1788	0.1859
0.0%	5.0% subsidy	0.82%	1.0076	1.0208	0.9992	3.04	3.80%	1.0055	0.1787	0.1883

(*) G/Y_1 is the ratio of government expenditure given in the benchmark economy (fixed across experiments) to the output that is computed in each experiment. G/Y_2 contains the amount the government spends on subsidy.

(b) Entrepreneurial activities, wealth Gini and CEV

Loan premium $\tilde{\phi}$		Y_E	K_E	L_E	Leverage ratio	% of entrep.	Entrep. income	Wealth Gini	CEV (%)
Benchmark 5.0%		1.0000	1.0000	1.0000	19.38%	12.04%	21.77%	0.6164	-
4.0%	1.0% subsidy	1.0114	1.0233	1.0082	20.61%	12.05%	21.93%	0.6235	0.002
3.0%	2.0% subsidy	1.0176	1.0353	1.0142	21.46%	12.05%	22.04%	0.6294	-0.138
2.0%	3.0% subsidy	1.0250	1.0516	1.0198	22.32%	12.06%	22.22%	0.6320	-0.252
1.0%	4.0% subsidy	1.0388	1.0789	1.0325	23.85%	12.07%	22.40%	0.6340	-0.333
0.0%	5.0% subsidy	1.0508	1.1066	1.0431	25.44%	12.07%	22.58%	0.6390	-0.570

Table 9: Separate treatment of entrepreneurs' investment income with flat tax system: Experiments in Section 7.5.1

(a) Aggregate variables

Flat rate τ_{E1}	τ_I	Y	K	L	K/Y	r	w	G/Y
Benchmark	-	1.0000	1.0000	1.0000	3.00	3.89%	1.0000	0.1800
0%	2.03%	1.0181	1.0585	0.9951	3.12	3.51%	1.0223	0.1768
5%	1.61%	1.0141	1.0450	0.9960	3.09	3.60%	1.0171	0.1775
10%	1.19%	1.0101	1.0323	0.9969	3.07	3.68%	1.0123	0.1782
15%	0.77%	1.0068	1.0221	0.9981	3.05	3.75%	1.0081	0.1788
20%	0.36%	1.0024	1.0085	0.9989	3.02	3.82%	1.0043	0.1796
25%	-0.08%	1.0011	1.0050	0.9998	3.01	3.90%	0.9995	0.1798

(b) Entrepreneurial activities, wealth Gini and CEV

Flat rate τ_{E1}	Y_E	K_E	L_E	Leverage ratio	% of entrep.	Entrep. income	Wealth Gini	CEV (%)
Benchmark	1.0000	1.0000	1.0000	19.38%	12.04%	21.77%	0.6164	-
0%	1.0276	1.0767	1.0036	18.86%	11.95%	21.85%	0.6760	-0.650
5%	1.0215	1.0572	1.0028	19.16%	11.99%	21.88%	0.6644	-0.571
10%	1.0139	1.0402	0.9992	19.20%	11.99%	21.84%	0.6537	-0.463
15%	1.0120	1.0281	1.0044	19.20%	12.02%	21.83%	0.6420	-0.312
20%	1.0041	1.0112	1.0008	19.36%	12.01%	21.76%	0.6314	-0.238
25%	0.9979	0.9972	0.9985	19.36%	12.05%	21.74%	0.6138	0.047

Figure 1: CDF of assets: workers and entrepreneurs

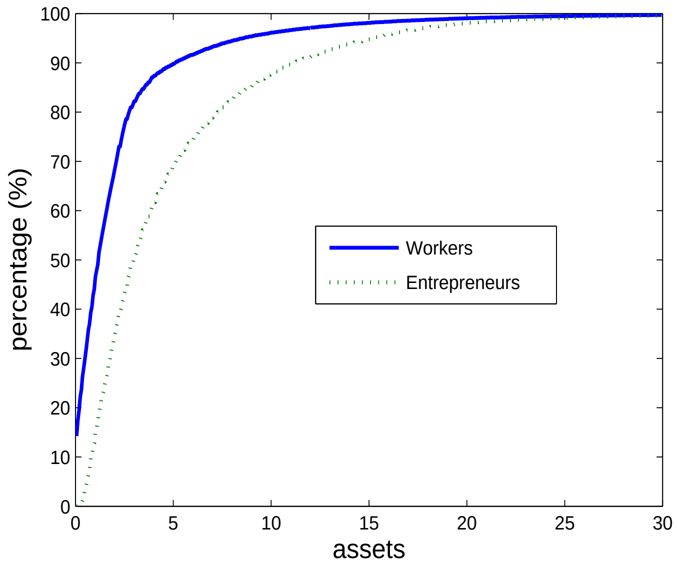
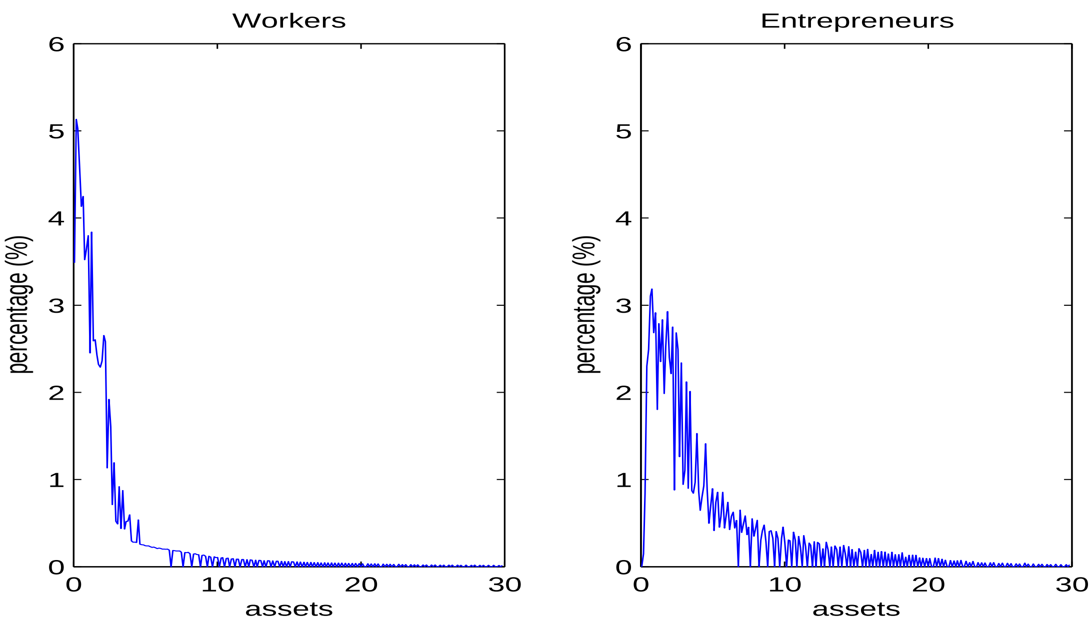


Figure 2: PDF of assets: workers and entrepreneurs



Note: To facilitate comparison, agents with zero assets are not included. 11.5% of workers have zero assets. There is no entrepreneur with zero assets. There are agents with assets more than the maximum level in the above figures, but they constitute less than 0.5% of the population (0.49% of workers and 0.34% of entrepreneurs) and we omit the thin long tail of the distribution for the sake of easy visual comparison.

Figure 3: Fraction of entrepreneurs by assets

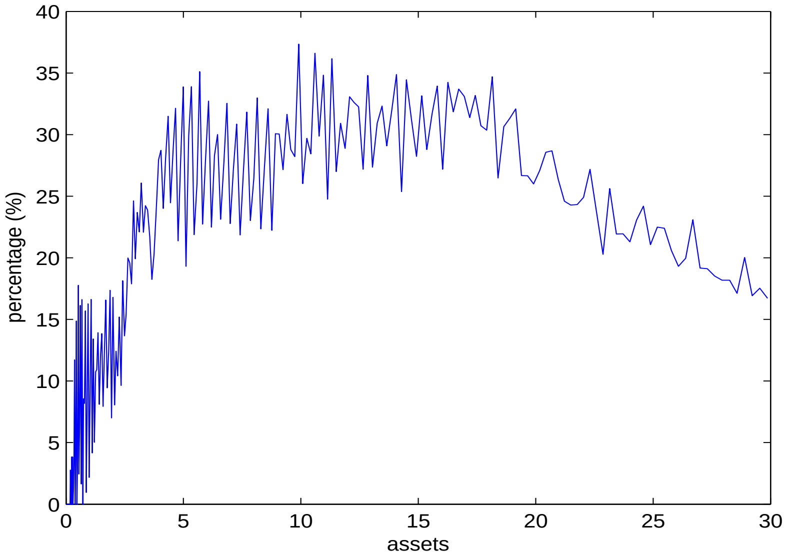


Figure 4: Distribution of entrepreneurial productivity θ

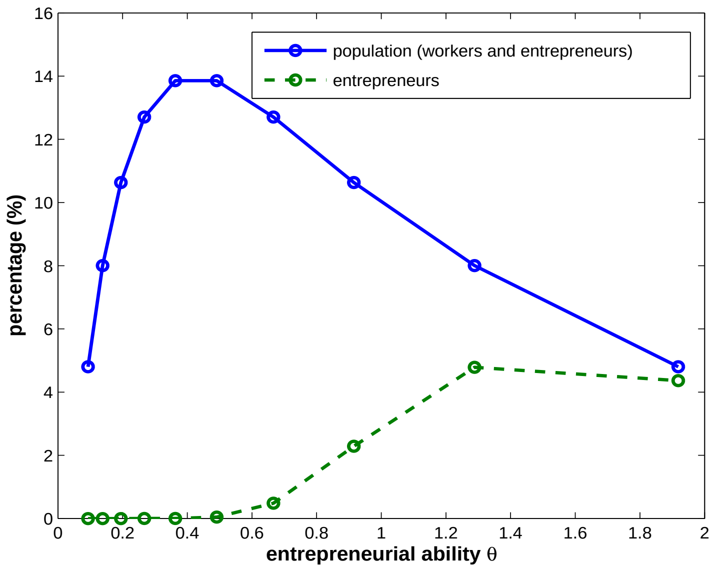


Figure 5: Entrepreneurs' assets and investment