Income taxation with uninsurable endowment and entrepreneurial investment risks

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March 21, 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. The income risks drive precautionary saving and lead to overaccumulation of capital, while underinvestment may result when return from undertaking entrepreneurial projects is uncertain. Additional capital market imperfections such as borrowing constraints or loan premiums faced by entrepreneurs would exacerbate the effects. We construct a dynamic general equilibrium model where agents make an occupational choice between running a business as an entrepreneur and earning salary wage as a worker, which is fairly simple yet captures the key incentive channels that affect tax incidences.

We find that 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 increase on non-capital income) discourage entrepreneurial investments. A higher capital tax generates the opposite effects, but comes at a cost of increased inequality and welfare deterioration. A more progressive tax system reduces inequality, but curtails both aggregate and entrepreneurial activities. A proportional tax system favors entrepreneurs and encourages their investment, but hurts workers and the poor. The effects of investment policies that effectively target investments can be imperfectly mimicked if we reduce income tax on entrepreneurs' business income by taxing their income separately at corporate and individual levels without double taxation.

*I thank Jess Benhabib, Pierpaolo Benigno, Mark Gertler, Martin Schneider and Gianluca Violante, seminar participants at NYU and University of Tokyo, and especially to Mariacristina De Nardi for useful comments and discussions. I am 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. Second, agents are also endowed with stochastic idiosyncratic entrepreneurial ability. 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. Markets are incomplete and the only way to protect themselves against an uneven flow of consumption is by way of riskless saving.

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 (see Conesa and Krueger (2004) and Conesa, Kitao, and Krueger (2004)). On the other hand, high riskiness of entrepreneurial investment return can discourage individuals from undertaking productive projects and putting profitable entrepreneurial ideas in business. Equilibrium investment demand can be 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 entrepreneurial business income 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. The policies, however, must be carefully structured as their incidences on the heterogeneous classes of agents are far from uniform and general equilibrium effects can generate adverse impact on other sectors. The required adjustments towards the fiscal balance as a consequence of the revenue shift could also create undesired distributional or aggregate effects.

The current paper studies the effect of income taxation in an economy populated by workers and entrepreneurs. 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. Everyone has an access to one-period riskless saving, which is restricted to be positive, but there is no insurance against stochastic process of the labor productivity and entrepreneurial abilities and income path remains uncertain. Entrepreneurs determine the project size optimally by choosing capital and labor inputs.

To finance investment, they can borrow from a bank, subject to a borrowing constraint that depends on their wealth. Occupational choice entails risk whether an agent chooses to be a worker or an entrepreneur, as their labor productivity and return from investment are uncertain when they decide the occupation. The degree of uncertainty, however, is different.

We find that 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 and welfare deterioration. A proportional income tax system will bring aggregate effects similar to the case of zero or low capital tax, but entrepreneurial investments will be also higher since many entrepreneurs face a lower marginal tax on investment returns. The policy, however, results in increased inequality and makes workers and the poor worse off. 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

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

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 (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 significantly contribute to innovations, 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]

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 entrepreneurial investment 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 show that reduction in estate tax generates significant effects on aggregate variables since it relaxes the financial constraints faced by entrepreneurs and

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

encourages their investments. Our model is similar, but differs from theirs in that occupational decision has to be made when the productivity shocks are yet to be realized and the return from entrepreneurial investment is uncertain. In their model, entrepreneurs do not use labor as production inputs and changes in the wage rate do not directly affect entrepreneurs' production cost. Out paper abstracts 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, the size distribution of entrepreneurial project is exogenously determined. The current paper attempts to build endogenous determination of size distribution into the model and study the incentive effects of taxation on the 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.

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.

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: the corporate sector operating a constant returns to scale technology without return risk and the entrepreneurial, non-corporate sector, where entrepreneurs operate and engage in risky projects. We focus on entrepreneurs that are defined as people who own and actively manage their own firm and business, rather than working for a firm as wage earners. Our definition of entrepreneurship differs from that of venture capitals that in fact constitute a very 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.[4]

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.[5] 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.[6] 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.[7]

In terms of organizational structure of business, many entrepreneurs choose to form

[3]Venture capitals account for less than one percent of the entire private equity market (Moskowitz and Vissing-Jorgensen (2002)).

[4]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%.

[5]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.

[6]A large literature examines the role of access to capital for entrepreneurs. See, for example, Evans and Jovanovic (1989), Holtz-Eakin, Joulfaian, and Rosen (1993,1994), Cagetti and De Nardi (2003), Gentry and Hubbard (2004) and Fernández-Villaverde, Galdón-Sánchez, and Carranza (2003).

[7]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.

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. 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 marketable time normalized to a unity and enters a period with predetermined occupation, which he has chosen in the previous period. 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. An entrepreneur can manage only one entrepreneurial business at one time. 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 $\{c_t\}_{t=0}^{\infty}$ according to the expected discounted utility given as

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

where one-period utility from consumption $c \geq 0$ is defined as a standard CES form, $u(c) = c^{1-\sigma}/(1-\sigma)$. σ is the coefficient of relative risk aversion.

3.3 Technology and production

The economy has two sectors of production. One sector that we call the non-corporate or entrepreneurial sector consists of entrepreneurial firms engaged in risky projects. The other sector is called corporate sector and is populated by larger firms. A household deciding to undertake a project will operate a firm in the non-corporate sector. Description of each sector follows.

Non-corporate sector: Each entrepreneur runs his own technology and produces output according to the following production function.

$$y = f(k, n, \theta) = \theta k^a n^b,$$

where k is invested capital, n is efficiency units of labor employed in the firm and θ is the stochastic entrepreneurial ability. a and b determine the input share of capital and labor. $(1 - a - b)$ is the share of output retained as rents by an entrepreneur for managing the investment project. With $a + b < 1$, 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 parameter 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 $(1+d)a$.[8]

3.5 Government

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

Individual 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. as we discuss more in the calibration section. 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 two periods, all the decisions including next period's occupation can be made right after the realization of current shocks.[9] Entrepreneurs decide capital and labor inputs used in their project and allocations for consumption and saving.

Later in the period production takes place both in corporate and non-corporate sectors, which is followed by factor payments and repayment of loans. Workers and en-

[8]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.

[9]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.

trepreneurs 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.

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

   subject to

$$(1 + \tau_c)c + a' = \eta w + (1 + r)a - T(I) \tag{3}$$
$$I = \eta w + ra \tag{4}$$
$$a' \geq 0, \quad c \geq 0, \quad i_\xi \in \{0,\ 1\}$$

   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.[10] I in equation (4) represents the worker's taxable income, which consists of labor income, ηw, and capital income from saving, ra. Each worker inelastically supplies work hours, which is normalized to unity, and efficiency units provided by each agent $l(s)$ is simply η. 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.

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

   subject to

$$(1 + \tau_c)c + a' = \pi^E(s) \tag{6}$$
$$a' \geq 0, \quad c \geq 0, \quad i_\xi \in \{0,\ 1\}$$

[10] 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 $\xi' = W, E$.

We assume that entrepreneurs spend their time endowment at work and their labor contribution is counted as well. Their work effort is dedicated to their own project and it is part of labor n used in the production, though partially if the optimally chosen demand is less than their efficiency contribution η.

$\pi^E(s)$ 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.

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

where

$$I = f(k,n,\theta) - \delta k - \tilde{r}(k-a) - wn + w_E \quad (8)$$

$$k \leq (1+d)a \quad (9)$$

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 entrepreneur's output from the production, which depends on capital and labor inputs (k and n), as well as his entrepreneurial ability θ. 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. We assume entrepreneurs can supply only in their own firms, but not for others. Their efficiency units η contribute towards the labor used in production and w_E is the wage paid to the labor. More precisely, their labor contribution is given as $l(s) = \min\{n, \eta\}$ and the wage is given as $w_E = wl(s)$, i.e. entrepreneurs are paid the fair market wage for the labor services rendered by themselves, but if the optimally chosen labor input n is less than η, $\eta - n$ is not used for production and wage is paid only to the portion that contributed to the output.[11] 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

- interest rate r and wage rate w,

[11] For example, if an entrepreneur decides it's optimal not to engage in any production, i.e. $n = 0$, no output will be produced and wage can't be paid.

- occupational choice and allocation functions for each state vector s. Allocations are $\{c, a'\}$ 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. $\Phi_{t+1} = R_\Phi(\Phi_t)$.[12]

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

[12]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

This section describes calibration of the parameters used in the benchmark model. Calibrated parameters are summarized in Table 1.

5.1 Preference

For the parameters in the utility function defined in equation (1), the coefficient of relative risk aversion σ is set to 2.0 (Prescott (1986) and Gourinchas and Parker (2002)).

Subjective time discount factor β is set to 0.943 so that the economy attains the aggregate capital-output ratio of 2.65 in a stationary equilibrium.[13]

5.2 Endowment and technology

Labor productivity: 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 0.984 and 0.022 respectively, taken from the study of Storesletten, Telmer, and Yaron (2000). 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 η is unity. The calibrated Markov process of η is given as follows.

$$\eta \text{ grid} = \begin{bmatrix} 0.646 & 0.798 & 0.966 & 1.169 & 1.444 \end{bmatrix}$$

$$\text{transition matrix } P_\eta = \begin{bmatrix} 0.731 & 0.253 & 0.016 & 0.000 & 0.000 \\ 0.192 & 0.555 & 0.236 & 0.017 & 0.000 \\ 0.011 & 0.222 & 0.533 & 0.222 & 0.011 \\ 0.000 & 0.017 & 0.236 & 0.555 & 0.192 \\ 0.000 & 0.000 & 0.016 & 0.253 & 0.731 \end{bmatrix}$$

Entrepreneurial ability and technology: Entrepreneurs use capital k and labor n and produce output y. Recall the production function.

$$y = f(k, n, \theta) = \theta k^a n^b$$

We assume relative shares of capital and labor are the same as in the corporate sector, i.e. $y = \theta(k^\alpha n^{1-\alpha})^\nu$, where α is the relative capital share and $\nu = a + b \in (0, 1)$. We are left to set the parameter ν, which determines the degree of returns to scale.

[13] In the absence of public capital, capital in the model corresponds to equipment and structures, inventories, land and residential structures. The target at 2.65 following Quadrini (2000) and Li (2002).

θ is the entrepreneurial ability, which evolves stochastically. This calibration is somewhat challenging, due to the lack of appropriate micro data or estimation. First, we assume it follows a four-state Markov process, and the four states are proportional to $[0, 1-x, 1, 1+x]$, where $x \in (0, 1)$. The vector is scaled by $\bar{x}$ and the states are given as $\bar{x} \cdot [0, 1-x, 1, 1+x]$. The transition matrix P_θ is of size 4×4, with an (i, j)-th element p_{ij}, which stands for $p_\theta(\theta_i, \theta_j) = prob(\theta_{t+1} = \theta_j | \theta_t = \theta_i)$. We assume the entrepreneurial ability develops stochastically but only gradually. From one period to the next, it jumps up and down by at most one grid to the adjoining θ, i.e. we assume $p_{ij} = 0$ if $|i - j| > 1$. Hence we have the following grid of θ and transition matrix P_θ of entrepreneurial ability θ.

$$
\begin{aligned}
\text{grid } \theta &= \bar{x} \cdot \begin{bmatrix} 0 & 1-x & 1 & 1+x \end{bmatrix} \\
\text{transition matrix } P_\theta &= \begin{bmatrix} p_{11} & (1-p_{11}) & 0 & 0 \\ p_{21} & p_{22} & (1-p_{21}-p_{22}) & 0 \\ 0 & p_{32} & p_{33} & (1-p_{32}-p_{33}) \\ 0 & 0 & p_{43} & p_{44} \end{bmatrix}
\end{aligned}
$$

In an effort to reduce the number of parameters to calibrate, we also assume non-zero elements in the middle two rows are the same, i.e. $p_{22} = p_{33}$ and $p_{21} = p_{32}$.

We calibrate the parameters that define the process of θ, and the parameter ν for the entrepreneur's production function to achieve the following targets in the benchmark: the fraction of entrepreneurs in the economy, the share of income earned by entrepreneurs, the average exit rate of entrepreneurs, the exit rate of new entrepreneurs with one period tenure, the share of capital used in entrepreneurial sector, share of assets owned by entrepreneurs and ratio of median assets of entrepreneurs to workers.

Quadrini (2000) reports the fraction of entrepreneurs of 12% using the average of family data from the PSID for the period 1970-1992 and from 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 samples. Hipple (2004) reports 11.1% of the labor force are identified as self-employed using Current Population Survey (CPS) data for 2003.[15] We set a target fraction of 12% in our model. We also target the fraction of total income earned by entrepreneurs at 27%. Quadrini (2000) reports that entrepreneurs earned 22% of income from the PSID samples for 1984, 1989 and 1994 (Quadrini (1999) reports 25% using 1989 PSID data). These numbers, however, underestimates the entrepreneurial income in our theoretical model. First, the model has no entrepreneurs that incur losses, since

[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]CPS asks a question: "Last month, were you employed by government, by a private company, a nonprofit organization, or were you self-employed?" If individuals respond self-employed, they are also asked "Is this business incorporated?" 11.1% reported in Hipple (2004) (Tables 1 and 2, pp. 14-15) include self-employed with both incorporated and unincorporated businesses, which corresponds to the definition of entrepreneurs in our model.

we assume entrepreneurs can always choose not to invest anything and make zero profit, which is the lower bound of their profit and loss account. In data, while entrepreneurs earn more on average than workers, a fair number of them also make losses.[16] Second, in the model, capital used in the production is liquidated every period and all the remaining assets after the factor payments are recognized as earnings. Putting aside the retained earnings for continuous operation is not allowed, as it is in reality if the business takes more general forms of corporation (C-corporation or limited liabilities company(LLC), but not S-corporation). Third, the model obviously is not capable of capturing all the deductions that entrepreneurs can utilize. It is argued that entrepreneurs have more flexibility in making deductions than workers. Lastly, given the absence of transfers, the income in our model is in effect earnings. Earnings are more unequally distributed than income.[17] We set 27% as the target for the income earned by entrepreneurs.

For the exit rate of entrepreneurs, we target the average exit rate at 20% for all the entrepreneurs and 40% for the new entrepreneurs with one year of business tenure. As shown in Quadrini (2000) (Table IV), there is substantial differences in the mobilities between the experienced and inexperienced entrepreneurs, reflecting the "learning process" of entrepreneurs who accumulate business skills and face lower exit rates as the tenure increases. Quadrini (2000) argues that the fraction of capital employed in the unincorporated businesses is estimated to be around 30%, but that the number underestimates the size of the sector in the model since some businesses take the form of corporations. We set a target so that the entrepreneurial sector employs 35-40% of aggregate capital.

Gentry and Hubbard (2004) report that entrepreneurs own 40.8% of assets and the median net worth of entrepreneurs is 8 times as large as that of non-entrepreneurs.[18] We target these figures in the benchmark model.

Given these targets, the decreasing returns to scale parameter ν is set at 0.88 and the Markov process of θ is given as follows.

$$\theta \text{ grid} = \begin{bmatrix} 0.000 & 0.706 & 1.470 & 2.234 \end{bmatrix}$$

$$\text{transition matrix } P_\theta = \begin{bmatrix} 0.770 & 0.230 & 0.000 & 0.000 \\ 0.430 & 0.420 & 0.150 & 0.000 \\ 0.000 & 0.430 & 0.420 & 0.150 \\ 0.000 & 0.000 & 0.230 & 0.770 \end{bmatrix}$$

We discuss the model performance in matching the targets in Section 6.

Corporate technology: In the corporate sector, the production function is given as $Y = F(K, L) = AK^\alpha N^{1-\alpha}$. We normalize the parameter A so that the wage is unity in the benchmark. The share of income that goes to capital, α, is fixed at 0.36 in both sectors. Depreciation rate δ is set at 6%.

[16]See Quadrini (1999) (Table 9), for example.

[17]Budría Rodríguez, Díaz-Giménez, Quadrini, and Ríos-Rull (2002) report the earnings Gini of 0.611 and income Gini of 0.553 using 1998 SCF data.

[18]In the main text, Gentry and Hubbard (2004) report entrepreneurs own 37.7% of assets, which is based on the definition of entrepreneurs that have more than $5,000 total assets. According to the definition without threshold, the fraction is 40.8% as reported in the footnote (p.5).

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%. Evans and Jovanovic (1989) conduct empirical study on entrepreneurs' liquidity conditions and argue that "a person can not use more than 1.5 times of his or her initial assets for starting a new venture."[19] Since it is a parameter that is very difficult to accurately calibrate or verify, we conduct sensitivity analysis.

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 $\tau_c = 5.67\%$, which is the average over 1965-1996, based on the computation of effective consumption tax rate as in Mendoza et al. (1994) and also their unpublished data for more recent years available on Mendoza's webpage.

To approximate the U.S. income tax system, we employ a parametric assumption and use the following functional form of tax schedules.

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

where I is the total taxable income of an individual. The first non-linear part is constructed from applying the equal sacrifice principle and captures the progressive income tax system in the U.S.[20] $\{a_0, a_1, a_2\}$ are the parameters that determine the shape of a tax function.[21] 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.[22]

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

[20] 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.

[21] 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.

[22] 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.

They define tax as the final liabilities of the individual tax return.[23] 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.[24] We use Gouveia and Strauss (1994)'s parameter values in the benchmark model and pin down a_2 in equilibrium so that the share of the government expenditures raised by the progressive part of the function equals 65%, which is the fraction of government tax revenues raised by income taxes.[25]

The second linear part of tax liabilities $\tau_I I$ captures the rest of individual taxation, that is neither consumption or income tax and we assume it to be proportional to income.[26] τ_I is determined in equilibrium so that we have the overall government budget balanced.

Table 1: Parameters calibration

Parameter	Description	Values
σ	relative risk aversion	2.0
β	discount factor	0.943
α	capital share	0.36
ν	non-corporate production parameter	0.88
a	non-corporate production parameter	0.3168
b	non-corporate production parameter	0.5632
δ	depreciation rate of capital	0.06
ρ_η	autoregressive coefficient for η process	0.984
σ_η	AR(1) error variance for η process	0.022
$\{a_0, a_1, a_2\}$	parameters for non-linear income tax schedule	$\{0.258, 0.768, 0.438\}$
τ_I	proportional tax rate on income	3.16%

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. We also present results of some sensitivity analysis of some key parameter values.

Table 2 exhibits the moments we used as calibration targets and the values obtained from the model, as well as some other statistics that we don't explicitly target. We match all the targets within the 10% precision.

[23] 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).

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

[25] The fraction is based on U.S. tax data in OECD Revenue Statistics (2003), excluding social security contributions.

[26] The taxes not captured by the income or consumption taxes include property tax, estate tax, inheritance and gift taxes, among others (Revenue Statistics 2002).

Table 2: Calibration targets and results

	Target	Model
capital-output ratio	2.65	2.656
government expenditures/GDP	18%	18.00%
income tax/total tax revenue	65%	65.00%
fraction of entrepreneurs	12%	11.96%
share of entrepreneurs' income	27%	29.16%
exit rate (overall)	20%	21.05%
exit rate (new entrants)	40%	36.78%
capital used by entrepreneurs	35-40%	35.94%
assets owned by entrepreneurs	40%	37.35%
ratio of median assets (entrepreneur to worker)	8	8.13

		Model
interest rate	-	3.12%
entry rate to entrepreneurship	-	2.86%

Table 3 displays statistics for wealth distribution in the benchmark economy and compares the performance with the data in the U.S. economy. There is a fair degree of inequality in our model economy that matches the U.S. data. Gini coefficient of wealth is 80% and the wealthiest 10% own about 70% of the total assets.[27]

Table 3: Benchmark model: wealth distribution

	wealth	wealth in the top			
	Gini	5%	10%	20%	40%
US data	0.803	57.8%	69.1%	81.7%	93.9%
Model	0.799	50.2%	68.1%	83.9%	94.9%

The U.S. figures for wealth concentration are from Budría Rodríguez et al. (2002).

Entrepreneurs in our model are characterized by the higher level assets and higher 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 and few agents become entrepreneurs with assets close to zero. The probability distribution of entrepreneurs has a much thicker tail towards the right tail of the wealth distribution.

[27] For more on wealth distribution and inequality, Cagetti and De Nardi (2004b) provides an excellent survey of various models in the literature.

Table 4: Benchmark model: non-corporate activities by entrepreneurial ability θ

θ grid	θ value	% in pop.	% in entrep.	avg. k	avg. a	avg. lev. ratio
θ_1	0.000	0.00%	0.00%	-	-	-
θ_2	0.706	2.31%	19.27%	3.32	14.75	2.2%
θ_3	1.470	3.77%	31.51%	12.61	17.19	13.6%
θ_4	2.234	5.89%	49.22%	27.66	21.71	31.2%
total	-	11.96%	100.00%	-	-	-
average	-	-	-	18.23	18.94	20.1%

Figure 1: Benchmark model: CDF of assets: workers and entrepreneurs

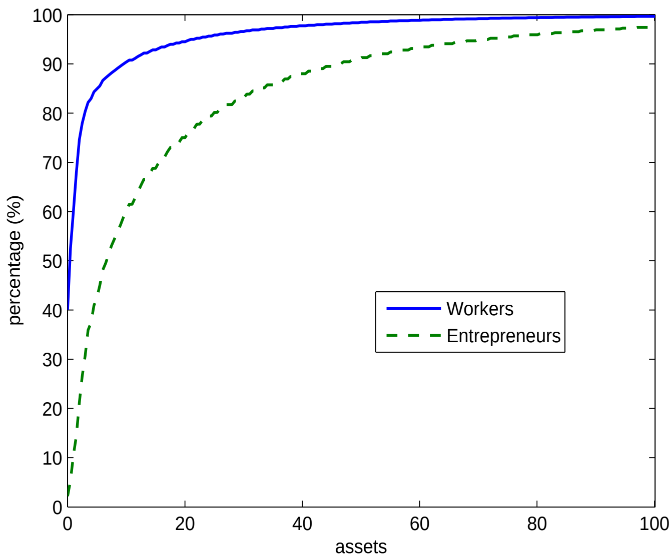


Table 4 displays the distribution and some characterization of entrepreneurs across different values of θ. More productive entrepreneurs undertake larger projects and rely more on outside financing, as shown by the average leverage ratios in the last column. Figure 2 displays the distribution of θ for 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.

Figure 2: Benchmark model: distribution of entrepreneurial productivity θ

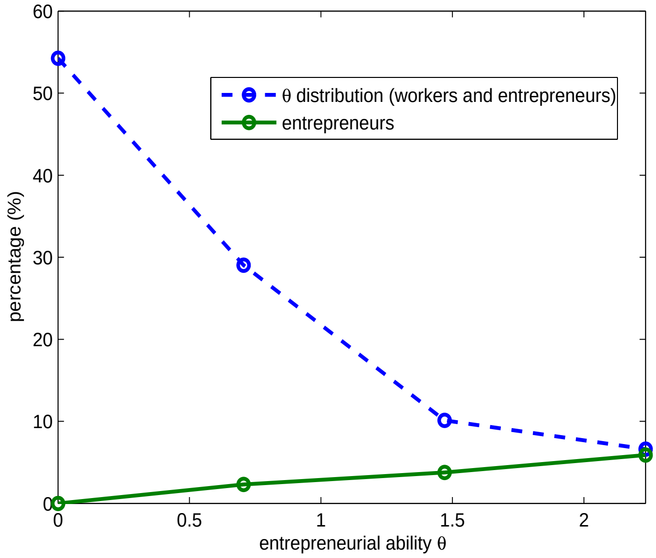
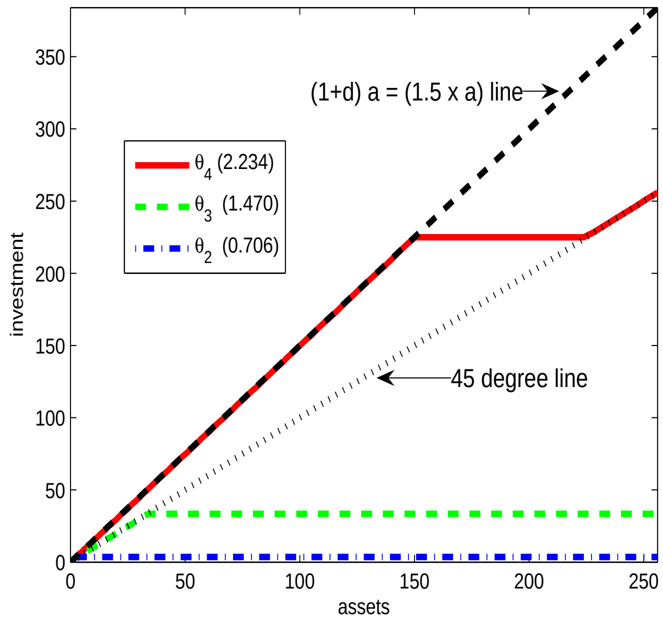


Figure 3 displays the investment by entrepreneurs across different levels of assets. We plot the investment by the agents with θ's that are positive (θ_4, θ_3 and θ_2). First, look at the curve on the top, the investments by entrepreneurs with the highest $\theta = \theta_4$. The distance between the curve and a 45 degree line represents the borrowing from an intermediary. Many of the most productive entrepreneurs are borrowing to expand their business. As the investment increases, the marginal return decreases since the production function exhibits decreasing returns to scale. Once the level of investment reaches the point where the marginal return from investment equals a borrowing cost, it no longer pays off 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 curve for θ_4. For entrepreneurs with a lower productivity, only a small number of them borrow since financing investment with the costly external borrowing incurs a marginal loss. They invest 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. Hence the fraction of assets invested in the business is higher if assets are low.

Figure 3: Benchmark model: entrepreneurs' assets and investment



In our model, three features contribute to the model's capability to generate an endogenously determined non-degenerate distribution of firms' size. First, 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.[28] Second, the existence of borrowing constraints precludes those with few assets from expanding business or even from starting up. Lastly, 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.

6.1 Sensitivity analysis of the benchmark economy

In this subsection, we conduct some sensitivity analysis over the values of parameters that are important in characterizing entrepreneurs' activities.[29]

Borrowing limit: First, we conduct experiments with alternative values of maximum leverage ratio d, which determines the tightness of the entrepreneurs' borrowing limit. Recall that for given assets a, entrepreneurs can borrow up to $a \times d$ and the maximum possible investment size is $(1 + d)a$.

The results are shown in Tables 5(a), 5(b) and 5(c). Table 5(a) shows that the level of entrepreneurial activities is higher when the borrowing limit is relaxed. Also notice

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

[29] We only change the parameter value of interest from the benchmark model and keep the other parameter values the same, except for the tax parameters a_2 and τ_I which adjust to balance the government budget.

that the effect on the investment is larger for more productive entrepreneurs, as shown in Table 5(c). The effect on aggregate variable is much less. The aggregate capital is higher only by 0.48% when the maximum leverage ratio increases as much as 20%. The economy's resources shifted from the corporate sector to the entrepreneurial sector. Wealth held by the richest increases when d is higher, as shown in Table 5(b). The wealth Gini increases, though the magnitude is small.

Capital ratio: Next we conduct a sensitivity analysis over the parameters a and b in the production technology of entrepreneurs, which determine the capital and labor intensity. Since entrepreneurial firms rely more on labor as a production input, changing the capital ratio would affect how the sector weighs in the overall economic activities and how it affects factor demand and prices. Recall the production technology of entrepreneurs:

$$y = \theta k^a n^b = \theta (k^\alpha n^{1-\alpha})^\nu,$$

where the last equality is due to the assumption we made that the relative capital ratio is the same in corporate and non-corporate sectors. We set $\alpha = 0.36$ and $\nu = 0.88$ in the benchmark. We compute the equilibrium with two alternative values of α, $\alpha = 0.33$ and 0.39.[30] Results are shown in Tables 6(a), 6(b) and 6(c).

When α is high, the marginal return from investment is higher and entrepreneurs rely more heavily on capital as a production input. It becomes more important to have enough assets to undertake a large project. Table 6(a) shows how the capital intensity change with the value of α. As shown in Table 6(b), when α is increased to 0.39, the economy's distribution is more unequal and the rich hold more wealth.

[30] As in the sensitivity analysis of the borrowing limit, we depart from the benchmark only by changing the parameter value of α in the entrepreneurs' production function. The technology of corporate sector remains unchanged and the capital ratio is 0.33.

Table 5: Sensitivity analysis: borrowing limit

(a) Aggregate and entrepreneurial activities

maximum leverage	aggregate variables				entrepreneurs' activities			
ratio d	Y	K	r	w	% of E	Y_E	K_E	L_E
70%	1.0144	1.0048	2.97	1.0092	12.0%	1.0817	1.1198	1.0693
60%	1.0067	1.0015	3.05	1.0043	12.0%	1.0403	1.0589	1.0350
50% (benchmark)	1.0000	1.0000	3.12	1.0000	12.0%	1.0000	1.0000	1.0000
40%	0.9917	0.9970	3.21	0.9942	11.9%	0.9540	0.9374	0.9604
30%	0.9822	0.9935	3.32	0.9877	11.9%	0.9025	0.8682	0.9159

(b) Distribution of wealth

maximum leverage	wealth	wealth in the top			
ratio d	Gini	5%	10%	20%	40%
70%	0.805	51.3%	69.2%	85.3%	95.0%
60%	0.802	50.8%	68.7%	84.9%	94.9%
50% (benchmark)	0.799	50.2%	68.1%	83.9%	94.9%
40%	0.796	50.8%	68.5%	83.6%	94.2%
30%	0.790	49.8%	67.6%	82.9%	94.1%

(c) Investment and leverage by θ

maximum leverage	investment (% leverage in parentheses)			
ratio d	$\theta_2 = 0.706$	$\theta_3 = 1.470$	$\theta_4 = 2.234$	weighted. avg
70%	3.38 (2.8%)	12.98 (17.1%)	31.82 (39.0%)	20.40 (25.1%)
60%	3.37 (2.8%)	12.72 (14.9%)	29.66 (35.0%)	19.22 (22.4%)
50% (benchmark)	3.32 (2.2%)	12.61 (13.6%)	27.66 (31.2%)	18.23 (20.1%)
70%	3.34 (2.0%)	12.49 (11.7%)	25.52 (26.4%)	17.18 (17.1%)
70%	3.28 (1.3%)	12.28 (8.4%)	23.37 (19.7%)	16.06 (12.6%)

Table 6: Sensitivity analysis: capital ratio

(a) Aggregate and entrepreneurial activities

capital	aggregate variables				entrepreneurs' activities			
ratio α	Y	K	r	w	% of E	Y_E	K_E	L_E
0.33	0.9534	0.9150	3.49	0.9778	11.9%	0.9247	0.8485	0.9886
0.36 (benchmark)	1.0000	1.0000	3.12	1.0000	12.0%	1.0000	1.0000	1.0000
0.39	1.0560	1.1038	2.71	1.0263	11.9%	1.0896	1.1835	1.0121

(b) Distribution of wealth

capital	wealth	wealth in the top			
ratio α	Gini	5%	10%	20%	40%
0.33	0.778	47.4%	65.7%	81.5%	93.5%
0.36 (benchmark)	0.799	50.2%	68.1%	83.9%	94.9%
0.39	0.818	54.4%	71.4%	86.1%	95.5%

(c) Investment and leverage by θ

capital	investment (% leverage in parentheses)			
ratio α	$\theta_2 = 0.706$	$\theta_3 = 1.470$	$\theta_4 = 2.234$	weighted. avg
0.33	2.81 (1.1%)	9.56 (11.3%)	24.40 (30.8%)	15.60 (19.0%)
0.36 (benchmark)	3.32 (2.2%)	12.61 (13.6%)	27.66 (31.2%)	18.23 (20.1%)
0.39	4.08 (4.0%)	16.70 (16.9%)	31.62 (31.3%)	21.64 (21.5%)

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 (section 7.1)
    - 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 (section 7.2.1)
    - more/less progressive income tax system (section 7.2.2)
3. investment-targeted policies
    - accelerated/increased depreciation expense for entrepreneurs (section 7.3.1)
    - loan interest subsidy and reduction in entrepreneurs' borrowing costs (section 7.3.2)
4. Separate treatment of entrepreneurs' investment income without double taxation (section 7.4)

To compare the long-run welfare costs and benefits of different tax systems, we compute the consumption equivalent variation (CEV). It measures the constant increment in percentage of consumption in every state that has to be given to each agent so that he is indifferent between living the new tax system and remaining in the benchmark. We compute the average of CEV for workers and entrepreneurs according to the stationary distribution, which evaluates how much an agent would value a particular system compared to the benchmark ex-ante, conditional only upon his being a worker (or an entrepreneur).

7.1 Capital income tax

In this section, we implement a flat capital income tax on the return from saving, 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 τ_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:

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

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

Results are summarized in Figures 4 and 5. As shown in the top left panel of Figure 5, lower capital income tax encourages the saving and raises the level of aggregate capital and output. Interest rate goes down with the capital tax rate, together with an increasing capital labor ratio in the corporate sector. Wage moves in the opposite direction as the labor becomes more scarce relative to the capital.

Figure 5 (top right) displays the economic activities in the 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 the net-of-tax return from saving is higher and other sources of income including profit from entrepreneurial business are taxed at a higher rate to compensate for the reduction in the tax revenue (see the bottom left panel of Figure 4 for the changes in proportional tax rate τ_I). 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 a fraction of entrepreneurs who borrow from the intermediary. Entrepreneurs rely more heavily on labor inputs and capital-labor ratio 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 Figure 4 (top left), when the capital tax is zero, wage is 1.5% higher than in the benchmark, which forces the entrepreneurs adjust the technology (input shares) and pushes down the total labor used in the sector by as much as 4.5%. The production goes down by 3.1%.

Reduction in capital tax favors workers more than entrepreneurs, as shown by consumption equivalent variations in Figure 5 (bottom right). 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 a consequence, the economy is more equal in wealth distribution as reflected in a lower Gini coefficient in Figure 5 (bottom left). 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 and this alone does not dominate in determining the direction of wealth inequality.

7.2 Different degrees of income tax progressivity

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

7.2.1 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 government expenditures.

Results are summarized in Tables 7(a), 7(b) and 7(c). The equilibrium flat income tax rate that balances the government budget is 16.91%, which is higher than the marginal tax rate 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 2.759, significantly higher than the benchmark level of 2.656. With increased economic investment and output, the relative size of the government, which is expressed in terms of the ratio of public expenditures to GDP, is lower at 17.77%, compared to 18.00% in the benchmark. The wealth distribution of the economy becomes more unequal (wealth Gini increases from 0.799 to 0.811), but not so dramatically as low-income/low-asset workers also benefit from the higher wage. As shown in Table 7(c), a larger fraction of wealth is held by the rich.

Cagetti and De Nardi (2004a) and Meh (2002) also run a policy experiment of proportional tax reform in a model with entrepreneurs. Our quantitative results are similar to theirs, but the magnitude of the aggregate and distributional effects are much larger in Cagetti and De Nardi (2004a). (Aggregate capital increases by 60% in their model and it is 10% in ours. Wealth held by top 5% increase by 14% in theirs and it is 3.2% in ours.) One possible reason can be that in their model entrepreneurs do not use labor as inputs and wage increase due to increased demand does not directly hit entrepreneurs' production costs and constrain them from expanding the business. Increased activities in the non-corporate sector do not directly give upward pressure on wages, either. Of course, there are other features the two models do not share, which could have contributed to the different results.

Our results also contrasts with the effects of proportional tax reform without the entrepreneurial sector. Conesa and Krueger (2004) shows in their dynamic overlapping generations model that the reform will raise the capital stock by 14% and output by 9%.

When we compare the results to the experiments of abolishing or reducing capital tax in the previous section, the aggregate effects are similar (higher capital and output, low interest and high wage), but effects on entrepreneurial activities and wealth distribution are very different. With no capital tax, entrepreneurs have an incentive to allocate more resources to saving, rather than investing. Total investment in the non-corporate sector is lower than in the benchmark, while under the flat income 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.

7.2.2 Changing progressivity

Next we study the effect of less/more progressive tax system while keeping the non-linear structure of the tax schedule. We adjust the parameter a_0 of the income tax function. We will increase and reduce the parameter up to 30% and -30% by a 5% increment. A higher value of this parameter implies that the tax system has a higher top marginal tax rate and is more progressive, with an increased slope of the average and marginal tax schedules. The tax burden falls more heavily on agents with higher income. The proportional part of income tax τ_I will adjust to achieve the government budget balance. The total tax payment for a taxable income I is given by

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

where $\tilde{a}_0$ varies from $0.70 \times a_0 = 0.1806$ to $1.30 \times a_0 = 0.3354$ in the experiments.

Results are summarized in Figures 6 and 7. With a more progressive tax system, agents earning high income face an increase in the marginal tax, which discourages savings and investments by entrepreneurs, and reduces capital in both corporate and non-corporate sectors. As shown in Figure 7 (top right), with a_0 that is 30% above the benchmark, total investment of entrepreneurs is 2.42% lower. With a decreased demand for capital, the interest rate is higher and wage is lower. However, despite the lower wage notice that welfare of workers is not much affected by the changes in the progressivity as shown in Figure 7 (bottom right). When the system is more progressive (a_0 is high), more tax is collected from the rich, and the proportional tax rate τ_I on other sources of income required to balance the budget is much lower than in the benchmark (see the bottom left panel of Figure 6). On the other hand, entrepreneurs are worse off under the more progressive regime as the rent from projects are taxed more heavily, which contributes to the less wealth inequality as shown in Figure 7 (bottom left), though the degree is not so large.

Related to this experiment, Carroll, Holtz-Eakin, Rider, and Rosen (2000a) studied the effect of changes in the marginal tax rates on entrepreneurs' investment, using the IRS tax data before and after the Tax Reform Act of 1986, which reduced the top marginal rate from 50% to 28%. They conclude 5% increase in marginal tax rates leads to a 10% decline in the entrepreneurs' investment spending. We also find that the increase in the progressivity and the top marginal tax rate discourages entrepreneurial activities, though the quantitative effect is much smaller. They estimate the effect using a reduced form characterization of samples and general equilibrium effects such as the effect of price changes or the adjustment of other taxes to balance the government budget are not considered. Also missing are the technology adjustment by entrepreneurs given the changes in the input prices, and effects of heterogeneity among agents (different occupational choice, abilities, borrowing constraints, etc). Nonetheless, their empirical findings provide a strong support and need for investigating effects of tax changes on the economic activities of entrepreneurs, as they could respond very differently from workers and the effects can significantly affect aggregate economic conditions.

7.3 Investment-targeted policies

This section is a slight digression from the study of income taxation and we look at 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.

7.3.1 Accelerated depreciation expensing for entrepreneurs

This subsection studies the effect of allowing an accelerated depreciation deduction. The Jobs & Growth Tax Relief Reconciliation Act of 2003 (JGTRRA 2003) brought favorable tax treatments for businesses allowing an increased depreciation expensing. There are two major changes in the law, one is designed to target small businesses and the other one is for general investments.[31] We study the effect of policies targeted for entrepreneurs.

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 up to 100% with a 20% increment, i.e. λ =1.2, 1.4, 1.6, 1.8 and 2.0. Results are summarized in Figures 8 and 9. The policy has a strong effect and encourages investments by entrepreneurs and formation of larger projects. 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 workers' income from saving.

7.3.2 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 ϕ =

[31]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.

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% and 1%. The government uses the proportional income tax τ_I to balance the budget. The subsidy payment is additional expenditures of the government and added on top of other expenditures G.

Results are summarized in Figures 10 and 11. The effects on entrepreneurial activities are similar to the case of accelerated depreciation policy in the previous section. Reduction in loan premium pushes up the break-even point of investment financed by borrowing and raises the investments by entrepreneurs. The policy comes at the cost of workers, who face higher tax rates on their income, together with the lower interest rate on savings.

7.4 Separate treatment of entrepreneurs' investment income without double taxation

In this section, we consider a system that distinguishes entrepreneurs' business income at the firm level for the purpose of taxation, and treats it separately from the other sources of individual income. The current U.S. individual income tax code does not distinguish the sources of income. Accordingly, we combined different incomes lumped together in the benchmark, including wage income, capital income from savings and income from entrepreneurial business. The focus of this section is to understand the effect of reducing tax on the part of income from entrepreneurial business.

We can think of this exercise as a policy experiment where entrepreneurs are taxed twice as separate entities, once at the firm level for the business income, just as with the regular corporations, and at the individual level for the capital income and compensation for their labor services, but without double taxation. In practice, however, it is hard to impute the fair market wage for the services rendered by owners of entrepreneurial firms, although in some forms of entrepreneurship (S-corporations and LLCs in some cases) tax authorities require them to impute reasonable wages as the wage income is subject to the self-employment taxes (FICA taxes). Alternatively, the experiment can be interpreted as having entrepreneurs receive some special tax treatment (as with investment credit policy, or accelerated depreciation allowance) in computing the tax obligations.

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.

When we consider the 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,[32] the actual collection of tax from corporations is very small in size, only 1.4% of GDP,[33] implying the shape of the effective tax on the profits is very different from that of the statutory tax system, and it is a very challenging task to estimate such an effective tax 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 as we discuss below.

7.4.1 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 the form of workers' tax schedule. A proportional tax τ_I on the income at the individual level (both for entrepreneurs and workers) adjusts 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

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

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 40% by a 5% increment. Given that most entrepreneurs face near-top marginal tax rate in the benchmark, τ_{E1} below 25% can be considered as a reduction of taxes on the business income and an increase of burden if τ_{E1} is above that level. Results are summarized in Figures 12 and 13. A low marginal tax effectively increases entrepreneurs' investment and the output is higher both in entrepreneurial and corporate sectors. Effects are significant. When the government impose 10% tax on entrepreneurial business income, for example, non-corporate investment will increase by 11% and output by 2%.

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 (accelerated depreciation expense for entrepreneurs and loan interest subsidy). That is, the policy stimulates entrepreneurial production, with a large increase in investment and a moderate and limited effect on labor demand due to the rise in the wage rate. Entrepreneurs benefit from the policy and enjoy increased after-tax earnings. As with the two investment policies, wealth inequality becomes substantially increased. A lower tax on entrepreneurs' business income requires an increase in the tax burden on workers, but the welfare effect is mitigated by the increase in the wage rate (see Figure 13 (right bottom) for consumption equivalent variations and Figure 12 (top left) for wages).

[32] 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).

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

Also note that when the tax rate on entrepreneurs' business income is increased, both entrepreneurs and workers are worse off. Entrepreneurial as well as aggregate activities are curtailed (see top two panels in Figure 13) and the wage is lower. The only possible bright side is the lower inequality.

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. First, a higher wage pushes up the input cost of entrepreneurs' production since their production technology is more labor intensive due to the capital market imperfections and constraints they face in raising capital. Second, after-tax return from saving is higher and saving becomes more attractive use of available assets. Lastly, the government is required to raise tax on other sources of income, including income from entrepreneurial business, which also discourages investments. Raising capital tax will do the opposite, but such policy is shown to exacerbate the wealth inequality and ex-ante welfare becomes lower for both entrepreneurs and workers. Increasing the progressivity of income tax schedule will slightly reduce the inequality, but the entrepreneurial investments as well as aggregate activities are reduced.

We have also confirmed various non-tax policies to encourage entrepreneurial investments, such as accelerated depreciation allowance or loan subsidy, are very 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. When the tax on entrepreneurs is raised, on the other hand, investments can be significantly reduced and both entrepreneurs and workers become worse off.

We have demonstrated that the departure from a single-occupation model of incomplete markets provides interesting and possibly very important implications for the discussion of 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. Given the high non-linearity of the households problem, we solve for an equilibrium in a discretized space. We allow agents to choose savings from an asset space of 3,000 discrete points, and entrepreneurs to choose capital and labor from 1,000 points each. 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,[34] 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.

[34] 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.

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Figure 4: Flat capital income tax (1)
Experiment in Section 7.1

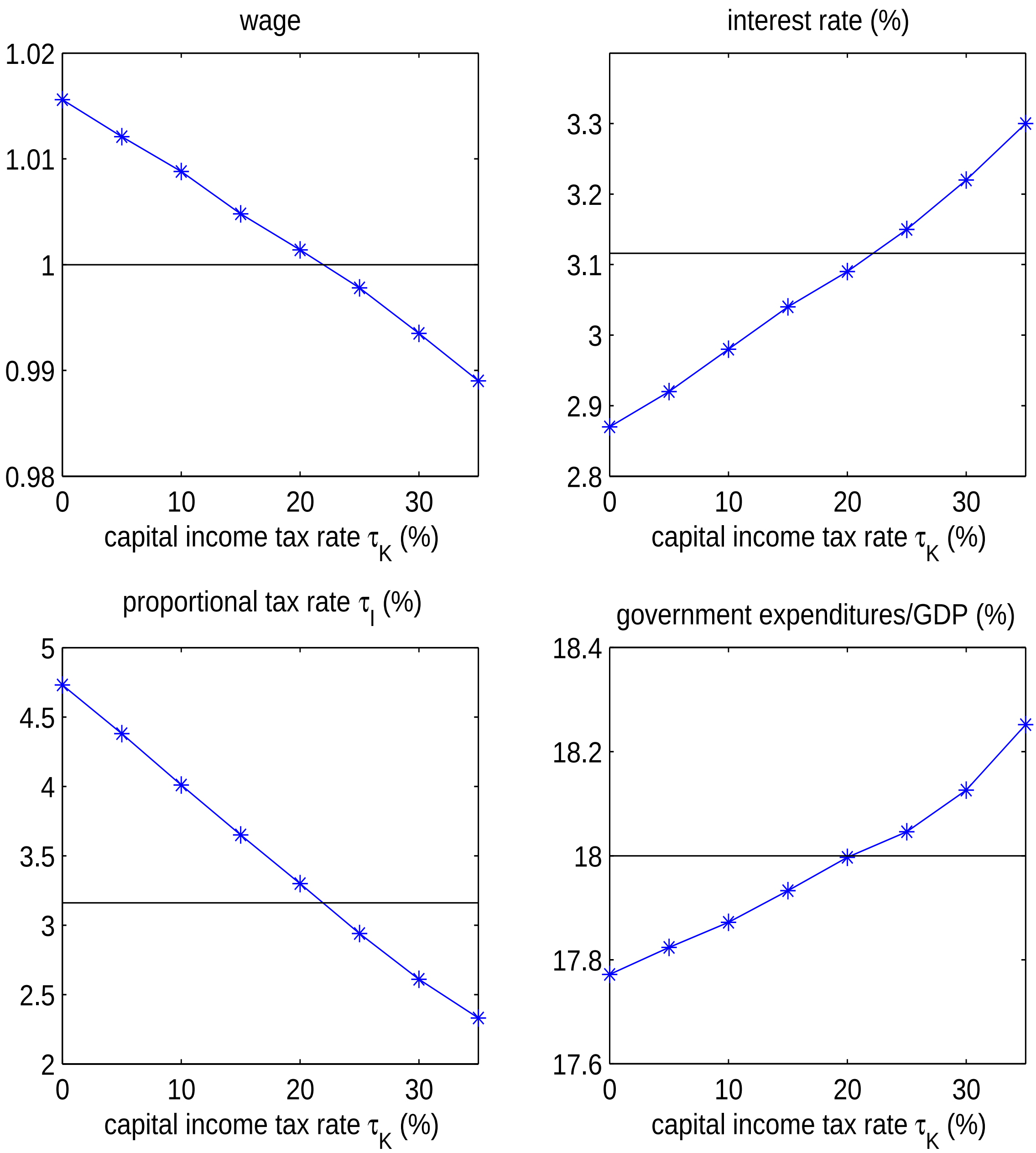

Figure 5: Flat capital income tax (2)
Experiment in Section 7.1

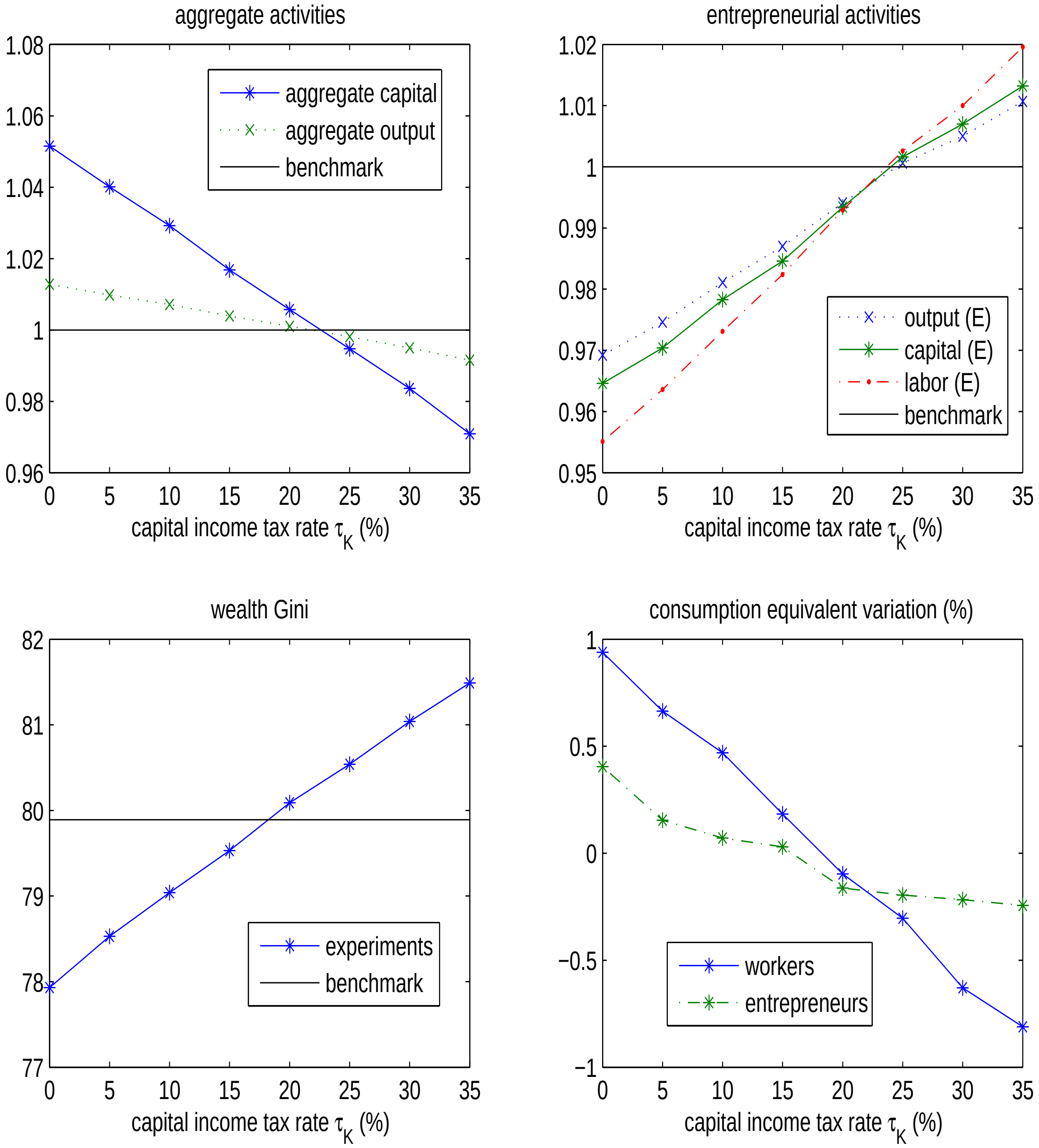

Table 7: Flat income tax system
Experiment in Section 7.2.1

(a) Aggregate variables

	Y	K	L	K/Y	r	w	G/Y
Benchmark	1.0000	1.0000	1.0000	2.656	3.116%	1.0000	0.1800
Flat rate 16.91%	1.0299	1.0991	1.000	2.759	2.868%	1.0304	0.1777

(b) Entrepreneurial activities and consumption equivalent variations (CEV)

	Y_E	K_E	L_E	% of entrep.	Entrep. income	CEV (W) (%)	CEV (E) (%)
Benchmark	1.0000	1.0000	1.0000	11.96%	29.16%	-	-
Flat rate 16.91%	1.0145	1.0840	0.9841	11.75%	28.64%	-0.201	1.707

(c) Distribution of wealth

	wealth Gini	wealth in the top 5%	10%	20%	40%
Benchmark	0.799	50.2%	68.1%	83.9%	94.9%
Flat rate 16.91%	0.811	53.4%	70.6%	85.5%	95.4%

Figure 6: Different progressivity of income tax (1)
Experiment in Section 7.2.2

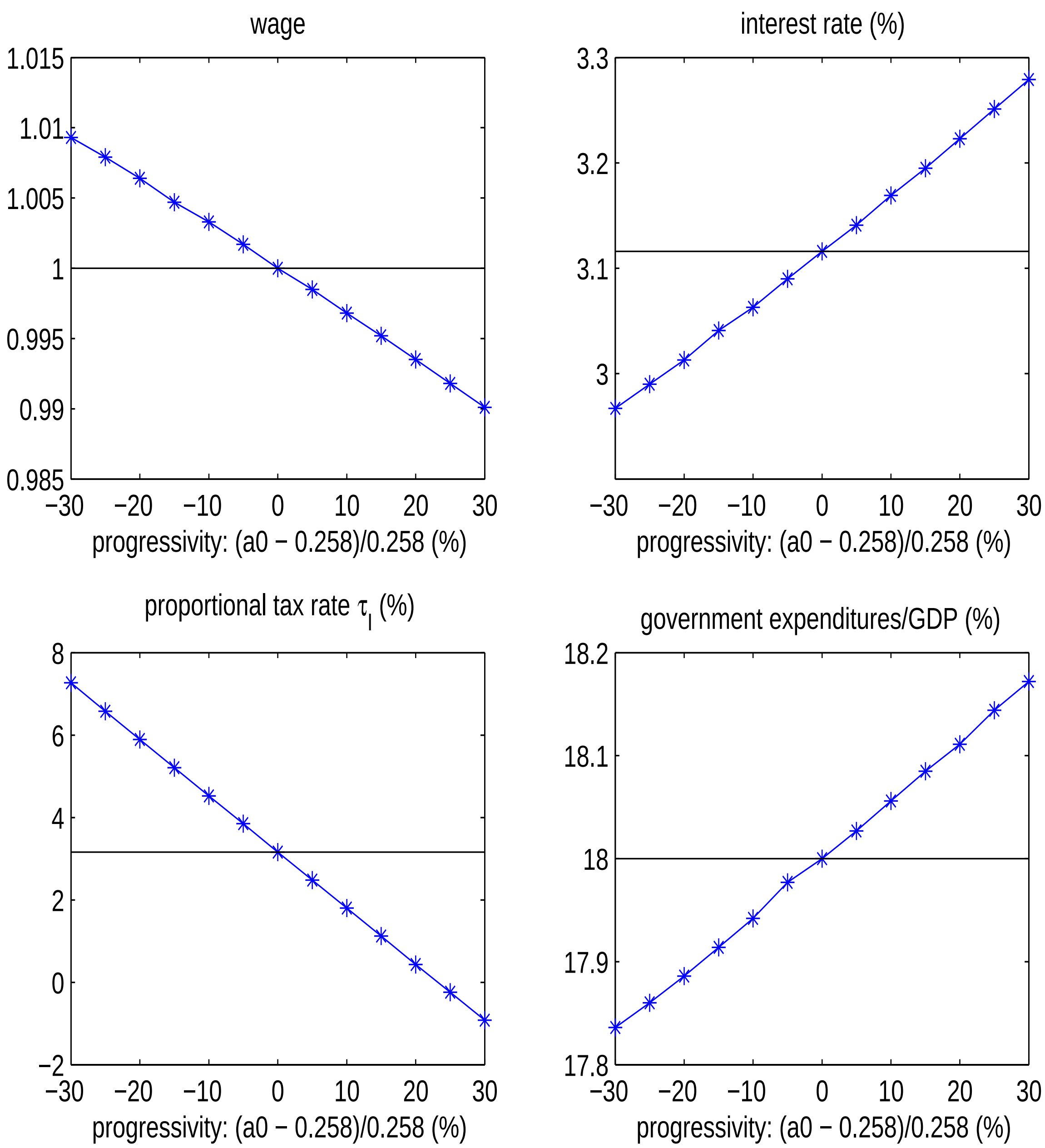

Figure 7: Different progressivity of income tax (2)
Experiment in Section 7.2.2

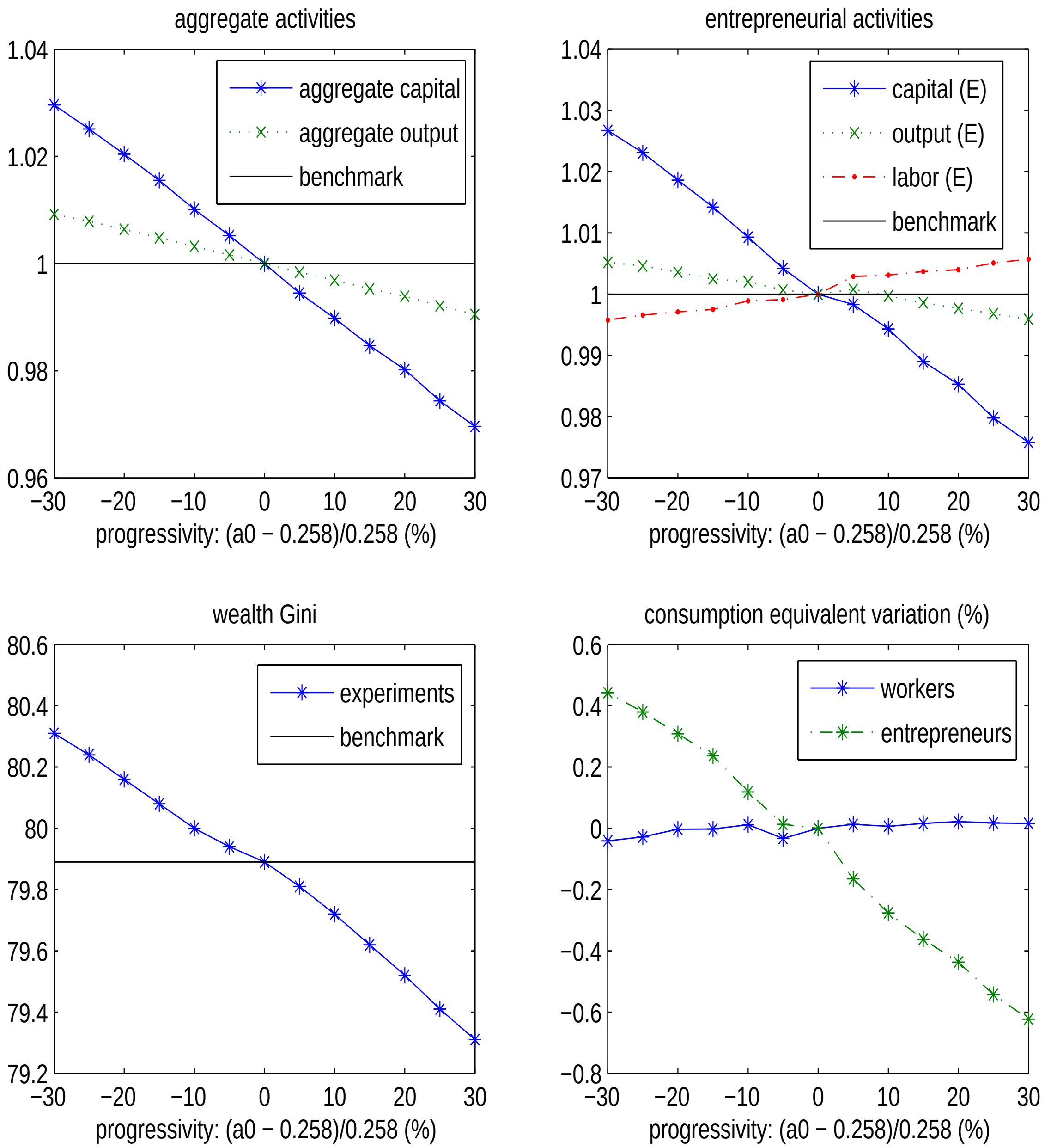

Figure 8: Accelerated depreciation allowance for entrepreneurs (1)
Experiment in Section 7.3.1

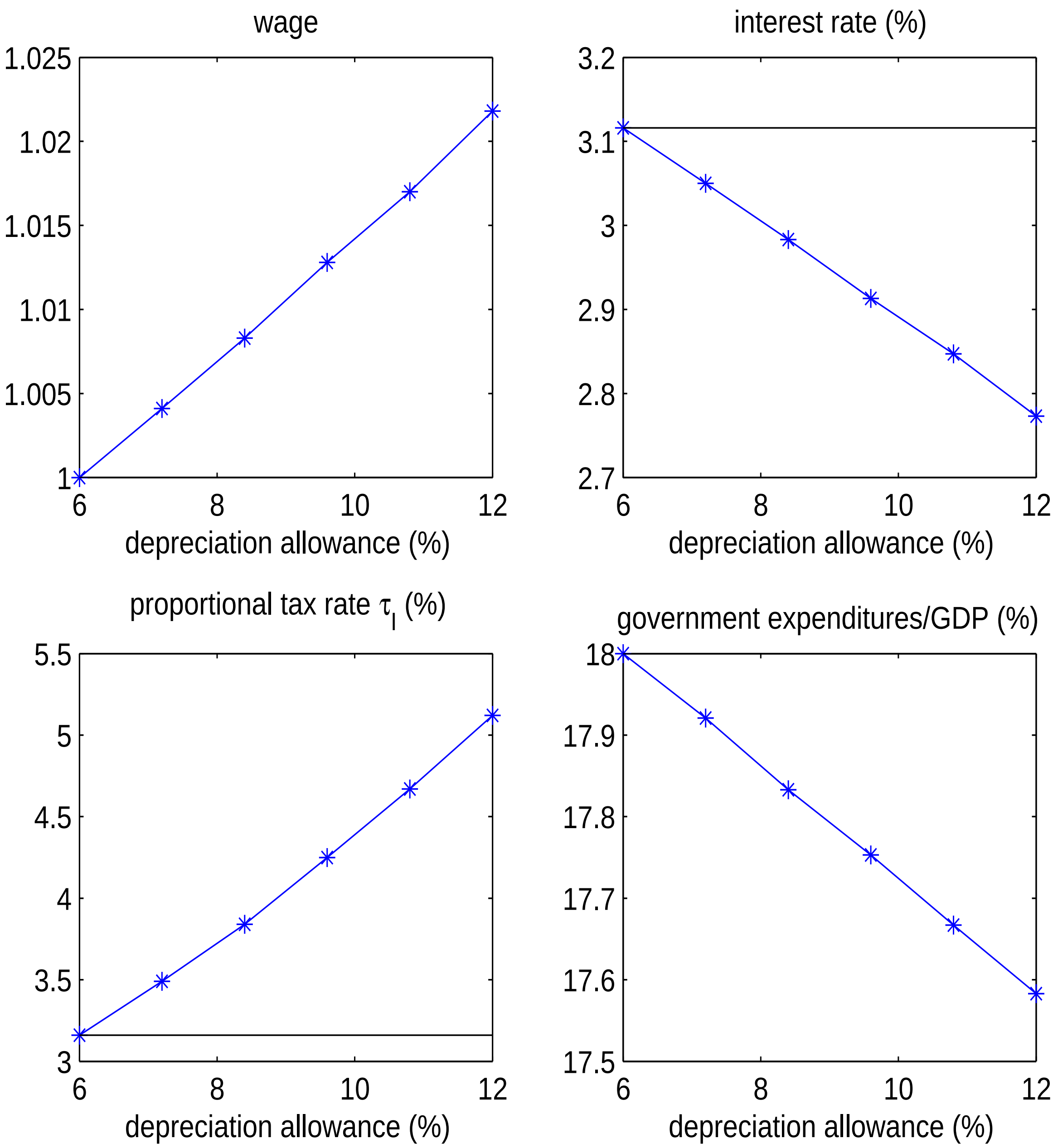

Figure 9: Accelerated depreciation allowance for entrepreneurs (2)
Experiment in Section 7.3.1

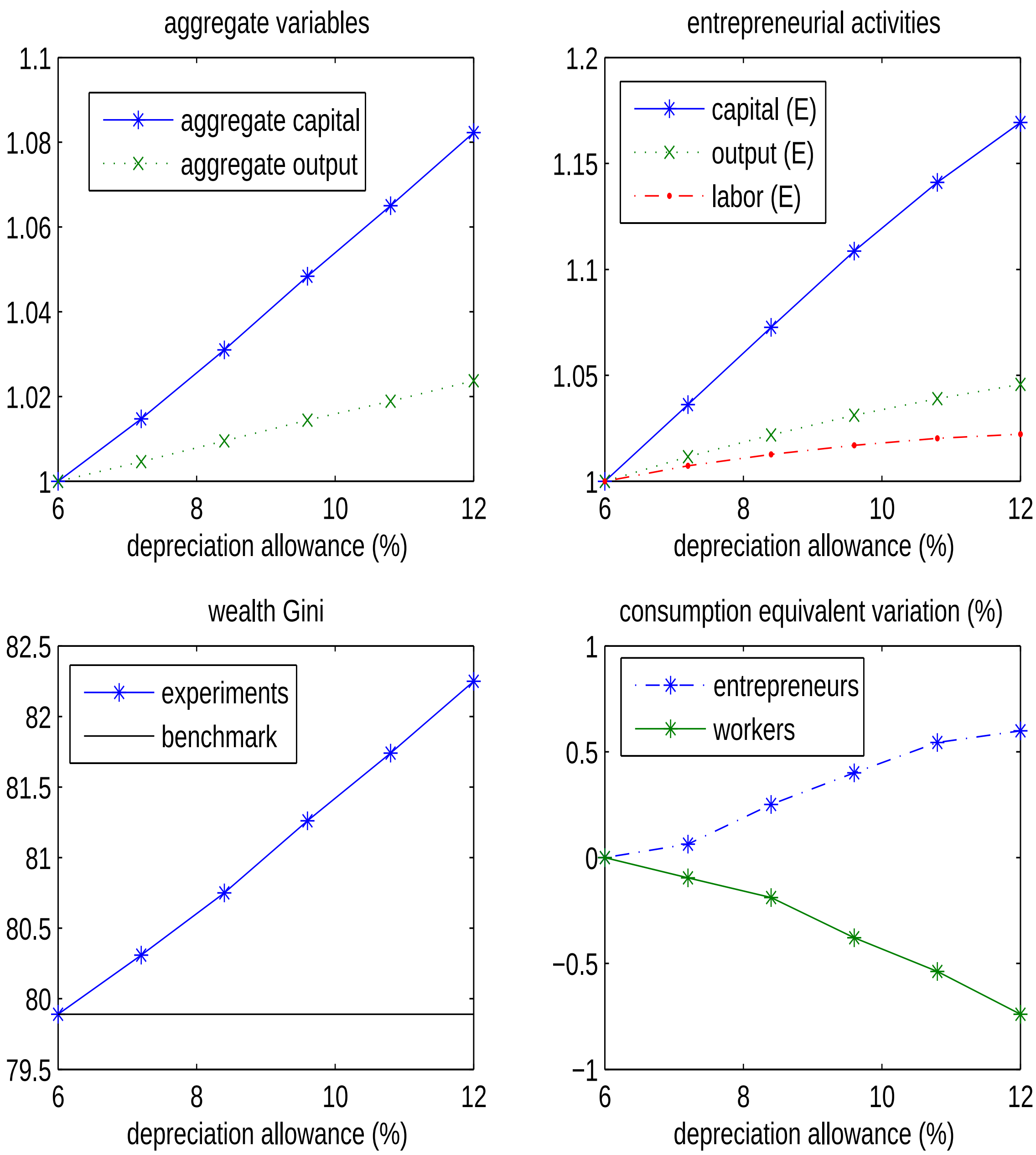

Figure 10: Loan subsidy to entrepreneurs (1)
Experiment in Section 7.3.2

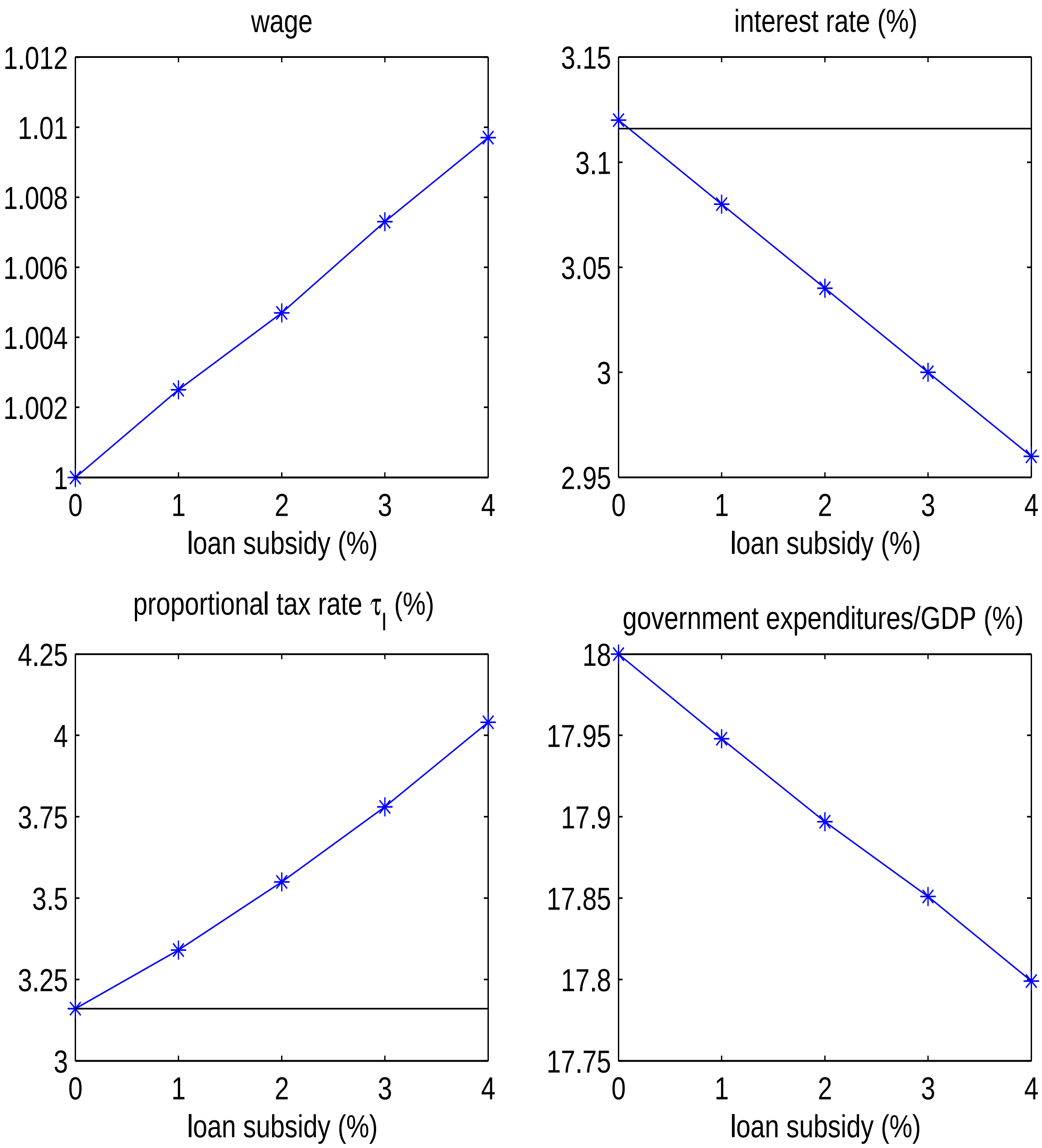

Figure 11: Loan subsidy to entrepreneurs (2)
Experiment in Section 7.3.2

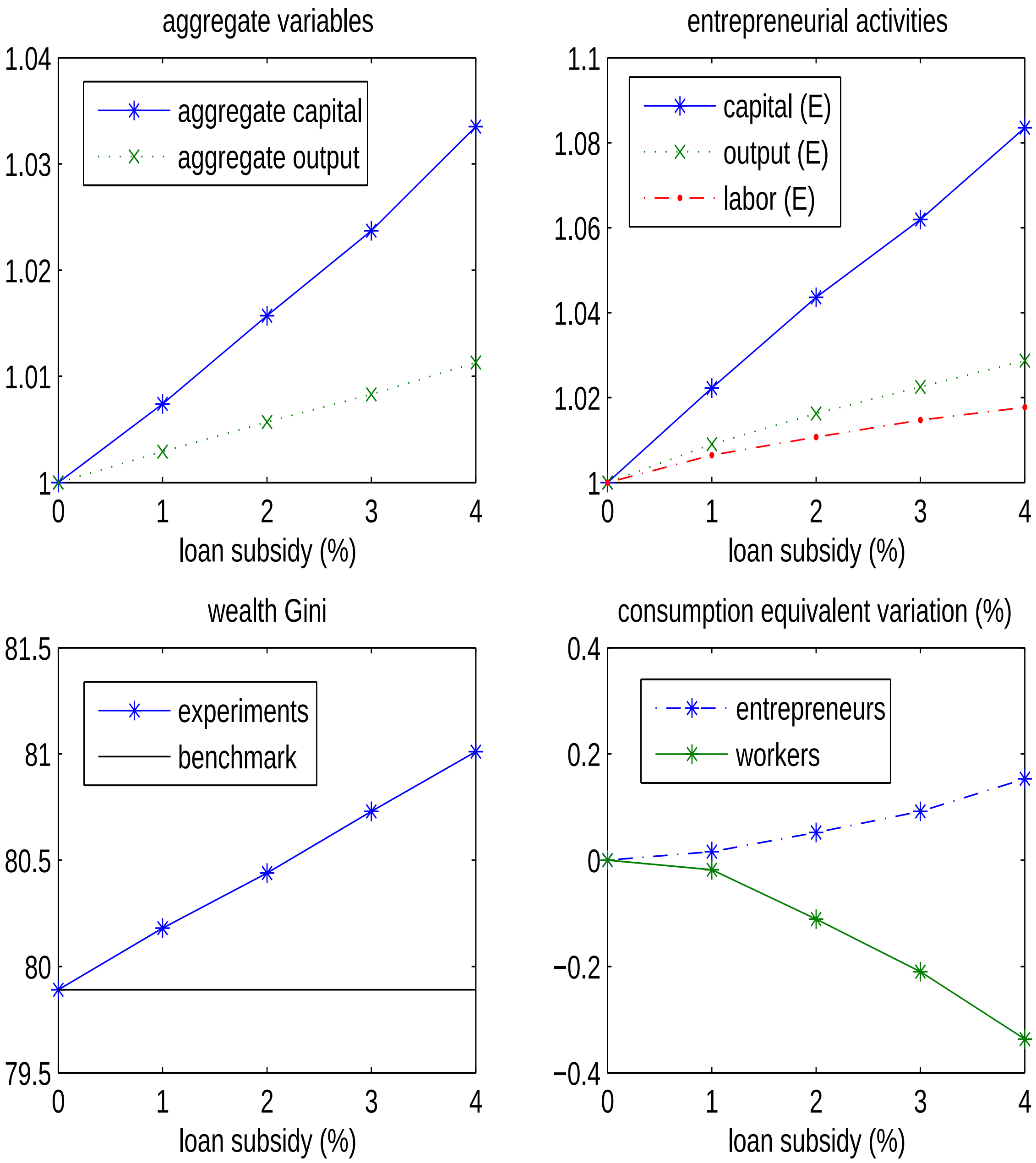

Figure 12: Separate tax for entrepreneurial income (1)
Experiment in Section 7.4

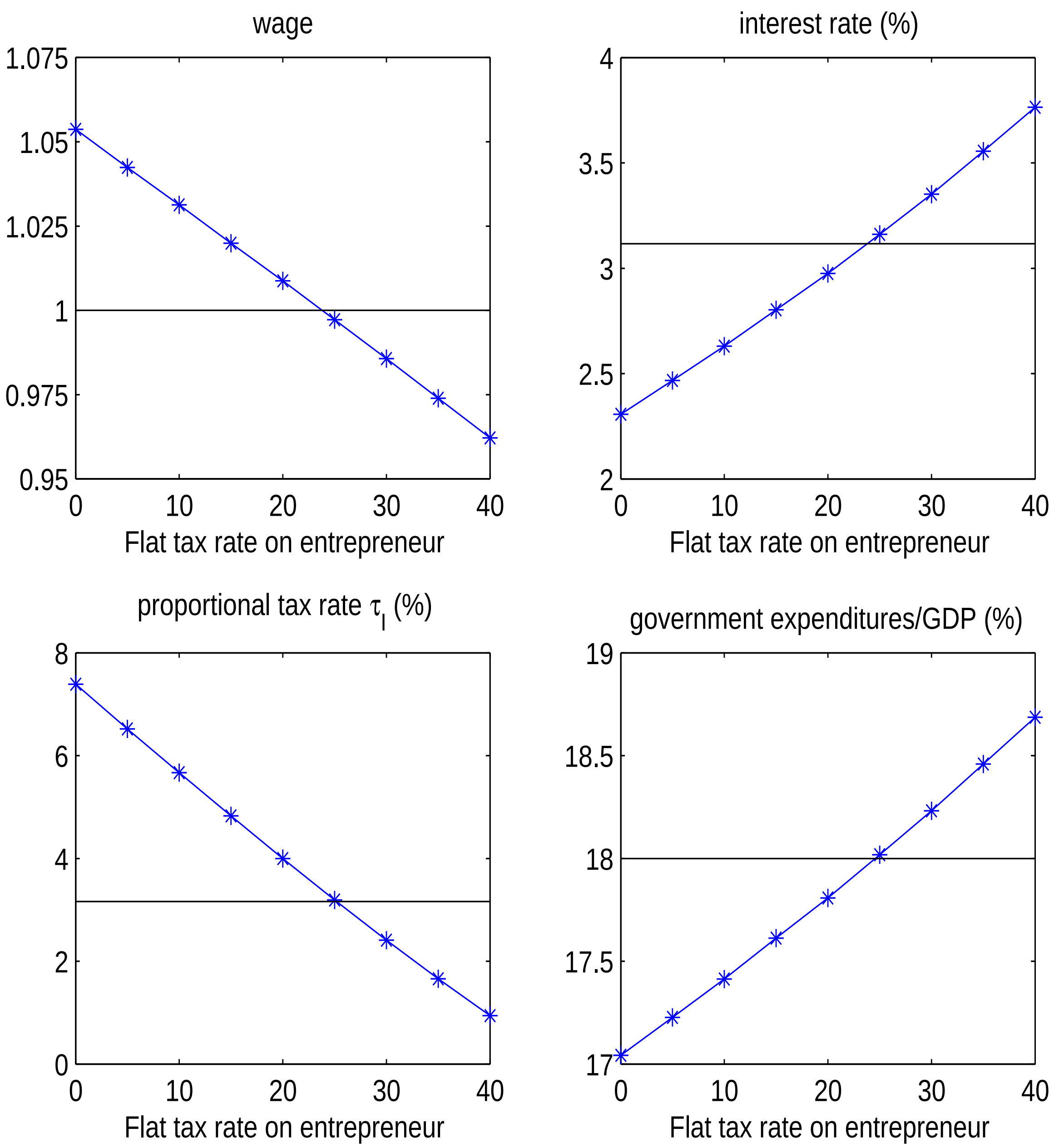

Figure 13: Separate tax for entrepreneurial income (2)
Experiment in Section 7.4